AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

112th Congress, 1st Session – – – – – – – – – – – – House Document 112–20

CALOOSAHATCHEE RIVER (C–43) WEST BASIN STORAGE RESERVOIR PROJECT

COMMUNICATION

FROM

THE CHIEF ENGINEER, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

PART 1 of 2



MAY 6, 2011.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT
PART 1 OF 2

112th Congress, 1st Session – – – – – – – – – – – – House Document 112–20

CALOOSAHATCHEE RIVER (C–43) WEST BASIN STORAGE RESERVOIR PROJECT

COMMUNICATION

FROM

THE CHIEF ENGINEER, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

PART 1 of 2



MAY 6, 2011.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

---

U.S. GOVERNMENT PRINTING OFFICE

66–223 WASHINGTON : 2011



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

APR 13 2011

Honorable John A. Boehner
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

Dear Mr. Speaker:

The Secretary of the Army recommends authorization of the Caloosahatchee River (C-43) West Basin Storage Reservoir project in Hendry County, Florida, for the purposes of ecosystem restoration and recreation. The project would be a major step in the modification of the Central and Southern Florida (C&SF) project to help restore, preserve, and protect the South Florida ecosystem, while providing for other water-related needs of the region. The project is described in the reports of the Chief of Engineers, dated March 11, 2010, and January 6, 2011, and the Integrated Project Implementation Report and Environmental Impact Statement, dated September 2007 (revised March 2010 and November 2010), which contain other pertinent documents. The views of the South Florida Water Management District (SFWMD), the State of Florida, the Department of the Interior, and the Environmental Protection Agency are set forth in the enclosed report.

The reports are submitted in accordance with Section 601(d) of the Water Resources Development Act (WRDA) of 2000, which requires the submission of a report and authorization of various features of the Comprehensive Everglades Restoration Plan (CERP). The recommended C-43 project is a feature of the CERP, which was approved by Section 601(b)(1) of the WRDA of 2000 as a framework for modifying the C&SF project. The Secretary of the Army plans to implement the C-43 project, as described herein, through the normal budget process at the appropriate time, considering national priorities, and the availability of funds.

The recommended C-43 project would significantly contribute to two CERP goals and objectives – improving habitat and functional quality, and improving native plant and animal species abundance and diversity. It would also contribute to the socioeconomic objective of providing incidental recreation and navigation opportunities. The reports identify the recommended ecosystem restoration improvements as an increment of a National Ecosystem Restoration (NER) Plan. We expect a future investigation of storage capabilities in the eastern portion of the watershed to incorporate the results of these reports and identify the NER Plan for the entire Caloosahatchee River watershed.

Printed on  Recycled Paper

The recommended project would improve the ecological function of the Caloosahatchee Estuary by capturing and storing excess surface water runoff from the Caloosahatchee River watershed and excess releases from Lake Okeechobee, and then releasing the stored water to augment inadequate flows during the dry season. These operations would reduce extreme changes in salinity in the estuary caused by extreme high and low flows in the river, and thereby create more stable aquatic habitat. The project is located on 10,700 acres of farm land near the Caloosahatchee River in Hendry County. The ecosystem restoration features include the construction of a 170,000 acre-foot reservoir within an embankment up to 37-feet high and a canal around the embankment perimeter. The new canal is necessary to continue operating existing canals at the site. Water would be moved by a 1500-cfs pump station and controlled by appurtenant spillways, culverts, outlets and other minor structures. Recreation features include a 12-mile-long trail on the embankment, a parking area, toilets, a kiosk, a boat ramp, a shade structure, fencing, and a foot bridge over the canal.

Based on October 2010 price levels, the estimated first cost of the recommended project is $579,599,000, which includes $576,643,000 for ecosystem restoration. In accordance with Section 601(e) of the WRDA of 2000, the Federal and non-Federal shares of the first cost for ecosystem restoration are $288,322,000 each. Based on a discount rate of 4.125 percent and a 40-year period of analysis, the equivalent average annual cost is $35,275,000, which includes the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) estimated at $3,160,000 annually. The OMRR&R estimate includes about $680,000 for monitoring water quality impacts. Ecological monitoring would be funded separately under the CERP Monitoring and Assessment Plan. In accordance with Section 601(e)(4), OMRR&R activities for ecosystem restoration are a non-Federal responsibility for implementation, but are cost shared equally between the Federal Government and the non-Federal sponsor. The estimated first cost of lands, easements, rights-of-way, relocations, and disposal areas for the recommended project is $84,650,000. The State of Florida has purchased 12,372 acres in the immediate area with funding provided by the Department of the Interior at a total cost of $32,800,000, of which about $27,567,000 was for acquiring lands required for this project. The latter amount is considered a Federal expenditure for cost sharing purposes since the funds were provided by the Federal government.

The project would also provide recreation opportunities incidental to ecosystem restoration. The estimated first cost of the recommended project includes $2,956,000 for recreation features. The Federal and the non-Federal shares of the first cost of the recreation features are $1,478,000 each in accordance with Section 103(c) of the WRDA of 1986. The equivalent average annual cost for recreation is $225,000, which includes $25,000 for annual OMRR&R. All of the OMRR&R for recreation is a non-Federal responsibility in accordance with Section 103(j) of WRDA 1986. The estimated average annual benefit for recreation is $384,000, resulting in net average annual benefits of about $159,000 and a benefit-to-cost ratio of about 1.7.

The estimated total Federal and non-Federal shares of the first cost of the project are $289,800,000 each. The total equivalent average annual cost is $35,500,000, which includes the total OMRR&R of about $3,185,000 annually.

Cost effectiveness and incremental cost analysis techniques were used to ensure that an appropriate ecosystem restoration plan was recommended. The recommended plan would improve the quality, quantity, and timing of flows in the lower Caloosahatchee River, which in turn would restore more natural hydrologic conditions and vegetative communities for fish and wildlife, including several endangered species, in the 71,000-acre Caloosahatchee Estuary. The plan would produce an average annual increase of 12,809 habitat units in the Caloosahatchee Estuary. As the next-added increment to CERP, the plan would deliver about 15,300 average annual habitat units. The ecosystem restoration first cost is about $8,200 for each acre of estuary restored.

The benefits to fish and wildlife habitat would be significant. The Caloosahatchee watershed and estuary are key components of the south Florida everglades ecosystem. The Everglades was designated as an International Biosphere Reserve (1976) and a World Heritage Site (1979) by the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and a Wetland of International Importance (1987) in accordance with the Ramsar Convention. The portion of the Everglades ecosystem directly affected by the recommended plan, including the project site and the Caloosahatchee River and Estuary, provides habitat for 21 Federally-listed endangered or threatened species, including the Florida panther, Everglades snail kite, wood stork, manatee, eastern indigo snake, Audubon's crested caracara and five species of sea turtles.

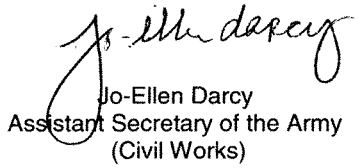
The SFWMD would be the non-Federal project sponsor and is legally capable of fulfilling those responsibilities. In accordance with Sections 601(h)(4(A)((iii)((IV) and (V) of the WRDA of 2000, the SFWMD would be responsible for reserving available water and additional water made available by the project that would be necessary to achieve the project's restoration goals and objectives. The report states that the State of Florida will reserve or allocate for the natural system the additional water made available by the project. The project would not provide additional water for water supply or other water-related needs in the watershed. It also would not reduce levels of service for flood protection in accordance with Section 601(h)(5)(B) of the WRDA of 2000.

Section 601(e)(5)(B) of the WRDA of 2000 authorizes credit toward the non-Federal share for non-Federal design and construction work completed during the period of design or construction, subject to the execution of the design or project partnership agreement, and subject to a determination by the Secretary that the work is integral to the project. The non-Federal sponsor intends to design and construct portions of this project and seek credit under this authority. The sponsor executed a Pre-Partnership Credit Agreement with the Department of the Army on August 13, 2009, which enables credit for certain work completed prior to an authorization of the project by the Congress and the execution of a project partnership agreement. The actual

amount of credit to be afforded will be subject to audit and a determination that the work has been constructed in accordance with applicable Federal and State laws.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress and concludes that the report recommendation is consistent with the policy and programs of the President. A copy of OMB's letter dated March 18, 2011, is enclosed. I am providing a copy of my letter to the House Committee on Appropriations' Subcommittee on Energy and Water Development, and the House Committee on Transportation and Infrastructure's Subcommittee on Water Resources and Environment. I am providing an identical letter to the President of the Senate.

Very truly yours,



Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

10 Enclosures

1. Report of the Chief of Engineers, March 11, 2010
2. Supplemental Report of the Chief of Engineers, January 6, 2011
3. South Florida Water Management District letter, November 6, 2009
4. Florida Dept. of Agriculture and Consumer Services letter, October 19, 2007
5. Florida Dept. of Environmental Protection letter, November 1, 2007
6. USACE response to Florida Dept. of Agriculture and Consumer Services, August 17, 2009
7. Department of the Interior letter, October 15, 2007
8. Environmental Protection Agency letter, October 18, 2007
9. OMB Clearance Letter, March 18, 2011
10. Integrated Project Implementation Report and Environmental Impact Statement, September 2007 (revised March 2010 and November 2010)

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:
CECW-SAD (1105-2-10a)

MAR 11 2010

SUBJECT: Comprehensive Everglades Restoration Plan, Central and Southern Florida, Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Hendry County, Florida

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on ecosystem restoration improvements for the Caloosahatchee River (C-43) West Basin Storage Reservoir project, located in Hendry County, Florida. It is accompanied by the report of the district and division engineers. These reports are in response to Section 601 of the Water Resources Development Act (WRDA) of 2000, which authorized the Comprehensive Everglades Restoration Plan (CERP) as a framework for modifications and operational changes to the Central and Southern Florida Project that are needed to restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. WRDA 2000 identified specific requirements for implementing components of the CERP, including development of a decision document known as a Project Implementation Report (PIR). The Caloosahatchee River (C-43) West Basin Storage Reservoir Project is a component of the CERP that was not specifically authorized in that Act. The authority for the preparation of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Implementation Report (PIR), one of a number of site-specific projects, is contained in Section 601(d) of WRDA 2000. Congress may authorize the project following review and approval of a PIR by the Secretary of the Army. The requirements of a PIR are addressed in this report. Preconstruction engineering and design activities for this Project will be continued under the existing CERP Design Agreement.

2. The PIR recommends a project that significantly contributes to two of the ecologic goals and objectives of the CERP: improving habitat and functional quality and improving native plant and animal species abundance and diversity. In addition, it contributes to the socioeconomic objective of providing recreational and navigation opportunities. Scientists have established that a mosaic of uplands, freshwater marsh, deep water sloughs, and estuarine habitats supporting a diverse community of fish and wildlife was one of the defining characteristics of the pre-drainage Everglades ecosystem. Currently in south Florida, habitat function and quality has significantly declined in remaining natural system areas due to water management projects and practices, resulting in a loss of suitable nesting, foraging, and fisheries habitat and a decline in native species diversity and abundance. The PIR confirms information in the CERP and provides project-level evaluation of costs and benefits associated with construction and operations of a reservoir. Constructing and operating a reservoir would reduce the extreme salinity changes in the Caloosahatchee Estuary by providing a more consistent flow of fresh water discharging at S-79 into the Caloosahatchee River Estuary. The extreme fresh water

fluctuations are due to fresh water flows from basin runoff and releases from Lake Okeechobee. Due to the advanced land acquisition activities conducted jointly by the Federal Government and the State of Florida, the Project can be implemented relatively quickly, significantly advancing the realization of project benefits in an area that has been degraded by past water management activities.

3. The reporting officers recommend implementing the Caloosahatchee River (C-43) West Basin Storage Reservoir to improve the ecological function of the Caloosahatchee Estuary by capturing and storing the excess surface water runoff from the Caloosahatchee River watershed (or C-43 Basin) and excess releases from Lake Okeechobee. Stored water will then be discharged to the estuary during the dry season to augment existing inadequate flows. The project site is located on farm land adjacent to the Caloosahatchee River (C-43) canal in Hendry County and totals approximately 10,700 acres. The reservoir will require approximately 10,480 acres of land in fee and 20 acres of perpetual channel easement. Approximately 200 additional acres will be required on a temporary basis during project construction for staging areas. Approximately 7,080 acres of project lands were acquired with a 50 percent Federal cost-share using funds appropriated via the 1996 Federal Farm Bill and the Land and Water Conservation Funds that were specifically designated for the acquisition of lands to restore the South Florida ecosystem. Major features of the reservoir include external (dam) embankments varying in height from 32-37 feet above existing grade, Soil-Bentonite slurry walls within and beneath the external embankments, an internal (dam) embankment separating the two reservoir cells with an approximate height of 31 feet above existing grade, an inflow pump station consisting of diesel-powered pumps with a total pumping capacity of 1,500 cfs, a perimeter canal, and pump station consisting of electric-powered pumps with a total pumping capacity of 195 cfs, and numerous spillways, culverts, perimeter canal structures, an internal cell balancing structure, and outlet structures. Recreational opportunities are also provided at the site within the project footprint.

4. The total first cost of the recommended plan from the Final PIR and Integrated EIS, dated September 2007, based on October 2009 price levels, is estimated to be $570,480,000. The fully funded cost, based on October 2009 price levels, is estimated to be $610,736,000. Project cost increases since the Central and Southern Florida Project Comprehensive Restudy Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement, April 1999, are primarily due to the fact that the recommended plan is a larger reservoir than originally envisioned (170,000 acre-feet of storage compared to 160,000 acre-feet in the Restudy), that design refinements were needed to incorporate current methods and criteria for addressing dam safety requirements, and that real estate costs increased. Project cost increases from the final PIR to present are due to revisions to the land valuation crediting policy for CERP.

5. In accordance with the cost-sharing requirements of Section 601(e) of the WRDA 2000, as amended, the Federal cost of the recommended plan would be $ 305,368,000 and the non-Federal cost would be $305,368,000. The estimated lands, easements, rights-of-way, and relocations costs for the recommended plan are $84,650,000 of which approximately

$27,566,500 (Rounded) has been provided to the State through the Federal Department of Interior Grant Funds. Based on October 2009 price levels, a 40-year period of economic evaluation and a 4.375 percent discount rate, the equivalent annual cost of the proposed project is estimated at $37,600,000, which includes operation, maintenance, repair, rehabilitation and replacement (OMRR&R), interest and amortization. The estimated annual costs for restoration OMRR&R are $3,100,000. The annual OMRR&R costs for recreation are estimated at $25,000. As a component of the CERP program, the interagency/interdisciplinary scientific and technical team, formed to ensure that system-wide goals are met, will participate in the annual monitoring to assess system-wide changes. In accordance with Sections 601(e)(4) and 601(e)(5)(D) of WRDA 2000 as amended, OMRR&R costs and adaptive assessment and monitoring costs will be shared equally between the Federal Government and the non-Federal sponsor. OMRR&R costs related to recreation features will be funded 100 percent by the non-Federal sponsor.

6. To ensure that an effective ecosystem restoration plan was recommended, cost effectiveness/incremental cost analysis techniques were used to evaluate alternative restoration plans. These techniques determined the selected alternative plan to be cost effective. The plan recommended for implementation is an increment of the National Ecosystem Restoration (NER) plan, it supports the adaptive management recommendations established by the National Research Council, and it meets the policy criteria established in U.S Army Corps of Engineers (USACE) guidance for planning in a collaborative environment. The recommended plan provides benefits by: 1) reducing harmful discharges to the Caloosahatchee Estuary by capturing a portion of high flow releases from Lake Okeechobee and basin runoff from the lower West Caloosahatchee River Basin during the wet season, 2) storing the water until needed in a reservoir, and 3) discharging stored water to supplement inadequate flows over S-79 to Caloosahatchee Estuary during the dry season, thereby reducing stress on the natural system. Hydrologic output comparisons were made between the flow frequency distribution of each alternative plan and the target frequency distribution for the combined monthly and weekly average freshwater inflows at S-79 for a nine year period of record. The nine years chosen out of the 36 year period of record contain three wet, three dry and three normal years. Biological outputs used to compare plans are based on several parameters that indicate the degree to which natural vegetative conditions and key indicator species are restored. The parameters for both hydrologic outputs and biological outputs are based on established peer-reviewed hydrologic and conceptual ecological models developed to guide the restoration of the South Florida ecosystem.

7. The recommended plan improves functional fish and wildlife habitat in the Caloosahatchee River Estuary. The Everglades has been designated an International Biosphere Reserve (1976) and a World Heritage Site (1979) by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and a Wetland of International Importance (1987) in accordance with the Ramsar Convention. The portion of the Everglades ecosystem directly affected by the Caloosahatchee River (C-43) West Basin Storage Reservoir, including the project site and the Caloosahatchee River and Estuary, provides habitat for 21 federally-listed endangered or threatened species, including the Florida panther, Everglades snail kite, wood stork, manatee, eastern indigo snake, Audubon's crested caracara and five species of sea turtles. In accordance

with the WRDA 2000 Section 601(f)(2), individual CERP projects shall be justified by the environmental benefits derived by the South Florida ecosystem. Similarly, Section 385.9(a) of the CERP Programmatic Regulations (33 CFR Part 385) requires that individual projects shall be formulated, evaluated, and justified based on their ability to contribute to the goals and purposes of the Plan and on their ability to provide benefits that justify costs on a next-added increment basis. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project, operating in conjunction with other projects in the comprehensive plan produces an average annual increase of 12,809 habitat units in the Caloosahatchee River Estuary. On a next-added increment (NAI) basis (meaning adding the Caloosahatchee River (C-43) West Basin Storage Reservoir as the next project to be added to a system of projects) the Caloosahatchee River (C-43) West Basin Storage Reservoir project delivers about 15,300 average annual habitat units. Based on restoration first cost and the Caloosahatchee Estuary, the cost per acre benefited is about $8,034. On a next-added increment basis, the average annual cost per average annual habitat unit is approximately $2,825. Based on these parameters, the Caloosahatchee River (C-43) West Basin Storage Reservoir project is justified by the environmental benefits derived by the South Florida ecosystem and on a next-added increment basis. All NEPA compliance requirements have been completed. Final EIS coordination began on 21 September 2007 and concluded on 22 October 2007. No significant environmental changes have occurred since the EIS coordination was finalized in 2007.

8. Section 601(e)(5)(B) of the Water Resources Development Act of 2000, as amended by Section 6004 of the Water Resources Development Act of 2007, authorizes credit toward the non-Federal share for non-Federal design and construction work completed during the period of design or construction, subject to the execution of the design or project partnership agreement, and subject to a determination by the Secretary that the work is integral to the project. This project is included in the "Expedited Projects" formerly called Acceler8. The reporting officers recommend that the non-Federal sponsor be credited for all reasonable, allowable, necessary, auditable, and allocable costs applicable to The Caloosahatchee River (C-43) West Basin Storage Reservoir Project as may be authorized by law, including those incurred in advance of executing a project partnership agreement for this project, subject to authorization of the Project by law, a determination by the Assistant Secretary of the Army (Civil Works) or his/her designee that the In-kind work is integral to the Authorized CERP Project, that the costs are reasonable, allowable, necessary, auditable, and allocable, and that the In-kind work has been implemented in accordance with Government standards and applicable Federal and State laws.

9. Credits for non-Federal design and construction will be evaluated in accordance with the terms of the Master Agreement Between the Department of the Army and South Florida Water Management District for Cooperation in Constructing and Operating, Maintaining, Repairing, Replacing, and Rehabilitating Projects Authorized to be Undertaken Pursuant to the Comprehensive Everglades Restoration Plan, executed on 13 August 2009 (hereinafter "Master Agreement"). All documentation provided by the non-Federal sponsor will be thoroughly reviewed by USACE to determine reasonable, allowable, necessary, auditable, and allocable costs. Upon completion of this review, a financial audit will be conducted prior to granting final

credit. Coordination between USACE and the Sponsor will occur throughout design and construction via the USACE Regulatory process. The credit afforded to the non-Federal sponsor will be limited to the lesser of the following: (1) actual costs that are reasonable, allowable, necessary, auditable, and allocable to the Project; or (2) the USACE estimate of the cost of the work allocable to the Project had USACE performed the work. The non-Federal sponsor intends to implement this work using its own funds and would not use funds originating from other Federal sources unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute and in accordance with Section 601 (e)(3) of WRDA 2000 as amended and the Master Agreement.

10. The plan recommended by the reporting officers is environmentally justified, technically sound, cost effective, and socially acceptable. The plan conforms to essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies and complies with other administration and legislative policies and guidelines. Also, the views of interested parties, including Federal, State and local agencies, have been considered.

State and Agency comments received during review of the Final PIR/EIS included concerns raised by the Florida Department of Agriculture and Consumer Services (FDACS) related to savings clause requirements and water reservations within the Caloosahatchee Basin. These concerns were addressed through several multi-agency meetings and ultimately resolved in a Headquarters, US Army Corps of Engineers (HQUSACE) response dated August 11, 2009. This letter stated that "all water to be protected for the natural system is a result of being able to capture and store excess Lake Okeechobee discharges to tide, and then delivering that water at the right time to meet estuary salinity targets. This project as simulated in the modeling, and as it will be operated, will not reduce the amount of water available from existing sources in the C-43 Basin or the amount available to existing legal users."

The U.S. Environmental Protection Agency, the Southwest Florida Regional Planning Council (SWFRPC), Lee County, and the City of Sanibel provided comments expressing water quality concerns associated with the construction and operations of the reservoir. In response, USACE and the non-Federal sponsor explained that the intent of this project is to focus on meeting salinity targets in the estuary. Future CERP planning efforts will focus on other problems, including water quality, identified in the Caloosahatchee River Basin. This project is permitted through the Florida Department of Environmental Protection (FDEP) and compliant with State water quality standards. The FDEP finds that there are reasonable assurances that "State water quality standards, including water quality criteria and moderating provisions, will be met." (FDEP letter to the Mayor of Sanibel dated April 30, 2007). USACE will require the permit holder to conduct limited algal monitoring. The primary purpose of monitoring for algae in the reservoir will be for the prevention of harmful algal bloom exposure to recreationists and users of the downstream potable water supply systems. This initial monitoring program will be assessed after two years to determine if modifications are needed. USACE also intends to require that the permit holder develop an Algal Monitoring and Management Plan for the

reservoir. This plan should include a long-term monitoring program as well as management plans should an algal bloom develop. Additionally, the non-Federal sponsor in conjunction with Lee County has acquired the Boma Property immediately east of S-78 along the Caloosahatchee River for the construction of a water quality treatment facility targeting nitrogen removal. Plans for this facility are being developed as part of the Northern Everglades Program, Caloosahatchee River Watershed Protection Plan, a cooperative State effort between the non-Federal sponsor, FDEP, and FDACS.

The SWFRPC additionally expressed concerns with the intended use of the Picayune Strand Restoration Project lands as mitigation for Florida panther habitat impacted by the construction and operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir. In response, USACE stated that the USFWS has lead responsibility for programmatic tracking of Florida panther habitat losses and gains associated with CERP projects. Although individual projects may cause some panther habitat loss, this loss is being evaluated in the context of the conservation of the species range-wide. Acquisition of lands for this project and other CERP projects has resulted in preservation of important lands that may have otherwise been used for development. A majority of Florida panther habitat to be preserved is associated with the nearby Picayune Strand Restoration Project (PSRP), which is adjacent to other large tracts of natural and preserved lands including Fakahatchee Strand Preserve State Park and Big Cypress National Preserve. Acquisition and preservation of lands in the Caloosahatchee River (C-43) West Basin Storage Reservoir study area are consistent with the USFWS' goal to locate, preserve, and restore tracts of lands containing sufficient area and appropriate land cover types to ensure the long-term survival of the Florida panther.

11. The Project complies with the following requirements of WRDA 2000 as amended:

a. Project Implementation Report (PIR). The requirements of a PIR as defined by Section 601(h)(4)(A).

b. Water Reservations. Sections 601(h)(4)(A)(iii)(IV) and (V) require identification of the appropriate quantity, timing, and distribution of water dedicated and managed for the natural system and the amount of water to be reserved or allocated for the natural system. Additional water delivered to and retained in natural areas was identified and will be reserved or allocated by the State of Florida.

c. Elimination or Transfer of Existing Legal Sources of Water. Section 601(h)(5)(A) states that existing legal sources of water shall not be eliminated or transferred until a new source of water supply of comparable quantity and quality is available to replace the water to be lost as a result of the Plan. Implementation of the Caloosahatchee River (C-43) West Basin Storage Reservoir project will not result in a transfer or elimination of sources of water to meet agricultural and urban demand in the Caloosahatchee River (C-43 Canal) Basin (remaining the same as before the project). Sources of water for the Seminole and Miccosukee Tribes and Everglades National Park are influenced by the regional water management system (C&SF

Project, including Lake Okeechobee), and will not be affected by this project. Therefore, there will be no elimination or transfer as a result of this project on existing legal sources of supply for: agricultural or urban water supply, allocation or entitlement to the Seminole Indian Tribe of Florida under Section 7 of the Seminole Indian Land Claims Settlement Act of 1987 (25 U.S.C. 1772e), the Miccosukee Tribe of Florida, water supply for Everglades National Park, or water supply for fish and wildlife.

d. Maintenance of Flood Protection. Section 601 (h)(5)(B) states that CERP shall not reduce levels of service for flood protection that are in existence on the date of enactment of this Act and in accordance with applicable law. Potential effects of the storage reservoir on water levels on adjacent lands were evaluated. In response to these evaluations, the Project includes a seepage management system, consisting of a seepage cut-off wall, seepage canal, and pump to ensure that adjacent lands in the immediate vicinity of the project are not adversely affected. The operations of this project will not change the operations of the Caloosahatchee River (C-43 Canal); therefore, there will be no system-wide effects on flood protection that will impact the regional basin as a result of the Project.

12. Agency technical reviews (ATR) of the Caloosahatchee River (C-43) West Basin Storage Reservoir document were carried out through collaboration with the National Ecosystem Restoration Planning Center of Expertise (PCX) in compliance with guidance at the time of Final PIR completion (2007). Extensive external scientific peer review through the National Academy of Science (NAS) has been conducted at the CERP programmatic level and will continue throughout the planning and implementation of the CERP program through the NAS biennial reports to Congress. In particular, the NAS promoted the use of traditional water storage technologies and the use of adaptive management principles within the formulation process. Both of these comments have been integrated into the formulation and design of the C-43 project. No further IEPR was deemed necessary or recommended for the study. In addition, no further IEPR is needed in response to WRDA 2007, since C-43 studies had been initiated and alternatives identified more than two years prior to its enactment and the final report had been submitted for approval prior to its passage.

13. I generally concur with the findings, conclusions, and recommendations of the reporting officers. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project requires specific authorization by Congress in accordance with Section 601(d) of the WRDA 2000. Accordingly, I recommend that the plan described herein for ecosystem restoration be authorized for implementation as a Federal Project, with such modifications as in the discretion of the Chief of Engineers may be advisable, and subject to cost-sharing, financing, and other applicable requirements of Section 601 of WRDA 2000 as amended. In addition, I recommend that the non-Federal sponsor be authorized to receive credit for work accomplished prior to the execution of a Project Partnership Agreement (PPA) for this Project, in accordance with Section 601 of WRDA 2000, as amended, and the terms of the Master Agreement.

CECW-SAD
SUBJECT: Comprehensive Everglades Restoration Plan, Central and Southern Florida, Caloosahatchee River (C-43) West Basin Storage Reservoir project, Hendry County, Florida

Further, this recommendation is subject to the non-Federal sponsor agreeing to comply with all applicable Federal laws and agreeing to perform the following items of local cooperation:

a. Provide 50 percent of total project costs consistent with the provisions of Section 601(e) of the Water Resources Development Act of 2000 as amended including authority to perform design and construction of project features consistent with Federal law and regulation;

b. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations that the Government and the Non-Federal Sponsor jointly determine to be necessary for the construction, operation, maintenance, repair, replacement and rehabilitation of the Project and valuation will be in accordance with the Master Agreement;

c. Shall not use the ecosystem restoration features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any other projects.

d. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land that the non-Federal sponsor owns or controls for access to the Project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project;

e. Assume responsibility for operating, maintaining, repairing, replacing, and rehabilitating (OMRR&R) the Project or completed functional portions of the Project, including mitigation features, in a manner compatible with the Project's authorized purposes and in accordance with applicable Federal and State laws and specific directions prescribed in the OMRR&R manuals and any subsequent amendments thereto. Cost sharing for OMRR&R will be in accordance with Section 601 of WRDA 2000 as amended;

f. The non-Federal Sponsor shall operate, maintain, repair, replace and rehabilitate the recreation features of the Project with responsibility for 100 percent of the cost;

g. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms;

h. Unless otherwise provided for in the statutory authorization for this Project, comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the WRDA of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the Project or separable element;

i. Hold and save the Government free from all damages arising from construction, operation, maintenance, repair, replacement and rehabilitation of the Project and any project-related

betterments, except for damages due to the fault or negligence of the Government or the Government's contractors;

j. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project to the extent and in such detail as will properly reflect total project costs and comply with the provisions of the Master Agreement;

k. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the Project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government;

l. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-ways that the Government determines necessary for construction, operation, maintenance, repair, replacement and rehabilitation;

m. As between the Government and the non-Federal Sponsor, the non-Federal Sponsor shall be considered the operator of the Project for purposes of CERCLA liability. To the maximum extent practicable, the non-Federal Sponsor shall operate, maintain, repair, replace, and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA;

n. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function;

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

p. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7,

entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army;" and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708[revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)];

q. Comply with Section 106 of the National Historic Preservation Act in completion of all consultation with the Florida State Historic Preservation Officer, and as necessary, the Advisory Council on Historic Preservation, prior to construction as part of the preconstruction engineering and design phase of the project;

r. Provide 50 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to the Project that are in excess of one percent of the total amount authorized to be appropriated for the Project;

s. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized and in accordance with Section 601 (e)(3) of the WRDA of 2000, as amended, and in accordance with the Master Agreement;

t. The Non-Federal Sponsor agrees to participate in and comply with applicable Federal floodplain management and flood insurance programs consistent with its statutory authority.

(1) Not less than once each year the Non-Federal Sponsor shall inform affected interests of the extent of protection afforded by the Project.

(2) The Non-Federal Sponsor shall publicize flood plain information in the area concerned and shall provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the Project.

(3) The Non-Federal Sponsor shall comply with Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to have prepared, within one year after the date of signing a PPA for the Project, a floodplain management plan. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by non-Federal interests to preserve the level of flood protection provided by the Project. As required by Section 402, as amended, the non-Federal interest shall implement such plan not later than one year after completion of construction of the Project. The Non-Federal Sponsor shall provide an information copy of the plan to the Government upon its preparation.

(4) The Non-Federal Sponsor shall prescribe and enforce regulations to prevent obstruction of or encroachment on the Project or on the lands, easements, and rights-of-way determined by the Government to be required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project, that could reduce the level of protection the Project affords, hinder operation or maintenance of the Project, or interfere with the Project's proper function.

u. The overarching objective of the Plan is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Federal Government and the non-Federal sponsor are committed to the protection of the appropriate quantity, quality, timing, and distribution of water to ensure the restoration, preservation, and protection of the natural system as defined in Section 601 of WRDA 2000, for so long as the project remains authorized. This quantity, quality, timing, and distribution of water shall meet applicable water quality standards and be consistent with the natural system restoration goals and objectives of the CERP, as the Plan is defined in the Programmatic Regulations. The non-Federal sponsor will protect the water for the natural system by taking the following actions to achieve the overarching natural system objectives of the Plan:

(1) Ensure, through appropriate and legally enforceable means under Florida law, that the quantity, quality, timing, and distribution of existing water that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report is available and beneficial to the natural system, will be available at the time the Project Partnership Agreement for the project is executed and will remain available for so long as the Project remains authorized.

(a) Prior to the execution of the Project Partnership Agreement, reserve or allocate for the natural system the necessary amount of water that will be made available by the project that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report.

(b) After the Project Partnership Agreement is signed and the project becomes operational, make such revisions under Florida law to this reservation or allocation of water that the non-Federal sponsor determines, as a result of changed circumstances or new information, is necessary for the natural system.

(2) For so long as the Project remains authorized, notify and consult with the Secretary of the Army should any revision in the reservation of water or other legally enforceable means of protecting water be proposed by the non-Federal sponsor, so that the Federal Government can assure itself that the changed reservation or legally enforceable means of protecting water conform with the non-Federal sponsor's commitments under paragraphs 1 and 2. Any change to

CECW-SAD
SUBJECT: Comprehensive Everglades Restoration Plan, Central and Southern Florida, Caloosahatchee River (C-43) West Basin Storage Reservoir project, Hendry County, Florida

a reservation of water made available by the project shall require an amendment to the Project Partnership Agreement.

14. The recommendation contained herein reflects the information available at this time and current Departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities in the formulation of a national Civil Works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding.

R. L. VAN ANTWERP
Lieutenant General, US Army
Chief of Engineers

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

JAN 0 6 2011

CECW-SAD (1105-2-10a)

SUBJECT: Comprehensive Everglades Restoration Plan, Central and Southern Florida, Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Hendry County, Florida - Supplemental

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress this supplement to my report on ecosystem restoration and recreation for the Caloosahatchee River (C 43) West Basin Storage Reservoir project, located in Hendry County, Florida, dated March 11, 2010. The purpose of this supplement is to clarify the authority for cost sharing of the recreational features recommended for the project.

2. In accordance with the Federal Water Project Recreation Act of 1965, full consideration was given to opportunities the project affords for recreation. The recommended C-43 West Basin Storage Reservoir project contains approximately $3,000,000 of recreation features, including a 12-mile multi-purpose trail and associated parking and toilet facilities, information kiosk, canoe/kayak launch facility, a shade structure, traffic control fencing, and a pedestrian footbridge to provide public access to the reservoir. These recreation features have been justified in accordance with policy.

3. Although cost sharing of the ecosystem restoration features for this project is governed by Section 601 of the Water Resources Development Act (WRDA) of 2000, as amended, cost sharing of the recreation features is governed by Section 103 of the WRDA 1986, as amended. In particular, in accordance with Section 103(j) of WRDA 1986, 100 percent of the cost of operation, maintenance, repair, replacement, and rehabilitation of the recreation features is the non-Federal sponsor's responsibility. In addition, Section 601(e)(5)(B) of WRDA 2000, as amended, governs credit for non-Federal sponsor design and construction work on the ecosystem restoration features of the project, whereas Section 221(a)(4) of the Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b(a)(4)) governs credit for non-Federal sponsor design and construction work on the recreation features of the project.

4. As part of this supplement, the costs of the project have been escalated and updated to October 2010 price levels and the reporting format has been changed from fully funded costs to initial investment. The total first cost of the recommended plan from the Final Project Implementation Report and Integrated Environmental Impact Statement, dated September 2007, based on October 2010 price levels, is estimated to be $579,599,000, including $576,643,000 for ecosystem restoration and $2,956,000 for recreation. In accordance with Section 601 of the

CECW-SAD (1105-2-10a)
SUBJECT: Comprehensive Everglades Restoration Plan, Central and Southern Florida, Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Hendry County, Florida - Supplemental

WRDA 2000, as amended, for the ecosystem restoration features of the recommended plan, the estimated Federal cost is $288,321,500 and the estimated non-Federal cost is $288,321,500. In accordance with Section 103(c) of the WRDA 1986, as amended, for the recreational features of the recommended plan, the estimated Federal cost of $1,478,000; and the non-Federal cost is $1,478,000. The estimated lands, easements, rights-of-way, and relocations costs for the recommended plan are $84,650,000 of which approximately $27,567,000 has been provided to the State through the Federal Department of Interior Grant Funds. Based on October 2010 price levels, a 40-year period of economic evaluation and a 4.12 percent discount rate, the equivalent annual cost of the proposed project is estimated at $35,500,000, which includes operation, maintenance, repair, rehabilitation and replacement (OMRR&R), interest and amortization. The estimated annual OMRR&R costs for ecosystem restoration are $3,160,000. The annual OMRR&R costs for recreation are estimated at $25,000. In accordance with Section 601 of WRDA 2000 as amended, OMRR&R costs and adaptive assessment and monitoring costs for ecosystem restoration will be shared equally between the Federal Government and the non-Federal sponsor. In accordance with Section 103(j) of the WRDA 1986, as amended, OMRR&R costs related to recreation features will be funded 100 percent by the non-Federal sponsor.

Respectfully,

R. L. VAN ANTWERP
Lieutenant General, US Army
Chief of Engineers

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJ 04.N.2.9

November 6, 2009

Colonel Alfred A. Pantano, Jr.
District Engineer Jacksonville District
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Colonel Pantano:

Subject: Letter of Support for the November 2009 Update of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Implementation Report

The purpose of this letter is to express the South Florida Water Management District's (District) continuing support for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project consistent with the Governing Board resolution approving submittal of the Letter of Support (August 9, 2007). We appreciate the U.S. Army Corps of Engineers' (Corps) efforts to work with the State of Florida and resolve the outstanding real estate valuation and crediting concerns. The Final Project Implementation Report, including the revision to project cost estimates to reflect use of the Corps' nationwide policy for valuation and crediting of lands, is the result of a collaborative effort over the last five years. The Recommended Plan will provide improved timing of freshwater deliveries to the Caloosahatchee Estuary which will help to restore habitat function and quality in the Estuary, resulting in improved plant and animal species abundance and diversity.

The successful development of the Recommended Plan outlined in this Project Implementation Report was dependent upon its many contributors. The Corps and the District played key leadership roles. However, the Recommended Plan was significantly enhanced through contributions from the Florida Department of Environmental Protection, the Florida Fish and Wildlife Conservation Commission and the U.S. Department of the Interior, as well as numerous other state, federal and local agencies.

As you know, the District has completed detailed design for this project in collaboration with the Corps' Jacksonville Engineering Division. It is anticipated that minor refinements in the plans and specifications may be necessary prior to solicitation of construction bids. We fully intend to collaborate with the Corps to accomplish any necessary refinements. It is our hope and expectation that this project will be authorized for construction in the 2010 Water Resources Development Act.

The District is proud to share a partnership with the Corps on this vital and exciting project.

Sincerely,

Carol Ann Wehle

Carol Ann Wehle
Executive Director
South Florida Water Management District

CAW/pw

c: Stuart Appelbaum, USACE, Jacksonville
Kimberly Taplin, USACE, West Palm Beach
Steve Kopecky, USACE, Washington

Florida Department of Agriculture and Consumer Services
CHARLES H. BRONSON, Commissioner
The Capitol • Tallahassee, FL 32399-0800
www.doacs.state.fl.us

Please Respond to:

October 19, 2007

Headquarters
U.S. Army Corps of Engineers
ATTN: CECW-P (IP)
7701 Telegraph Road
Alexandria, VA 22315-3860

Florida Department of Agriculture and Consumer Services' Comments on the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Final Integrated Project Implementation Report and Environmental Impact Statement

The Florida Department of Agriculture and Consumer Services (FDACS) appreciates the opportunity to comment and requests the following concerns be addressed in the review of the Corps' Caloosahatchee River (C-43) West Basin Storage Reservoir (BSR) Project Final Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS). FDACS has submitted comments formally at the agency level and to the Project Delivery Team (PDT) throughout the project development process and during public review periods. The review issues that we consider as remaining to be addressed are summarized below and detailed in the "FDACS Staff Comments" attachment.

The Final PIR and EIS do not acknowledge the Yellow Book's original "source switch" function for the C-43 reservoir project, rather it rewrites the project's conceptual history to match the current outcome. An accurate account should be included of the original plan to switch basin irrigation demand from Lake Okeechobee to the basin run-off captured in the proposed C-43 reservoir as opposed to the current PIR's plan to capture excess basin run-off and Lake Okeechobee regulatory releases for estuary use exclusively. This change has implications beyond this particular project because other CERP projects use planning conditions based on the original concept of restricting Lake Okeechobee irrigation releases for agricultural water demand in the C-43 Basin. The Final PIR/EIS Annex B – Draft PIR Comment Matrix (page B-82) responds to an earlier FDACS comment on this issue, but merely confirms the change: "The reservoir proposed in this project allows estuary demands to be supplemented by reservoir storage during the dry season, thus relieving some dry-season demands on Lake Okeechobee allowing more water within the lake to be used system wide." While not stating that these system wide uses include C-43 basin irrigation demand, it is not apparent how the irrigation demand would otherwise be met.

Annex C contains an analysis that identifies the volume of water made available by the project for the natural system. The amount identified under the Initial Operating Regime (IOR) is anticipated to be substantially more than the amount that will ultimately be available for the natural system as identified in the Next Added Increment (NAI) analysis. Under the driest conditions, the IOR amount is approximately 50% greater than the NAI amount (Table C-3: Identification of the Volume of Water (Ac-Ft/Year) Made Available for the Natural System to Achieve the Benefits of the Project, Page C-24, Annex C, Caloosahatchee River (C-43) West Basin Storage Reservoir (BSR) Project Final Integrated PIR and EIS). The larger amount identified in the IOR is recommended to be reserved for the natural system under Florida law. The recently released "Revised Final Draft CERP Guidance Memoranda - GM #4: Identifying Water Made Available for the Natural System and for Other Water Related Needs" refers to changing water reservations in response to changing conditions as more CERP projects are completed. The language of GM #4 appears to address the incorporation of additional water made available and not subsequent reductions in water made available. FDACS is concerned that it may be difficult to maintain an accurate accounting of the water made available for the natural system by the Caloosahatchee (C-43) West BSR relative to reductions in that amount that result when other projects are implemented. Moreover, the prospect of "rolling back" an already established reservation raises some significant legal questions, and underscores the need to carefully account for "water made available" by this project and to consider how the potential future reductions in "water made available" will be dealt with. The USACE did not provide a response in the Final PIR/EIS Annex B – Draft PIR Comment Matrix to an earlier FDACS comment that raised this issue.

Our remaining concern is the lack of an evaluation tool to determine if the Caloosahatchee (C-43) West BSR will create a greater demand on the Caloosahatchee River with an associated greater demand on Lake Okeechobee during drought years. Consequently, meeting the Savings Clause requirements for an existing legal source as of December 11, 2000, consistent with Federal law, is still an open question for the Caloosahatchee River (C-43) West BSR Project Final Integrated PIR and EIS. While we agree with the USACE that the possibility of significant negative impacts to existing users in the area of the project is minimal, we are not convinced that an adequate analysis of impacts to water supply during drought years has been performed or that the methodology described in "Revised Final Draft CERP Guidance Memoranda GM #3: Savings Clause Requirements" has been followed. It is not clear whether the system wide effect of an additional demand on Lake Okeechobee was considered at all. We believe that the information and analyses provided do not address this issue and are not adequate to provide the assurances required by state or federal law.

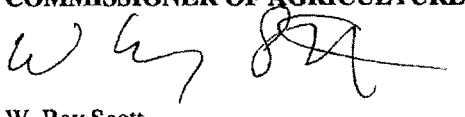
The underlying issue for all our concerns is that the modeling conducted for the Caloosahatchee (C-43) West BSR relied upon delivery of a specific volume of water from Lake Okeechobee, and it is not clear what system wide impacts this demand on the lake will have, particularly under drought conditions. First, there is a potential conflict with the original Yellow Book assumption that the project would restrict deliveries to the C-43 basin and consequently with the planning assumptions for other CERP projects.

Second, the apparent anomaly between the water made available under the IOR scenario and the NAI scenario likely hinges on the discrepancy between potentially competing water demands from Lake Okeechobee. Finally, we are less concerned with Savings Clause assurances in the immediate project area than with a potential reduction in water supply availability outside the project area if the reservoir creates an additional demand on Lake Okeechobee. The enclosed attachment, "FDACS Staff Comments," provides additional details regarding our concerns.

Again, we appreciate the opportunity to comment on the Caloosahatchee River (C-43) West BSR Project Final Integrated PIR and EIS. Our level of concern with the issues we raise here is heightened by current system conditions, and we believe that a better understanding of the effect of this project under such conditions is needed. Moreover, we do not believe that the Savings Claus analysis adequately addresses potential impacts outside the area of the project, nor do the PIR and EIS provide sufficient information to provide the assurances required under Florida law. If you should have questions regarding FDACS' comments, please contact Ray Scott at (850) 410-6714.

Sincerely,

CHARLES H. BRONSON
COMMISSIONER OF AGRICULTURE



W. Ray Scott
Conservation & Water Policy
Federal Program Coordinator

FDACS STAFF COMMENTS:

Review Comments for the Caloosahatchee River (C-43) West BSR Project Final Integrated PIR and EIS

The Yellow Book's Original " Source Switching" Conceptual Plan for the C-43 Reservoir has been Omitted from the Project's Background Information

During development of the conceptual plan for the Restudy, one of the main concepts of the regional storage components was to provide additional storage for water supply in the Caloosahatchee, St. Lucie and Kissimmee Basins which should ultimately reduce irrigation demands on Lake Okeechobee. Water could then be conserved in the lake and would be "...available for sustaining the health of lake and downstream natural areas ..." (Sections 6.4.2 and 6.4.1.2). The source for agricultural irrigation demands would be "switched" to the reservoirs as much as possible and be supplemented as needed by the lake. More lake water would be available for natural system needs.

Since the only purpose of the C-43 reservoir is now to meet estuary demands, and not to "switch sources" for local irrigation demands, that change from the Yellowbook concept needs to be acknowledged and the planning conditions for other projects need to be updated based on that change. At this time, urban and agricultural demands have all been removed from the alternative evaluation. How does this fit into the regional plan as developed by CERP for the capture of local basin run-off to meet existing demands in the "reservoir" basins (Caloosahatchee, St. Lucie, and EAA basins) and retaining Lake Okeechobee water for natural system needs. How will the difference in concepts be accommodated going forward?

FDACS maintains that the difference in the Lake Okeechobee boundary condition used by the Caloosahatchee River (C-43) West Basin Storage Reservoir and that used by other CERP projects is problematic and should be acknowledged in the PIR and addressed in the appropriate forum. The following examples from the Final PIR/EIS document illustrate the point.

In Appendix C on pages C-75 and C-76, nutrient load reductions of 29% to 38% are projected "due to the reduction in flow resulting from the implementation of CERP components other than the C-43 West Reservoir." It is inconsistent to evaluate the nutrient removal potential of Alternatives combined with implementation of the rest of CERP while ignoring how reductions in flows resulting CERP's full CERP implementation will impact water supply for existing legal users in the C-43 Basin.

NAI performance is 28% greater than the CERP System-wide Analyses performance. The NAI performance to CERP system-wide performance evaluation compares the benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir as a stand alone project to the performance achieved by the system-wide conditions anticipated by CERP implementation. The Final PIR/EIS, Section 7, page 7-25, describes some

potential reasons for this difference including "The first and most influential of these results from the rest of CERP's impact on the overall water budget provided to the Caloosahatchee River (C-43) basin. The system-wide analysis has a lower water budget than the NAI analysis, leading to diminished dry season conditions."

The full implementation of CERP predicts that the Lake Okeechobee releases will be minimal and that the C-43 Basin will be "off the lake". Phase I has not restricted the use of Lake Okeechobee water for irrigation. If this assumption changes to what is currently being used in all other CERP projects (restricted deliveries of Lake Okeechobee water to C-43), access to water currently available for existing legal users would be compromised and a Savings Clause violation for the full project implementation would occur in Phase II. The version of the model used during the Restudy used a surface water run-off volume in the C-43 Basin that has been determined to be too high. The Yellow Book C-43 project relied on the higher basin run-off to meet agricultural irrigation demands. This assumption has resulted in restrictions on deliveries to meet irrigation demands from Lake Okeechobee in current CERP modeling.

Initial Operating Regime (IOR) Water Availability is Greater than Next Added Increment (NAI) Water Availability and the Greater Amount is Being Reserved

Annex C contains an analysis showing the identification of water made available by the project for the natural system. The amount identified under the IOR is anticipated to be more than the amount identified in the NAI, and the IOR amount is recommended to be reserved for the natural system under Florida law. FDACS is concerned it will be very difficult to maintain an accurate accounting of how much of the "C-43 project reservation amount" is included in the natural system amounts made available by other projects (e.g., the EAA Reservoir). The recently released "Revised Final Draft CERP Guidance Memoranda - GM #4: Identifying Water Made Available for the Natural System and for Other Water Related Needs" refers to changing water reservations in response to changing conditions as more CERP projects are completed. However, the wording indicates that this is to incorporate additional water made available and not to account for reductions in water made available.

One explanation for using the larger IOR volume for natural system reservation is that even if future operations divert water from the Caloosahatchee estuary and degrades the performance of the reservoir, that would be acceptable because the environmental benefits realized system wide by CERP would off-set the loss of benefits in the Caloosahatchee Estuary. Making this case to advocates for the Caloosahatchee Estuary will be difficult and sets the stage for water availability competition among CERP projects and potential legal complications related to the transfer of beneficial water to another basin.

Basin-wide and System-wide Savings Clause Analyses Not Performed According to Draft CERP Guidance Memoranda GM #3: Savings Clause Requirements Due to Inadequate Evaluation Tools

FDACS is concerned that the extensive changes in groundwater seepage and surface water dynamics resulting from the Caloosahatchee River (C-43) West Basin Storage Reservoir has the potential to impact water quantity and water quality in ways that may not be evident at the Pilot Test Cell scale. Construction and operation of the C-43 Part I Phase I Reservoir on the Berry Groves site will create a substantial change in the hydrodynamic interactions between groundwater, surface water, and water use in the vicinity of the reservoir that could impact water availability for existing legal users dependent upon the C-43 Canal and Lake Okeechobee for water supply.

The slurry wall will prevent seepage currently flowing north from properties south of the reservoir site from reaching the C-43 Canal along the historic path under the reservoir site. The C-43 Canal and the properties between the reservoir and the C-43 Canal will no longer be supplied by the historic groundwater seepage source. The C-43 Part I Phase I Reservoir operating plan uses perimeter canal seepage to maintain groundwater levels and water supply to existing legal users in the vicinity of the reservoir. Water will be pumped from the C-43 Canal to maintain the perimeter canal water levels and seepage during dry conditions when the reservoir can no longer be used to supply the perimeter canal.

An analysis comparing pre project and post project water volumes associated with "replacing" the historic ground water seepage flows into the C-43 Canal along the length of the reservoir and maintaining surface water levels of the perimeter canal throughout the period of record is needed. Ideally, a sub regional evaluation tool would be used to compare the pre project and post project water budget performance over the period of record between S-77 and S-79 using a time step not exceeding one month.

According to the Restoration Coordination and Verification (RECOVER) report provided in Annex E, the type of data needed to evaluate project alternatives for the system-wide performance measure "WS-1- Lake Okeechobee Service Area (LOSA) Water Supply" was not available and the water supply evaluation was incomplete. The RECOVER report (Section E.5.2) states, "In order to determine the full extent of predicted water supply impacts in the C-43 Basin, the severity and duration of any water restrictions above those that might be expected when drought levels exceed a 1 in 10 condition needs to be reviewed. In order to perform the Supply Side Management (SSM) based review, raw data or post-processed data that will allow the determination of monthly demand volume, number of days per month with cutbacks (demands not met), and volume of cutbacks (demand not met) per each month is required. Since this data is not readily available from MIKE SHE output, annual average volumes (AAV) were evaluated. It is important to note that the average annual number will not allow for a determination of differences in alternative performance regarding water supply deliveries."

SFWMD had intended to use the MIKE SHE Freshwater Caloosahatchee Model throughout the model's nine year Period of Record (POR) to determine the pre and post project water budget in response to FDACS' concerns about water supply assurances for existing legal users. Volumes between pre and post project when reservoir operations draw water from the C-43 for water supply purposes during dry conditions were to be

compared to determine if there is a reasonable assurance that existing users will not be adversely impacted by water supply demands via the perimeter canal operations. The results were to be included in the final State Compliance Report. However, because this pre and post volume comparison for water supply withdrawals was not made, no results were available and this information was not included in the report.

SFWMD in partnership with their consultant, DHI, worked diligently to provide FDACS with other additional information and analyses to demonstrate that the water supply assurances required under Florida law are being provided for existing legal users. While recognizing the minimal likelihood of significant adverse impacts within the area of the project, we remained unconvinced that an adequate analysis of impacts to water supply during drought years had been conducted. It was not clear whether the system wide effect of an additional demand on Lake Okeechobee was considered at all. In addition, a volume probability curve for the Caloosahatchee Basin, consistent with the methodology described in "Revised Final Draft CERP Guidance Memoranda GM #3: Savings Clause Requirements" was not provided. We believe that the information and analyses provided do not fully address the issue and are inadequate to provide the assurances required by state or federal law.

Information provided by SFWMD to FDACS but not included as part of the Final State Compliance Report Caloosahatchee River (C-43) West Basin Storage Reservoir Project submitted to the Florida Department of Environmental protection (FDEP) or in the Caloosahatchee River (C-43) West BSR Project Final Integrated PIR and EIS Annex C are:

* Spreadsheet Model Results prepared for the draft PIR
* DHI Report on Analysis of MIKE-SHE results
* Acceler8 C-43 Water Storage Reservoir 60% design submittal – 30 May 07
* Stanley Consultants Technical memorandum – Townsend Canal Impacts for Various Pumping Scenarios at C43PS-1
* DHI Technical Memorandum – Comparison of Irrigation Applications in the C-43 Basin and C-43 Reservoir – FDACS Request

None of these provided a reliable quantification of the pre and post project water supply volumes for reasons detailed below.

Spreadsheet Model Results prepared for the draft PIR - The Spreadsheet Model only predicts flows over the S-79 Structure based on C-43 West BSR operations.

DHI Report on Analysis of MIKE-SHE results -The MIKE-SHE Model analysis only addresses flows over the S-79 Structure based on C-43 West BSR operations.

Acceler8 C-43 Water Storage Reservoir 60% design submittal – 30 May 07 - The 60% design submittal does not address water supply in drought conditions.

Stanley Consultants Technical memorandum – Townsend Canal Impacts for Various Pumping Scenarios at C43PS-1 - This modeling analysis only addresses canal flows and groundwater levels in the vicinity of the C-43 West BSR.

DHI Technical Memorandum – Comparison of Irrigation Applications in the C-43 Basin and C-43 Reservoir – FDACS Request - This technical memorandum provided two model evaluations for review. One identified Irrigation Command Areas (ICAs) throughout the basin and compared pre and post project irrigation delivery results. The other graphed Townsend Canal pumping rates pre and post project. The FDACS analysis of the results yielded no clear conclusion regarding basin-wide or system-wide impacts to water supply during drought years.

Irrigation Command Center Results

We have no confidence that the "Irrigation Command Areas (ICA)" data provided by the South Florida Management District from DHI, is of sufficient quality to allow for any meaningful conclusions.

The main reason for the lack of confidence is the perplexing result of impacts far away from the reservoir where no difference should be occurring. There is no mechanism-based process to explain why the ICAs away from the reservoir show any difference. The SFWMD technical explanation provided is that this is "within the model confidence limits" but the results are questionable and indicate poorly understood sub routines within the model.

Also, interpretation of results is ambiguous. Even between the FDACS reviewers there is a difference of opinion on whether more irrigation applications indicate a better or worse scenario for water users during water shortage conditions. As detailed below, there is a definite difference for the modeled irrigation applications pre and post project in drought years for ICAs near the reservoir. The implication of these differences is unknown.

The results as modeled and presented by DHI indicate that overall the irrigation applications between the with and without project scenarios is very similar throughout 1978 to 1985 with the exception of an increase in irrigation applications from the Caloosahatchee River in the '81-'82 drought years for ICA 122 and ICA 44. ICA 122 lies off the NE corner of the C-43 Reservoir, an area that will be supplied by the PS-4 via the perimeter canal when the reservoir is dry. ICA 44 lies just south of the C-43 Reservoir.

The increase in irrigation applications are significant for '81-'82 is because most of the ICAs and years modeled show the "with project" scenario as having less irrigation applications where as the ICA 122 and 44 drought applications go in the opposite direction. ICA 122 shows a 19 % (4.1") increase in '81 and a 12% (1.54") increase in '82. ICA 44 shows a 13% (2.43") increase in '81 and only a 1% (0.14") increase in '82.

Townsend Canal Pumping Results – no water volume quantification available

The Berry Grove Pump will be replaced by both the C-43 West BSR PS-1 and PS-4 pumps. The PS-4 is not directly comparable to the Berry Groves Pump. PS-4 is only used when the reservoir is dry to convey water from the Townsend Canal into the perimeter canal for water supply purposes.

The difficulty encountered is that the units reported are a withdrawal rate (cfs) and not a volume. The Berry Groves pump shows a much greater variety of pumping rates than the Duda Pump or PS-4 throughout the dry year of '78 and the '81-'82 drought. Visual inspection of the pumping rate graph was the only information available. This did not provide for a pre and post water supply volume comparison. The most relevant results for a determination of water supply impacts is the "without project" combined Berry Groves Pump and Duda Pump volumes compared to the "with project" combined PS-4 and Duda Pump volumes for each month in '78, '81 and '82. Volume information was requested, but the SFWMD was not able to provide that information.

Florida Department of
Environmental Protection

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Charlie Crist
Governor

Jeff Kottkamp
Lt. Governor

Michael W. Sole
Secretary

November 1, 2007

Mr. Thomas W. Waters, P.E.
Headquarters, CECW-P (IP)
U.S. Army Corps of Engineers
7701 Telegraph Road
Alexandria, VA 22315-3860

RE: Department of the Army, Jacksonville District Corps of Engineers – Final Integrated Project Implementation Report and Environmental Impact Statement for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project – Hendry County, Florida.
SAI # FL200709193767C (Reference SAI # FL200704263301C)

Dear Mr. Waters:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16, U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4231, 4331-4335, 4341-4347, as amended, has coordinated a review of the Final Integrated Project Implementation Report and Environmental Impact Statement (FPIR/EIS).

The Florida Department of Environmental Protection (DEP) fully supports the construction of the Comprehensive Everglades Restoration C-43 West Basin Reservoir Project. The DEP also commends the U.S. Army Corps of Engineers for working with staff to develop additional water quality analyses to address reasonable assurance that the project will not "cause or contribute" to water quality violations. Staff will continue to work closely with the Corps of Engineers and the South Florida Water Management District to facilitate permit issuance and implement the Comprehensive Everglades Restoration Plan.

The Florida Department of Agriculture and Consumer Services (FDACS) appreciates the opportunity to review the FPIR/EIS and requests that the document include information regarding the original plan to switch basin irrigation demand from Lake

Okeechobee to the basin run-off captured in the proposed C-43 reservoir as opposed to the current PIR plan to capture excess basin run-off and Lake Okeechobee regulatory releases for estuary use exclusively. FDACS has also expressed concerns that it may be difficult to maintain an accurate accounting of the water made available for the natural system by the C-43 reservoir relative to reductions in that amount that result when other projects are implemented. In addition, staff is less concerned with Savings Clause assurances in the immediate project area than with a potential reduction in water supply availability outside the project area if the reservoir creates additional demands on Lake Okeechobee. FDACS advises that the information and analyses provided do not address this issue sufficiently and are not adequate to provide the assurances required by state or federal law. Please refer to the enclosed FDACS memorandum for further details.

The Southwest Florida Regional Planning Council (SWFRPC) supports the components of the project that will benefit Caloosahatchee River area hydrology, water quality, wetlands, and wildlife and notes concerns regarding the acquisition of lands in Picayune Strand State Forest to off-set the loss of Florida panther habitat; the exclusion of the Oyster Restoration Plan for the Tidal Caloosahatchee in the FPIR/EIS; and utilization of water quality stations significantly downstream from the C-43 reservoir to monitor its water quality benefits. Staff continues to strongly recommend that the PIR incorporate: a water quality treatment component in the design of the reservoir project; plans for construction of littoral areas at the corners of the seepage canal; the planting of native shade tree species where new trees are proposed; an Oyster Restoration Plan for the Tidal Caloosahatchee; and a recalculation of the available mitigation credits created by habitat restoration within Picayune Strand State Forest to determine the real net benefit to the Florida panther. Though the SWFRPC supports the concept and implementation of the C-43 reservoir project, water quality protections should not be deferred in development of the project. Please refer to the enclosed SWFRPC letter for additional comments and recommendations.

Based on the information contained in the FPIR/EIS and the enclosed state agency comments, the state has determined that, at this stage, the proposed activities are consistent with the Florida Coastal Management Program (FCMP). The concerns identified by our reviewing agencies must be addressed prior to project implementation. The state's continued concurrence with the project will be based, in part, on the adequate resolution of issues identified during this and subsequent reviews. The state's final review of the project's consistency with the FCMP will be conducted during the environmental permitting stage.

Thank you for the opportunity to review the proposed project. Should you have any questions regarding this letter, please contact Ms. Lauren P. Milligan at (850) 245-2170.

Yours sincerely,

Sally B. Mann

Sally B. Mann, Director
Office of Intergovernmental Programs

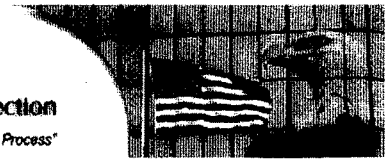
SBM/lm
Enclosures

cc: Susan Conner, USACE, Jacksonville
John Outland, DEP, MS 45
Shelley Yaun, DEP, MS 3560
W. Ray Scott, FDACS
Forrest Watson, FDACS
Nichole Gwinnett, SWFRPC



Florida
Department of Environmental Protection

"More Protection, Less Process"



Project Information	
Project:	FL200709193767C
Comments Due:	10/23/2007
Letter Due:	11/02/2007
Description:	DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT CORPS OF ENGINEERS - FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT (PIR) AND ENVIRONMENTAL IMPACT STATEMENT FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT - HENDRY COUNTY, FLORIDA
Keywords:	ACOE - FIPIR/EIS CALOOSAHATCHEE RIVER C-43 WEST BASIN STORAGE RESERVOIR - HENDRY
CFDA #:	99.997

Agency Comments:

TRANSPORTATION - FLORIDA DEPARTMENT OF TRANSPORTATION

The Florida Department of Transportation (FDOT) has concluded its review of the Final Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS) for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project in Hendry County and offers the following comments: If the applicant performs excavation in FDOT right-of-way, any asbestos-containing material (ACM) encountered must be properly handled in accordance with all local, state and federal regulations. In no case shall ACM be crushed and buried within FDOT right-of-way. If this proposal results in impacts to FDOT roadways, all necessary permits must be obtained from the District One Operations Center prior to construction activities occurring within the state road right-of-way. Any contaminated soil that must be excavated in order to install utility features should be properly handled and disposed of and contaminated effluent from dewatering operations should be properly treated and discharged. All necessary worker safety precautions should be followed.

AGRICULTURE - FLORIDA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES

The FDACS appreciates the opportunity to review the FPIR/EIS and requests that the document include information regarding the original plan to switch basin irrigation demand from Lake Okeechobee to the basin run-off captured in the proposed C-43 reservoir as opposed to the current PIR's plan to capture excess basin run-off and Lake Okeechobee regulatory releases for estuary use exclusively. This change has implications beyond the current project because other CERP projects use planning conditions based on the original concept of restricting Lake Okeechobee irrigation releases for agricultural water demand in the C-43 Basin. FDACS has also expressed concerns that it may be difficult to maintain an accurate accounting of the water made available for the natural system by the C-43 reservoir relative to reductions in that amount that result when other projects are implemented. There is a need to carefully account for "water made available" by this project and to consider how the potential future reductions in that water will be handled. In addition, staff are less concerned with Savings Clause assurances in the immediate project area than with a potential reduction in water supply availability outside the project area if the reservoir creates additional demands on Lake Okeechobee. FDACS advises that the information and analyses provided do not address this issue sufficiently and are not adequate to provide the assurances required by state or federal law.

COMMUNITY AFFAIRS - FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS

DCA has no comments.

ENVIRONMENTAL PROTECTION - FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
The Florida Department of Environmental Protection (DEP) commends the U.S. Army Corps of Engineers for working with staff to develop additional water quality analyses to address reasonable assurance that the project will not "cause or contribute" to water quality violations. The DEP will continue to work closely with the Corps of Engineers and the South Florida Water Management District (SFWMD) to facilitate permit issuance. DEP staff looks forward to continuing our relationship with the Corps of Engineers and the SFWMD as we move forward with implementing the Comprehensive Everglades Restoration Plan. If you have any questions regarding these comments, please feel free to contact Mr. Greg Knecht at (850) 245-2088.
FISH and WILDLIFE COMMISSION - FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION
No Comments Received
STATE - FLORIDA DEPARTMENT OF STATE
No Comments
SOUTH FLORIDA WMD - SOUTH FLORIDA WATER MANAGEMENT DISTRICT
A consistency determination is not necessary. The District is the local sponsor for this project.
SW FLORIDA RPC - SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL
The Southwest Florida Regional Planning Council (SWFRPC) supports the components of the project that will benefit Caloosahatchee River area hydrology, water quality, wetlands, and wildlife and notes concerns regarding the acquisition of lands in Picayune Strand State Forest to off-set the loss of Florida panther habitat, the exclusion of the Oyster Restoration Plan for the Tidal Caloosahatchee in the FPIR/EIS, and utilization of water quality stations significantly downstream from the C-43 reservoir to monitor its water quality benefits. Staff continues to strongly recommend that the project incorporate: a water quality treatment component in the design of the reservoir project; plans for construction of littoral areas at the corners of the seepage canal; the planting of native shade tree species where new trees are proposed; an Oyster Restoration Plan for the Tidal Caloosahatchee; and a recalculation of the available mitigation credits created by habitat restoration within the Picayune Strand State Forest to determine the real net benefit to the Florida panther. Though the SWFRPC supports the concept and implementation of the C-43 reservoir project, water quality protections should not be deferred in development of the project.
HENDRY -

For more information or to submit comments, please contact the Clearinghouse Office at:

3900 COMMONWEALTH BOULEVARD, M.S. 47
TALLAHASSEE, FLORIDA 32399-3000
TELEPHONE: (850) 245-2161
FAX: (850) 245-2190

Visit the Clearinghouse Home Page to query other projects.

Copyright and Disclaimer
Privacy Statement

Memorandum

TO: Florida State Clearinghouse

THROUGH: Greg Knecht, Director
Ecosystems Projects Coordination

FROM: Stacey Feken, Jennifer Nelson and LaDawna McDonald

DATE: October 23, 2007

SUBJECT: United States Army Corps of Engineers, Jacksonville District - Final Integrated Project Implementation Report and Environmental Impact Statement for the Caloosahatchee River West Basin Storage Reservoir Project - Hendry County, Florida

SAI #: FL07-3767C

Background:

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to contribute to the restoration of the Caloosahatchee Estuary as part of the Comprehensive Everglades Restoration Plan (CERP) established by the 2000 Water Resources Development Act. The tentatively selected plan, Alternative 3B, consists of a 170,000 acre-ft. above-ground storage reservoir, a 1500 cfs pump station, external and internal embankments, internal control and outflow water control structures, and environmentally responsible design features to provide fish and wildlife habitat such as littoral areas in the perimeter canal and deep water refugia within the reservoir.

Comments:

The Florida Department of Environmental Protection commends the U.S. Army Corps of Engineers for working with us to develop the additional water quality analysis to address reasonable assurance that the project will not "cause or contribute" to water quality violations. The Department will continue to work closely with the Corps of Engineers and the South Florida Water Management District (SFWMD) to facilitate permit issuance.

We look forward to continuing our relationship with the Corps of Engineers and the SFWMD as we move forward with implementing the Comprehensive Everglades Restoration Plan. If you have any questions regarding these comments, please feel free to contact Greg Knecht at (850) 245-2088.

Florida Department of Agriculture and Consumer Services
CHARLES H. BRONSON, Commissioner
The Capitol • Tallahassee, FL 32399-0800
www.doacs.state.fl.us

TO: Lauren P. Milligan, Environmental Manager
Florida State Clearinghouse

FROM: W. Ray Scott, Conservation and Water Quality Federal Programs Coordinator
Office of Agricultural Water Policy

DATE: October 25, 2007

SUBJECT: Comments on the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Final Integrated Project Implementation Report and Environmental Impact Statement

---

The Florida Department of Agriculture and Consumer Services (FDACS) appreciates the opportunity to comment and requests the following concerns be addressed in the review of the Corps' Caloosahatchee River (C-43) West Basin Storage Reservoir (BSR) Project Final Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS). FDACS has submitted comments formally at the agency level and to the Project Delivery Team (PDT) throughout the project development process and during public review periods. The review issues that we consider as remaining to be addressed are summarized below.

The Final PIR and EIS do not acknowledge the Yellow Book's original "source switch" function for the C-43 reservoir project. Rather, it rewrites the project's conceptual history to match the current outcome. An accurate account should be included of the original plan to switch basin irrigation demand from Lake Okeechobee to the basin run-off captured in the proposed C-43 reservoir as opposed to the current PIR's plan to capture excess basin run-off and Lake Okeechobee regulatory releases for estuary use exclusively. This change has implications beyond this particular project because other CERP projects use planning conditions based on the original concept of restricting Lake Okeechobee irrigation releases for agricultural water demand in the C-43 Basin. The Final PIR/EIS Annex B – Draft PIR Comment Matrix (page B-82) responds to an earlier FDACS comment on this issue, but merely confirms the change: "The reservoir proposed in this project allows estuary demands to be supplemented by reservoir storage during the dry season, thus relieving some dry-season demands on Lake Okeechobee allowing more water within the lake to be used system wide." While not stating that these system wide uses include C-43 basin irrigation demand, it is not apparent how the irrigation demand would otherwise be met.

Annex C contains an analysis that identifies the volume of water made available by the project for the natural system. The amount identified under the Initial Operating Regime (IOR) is anticipated to be substantially more than the amount that will ultimately be available for the natural system as identified in the Next Added Increment (NAI) analysis. Under the driest conditions, the IOR amount is approximately 50% greater than the NAI amount (Table C-3: Identification of the Volume of Water (Ac-Ft/Year) Made Available for the Natural System to Achieve the Benefits of the Project, Page C-24, Annex C, Caloosahatchee River (C-43) West Basin Storage Reservoir (BSR) Project Final Integrated PIR and EIS).

The larger amount identified in the IOR is recommended to be reserved for the natural system under Florida law. The recently released "Revised Final Draft CERP Guidance Memoranda - GM #4: Identifying Water Made Available for the Natural System and for Other Water Related Needs" refers to changing water reservations in response to changing conditions as more CERP projects are completed. The language of GM #4 appears to address the incorporation of additional water made available and not subsequent reductions in water made available. FDACS is concerned that it may be difficult to maintain an accurate accounting of the water made available for the natural system by the Caloosahatchee (C-43) West BSR relative to reductions in that amount that result when other projects are implemented. Moreover, the prospect of "rolling back" an already established reservation raises some significant legal questions, and underscores the need to carefully account for "water made available" by this project and to consider how the potential future reductions in "water made available" will be dealt with. The USACE did not provide a response in the Final PIR/EIS Annex B – Draft PIR Comment Matrix to an earlier FDACS comment that raised this issue.

Our remaining concern is the lack of an evaluation tool to determine if the Caloosahatchee (C-43) West BSR will create a greater demand on the Caloosahatchee River with an associated greater demand on Lake Okeechobee during drought years. Consequently, meeting the Savings Clause requirements for an existing legal source as of December 11, 2000, consistent with Federal law, is still an open question for the Caloosahatchee River (C-43) West BSR Project Final Integrated PIR and EIS. While we agree with the USACE that the possibility of significant negative impacts to existing users in the area of the project is minimal, we are not convinced that an adequate analysis of impacts to water supply during drought years has been performed or that the methodology described in "Revised Final Draft CERP Guidance Memoranda GM #3: Savings Clause Requirements" has been followed. It is not clear whether the system wide effect of an additional demand on Lake Okeechobee was considered at all. We believe that the information and analyses provided do not address this issue and are not adequate to provide the assurances required by state or federal law.

The underlying issue for all our concerns is that the modeling conducted for the Caloosahatchee (C-43) West BSR relied upon delivery of a specific volume of water from Lake Okeechobee, and it is not clear what system wide impacts this demand on the lake will have, particularly under drought conditions. First, there is a potential conflict with the original Yellow Book assumption that the project would restrict deliveries to the C-43 basin and consequently with the planning assumptions for other CERP projects. Second, the apparent anomaly between the water made available under the IOR scenario and the NAI scenario likely hinges on the discrepancy between potentially competing water demands from Lake Okeechobee. Finally, we are less concerned with Savings Clause assurances in the immediate project area than with a potential reduction in water supply availability outside the project area if the reservoir creates an additional demand on Lake Okeechobee.

Again, we appreciate the opportunity to comment on the Caloosahatchee River (C-43) West BSR Project Final Integrated PIR and EIS. Our level of concern with the issues we raise here is heightened by current system conditions, and we believe that a better understanding of the effect of this project under such conditions is needed. Moreover, we do not believe that the Savings Claus analysis adequately addresses potential impacts outside the area of the project, nor do the PIR and EIS provide sufficient information to provide the assurances required under Florida law.

If you should have questions regarding FDACS' comments, please contact me at (850) 410-6714.

Southwest Florida Regional Planning Council
1926 Victoria Avenue, Fort Myers,
(239)338-2550 FAX (239)338-2560 SUNCOM (239)748-2550

RECEIVED
OCT 29 2007
OIP / OLGA

October 25, 2007

Ms. Sally B. Mann
Coordinator
FDEP - Florida State Clearinghouse
3900 Commonwealth Boulevard, Mail Station 47
Tallahassee, FL 32399-3000

Re: IC&R 2007-059
SAI#FL 200709193767C
Hendry County, Caloosahatchee River (C-43) West Basin Storage Reservoir, Final Integrates Project Implementation Report (PIR) and Final Environmental Impact Statement (EIS), Permit 3005-5958(IP-TKW)

Dear Ms. Mann:

The Southwest Florida Regional Planning Council (SWFRPC) has reviewed the Final Integrated Project Implementation Report (PIR) and Final Environmental Impact Statement (EIS) for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, and has the following comments:

The request dated, September 19, 2007 was received for our review on September 21, 2007.

The proposed project has the potential to effect hydrology, water quality, wetlands, and wildlife within one of the largest manmade canal systems and watersheds within the southwest Florida region.

There are several components of the Final Integrated Project Implementation Report (PIR) that will have environmental benefits including:

- Construction of a 170,000 acre-feet reservoir with the expressed purpose of reducing the number and duration of extreme hydrologic events at S-79 locks on the Caloosahatchee River.
- Reduction in the number and duration of high flow (>4500 cfs) and low flow (<450 cfs) events in the Caloosahatchee River.
- Adopting and implementing targets of 0 flows below 450 cfs and above 4,500 cfs for the Caloosahatchee River.

TO: Ms. Sally B. Mann

DATE: October 25, 2007

PAGE: Two

RE: IC&R 2007-059 - SAI#FL 200709193767C

- Commitment to use the water quality prediction tools currently in development, such as reservoir and estuary water quality models, to optimize the reservoir operations with the goal of improving downstream water quality. (reference: Page C-83)
- Commitment to 5 years of water quality monitoring associated with design and initial operations of the reservoir.

A component of the Draft Final Integrated Project Implementation Report (PIR) that would have had environmental benefits that has been removed and/or are not included in the PIR including:

- An Oyster Restoration Plan for the Tidal Caloosahatchee that anticipated an increase from 3.02 acres of oyster reef habitat in 2004 to 30 acres of oyster reef habitat within 10 to 15 years. With the ultimate addition of hard, suitable substrate the target of oyster reef habitat increases to 100 acres. (References: Page 5-36 of the PIR. Page C-67)

There are several components of the Final Integrated Project Implementation Report (PIR) that are questionable in conception and execution including:

- The use of the acquisition of lands in the Picayune Strand State Forest as mitigative off-site to the loss of Florida panther habitat accrued by the C-43 project flooding of Florida panther habitat area. The issue is compounded by the mixed sources of funding that were used to acquire the land that today constitutes the Picayune Strand State Forest. The forest was variously acquired by direct federal fund allocations that did not specify that the land acquisition constituted a mitigation bank or mitigation area, State funds from the CARL and Florida Forever funding sources that are not bonded as mitigation banks or areas, private conservation entity acquired lands donated to the State, already existing mitigation sites utilized as off-sets to other listed species impacts including Florida panther and red-cockaded woodpecker project impacts for private developments, and other donated lands. It is therefore questionable to ex post facto utilize and existing public conservation land set aside by funding sources that did not envision or specify that this land was to constitute mitigation for impacts to federal listed species habitat elsewhere. Following this train of thought all existing State and federal lands not previously debited could be considered mitigation banks against future projects. In addition, many areas of the Picayune State Forest will be negatively impacted and rendered useless for Florida panther habitat by construction features and upland flooding caused by the construction activities of the restoration project including spreader

TO: Ms. Sally B. Mann
DATE: October 25, 2007
PAGE: Three
RE: IC&R 2007-059 - SAI#FL 200709193767C

berm/swale and pump station construction and higher water discharges across upland and short hydroperiod wetland systems.

- The use of water quality monitoring stations significantly downstream of the C-43 reservoir as a monitoring surrogate of the water quality benefits to the Caloosahatchee estuary of the discharge from the reservoir is questionable in large part since a significant number of other factors in the main line of the River and contributions to the river from downstream and in-stream water sources will swamp out the water quality content and volume effects of the reservoir. Since there are many other water quality improvement projects that will be occurring concurrent with the C-43 reservoir project including reductions in domestic fertilizer use, restorations of tributary creeks downstream of the C-43 structure, and improvements to wastewater treatment plants, it will not be possible to identify the source of water quality improvement to the Caloosahatchee River and thereby attribute it to the reservoir's project.

The SWFRPC strongly recommends incorporation of the following into the PIR:

1) A water quality treatment component needs to be included in the design of the reservoir project. The need for a water quality treatment component was identified early in the process of alternative development review by federal, state, regional, and local agency participants of the PDT in the development of the PIR. It was deferred from consideration by the SFWMD and the USACOE. We understand that this reservoir project is the only reservoir design currently under consideration for CERP funding that does not have a water quality treatment feature. Based upon materials posted on the CERP web-site, east coast reservoirs have water quality treatment features included in their design. It is important that the current project design not preclude the necessary water quality treatment features. It is important that land not be surplused from the project footprint before necessary water quality treatment features are planned and constructed. Addressing hydrology without including water quality improvement is insufficient in protecting the estuary and aquatic resources of the Caloosahatchee River and the nationally recognized Outstanding Florida Waters estuaries at its confluence. H.R. 1816, the "Restoring the Caloosahatchee River: A Legacy for Florida" Act, was introduced by Congressman Connie Mack and the State of Florida Appropriations Bill delivered to Governor Crist includes funding a water quality component for the C-43 Reservoir project. The TSP should include water quality treatment features with sufficient space for their construction.

TO: Ms. Sally B. Mann

DATE: October 25, 2007

PAGE: Four

RE: IC&R 2007-059 - SAI#FL 200709193767C

2) The littoral areas proposed at the corners of the seepage canal as part of the project should be constructed. We concur with the Florida Fish & Wildlife Conservation Commission that these littoral areas will provide habitat benefits and potential water quality benefits.

3) All shade trees proposed on the outside area of the north rim canal adjacent to parking areas should be native to the Caloosahatchee basin. Past selection and planting of exotic tree species in USACOE projects has led to damage to reservoir banks and project canal banks resulting in expensive removal programs and the need to construction repairs.

4) An Oyster Restoration Plan for the Tidal Caloosahatchee which anticipates an increase from 3.02 acres of oyster reef habitat in 2004 to 30 acres of oyster reef habitat within 10 to 15 years. With the ultimate addition of hard, suitable substrate the target of oyster reef habitat increases to 100 acres.

5) The use of the past acquisition of existing conservation lands as Florida panther habitat impact mitigation for new projects such as the C-43 reservoir needs to be seriously reconsidered. The balance of mitigation created by such a practice will ultimately lead to net significant habitat loss for the Florida panther as each new project is "offset " by the existence of already protected conservation lands that add no new net increase in habitat extents for the species. In any case, lands that are impacted by project activities on the Picayune State Forest that will render land useless as Florida panther habitat should not be utilized as mitigation credits. Similarly, lands that were acquired by funding sources other than those specifically intended to serve as mitigation banks should not be utilized to generate mitigation credits from the acquisition itself. Only the net lift in panther habitat improvement created by a new restoration plan for panther habitat should be considered as available mitigation credits to be utilized for the C-43 project and similar future CERP projects. Therefore, we recommend a recalculation of the available mitigation credits that are created by habitat restoration within the Picayune State Forest based upon the current version of the restoration plan and then an audited accounting of the post-restoration project habitat restoration outcomes to determine the real net positive effects for the Florida panther of that restoration effort. The subsequent balance should then be addressed if the mitigative lift is less than the level of impact accrued by the C-43 project.

TO: Ms. Sally B. Mann
DATE: October 25, 2007
PAGE: Five
RE: IC&R 2007-059 - SAI#FL 200709193767C

The SWFRPC supports the concept and development of the C-43 reservoir project to reduce the negative hydrologic discharges to the Caloosahatchee River, restoration of base flows for the Caloosahatchee River, and improvement in water quality of the Caloosahatchee River. Our staff has participated cooperatively in the development of the PIR and EIS. We did not and do not agree; however, that water quality protections should be deferred in development of this project.

We look forward to cooperating with the applicant and other relevant agencies to resolve the issues that we have identified in this letter in order to ensure consistency with the Coastal Zone Management Act/Florida Coastal Management Program and to ensure that the PIR proceeds in a fashion that minimizes impacts to water quality, hydrology, and fish and wildlife resources in the Southwest Florida Region. Please feel free to call me if you would like to coordinate further discussion of these issues; I will be glad to facilitate any such efforts. If you have specific questions about the content of this letter, please contact Mr. Jim Beever directly at (239) 338-2550 ext 224 or by e-mail jbeever@swfrpc.org.

Sincerely,

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL

Mr. Kenneth Heatherington
Executive Director

Cc: Mr. David S. Hobbie
Chief, Regulatory Division
Department of the Army
Jacksonville Distinct Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32332-0019

U.S. Fish and Wildlife Service
6620 Southpoint Drive South, Suite 310
Jacksonville, Florida 32216-0912

TO: Ms. Sally B. Mann

DATE: October 25, 2007

PAGE: Six

RE: IC&R 2007-059 - SAI#FL 200709193767C

Ms. Susan Conner
U.S. Army Corps of Engineers
P.O Box 4970
Jacksonville FL 32232-0019
CRWBSRComments@evergladesplan.org

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
WASHINGTON, D.C. 20314-1000

AUG 11 2009

South Atlantic Division
Regional Integration Team

Charles H. Bronson, Commissioner
Florida Department of Agriculture and Consumer Services
The Capitol
Tallahassee, FL 32399-0800

Dear Commissioner Bronson:

Thank you for your letter dated October 19, 2007 on the Caloosahatchee Basin Storage Reservoir Project Final Project Implementation Report. Since that time, there have been several productive meetings with your staff and contracted consultants, as well as with the South Florida Water Management District, Florida Department of Environmental Protection, and Corps of Engineers, Jacksonville District staff to clarify and better understand the Department's concerns. In addition, several national policy concerns were reviewed as required pending final assessment of the report and have been a reason for the postponement of response until this date. We appreciate your staff's willingness to identify issues of concern and possible resolutions, and we would like to offer the following information and explanations in response to your letter based on staff discussions and policy review.

Project-Specific Objectives and System-wide Issues
Your letter states on page one:

> *"An accurate accounting should be included of the original plan to switch basin irrigation demand from Lake Okeechobee to the basin run-off captured in the proposed C-43 reservoir as opposed to the current PIR's plan to capture excess basin run-off and Lake Okeechobee regulatory releases for estuary use exclusively."*

It is true that the objectives for this project were updated since the original formulation of the C-43 reservoir feature in the 1999 Comprehensive Review Study. Changed conditions in the C-43 basin and an updated analysis of the availability of excess basin runoff that could be captured and back-pumped to Lake Okeechobee, along with the acquisition of the Berry Groves site and uncertainties about the feasibility of implementing the aquifer storage and recovery (ASR) project that was associated with the reservoir, caused the project delivery team to recommend new project objectives, evaluation criteria, and reservoir operations focused on restoring the Caloosahatchee Estuary.

These changed conditions and the basis for changing project goals and objectives were discussed and presented at several key milestones during project planning, and were documented in the Draft (April 2007) and Final (September 2007) Project Implementation Reports (PIRs). At those milestone meetings and in written comments on the Draft and Final PIRs, Department staff

duly noted their concerns about the modified project objectives and deferring consideration of additional water supply to future planning efforts. Nevertheless, in the interest of finalizing planning, approval, and authorization of a key component of the CERP for which the State of Florida had already acquired a significant portion of project lands, leaders at the South Florida Water Management District and the Corps of Engineers made a collective decision to proceed with preparing and finalizing a project implementation report focusing on the reservoir and restoration of the Caloosahatchee Estuary.

The Department's concerns about potential project impacts on water available for agricultural water supply and deferring planning efforts addressing agricultural water supply issues in the Caloosahatchee Basin are easily understood, especially considering that South Florida has recently experienced unprecedented drought conditions and record low water levels in Lake Okeechobee. But it must be emphasized that the goal of the Caloosahatchee (C-43) West Basin Storage Reservoir project is to create additional capability to manage water resources to meet ecosystem restoration objectives in the Caloosahatchee Estuary by capturing excess (flood control) releases from Lake Okeechobee, without impacting municipal or agricultural supplies elsewhere in the basin.

Furthermore, the reservoir project was not formulated to address other system-wide objectives outside the C-43 basin (e.g., increase the amount of water available in Lake Okeechobee to meet regional irrigation demands). Other CERP projects and operational planning efforts (for example, EAA Storage Reservoir, Site 1 Impoundment, and Broward County Water Preserve Areas, System Operating Manual) have been or will be formulated to increase the amount of water available from both project and system-wide operations to meet restoration targets and provide water for other water-related needs, including irrigation. We strongly encourage your Department's participation in the initial formulation and evaluation of those other CERP efforts to ensure that your agency's concerns are fully incorporated in project planning, including modeling and analysis and preparation of draft project operating manuals.

Modeling

The Department raised concerns about modeling conducted for the analyses presented in the PIR and assumptions supporting that modeling. Although we and SFWMD acknowledge that the basin-level modeling and the water budget for the reservoir is based on an assumption about in-flows from Lake Okeechobee, that assumption is consistent with the policies and procedures in the current draft "Six Program-Wide Guidance Memoranda" (July 2007) proposed by the agencies responsible for implementing the CERP. These policies and procedures address how projects will be formulated and justified, how compliance with the Savings Clause is to be analyzed, and how water is quantified to be reserved or allocated by the State of Florida.

We also understand that basin-scale modeling performed by the SFWMD to design the project prompted additional requests for more information than what was presented in the project implementation report to demonstrate compliance with the Savings Clause. Additional comparison analysis of dry season monthly pumping was conducted by Jacksonville District staff and shared with the Department's staff and contracted consultants (MacVicar, Federico, and Lamb). The comparison of monthly pumping volumes from the Caloosahatchee River by the Berry Groves

pump (historical condition) and the proposed PS4 pump (future with project condition) during the dry season over a 9-year period of record confirmed that the project would not create an additional demand on the River or Lake Okeechobee to maintain the proposed perimeter canal surrounding the reservoir. In fact, the analysis showed that, in comparison to the Berry Groves pump as previously operated, the project's PS 4 pump would pull only approximately 25% of the water that the Berry Groves pump did over the entire1978-1986 period of analysis. In many years the PS 4 pump would not even be needed, because the reservoir contains sufficient water to maintain the perimeter canal in the dry season. In only two months over the period of record would the PS 4 pump pull slightly more water than the Berry Groves pump, and this is far outweighed by the much lower demand over the entire period.

This analysis also demonstrated that the reservoir and its cut-off walls will not affect water availability north of the reservoir or to the C-43 Canal. The perimeter canal, which is outside of the cutoff wall, will intercept groundwater flow and route it north, making water available to properties north of the reservoir and C-43.

Water Reservations or Allocations

Your letter correctly notes that the Initial Operating Regime (IOR) model simulation indicates that there is more water to be protected by the State of Florida than is generated by the NAI model simulation; however, the current policy of the State of Florida which is consistent with the Draft Guidance Memoranda is to protect water based on an analysis of the IOR. As you know, reservation or allocation of CERP project water for the natural system by the State of Florida is through adoption of an administrative rule. If conditions change, particularly as a result of implementation of other CERP projects, it is expected that the SWFMD would seek to modify a reservation or allocation to be consistent with the analyses performed for in future CERP PIRs. Updates of the reservation or allocation rules would be consistent with CERP Programmatic Regulations which contemplated the need for updates. The Department will have ample opportunity to address the technical aspects of the initial and subsequent rule-making efforts through the State of Florida's administrative process.

For this project, a key point is that all of the water to be protected for the natural system is a result of being able to capture and store excess Lake Okeechobee discharges to tide in the reservoir, and then delivering that water at the right time to meet estuary salinity targets. This project as simulated in the modeling, and as it will be operated, will not reduce the amount of water available from existing sources in the C-43 basin or the amount available to existing legal users.

We trust that the above information and explanations, together with the actions generated by the discussions that have occurred since your original letter, sufficiently address your concerns. If you would like to discuss these issues further, please contact Ms. Beth Marlowe, our Jacksonville District Project Manager, at 904-232-2074.

Sincerely,

Steven L. Stockton, P.E.
Director of Civil Works

encl

cf: W. Ray Scott
cf: Mike Magley

CESAJ-DR-PE 03 June 2008

MEMORANDUM FOR THE RECORD

SUBJECT:	Conference Call regarding C-43 West Basin Storage Reservoir Concerns Raised by Florida Department of Agriculture and Consumer Services (FDACS)
CALL DATE:	May 13, 2008
ATTENDEES:	Rebecca Elliott, FDACS Steve Lamb, Contractor to FDACS Brenda Mills, South Florida Water Management District (SFWMD) Allen Hall, SFWMD Brian Cornwell, US Army Corps of Engineers (USACE) Beth Marlowe, USACE

Brenda opened the meeting with acknowledgement of FDACS concerns raised in their October 19, 2007 letter in response to Corps HQ request for State and Agency review comments on the Caloosahatchee (C-43) West Basin Storage Reservoir Final Project Implementation Report and draft proposed Chief's Report. The group discussed two outstanding technical questions raised regarding the effects of the reservoir on regional water supply.

Issue 1: Will the PS4 pump associated with the C-43 reservoir pull enough water from the C-43 (and ultimately Lake Okeechobee) during dry times to become, in effect, a regional water user?

FDACS agrees that, intuitively, it should not be, but they are looking for appropriate quantification on paper to confirm the intuitive argument, so that five years from now everyone understands and can remember what was agreed to, and so that performance can be tracked in future years and compared to expectations.

Brian Cornwell clarified where withdrawals are occurring now, and how water would be routed around the proposed reservoir to maintain water supply to properties to the east of the proposed reservoir. The Paul property historically has pulled surface water from the LPDD header canal during the dry season. This canal depended on pumping of surface water from the Townsend and C-43 canals by the Berry Groves pump. In the future with project water will be supplied from the reservoir unless it is dry, in which case water will be supplied from the reservoir perimeter canal, which pulls from the Townsend Canal, and ultimately, from the C-43. Brian prepared a comparison analysis of monthly dry season pumping of the Berry Groves pump and the proposed PS4 pump during the dry season over a 9-year period of record. The results show cumulative pumping from the C-43 would decrease significantly in the future with project condition. There would be no significant increase in pumping in any single month, compared to Berry Groves pump. The PS4 pump is not expected to create a new demand on the C-43 or Lake Okeechobee during the dry season. See attachment 1 for details.

Rebecca Elliott and Steve Lamb agreed that the quantitative analysis provided addressed their concerns. The group agreed that the issue resolution would be documented by preparation of this meeting summary, and an explanation of the data files used and how the analysis was conducted. In addition, a short summary of the issue and its resolution will be included in the USACE response letter to the October 19, 2007 FDACS letter of concern.

Issue 2: What effect will the proposed reservoir's cut-off wall have on groundwater flow?

Brenda explained that in general, the perimeter canal will replace any groundwater lost to existing users with surface water. The perimeter canal will capture groundwater flow outside the cut-off wall. The group agreed that the monthly pumping volume chart prepared by Brian to address Issue 1 largely answers the second question because it shows all pull from the C-43 to the perimeter canal. The group determined it was not worth it to create more complicated analyses because we can extract the answers needed from what we have.

The group asked if there were any other potential concerns that needed to be addressed. Rebecca Elliott asked about any potential concerns in moderate events, and whether water quality would be different because of the change in source. The group responded that data will be collected early to identify any changes and make any necessary adjustments. The consensus was this issue has been resolved.

The conference call was then adjourned.

Attachment 1:
Comparison of Monthly Dry Season Pumping Volumes from the Berry Groves and Proposed PS4 Pumps

The Caloosahatchee River (C-43) West Basin Storage Reservoir is planned to be constructed at the current Berry Groves site. The reservoir embankment will contain a slurry wall to reduce seepage out of the reservoir as well as a perimeter canal, located outside of the slurry wall. In addition to intercepting any potential seepage, the perimeter canal will maintain existing groundwater levels and deliver surface water that currently is conveyed by the LPDD Header Canal to properties east of the reservoir.

During normal wet season operations, the PS1 pump station will pump excess flows from the C-43 into the reservoir. During the dry season, this reservoir water is released into the perimeter canal, then into the Townsend Canal, Fort Simmons Branch, and Banana Branch, and ultimately into the C-43 to augment low flows to the Caloosahatchee Estuary.

The perimeter canal will also deliver surface water that is currently conveyed by the LPDD Header Canal to properties east of the reservoir. When water is available in the reservoir, releases are made via the S-8 structure into the perimeter canal. When there is no water in the reservoir, the PS-4 pump station will pump water from the Townsend Canal, into the perimeter canal to maintain existing water supply.

In addition to intercepting any potential seepage, the perimeter canal will also serve the purpose of maintaining existing groundwater levels and gradients in the local vicinity of the project. Users who rely on groundwater will not be impacted by the slurry cutoff wall due to the fact that the perimeter canal will provide a relatively constant water level outside the slurry wall.

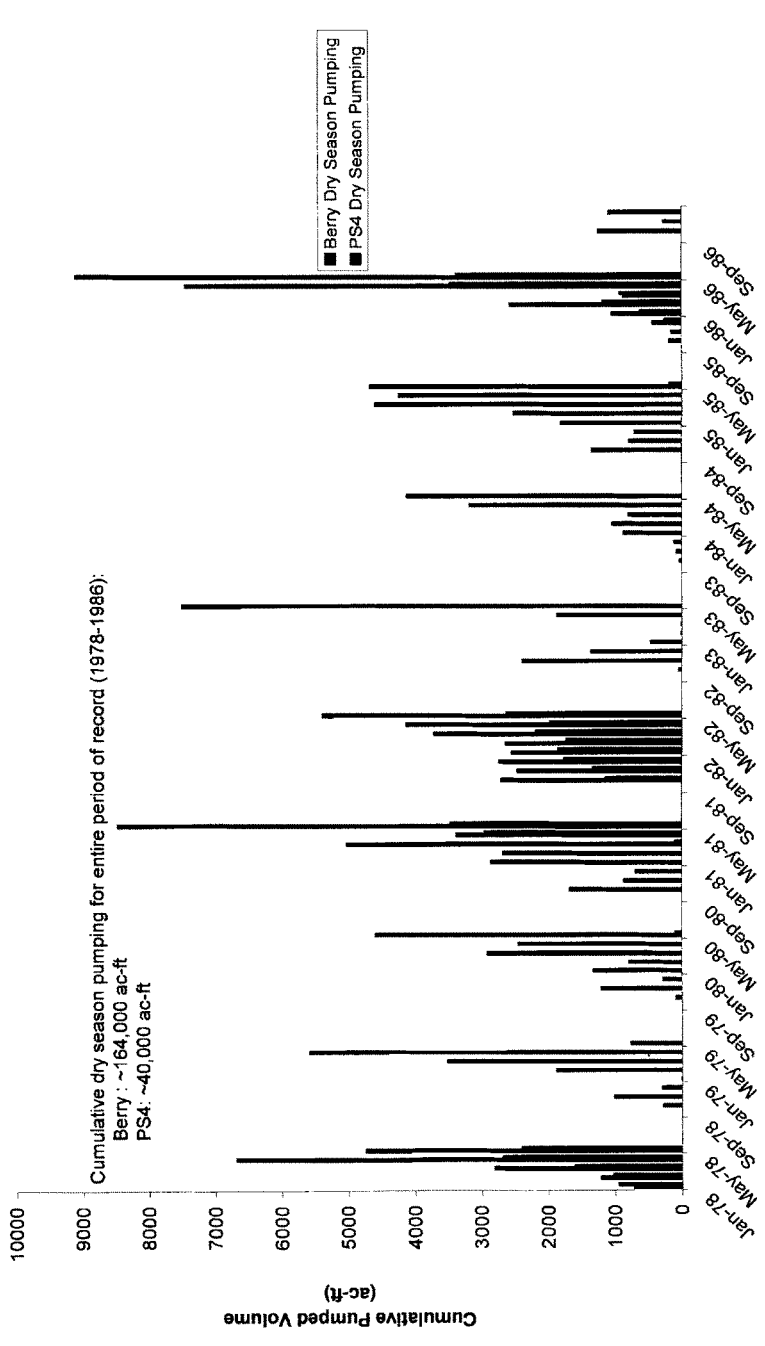
Concerns have been raised that the maintenance of water levels in the perimeter canal could create a new demand on the C-43, and ultimately on the Lake Okeechobee Service Area. An analysis was conducted using the integrated surface water-groundwater model MIKE SHE, comparing the pre-project existing condition to the with-project condition. In accordance with the Savings Clause (WRDA 2000), the analysis was conducted using the 2000 land use condition for with project and without project conditions.

The data is presented as monthly volume pumped by the PS-4 pump station (with-project), compared to the monthly volume of water pumped by the Berry Groves pump station (existing condition). Since water is pumped by the PS-4 pump station only in extremely dry times when the reservoir is empty, the data has been simplified by only showing dry season pumping, conservatively assumed to be from October 1 through May 31.

As shown in Figure 1, the with-project condition introduces no significant increase in pumping for any individual month and actually shows a very significant reduction in cumulative dry season pumping for the period 1978 through 1986.

This analysis illustrates that, when compared to existing conditions, the perimeter canal will not create a new demand on the C-43 or Lake Okeechobee.

Figure 1
Monthly Dry Season Pumping for Berry Groves and PS4



revd 10118107

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

Oct 15, 2007

Honorable John Paul Woodley
Assistant Secretary of the Army
U.S. Department of the Army
Office of the Assistant Secretary Civil Works
108 Army Pentagon
Washington, DC 20310-0108

Dear Mr. Secretary:

Thank you for the opportunity to review and provide comments on the *Chief of Engineers Proposed Report on the Comprehensive Everglades Restoration Plan, Central and Southern Florida Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, Final Project Implementation Report, Hendry County, FL* (Chief's Report). The Department of the Interior (Department) provided funds for the purchase of lands utilized in this project.

The Department supports the Chief's Report on the recommended plan for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, as described in the *Central and Southern Florida Project Comprehensive Everglades Restoration Plan Caloosahatchee River (C-43) West Basin Storage Reservoir Project Final Integrated Project Implementation Report and Final Environmental Impact Statement, September 2007.*

The Caloosahatchee River and Estuary is at the head of a vast estuarine and marine ecosystem that includes aquatic preserves managed by the state of Florida, the federally designated Charlotte Harbor National Estuary and the J.N. "Ding" Darling National Wildlife Refuge. Currently, there is not enough storage capacity in the regional water management system to minimize or prevent the harmful periodic excessive discharges of freshwater to the Caloosahatchee Estuary. Conversely, during dry periods, there are many times when there is not enough freshwater available in the regional system to maintain desirable salinity levels in the estuary. The combined result of too much or too little freshwater flowing to the Caloosahatchee Estuary is a degraded estuarine ecological community. Restoration of a healthy and productive aquatic ecosystem in the Caloosahatchee River is essential to maintaining the ecological integrity in these publicly owned and managed areas. The recommended plan provides benefits by reducing harmful discharges to the Caloosahatchee Estuary by capturing a portion of damaging high flows in the Caloosahatchee River, storing the water until needed in a reservoir and discharging the stored water to supplement inadequate flows to the Caloosahatchee Estuary during the dry season.

The portion of the Everglades ecosystem directly affected by the Caloosahatchee River (C-43) West Basin Reservoir, including the project site, the Caloosahatchee River and Estuary and the lower West Caloosahatchee River Basin, provides habitat for 21 federally listed endangered or threatened species, including the endangered Florida panther, Everglades snail kite, wood stork, manatee, eastern indigo snake, and Audubon's crested caracara. The Department is pleased that there will be monitoring of project effects on the endangered eastern indigo snake and Audubon's crested caracara. The Department looks forward to working with you to monitor the effects of reservoir operations on endangered species, such as the Florida panther, and to manage adaptively to maximize benefits on all fish and wildlife resources.

Sincerely,

Terrence C. Salt
Director of Everglades Restoration Initiatives

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

October 18, 2007

Mr. Thomas W. Waters P.E.
Chief, Policy and Policy Compliance Division
Directorate of Civil Works
Headquarters
U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, Virginia 22315-3860

Subject: EPA NEPA Review of the COE "Final Caloosahatchee River (C-43) West Basin Storage Reservoir Project" (September 2007); Hendry County, FL; CEQ# 20070394; ERP# COE-E39068-FL

Dear Mr. Waters:

In accordance with our responsibilities under Section 102(2)(C) of the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA) has reviewed the referenced U.S. Army Corps of Engineers (COE) Final Environmental Impact Statement (FEIS) for the proposed C-43 Basin Storage Reservoir (BSR). This proposed project is a major component of the Comprehensive Everglades Restoration Plan (CERP) and therefore was reviewed as a project implementing the overall goals and objectives of Everglades restoration.

EPA provided comments on the draft EIS (DEIS) to the COE Jacksonville District in a letter dated June 7, 2007. EPA continues to support the COE's expedited approval and implementation of the Caloosahatchee C-43 Reservoir to provide additional water storage along the Okeechobee Waterway. We offer our continued technical water quality assistance as appropriate.

EPA focused its NEPA review of the FEIS on the COE's responses to our comment letter on the DEIS found in Annex B (pp. B-73 to B-81). As noted below, we find this section to be generally responsive to our comments on the DEIS but not always organized in a user-friendly manner. We offer the following response-specific and general comments:

* General Responses – Several responses were generic, indicating that the FEIS will be modified or that the COE agrees/concurs with the comment, as opposed to what volume, section or page of the FEIS was modified and/or a synopsis of that modification. To the extent feasible, we request that the responses in future COE NEPA documents be more specific to facilitate the public review, although we realize that this is a six-volume

document and draft documents often change until publication, such that section numbers and page numbers may be difficult to identify.

* Response 9 (Project Sizing) – We are pleased to find that additional water storage along the Caloosahatchee River is planned via another storage reservoir project (Caloosahatchee Watershed Project).

* Response 11 (Wetlands) – The EPA comment for this response was incorrectly transferred in the Annex. Page 8 of our DEIS letter indicated that page 20 of the DEIS stated that "[t]here will be no mitigation for wetlands as a result of the federal project" while page B-76 of Annex B stated that "[t]here will be mitigation for wetlands as a result of the federal project".

* Locating Responses – For future COE NEPA documents, we suggest that locating the COE's responses to agency/public comments be facilitated. Although Section 9.35.1 of the main document is titled as *Comments Received and Responses*, it refers the reader to Annex B. Annex B then refers to *Agency Correspondence* (B.3.3) and *Public Correspondence* (B.3.4) and could have been improved to read agency and public correspondence "with COE responses". In addition, it is unclear why EPA's comments are included under public rather than agency correspondence. In general, a six-volume document should be made as user-friendly as possible for public review.

In addition to the responses section, we are pleased to note that modifications in FEIS were also made. We particularly note that Appendix C (*Environmental Information*: pp. C-72 to C-119) addressed most of our water quality concerns. We appreciate this summary. Beyond this write-up, however, we encourage the Jacksonville COE to annually provide our EPA Region 4 South Florida Office with the C-43 BSR water quality monitoring program analysis. Coordination with downstream users such as Lee County and City of Sanibel is also recommended. We have also reviewed the *Draft Project Operating Plan* in Annex D and generally find it acceptable for water quality. EPA wishes to participate in the reservoir operations team and will await a schedule of events from the COE.

Although the above responses and sections were generally well done, we wish to offer a few comments on the *Water Quality Management Plan* (WQMP) in Annex D (pg. D-76). We have two main concerns with the WQMP: 1) identification of the project category and 2) water quality monitoring of the reservoir. Regarding our first concern, Section 1 of the WQMP defines the C-43 BSR Project as a Category "C" project instead of a Category "B" project (which are projects designed to achieve water quality improvement even though they do not contain water quality improvement features). Accordingly, we recommend that the C-43 BSR Project be re-characterized as a Category "B" project in the COE's Record of Decision (ROD). Regarding our second concern, we continue to request that the project include warm-weather monitoring of the reservoir (in addition to the proposed monitoring of chlorophyll-*a* at the discharge structures). Specifically, reservoir monitoring should entail sampling for blue-green algae from April to October at 1-ft below the surface. Along with algal sampling, monitoring should also

include taking *in situ* water quality profiles for reservoir temperature and dissolved oxygen during these months to document reservoir water quality and determine any thermal stratification. We recommend that the COE's ROD provide a commitment for such warm-weather monitoring of the reservoir (if such a commitment is not forthcoming, the ROD should fully substantiate how the monitoring of chlorophyll-*a* would serve as a surrogate for the recommended reservoir monitoring). Given the project's intent to improve the downstream water quantity and quality concerns associated with the current water releases from Lake Okeechobee, we find it essential to maintain the water quality of the reservoir and to determine the water quality prior to releases downstream to the lower Caloosahatchee River and Estuary at S-79. The water quality of the C-43 BSR release waters should be no worse than – and preferably better than – the ambient waters of the Caloosahatchee. Such monitoring data should also be of interest to the reservoir operations team.

Should you have questions regarding our comments, feel free to contact Chris Hoberg of my staff for NEPA-related issues (404/562-9619 or hoberg.chris@epa.gov) or Eric Hughes in our EPA Water Management Division (located in the Jacksonville District office) for technical issues (904/232-2464 or hughes.eric@epa.gov).

Sincerely,

Heinz J. Mueller, Chief
NEPA Program Office
Office of Policy and Management

cc:

Stuart Appelbaum – COE Jacksonville District; Jacksonville, FL
Ray Judah – Lee County Commissioner; Ft. Myers, FL
Roland Ottolini – Lee County Natural Resources; Ft. Myers, FL (Attn: Wayne Daltry)
Mike Sole – Secretary: FDEP, Tallahassee, FL (Attn: Greg Knecht)
Paul Souza – Field Supervisor: FWS; Vero Beach, FL (Attn: Joyce Mazourek)
Carol Wehle – Executive Director: SFWMD; West Palm Beach, FL (Attn: Larry Gerry)

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

RECEIVED
MAR 30 2011
Office of the ASA (CW)
Washington, DC

March 18, 2011

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington D.C. 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget completed its review of your recommendation for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project in Hendry County, Florida.

Based on our review of the project, we concluded that your recommendation is consistent with the policy and programs of the President. The Office of Management and Budget does not object to you submitting this report to Congress for authorization.

Sincerely,

Richard A. Mertens
Deputy Associate Director
Energy, Science, and Water

US Army Corps
of Engineers ®
Jacksonville District

Central and Southern Florida Project
Comprehensive Everglades
Restoration Plan

Caloosahatchee River (C-43) West Basin Storage Reservoir Project

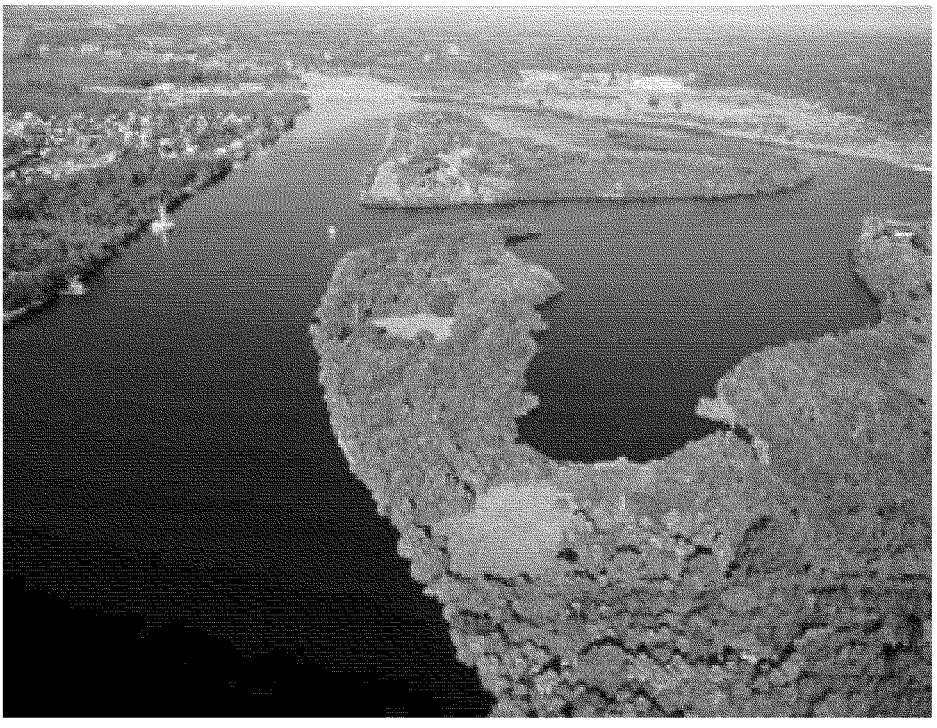
Final Integrated Project Implementation Report
and
Final Environmental Impact Statement



CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE EVERGLADES RESTORATION PLAN

CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT

FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT



November 2010

This Report Contains [5] Volumes

You Are Here

Volume 1 – Main Report – November 2010
- Addendum A
- Addendum B
- Executive Summary
- Section 1 – Introduction
- Section 2 – Existing Conditions/Affected Environment
- Section 3 – Future "Without Project" Condition
- Section 4 – Identification of Problems and Opportunities
- Section 5 – Formulation of Alternative Plans
- Section 6 – Environmental Effects of the Selected Alternative Plan
- Section 7 – The Selected Alternative Plan
- Section 8 – Plan Implementation
- Section 9 – Summary of Coordination, Public Views, and Comments
- Section 10 – Recommendations
- List of Report Preparers
- Index
- Glossary of Terms
- Acronyms
- References

Volume 2- Annex – September 2007
- Annex A – FWCA and Endangered Species Act Compliance

Volume 3 – Annexes – September 2007
- Annex B – NEPA Information
- Annex C – Analyses Required by WRDA 2000 and State Law
- Annex D – Draft Project Operating Manual and Monitoring Plan
- Annex E – Reports Provided by RECOVER to Support the PIR
- Annex F – CZM Consistency and 404(b)(1) Evaluations

Volume 4 – Appendices – November 2010
- Appendix A – Engineering

Volume 5 – Appendices – November 2010
- Appendix B – Cost Estimates
- Appendix C – Environmental Information
- Appendix D – Real Estate
- Appendix E – Agency / Public Coordination
- Appendix F – Plan Formulation
- Appendix G – Economic and Social Considerations
- Appendix H – Recreation

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C-43)
WEST BASIN STORAGE RESERVOIR PROJECT

FINAL INTEGRATED
PROJECT IMPLEMENTATION REPORT
AND
FINAL ENVIRONMENTAL IMPACT STATEMENT

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

SOUTH FLORIDA WATER
MANAGEMENT DISTRICT

November 2010

This page intentionally left blank.

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
FINAL INTEGRATED
PROJECT IMPLEMENTATION REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT
ADDENDUM A

Addendum Purpose:

The purpose of this Addendum is to document changes to project costs as presented in the Final Integrated Project Implementation Report and Environmental Impact Statement of July 2007, based on a revised project real estate cost completed in accordance with CECW-SAD memorandum dated July 30, 2009 signed by the Director of Civil Works, U.S. Army Corps of Engineers. The current guidance for the CERP, Land Valuation and Crediting is as follows:

a. Consistent with long-standing USACE practice, and as supported by the unique land credit provision for CERP contained in Section 601 (e)(5)(A) of WRDA 2000, tracts acquired by the SFWMD that are acquired and provided in furtherance of a CERP project should be valued and credited as individual tracts regardless of whether the acquisition was prior to or after execution of the Project Partnership Agreement (PPA) for that project. This general principle would not apply where the SFWMD acquired contiguous tracts that are required for a CERP project but it acquired such tracts prior to the PPA for a reason and use other than for implementation of the CERP project. A determination that a tract was acquired "in furtherance of a CERP project" should be supported by documentation existing at the time of acquisition.

b. The unique statutory land credit provision for CERP projects is clear that the non-Federal sponsor will be afforded credit for the value of lands, or interests in lands, that it provides in accordance with a PIR "regardless of the date of acquisition." *See* Section 601 (e)(5)(A) of WRDA 2000. To effectuate the clear intent of Congress reflected in this credit provision, land use restrictions imposed in furtherance of a CERP project after acquisition of a tract by the SFWMD should not be considered in valuing that tract for crediting purposes.

c. For the same reasons as expressed in subparagraph b. above, demolition of improvements after a tract was acquired in furtherance of a CERP project should not change the approach to value from that applicable at the time of acquisition. Accordingly, the tract should be valued for crediting purposes as it was improved when acquired by the SFWMD. To accomplish this result, the contributory value of the improvements, as of the date of the SFWMD's acquisition, should be added to the market value of the land on the date it is provided for the project as appraised in accordance with its highest and best use on the date of acquisition.

3. Incidental Costs. The SFWMD has requested that it be afforded credit for the costs incurred by other non-Federal governmental entities incidental to acquisition of project lands by such entities. The wording of Section 601 (e)(5)(A) is clear that credit may be afforded only for "incidental costs for land acquired by a non-Federal sponsor." Credit may be afforded for traditional incidental acquisition costs that are incurred by SFWMD (such as appraisal costs, mapping costs, or relocation assistance benefits) as well as costs actually incurred by SFWMD in obtaining the required real property rights from other non-Federal governmental entities. However, to be eligible for credit to be afforded to the SFWMD for incidental acquisition costs, SFWMD must have, in fact, incurred those costs. This Addendum is consistent with that guidance memorandum. This Addendum includes documentation and page number references for all edits to information contained in the Final PIR/EIS. This Addendum, as approved by CECW, will be appended to the Chief's Report and forwarded with it and the Final PIR/EIS to ASA (CW) for approval and transmission to Congress.

The increase in real estate costs does not affect alternative selection or site selection for the Caloosahatchee River (C-43) West Basin Storage Reservoir. Each alternative includes the same project footprint. As a result, the increase in real estate costs are the same for each of the four alternatives evaluated for this project. The change increases total project costs for all alternatives by the identical dollar amount and thus all alternatives maintain the same relative differences for the sake of comparison and alternative selection.

The Final Caloosahatchee River (C-43) West Basin Storage Reservoir PIR recommends 170,000 ac-ft of storage on approximately 10,700 ac with pump capacity of 1500 cfs. Originally estimated at FY07 (October 2006) price levels, the fully funded cost estimate was $565,700,000. This addendum reflects changes in the project costs due to revised project real estate costs. In addition, all project costs have been escalated to FY10 (October 2009) price levels, resulting in a revised fully funded cost estimate of $610,736,000.

Edits are organized by Final PIR section following the structure of the table of contents. This Addendum, as approved by CECW, will be appended to the Final PIR/EIS and forwarded with the Chief's Report to ASA(CW) for approval and transmission to Congress.

MAIN REPORT

The following revisions to the original text are proposed for the Main Report:

Executive Summary

1. Page xv, fourth paragraph, fifteenth line, change $2,740 to $2,825.

2. Page xvi, first paragraph, second line, change $7,146 to $8,035.

3. Page xx, third paragraph, fourth line, change $507,241,000 to $570,480,000.

4. Page xxi, replace Table ES-1 with the following table:

TABLE ES-1: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR COSTS OCTOBER 2009 PRICE LEVELS (INITIAL COSTS ROUNDED TO THE NEAREST $10,000)

Ecosystem Restoration Elements	TOTALS
Construction	
02 Relocations	$1,180,000
03 Reservoir	$12,780,000
04 Dams (embankments, slurry wall, drains, soil cement, perimeter canal, spillways, structures, etc.)	$278,780,000
09 Channels and Canals	$5,180,000
13 Pumping Plants	$83,300,000
14 Recreation	$2,930,000
15 Floodway Control-Diversion Structures	$18,430,000
Sub-Total Construction Cost	**$402,580,000**
Non-Construction	
01 Lands and Damages	$84,650,000
30 Planning, Engineering, and Design	$51,880,000
31 Construction Management	$31,370,000
Sub-Total Non-Construction Cost	**$167,900,000**
TOTAL INITIAL COST	**$570,480,000**

*The costs in this table are MII costs and can be found in the MII report in Appendix B Cost Estimates.

5. Page xxi, first paragraph, first sentence, change $3,000,000 to $3,100,000.

Section 1.0 Introduction

1. Page 1-11, last paragraph, change to read:

Storage of water within the C-43 Basin had been established as one of the primary management measures contributing to the goals and purposes of the Restudy. Based on these findings, the SFWMD originally acquired approximately 12,372 acres (including easements) using State funds and Federal funds. SFWMD exchanged approximately 541 acres of this previously acquired land for approximately 600 acres adjacent to the

property originally acquired. As the PIR development process was initiated, there was an effort to identify early opportunities to obtain system-wide benefits by utilizing readily available lands. One of these opportunities was the evaluation of a potential reservoir located in the western Caloosahatchee River Basin on lands acquired by SFWMD with both Department of Interior (DOI) and SFWMD funds (please see Real Estate Appendix D, section D1.10.2 for more information).

2. Page 1-21, paragraph 1.9, change to read as follows:

1.9 LAND ACQUISITION ACTIVITIES

As described previously, storage of water within the Caloosahatchee Basin has been established as one of the primary management measures contributing to the goals and purposes of the Restudy. The SFWMD and others have been very proactive in acquiring lands needed for CERP implementation. Based on the findings of the Restudy and CWMP, which both call for a storage reservoir in the Caloosahatchee Basin, the SFWMD, Department of Interior and the U.S. Army Corps of Engineers, Jacksonville District participated in the selection of the site for acquisition of the Berry Grove lands. An opportunity arose in October 2000 to acquire over 12,000 acres of grove land which was determined by SFWMD and the U.S. Army Corps of Engineers, Jacksonville District to be an ideal location for a reservoir for the C-43 reservoir project approved in the Central and Southern Florida Project, Comprehensive Review Study, Final Integrated Feasibility Report and Programmatic Environmental Impact Statement, April 1999. The Federal funds used for this project were appropriated to the DOI and a Grant Agreement entitled Everglades Watershed Restoration-Grant Number LWCF-1 was executed to acquire south Florida ecosystem restoration project lands in the C-43 Basin. The Florida Division of State Lands, in cooperation with the staff of the SFWMD, reached an agreement that allowed the SFWMD to acquire the Berry Groves. In addition the South Florida Water Management District acquired adjacent properties as a key component for Everglades restoration (February 2000). To date the State of Florida has purchased a total of 12,372 acres in the immediate area in anticipation of reservoir construction with Federal funding provided by the DOI at a total of approximately $32,800,000, a portion of which ($27,566,669) will be credited to the Federal government towards the acquisition of lands required for this project. SFWMD exchanged approximately 541 acres of this previously acquired land for approximately 600 acres adjacent to the property originally acquired. The revised total land would be approximately 12,430 acres. Of this approximately 12,430 acres, the Caloosahatchee River (C-43) West Basin Storage Reservoir project will require approximately 10,700 acres, of which approximately 10,480 acres will be required in fee, approximately 20 acres will be required in perpetual channel easement and approximately 200 acres will be required in temporary easements for staging areas.

Section 2.0 Existing Conditions/Affected Environment
No proposed edits

Section 3.0 Future Without Project Conditions
No proposed edits

Section 4.0 Identification of Problems and Opportunities
No proposed edits

Section 5.0 Formulation of Alternative Plans

1. Page 5-34, replace the first paragraph with the following language:

The costs in this section are ROM costs for consistent comparison of alternatives. These costs will not match the MII project costs.

Section 6.0 Environmental Effects of the Selected Alternative Plan
No proposed edits

Section 7.0 The Selected Alternative Plan

1. Page 7-12, second paragraph, first line, replace $2,519,000 with $2,930,000.

2. Page 7-12, second paragraph, third line, replace $2,972,000 with $3,457,000.

3. Page 7-13, first paragraph, fifth line, replace 4 7/8 with 4 3/8.

4. Page 7-13, replace Table 7-1 with the following table:

TABLE 7-1: SUMMARY OF RECREATION COSTS AND BENEFITS (OCTOBER 2009 PRICE LEVEL)

Recreation Construction Costs	**$2,930,000**
PED & S/A (18%)	$527,400
Total Recreation Construction	**$3,457,000**
Construction Duration	12 months
Interest During Construction Costs	$75,000
Total Recreation Investment	**$3,532,000**
Period of Analysis	40 years
Annualized Cost	$189,000
OMRR&R	$25,000
Average Annual Costs	**$214,000**
Annual Benefits	
User Day Value	$7.27
Daily Use	145
Annual Use	52,925
Average Annual Benefit	**$384,700**

5. Page 7-13, second paragraph, second line, replace $160,000 with $170,700.

6. Page 7-13, last paragraph, fifth line, replace October 2006 with October 2009.

7. Page 7-14, replace Table 7-2 with the following table:

TABLE 7-2: PROJECT COSTS FOR THE SELECTED ALTERNATIVE PLAN (OCTOBER 2009 PRICE LEVEL) (Initial cost rounded to the nearest $10,000)

Ecosystem Restoration Elements	TOTALS
Construction	
02 Relocations	$1,180,000
03 Reservoir	$12,780,000
04 Dams (embankments, slurry wall, drains, soil cement, perimeter canal, spillways, structures, etc.)	$278,780,000
09 Channels and Canals	$5,180,000
13 Pumping Plants	$83,300,000
14 Recreation	$2,930,000
15 Floodway Control-Diversion Structures	$18,430,000
Sub-Total Construction Cost	**$402,580,000**
Non-Construction	
01 Lands and Damages	$84,650,000
30 Planning, Engineering, and Design	$51,880,000
31 Construction Management	$31,370,000
Sub-Total Non-Construction Cost	**$167,900,000**
TOTAL INITIAL COST	**$570,480,000**

*The costs in this table are MII costs and can be found in the MII report in Appendix B Cost Estimates.

8. Page 7-14, first paragraph, second line, replace October 2006 with October 2009.

9. Page 7-15, replace Table 7-3 with the following table:

TABLE 7-3: COMPARISON OF YELLOW BOOK AND SELECTED ALTERNATIVE PLAN FIRST COST FOR CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT (OCT 2009 PRICE LEVEL)

Component	Yellow Book	Project First Cost	Fully Funded Cost
Caloosahatchee River (C-43) West Basin Storage Reservoir	$400,000,000	$570,480,000	$610,736,000*

* revised fully funded cost estimate based upon revised land valuation and crediting policy.

10. Page 7-15, first paragraph, second line, change $35,100,000 to $36,200,000

11. Page 7-15, first paragraph, fourth line, change $160,000 to $170,700.

12. Page 7-15, first paragraph, fifth line, change $2,740 to $2,825.

13. Page 7-17, last paragraph, first line, change $$27,567,669 to $27,566,659.

14. Page 7-18, Section 7.5.3, first paragraph, change first two sentences to read:

The existing conditions section of this document (Section 2) includes a summary of the Phase I/II Environmental Site Assessment (ESA) studies done on the properties originally acquired (totaling approximately 12,372 acres) and property the later acquired in an exchange (totaling approximately 600 acres) for the reservoir project. These are the Berry Groves tract composed of approximately 9,000 acres, the Bryan Paul Grove tract composed of approximately 600 acres, the MG Enterprises LLC property composed of approximately 2,399 acres, and the Griffin property composed of approximately 954 acres.

15. Page 7-22, third paragraph, eighth line, change $3,000,000 to $3,100,000.

Section 8.0 Plan Implementation

1. Page 8-2, revised values for the "Total Cost" column in Table 8-1 are listed below. The federal and non-federal cost share break-down has been updated using the revised numbers.

TABLE 8-1: COST APPORTIONMENT TABLE FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR (OCTOBER 2009 PRICE LEVEL ROUNDED TO THE NEAREST $10,000)

Item	Non-Federal Cost	Federal Cost	Total Cost
PED	$25,940,000	$25,940,000	$51,880,000
Lands & Damages*	$56,810,000	$27,840,000	$84,650,000
Construction Management**	$15,685,000	$15,685,000	$31,370,000
Construction Total	$186,805,000	$215,775,000	$402,580,000
Total	$285,240,000	$285,240,000	$570,480,000

* The numbers in this table are consistent with the revised MCACES cost report included in this Addendum in edits to Appendix B.

Section 9 Summary of Coordination
No proposed edits

Section 10.0 Recommendations
The recommendations section contains several changes to the 2007 report, to include an update of costs and several items of local cooperation. The costs were updated to reflect October 2009 price levels. The items of local cooperation were updated to include standard ecosystem restoration clauses, standard language regarding floodplain management and flood insurance programs, as well as changes reflecting the Master Agreement executed with the South Florida Water Management District in 2009.

The recommendations section of the July 2007 Final PIR shall be replaced by the following:

The Caloosahatchee River (C-43) West Basin Storage Reservoir project will provide an above-ground storage reservoir (including pump stations and water control structures) and associated conveyance canals as a cost-effective solution to achieving estuarine restoration benefits in the Caloosahatchee Estuary, which is integral to achieving system-wide benefits in the south Florida ecosystem. The Project will help reduce wet season high volume flows from Lake Okeechobee and contributing basin runoff from the lower West Caloosahatchee River Basin by capturing and storing a portion of these flows in the reservoir. Then during the dry season when water levels are at their lowest, water will be released from the reservoir to the Caloosahatchee River (C-43 Canal) to promote a healthy salinity balance in the estuary, thereby reducing saltwater migration into the freshwater portion of the estuary. In addition, the plan achieves the benefits of the Project as previously developed for the CERP.

This Project is integral to achieving restoration in the Caloosahatchee Estuary and plays an important role in meeting the CERP system-wide ecosystem restoration goals and objectives and other water-related needs of the region. Fish and wildlife habitat benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir project includes improving the timing of water deliveries to the estuary thereby providing a salinity range

suitable for a healthy ecosystem and reestablishment of natural hydropatterns within existing natural areas, improvement in seagrass beds in the estuary, and increase habitat for the eastern oyster, blue crab, and other fish and marine organisms. The Project is expected to produce a total of 12,809 average annual habitat units (HUs). Further, this Project is a critical building block upon which a subsequent study will be able to evaluate and achieve broader ecosystem restoration objectives in the Caloosahatchee River Watershed (includes the East Caloosahatchee River (upper) and West Caloosahatchee River (lower) fresh water river basin and the tidal basin).

I find that the Caloosahatchee River (C-43) West Basin Storage Reservoir project, located in western Hendry County, is an integral part of CERP. The Caloosahatchee River (C-43) West Basin Storage Reservoir project Recommended Plan features a reservoir with a storage capability of 170,000 ac-ft, a normal pool storage depth between 15 and 25 feet feet with a footprint of approximately 10,700 acres (of which approximately 10,480 acres are required in fee, approximately 20 acres will be perpetual easements, and approximately 200 acres will be used on a temporary basis for staging area).. The reservoir includes an individual inflow pump station of 1500 cfs capacity, discharge structures, emergency overflow spillways, and seepage control canals with associated structures. The reservoir may also provide opportunities to increase flood damage reduction capabilities through operational changes to the C&SF Project and local drainage systems. However, these opportunities are considered incidental and are not claimed as benefits. Additionally, the reservoir may provide some water quality improvements in the Townsend, Banana Branch and Ft. Simmons Branch canals and other areas. Again, these opportunities are considered incidental and are not claimed as benefits.

Therefore, I recommend that the Caloosahatchee River (C-43) West Basin Storage Reservoir project as described in the section of the report entitled "The Selected Plan", with such modifications that may be deemed advisable at the discretion of the Chief of Engineers, be authorized for construction. The total estimated first cost for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is $570,480,000 (October 2009 price level).The total first cost for the Caloosahatchee River (C-43) West Basin Storage Reservoir project includes recreation features totaling $2,930,000. The estimated total annual cost of OMRR&R of the ecosystem restoration elements is $3,100,000 with an estimated Federal annual OMRR&R cost of $1,550,000 and an estimated non-Federal OMRR&R cost of $1,550,000. The estimated cost for OMRR&R of the recreation elements is $25,000 which is 100 percent non-Federal.

The above recommendations are made with the provision that the non-Federal sponsor and the Secretary of the Army shall enter into a binding agreement defining the terms and conditions of cooperation for implementing the Project, and that the non-Federal sponsor agrees to perform the following items of local cooperation:

a. Provide 50 percent of total project costs consistent with the provisions of Section 601(e) of the Water Resources Development Act of 2000 as amended including

authority to perform design and construction of project features consistent with Federal law and regulation.

b. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations that the Government and the Non-Federal Sponsor jointly determine to be necessary for the construction, operation, maintenance, repair, replacement and rehabilitation of the Project and valuation will be in accordance with the Master Agreement.

c. Shall not use the ecosystem restoration features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any other projects.

d. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land that the non-Federal sponsor owns or controls for access to the Project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project;

e. Assume responsibility for operating, maintaining, repairing, replacing, and rehabilitating (OMRR&R) the Project or completed functional portions of the Project, including mitigation features, in a manner compatible with the Project's authorized purposes and in accordance with applicable Federal and State laws and specific directions prescribed in the OMRR&R manuals and any subsequent amendments thereto. Cost sharing for OMRR&R will be in accordance with Section 601 of WRDA 2000 as amended;

f. The non-Federal Sponsor shall operate, maintain, repair, replace and rehabilitate the recreation features of the Project with responsibility for 100 percent of the cost;

g. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms;

h. Unless otherwise provided for in the statutory authorization for this Project, comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the WRDA of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the Project or separable element;

i. Hold and save the Government free from all damages arising from construction, operation, maintenance, repair, replacement and rehabilitation of the Project and

any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors;

j. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project to the extent and in such detail as will properly reflect total project costs and comply with the provisions of the Master Agreement;

k. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the Project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government;

l. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-ways that the Government determines necessary for construction, operation, maintenance, repair, replacement and rehabilitation;

m. As between the Government and the non-Federal Sponsor, the non-Federal Sponsor shall be considered the operator of the Project for purposes of CERCLA liability. To the maximum extent practicable, the non-Federal Sponsor shall operate, maintain, repair, replace, and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA;

n. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function;

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

p. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42

U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army;" and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708[revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)];

q. Comply with Section 106 of the National Historic Preservation Act in completion of all consultation with the Florida State Historic Preservation Officer, and as necessary, the Advisory Council on Historic Preservation, prior to construction as part of the preconstruction engineering and design phase of the project;

r. Provide 50 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to the Project that are in excess of one percent of the total amount authorized to be appropriated for the Project;

s. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized and in accordance with Section 601 (e)(3) of the WRDA of 2000, as amended, and in accordance with the Master Agreement;

t. The Non-Federal Sponsor agrees to participate in and comply with applicable Federal floodplain management and flood insurance programs consistent with its statutory authority.

1. Not less than once each year the Non-Federal Sponsor shall inform affected interests of the extent of protection afforded by the Project.

2. The Non-Federal Sponsor shall publicize flood plain information in the area concerned and shall provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the Project.

3. The Non-Federal Sponsor shall comply with Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to have prepared, within one year after the date of signing a PPA for the Project, a floodplain management plan. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by non-Federal interests to preserve the level of flood protection provided by the Project. As required by Section 402, as

amended, the non-Federal interest shall implement such plan not later than one year after completion of construction of the Project. The Non-Federal Sponsor shall provide an information copy of the plan to the Government upon its preparation.

4. The Non-Federal Sponsor shall prescribe and enforce regulations to prevent obstruction of or encroachment on the Project or on the lands, easements, and rights-of-way determined by the Government to be required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project, that could reduce the level of protection the Project affords, hinder operation or maintenance of the Project, or interfere with the Project's proper function.

u. The overarching objective of the Plan is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Federal Government and the non-Federal sponsor are committed to the protection of the appropriate quantity, quality, timing, and distribution of water to ensure the restoration, preservation, and protection of the natural system as defined in Section 601 of WRDA 2000, for so long as the project remains authorized. This quantity, quality, timing, and distribution of water shall meet applicable water quality standards and be consistent with the natural system restoration goals and objectives of the CERP, as the Plan is defined in the Programmatic Regulations. The non-Federal sponsor will protect the water for the natural system by taking the following actions to achieve the overarching natural system objectives of the Plan:

1. Ensure, through appropriate and legally enforceable means under Florida law, that the quantity, quality, timing, and distribution of existing water that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report is available and beneficial to the natural system, will be available at the time the Project Partnership Agreement for the project is executed and will remain available for so long as the Project remains authorized.

2. (a) Prior to the execution of the Project Partnership Agreement, reserve or allocate for the natural system the necessary amount of water that will be made available by the project that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report.

   (b) After the Project Partnership Agreement is signed and the project becomes operational, make such revisions under Florida law to this reservation or allocation of water that the non-Federal sponsor determines, as a result of changed circumstances or new information, is necessary for the natural system.

3. For so long as the Project remains authorized, notify and consult with the Secretary of the Army should any revision in the reservation of water or other legally enforceable means of protecting water be proposed by the non-Federal sponsor, so that the Federal Government can assure itself that the changed reservation or legally enforceable means of protecting water conform with the non-Federal sponsor's commitments under paragraphs 1 and 2. Any change to a reservation of water made available by the project shall require an amendment to the Project Partnership Agreement.

Section 601(e)(5)(B) of the WRDA 2000 authorizes the Secretary of the Army to provide credit to the non-Federal sponsor for work completed by it during the period of construction pursuant to a PCA and a determination by the Secretary that the work is integral to the CERP. As part of its initiative for early implementation of certain expedited CERP projects, formerly known as the "Acceler8 Program", the non-Federal sponsor has stated that it may construct portions of the Caloosahatchee River (C-43) West Basin Storage Reservoir project consistent with this report, in advance of Congressional authorization and the signing of a PCA. The non-Federal sponsor is exploring alternative project delivery methods to expedite implementation of the Project. Such delivery methods may include public-private partnerships in which the non-Federal sponsor contracts with a private or not-for-profit entity for services that may include designing, building, operating or financing these components. I believe that it would be in the public interest for this Project to be implemented expeditiously due to the early benefits to the surrounding habitat, as well as hydrologic benefits to Federal lands and estuaries in other portions of the south Florida ecosystem. Therefore, I recommend that should the non-Federal sponsor construct portions of the Caloosahatchee River (C-43) West Basin Storage Reservoir project prior to the execution of a PAC for this Project, the non-Federal sponsor be credited for such construction costs at the time the PAC for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is executed. Such credit would be applied toward the non-Federal sponsor's share of the costs associated with the implementation of the CERP as authorized by Section 601(e)(5)(C) of WRDA 2000, shall not include cash reimbursements, and shall be subject to: a) the authorization of the Caloosahatchee River (C-43) West Basin Storage Reservoir project by law; b) a determination by the Secretary of the Army that the activities are integral to the CERP restoration project; c) a certification by the District Engineer that the costs are reasonable, allowable, necessary, auditable, and allocable; and d) a certification by the District Engineer that the activities have been implemented in accordance with USACE design and construction standards and applicable Federal and State laws.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding.

However, prior to transmittal to the Congress, the Sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Alfred A. Pantano
Colonel, Corps of Engineers
District Engineer

ANNEXES AND APPENDIXES

No revisions to Annexes A-F are necessary as a result of renegotiated real estate costs or escalated (October 2009) project costs.

Appendix A Engineering

1. Page A-62, section A.5.6.3, second line, replace $3,360,000 with $3,100,000.

Appendix B Cost Estimates

1. Page B-16 through B-28, replace the 2007 MCACES with the revised enclosed MCACES.

2. Page B-30 through B-32, replace the 2007 Fully Funded Cost Estimate with the revised enclosed Fully Funded Cost Estimate.

Print Date Wed 20 January 2010
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : svrit_C43_WSRB_10_20_2009
COE Standard Report Selections

Time 14:21:33
Title Page

This estimate is for the Selected Alternative Plan, Alternative 3B, a 170,000 acre-foot storage reservoir with 1,500 cubic feet per second pump capacity.

Estimated by USACE- SAJ and Stanley Consultants/Acceler8/SFWMD
Designed by Stanley Consultants/Acceler8/SFWMD
Prepared by Milton Switanek
Preparation Date 10/20/2009
Effective Date of Pricing 10/20/2009
Estimated Construction Time 1,025 Days

This report is not copyrighted, but the information contained herein is For Official Use Only.

Labor ID: LFL2009 EQ ID: EP07R03

Currency in US dollars

TRACES MII Version 3.01

Print Date Mon 26 October 2009 | U.S. Army Corps of Engineers | Time 10:17:39
Eff. Date 10/20/2009 | Project : swit_C43_WSRB_10_20_2009 | Project Notes Page 1
Jacksonville District Cost report

Date	Author	Note
5/16/2007	T. Leeser	Project Name:C43 Project Number: 114458 Project Type (e.g., Reconnaissance, Feasibility, Bid): PIR (Study Authority is the Water Resources Development Act of 2000) Scope of Work: Alternative B as described in the PIR, Appendix A, Engineering. Authorized Cost (if any): Not yet authorized. Contingency Amount (if any): 25%. This is a variation from Corps' guidance to allow for uncertainties in the design of the embankment and auxiliary structures. Some features have 30% contingency. Contingency on real estate is 25% on Federal administrative costs and 7% on non-Federal administrative costs, zero on RE Fee costs (per RE e-mail from A.Ayuso dated 6/19/07.) PED Amount (if any): 10% S&A Amount (if any): 7.6% Backup itemized and provided by CO. Sales Tax: 7% Job Office Overhead: 8% Home Office Overhead: 5% Profit: 10.1% Computed by weighted guidelines method. Bonds and Insurance: 1.5% Estimated Contract Award Date (mo/yr): Based on A8/SFWMD schedule (see below) as described in e-mail from LuAnn McVicar, SFWMD, to Gin Hightower, USACE, dated 14 May 2007. 1) Clearing & Grubbing contract - contract award 12 July 07. 2) Embankment Structure Pre-load contract - advertise week of 13 August 07; contract award 11 October 07. 3) Reservoir & Pump Stations contract (main contract) - Release RFPs on 18 September 07 (to pre-qualified group of contractors); Release RFBs (to RFP short-listed group of contractors) on 19 December 07; award contract on 14 February 08. Estimated Construction Start Date (mo/yr): 8/2007 (see above) Estimated Construction Midpoint Date (mo/yr): 2/2009 Estimated Construction Complete Date (mo/yr): Based on 1,025 days (per Stanley Consultants' 30% design cost estimate) this is 3 years or 8/2010. CWCCIS Indices used: Engineer Manual 1110-2-1304 dated 30 Mar 2007 Subfeature Date Index Published Index Composite 10/05 641.50 Composite 10/06 659.42 Estimate revised to reflect Tentatively Selected Plan, Alternative 3B. This estimate relies on the MCACES Gold cost estimate prepared by Stanley Consultant's for the Accelerate Program (A8)/South Florida Water Management District dated 5/31/06. Stanley Consultant's estimate uses the labor/equipment/materials makeup for costs and is crew/productivity based. The direct costs in Stanley Consultant's estimate are the basis of the unit costs in this estimate, for all cost items except as noted. The estimate is dated 5/31/06 so these costs are escalated to FY 2007 price levels. In addition, Stanley Consultants prepared a Technical Memorandum for the SFWMD/A8 program on the Townsend Canal Improvements. The TM included a cost summary; the costs are used herein. These costs are also escalated since the cost table in the TM equates the costs to their previous cost estimate and adds the two to obtain a revised total cost. Scope of Work: Taken from Draft Project Implementation Report dated April 2007, Engineering Appendix, beginning on page A-56. A two-cell 170,000 acre-foot above ground storage reservoir, a 1,500 cubic feet per second pumping station and a selection of water control structures. The reservoir project site would consist of approximately 10,500 acres. Site preparation: Clearing and grubbing the entire site to eight inches depth. Site work and access road: Maintenance of existing paved entrance road during construction and construction of a new entrance road after construction of the reservoir. Townsend Canal improvements: Widen channel bottom, add scour protection across entire channel width. Embankment: 14-foot wide crest (including soil cement protection), 3 horizontal to 1 vertical side slopes. Cell One elevation is +55 feet, NAVD, and Cell Two elevation is +54 feet. Construction material is random fill, with the borrow area on-site. Upstream slope protection and an interior drain are included, as well as a soil-bentonite wall. Downstream of the embankment is a 100-foot wide bend with a 24-foot access road. There is an interior embankment separating Cells One and Two, with a crest elevation of +50 feet, NAVD, also covered in soil-cement. Side slopes: To be seeded and sodded.

Labor ID: LFL2009 | EQ ID: EP07R03 | Currency in US dollars | TRACES MII Version 3.01

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39
Project Notes Page ii

Date	Author	Note
5/16/2007	T. Leeser	Relocations: Of electric and water utilities. Structures: Two pump stations, two outlet structure sluice gates, three perimeter canal structures (roller, slide and weir gates), two crested spillways, one balancing structure sluice gate and eight gated culverts (slide and weir gates). Demolition: Of two existing pump stations. Recreation features: A major recreation attraction of the C-43 Storage Reservoir, Part 1 will be an approximately 12-mile multi-purpose trail loop atop the levee constructed as part of the project. Recreation facilities proposed include: parking and toilet facilities (clivas multrum waterless vault toilets), information kiosk, canoe/kayak launch facility, a shade structure, traffic-control fencing and a pedestrian footbridge bridge over the perimeter canal to provide public access to the reservoir.
6/18/2007	T. Leeser	Revised estimate to remove four structures to be built by others, S-16 through S-19, per e-mail PM to EN-C (B. Marlowe to T. Leeser) on 15 June 2007. Changed real estate costs per e-mail from RE (A. Ayuso) dated 6/18/07.
6/27/2007	T. Leeser	Revised estimate to incorporate change in scope of work that raises dam/embankment height. Per DP e-mail on scope change and as coordinated through EN/ETL, increased quantities for random fill/embankment from 19,772,438 to 22,011,438 cy and for soil cement from 789,659 to 824,659 cubic yards. Also as directed through EN/ETL, increased contingency on other features expected to change slightly in design , by a corresponding amount (22,011,438/19,772,438=1.11), to 30% (25% X 1.11 = 28%, used 30%). Also per EN/ETL e-mail dated 28 June 2007, added manatee gate.
7/18/2007	T. Leeser	As a result of Independent Technical Review, profit on the prime contractor was changed by adjusting the weighted profit guidelines computation to better reflect project conditions. Also, separate profits were calculated for each subcontractor using the weighted profit guidelines (per EI 01D010). As a result, the non-construction costs 'Planning, Engineering and Design' and 'Construction Management' were revised. The cost book was changed to Region III and cost factors were updated (e.g., fuel) to reflect current pricing.
10/20/2009	Switanek	Revised Estimate to reflect current 2008 cost book and escalated by Cost Growth Index (USACE) to 2010 dollars as of 20 Oct 09. Also included $84,654,000 real estate cost without escalation and contigency. Because escalation and contigency was already included in Real- Estates cost estimate.

24

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39
Project Cost Summary Report Page 1

Description	Quantity	UOM	ContractCost	Escalation	Contingency	ProjectCost
Project Cost Summary Report			420,126,352	54,279,427	96,076,391	570,482,169
CONSTRUCTION COST	1	LS	276,220,352	44,692,453	81,670,071	402,582,876
02 Relocations	1	EA	815,000	131,867	236,717	1,183,584
0203 Cemetery, Utilities, & Structure	1	EA	815,000	131,867	236,717	1,183,584
04 Dams	1	EA	190,744,045	30,862,387	57,171,227	278,777,660
0401 Perimeter Dam and Canal, Separator Dam	1	EA	181,515,921	29,369,276	53,954,856	264,840,053
0402 Crested Spillways	1	EA	834,714	135,057	290,931	1,260,702
0403 Main Outlet Structures	1	EA	6,174,188	998,984	2,151,952	9,325,123
1500 Balancing Structure	1	EA	2,219,223	359,070	773,488	3,351,781
03 Reservoirs	1	EA	8,799,218	1,423,713	2,555,733	12,778,664
0300 Reservoirs	1	EA	8,799,218	1,423,713	2,555,733	12,778,664
14 Recreation Facilities	1	EA	2,519,000	407,574	0	2,926,574
1400 Recreation Facilities	1	EA	2,519,000	407,574	0	2,926,574
13 Pumping Plant	1	EA	57,357,560	9,280,453	16,659,503	83,297,517
1300 Pumping Plant	1	EA	57,357,560	9,280,453	16,659,503	83,297,517
15 Floodway Control-Diversion Struc	1	EA	12,415,183	2,008,777	4,009,884	18,433,844
1500 Floodway Control-Diversion Struc	1	EA	12,415,183	2,008,777	4,009,884	18,433,844
09 Channels and Canals	1	EA	3,570,345	577,682	1,037,007	5,185,033
0902 Canals	1	EA	3,570,345	577,682	1,037,007	5,185,033
NON-CONSTRUCTION COST	1	LS	143,906,000	9,586,974	14,406,320	167,899,294
01 Lands and Damages	1	EA	84,654,000	0	0	84,654,000
Construction Contracts Documents	1	EA	84,654,000	0	0	84,654,000
30 Planning, Engineering and Design	1	EA	37,652,000	6,092,094	8,132,600	51,876,694
Construction Contracts Documents	1	EA	28,000,000	4,530,400	8,132,600	40,663,000
Project Implementation Report	1	EA	9,652,000	1,561,694	0	11,213,694
31 Construction Management	1	EA	21,600,000	3,494,880	6,273,720	31,368,600
Construction Contracts	1	EA	21,600,000	3,494,880	6,273,720	31,368,600

Labor ID: LFL2009 EQ ID: EP07R03 Currency in US dollars TRACES MII Version 3.01

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39
Project Barecost to Direct Cost Report Page 2

Description	Quantity	UOM	BareCost	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost
Project Barecost to Direct Cost Report			353,142,489	353,142,489	17,265,779	370,408,268	49,718,084	420,126,352
CONSTRUCTION COST	1	LS	209,236,489	209,236,489	17,265,779	226,502,268	49,718,084	276,220,352
02 Relocations	1	EA	815,000	815,000	0	815,000	0	815,000
0203 Cemetery, Utilities, & Structure	1	EA	815,000	815,000	0	815,000	0	815,000
04 Dams	1	EA	149,139,486	149,139,486	4,913,573	154,053,159	36,690,887	190,744,046
0401 Perimeter Dam and Canal, Separator Dam	1	EA	142,907,285	142,907,285	3,326,949	146,234,234	35,281,687	181,515,921
0402 Crested Spillways	1	EA	563,723	563,723	143,524	707,247	127,467	834,714
0403 Main Outlet Structures	1	EA	4,169,729	4,169,729	1,061,617	5,231,346	942,842	6,174,188
1500 Balancing Structure	1	EA	1,498,749	1,498,749	381,583	1,880,332	338,891	2,219,223
03 Reservoirs	1	EA	7,036,077	7,036,077	9,057	7,045,134	1,754,084	8,799,218
0300 Reservoirs	1	EA	7,036,077	7,036,077	9,057	7,045,134	1,754,084	8,799,218
14 Recreation Facilities	1	EA	2,519,000	2,519,000	0	2,519,000	0	2,519,000
1400 Recreation Facilities	1	EA	2,519,000	2,519,000	0	2,519,000	0	2,519,000
13 Pumping Plant	1	EA	35,736,345	38,736,345	9,862,308	48,598,653	8,758,907	57,357,560
1300 Pumping Plant	1	EA	38,736,345	38,736,345	9,862,308	48,598,653	8,758,907	57,357,560
15 Floodway Control-Diversion Struc	1	EA	8,384,576	8,384,576	2,134,721	10,519,297	1,895,887	12,415,183
1500 Floodway Control-Diversion Struc	1	EA	8,384,576	8,384,576	2,134,721	10,519,297	1,895,887	12,415,183
09 Channels and Canals	1	EA	2,606,005	2,606,005	346,020	2,952,025	618,320	3,570,345
0902 Canals	1	EA	2,606,005	2,606,005	346,020	2,952,025	618,320	3,570,345
NON-CONSTRUCTION COST	1	LS	143,906,000	143,906,000	0	143,906,000	0	143,906,000
01 Lands and Damages	1	EA	84,654,000	84,654,000	0	84,654,000	0	84,654,000
Construction Contracts Documents	1	EA	84,654,000	84,654,000	0	84,654,000	0	84,654,000
30 Planning, Engineering and Design	1	EA	37,652,000	37,652,000	0	37,652,000	0	37,652,000
Construction Contracts Documents	1	EA	28,000,000	28,000,000	0	28,000,000	0	28,000,000
Project Implementation Report	1	EA	9,652,000	9,652,000	0	9,652,000	0	9,652,000
31 Construction Management	1	EA	21,600,000	21,600,000	0	21,600,000	0	21,600,000
Construction Contracts	1	EA	21,600,000	21,600,000	0	21,600,000	0	21,600,000

Labor ID: LFL2009 EQ ID: EP07R03 Currency in US dollars TRACES MII Version 3.01

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39
Project Direct Cost Report Page 3

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost
Project Direct Cost Report			0	0	0	0	353,142,489	353,142,489
CONSTRUCTION COST	1	LS	0	0	0	0	209,236,489	209,236,489
02 Relocations	1	EA	0	0	0	0	815,000	815,000
0203 Cemetery, Utilities, & Structure	1	EA	0	0	0	0	815,000	815,000
020318 Utilities	1	EA	0	0	0	0	815,000	815,000
02031816 Electrical	1	EA	0	0	0	0	815,000	815,000
04 Dams	1	EA	0	0	0	0	149,139,486	149,139,486
0401 Perimeter Dam and Canal, Separator Dam	1	EA	0	0	0	0	142,907,285	142,907,285
Seeding	1	EA	0	0	0	0	359,136	359,136
Clearing and Grubbing	1	EA	0	0	0	0	8,727,330	8,727,330
Stripping	1	EA	0	0	0	0	1,198,400	1,198,400
Blanket Drain	1	EA	0	0	0	0	8,421,847	8,421,847
Toe Drain	1	EA	0	0	0	0	994,164	994,164
Toe Drain Outfall End Treatment	1	EA	0	0	0	0	7,919	7,919
Embankment/Random Fill	1	EA	0	0	0	0	56,129,167	56,129,167
Chimney Drain	1	EA	0	0	0	0	441,548	441,548
Slurry Wall	1	EA	0	0	0	0	18,616,634	18,616,634
Soil Cement	1	EA	0	0	0	0	40,325,825	40,325,825
Select Fill	1	EA	0	0	0	0	349,730	349,730
Sodding	1	EA	0	0	0	0	4,780,095	4,780,095
Instruments and Controls	1	EA	0	0	0	0	37,599	37,599
Sitework	1	EA	0	0	0	0	2,517,891	2,517,891
0402 Crested Spillways	1	EA	0	0	0	0	563,723	563,723
C43CS-1	1	EA	0	0	0	0	330,648	330,648
C43CS-2	1	EA	0	0	0	0	233,075	233,075
0403 Main Outlet Structures	1	EA	0	0	0	0	4,169,729	4,169,729
C43S-1	1	EA	0	0	0	0	2,037,768	2,037,768
C43S-8	1	EA	0	0	0	0	2,131,961	2,131,961
1500 Balancing Structure	1	EA	0	0	0	0	1,498,749	1,498,749
C43S-12	1	EA	0	0	0	0	1,498,749	1,498,749

Labor ID: LFL2009 EQ ID: EP07R03 Currency in US dollars TRACES MII Version 3.01

27

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39
Project Direct Cost Report Page 4

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost
03 Reservoirs	1	EA	0	0	0	0	7,036,077	7,036,077
0300 Reservoirs	1	EA	0	0	0	0	7,036,077	7,036,077
030001 Mob, Demob & Preparatory Work	1	EA	0	0	0	0	7,000,000	7,000,000
030048 Demolition	1	EA	0	0	0	0	36,077	36,077
03004802 Site Work	1	EA	0	0	0	0	36,077	36,077
03004802 04 Removal of Structures	1	EA	0	0	0	0	36,077	36,077
Large Pump Station	1	EA	0	0	0	0	12,359	12,359
Small Pump Stations	1	EA	0	0	0	0	23,718	23,718
14 Recreation Facilities	1	EA	0	0	0	0	2,519,000	2,519,000
1400 Recreation Facilities	1	EA	0	0	0	0	2,519,000	2,519,000
Levee/Reservoir Area	1	EA	0	0	0	0	2,015,000	2,015,000
Double Lane Boat Ramp	1	EA	0	0	0	0	2,000,000	2,000,000
Vehicle Gate	1	EA	0	0	0	0	15,000	15,000
Entrance/Perimeter Area	1	EA	0	0	0	0	504,000	504,000
Shade Trees	1	EA	0	0	0	0	50,000	50,000
Footbridge	1	EA	0	0	0	0	135,000	135,000
Shade Shelter	1	EA	0	0	0	0	75,000	75,000
Canoe Launch	1	EA	0	0	0	0	39,000	39,000
Information Kiosk	1	EA	0	0	0	0	15,000	15,000
Parking Area Handicap Access	1	EA	0	0	0	0	50,000	50,000
Waterless Vault Toilet Facility	1	EA	0	0	0	0	90,000	90,000
Traffic Control Fencing	1	EA	0	0	0	0	50,000	50,000
13 Pumping Plant	1	EA	0	0	0	0	38,736,345	38,736,345
1300 Pumping Plant	1	EA	0	0	0	0	38,736,345	38,736,345
Pump Stations	1	EA	0	0	0	0	38,736,345	38,736,345
C43P-1	1	EA	0	0	0	0	34,395,990	34,395,990
C43P-4	1	EA	0	0	0	0	4,340,355	4,340,355
15 Floodway Control-Diversion Struc	1	EA	0	0	0	0	8,384,576	8,384,576
1500 Floodway Control-Diversion Struc	1	EA	0	0	0	0	8,384,576	8,384,576
Local Channel Gated Culverts	1	EA	0	0	0	0	3,688,939	3,688,939

Labor ID: LFL2009 EQ ID: EP07R03

Currency in US dollars

TRACES MII Version 3.01

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39
Project Direct Cost Report Page 5

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMati	DirectSubBid	DirectUserCost	DirectCost
C43S-7	1	EA	0	0	0	0	1,117,465	1,117,465
C43S-9	1	EA	0	0	0	0	706,012	706,012
C43S-14	1	EA	0	0	0	0	831,405	831,405
C43S-15	1	EA	0	0	0	0	1,034,057	1,034,057
1500 Perimeter Canal Structures	1	EA	0	0	0	0	4,695,637	4,695,637
Gated Culvert C43S-3	1	EA	0	0	0	0	1,275,476	1,275,476
Gated Spillway C43S-10	1	EA	0	0	0	0	1,429,262	1,429,262
Gated Spillway C43S-11	1	EA	0	0	0	0	1,990,899	1,990,899
09 Channels and Canals	1	EA	0	0	0	0	2,606,005	2,606,005
0902 Canals	1	EA	0	0	0	0	2,606,005	2,606,005
Manatee Protection Structure	1	EA	0	0	0	0	1,359,070	1,359,070
Townsend Canal Improvements	1	EA	0	0	0	0	1,246,935	1,246,935
Channel Excavation	1	EA	0	0	0	0	430,318	430,318
Rip rap	1	EA	0	0	0	0	563,452	563,452
Remove Weir	1	EA	0	0	0	0	253,165	253,165
NON-CONSTRUCTION COST	1	LS	0	0	0	0	143,906,000	143,906,000
01 Lands and Damages	1	EA	0	0	0	0	84,654,000	84,654,000
Construction Contracts Documents	1	EA	0	0	0	0	84,654,000	84,654,000
30 Planning, Engineering and Design	1	EA	0	0	0	0	37,652,000	37,652,000
Construction Contracts Documents	1	EA	0	0	0	0	28,000,000	28,000,000
302301 Plans and Specifications (P&S)	1	EA	0	0	0	0	22,400,000	22,400,000
302310 Engineering & Design During	1	EA	0	0	0	0	5,600,000	5,600,000
Project Implementation Report	1	EA	0	0	0	0	9,652,000	9,652,000
31 Construction Management	1	EA	0	0	0	0	21,600,000	21,600,000
Construction Contracts	1	EA	0	0	0	0	21,600,000	21,600,000

Labor ID: LFL2009 EQ ID: EP07R03 Currency in US dollars TRACES MII Version 3.01

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project : swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39

Table of Contents

Description	Page
Project Notes	i
Project Cost Summary Report	1
CONSTRUCTION COST	1
02 Relocations	1
04 Dams	1
03 Reservoirs	1
14 Recreation Facilities	1
13 Pumping Plant	1
15 Floodway Control-Diversion Struc	1
09 Channels and Canals	1
NON-CONSTRUCTION COST	1
01 Lands and Damages	1
30 Planning, Engineering and Design	1
31 Construction Management	1
Project Barecost to Direct Cost Report	2
CONSTRUCTION COST	2
02 Relocations	2
04 Dams	2
03 Reservoirs	2
14 Recreation Facilities	2
13 Pumping Plant	2
15 Floodway Control-Diversion Struc	2
09 Channels and Canals	2
NON-CONSTRUCTION COST	2
01 Lands and Damages	2
30 Planning, Engineering and Design	2
31 Construction Management	2
Project Direct Cost Report	3
CONSTRUCTION COST	3
02 Relocations	3
04 Dams	3
03 Reservoirs	3
03 Reservoirs	4
14 Recreation Facilities	4
13 Pumping Plant	4
15 Floodway Control-Diversion Struc	4
09 Channels and Canals	5
NON-CONSTRUCTION COST	5
01 Lands and Damages	5
30 Planning, Engineering and Design	5
31 Construction Management	5

Labor ID: LFL2009 EQ ID: EP07R03 Currency in US dollars TRACES MII Version 3.01

30

WBS 4 C-43 Basin Aquifer Storage Reservoir - Part 1 Project

FY2009/BY2011Fully Funded Estimate

(Amounts in Thousands of Dollars)

Effective Date: October 1, 2009

Fea	Description	Start Date	End Date	Mid Pt. Date	Infl Factor	Fully Funded Estimate	Fully Funded Cont.	Adj. To Total	Fully Funded Total	Adj. To Fed	Federal	Non-Federal	Remarks
						506,518	104,218	-	610,736	-	305,368	305,368	
01	LANDS & DAMAGES					84,654	0	0	84,654	0	42,327	42,327	
	C-43 Part 1 (DP1)	May-08	Jun-10	May-09	1.000	84,654	0		84,654		42,327	42,327	PM Updated Based on MCASES 26-Oct-09
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
02	RELOCATIONS					1,019	255	0	1,274	0	637	637	
	Cemetery, Utilities & Structures	Nov-12	Apr-16	Jul-14	1.076	1,019	255		1,274		637	637	PM Updated Based on MCASES 26-Oct-09
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
03	RESERVOIRS					11,002	2,751	0	13,753	0	6,876	6,876	
	Mob/Demob/Prep Work	Nov-12	Apr-16	Jul-14	1.076	11,002	2,751		13,753		6,876	6,876	PM Updated Based on MCASES 26-Oct-09
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
04	DAMS					238,493	61,528	0	300,021	0	150,010	150,010	
	Perimeter Dam/Canal/Sep Dam	Nov-12	Apr-16	Jul-14	1.076	226,955	58,067		285,022		142,511	142,511	PM Updated Based on MCASES 26-Oct-09
	Crested Spillway	Nov-12	Apr-16	Jul-14	1.076	1,044	313		1,357		679	679	
	Main Outlet Structures	Nov-12	Apr-16	Jul-14	1.076	7,720	2,316		10,036		5,018	5,018	
	C43S-12	Nov-12	Apr-16	Jul-14	1.076	2,774	832		3,606		1,803	1,803	
		Nov-12	Apr-16	Jul-14	1.076	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
09	CHANNELS & CANALS					4,464	1,116	0	5,580	0	2,790	2,790	
	Townsend Canal Improvements	Nov-12	Apr-16	Jul-14	1.076	2,143	536		2,678		1,339	1,339	PM Updated Based on MCASES 26-Oct-09
	Manatee Protection Structure	Nov-12	Apr-16	Jul-14	1.076	2,321	580		2,902		1,451	1,451	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
13	PUMPING PLANTS					71,716	17,929	0	89,645	0	44,822	44,822	
	C43P-1	Nov-12	Apr-16	Jul-14	1.076	63,827	15,957		79,784		39,892	39,892	PM Updated Based on MCASES 26-Oct-09
	C43P-4	Nov-12	Apr-16	Jul-14	1.076	7,889	1,972		9,861		4,930	4,930	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
14	RECREATION FAC					3,150	0	0	3,150	0	1,575	1,575	
	Levee/Reservoir Area	Nov-12	Apr-16	Jul-14	1.076	2,520	0		2,520		1,260	1,260	PM Updated Based on MCASES 26-Oct-09
	Entrance/Perimeter Area	Nov-12	Apr-16	Jul-14	1.076	630	0		630		315	315	
		Nov-12	Apr-16	Jul-14	1.076	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	
				N/A	1.000	0	0		0		0	0	

15	FL CNTR & DIV STR				15,523	4,316	0	19,839	0	9,919	9,919	
			N/A	1.000	0	0		0		0	0	PM Updated Based on MCASES
	Gated Culvert C43S-3	Nov-12 Apr-16	Jul-14	1.076	2,375	660		3,035		1,518	1,518	26-Oct-09
	Gated Spillway C43S-10	Nov-12 Apr-16	Jul-14	1.076	2,639	734		3,373		1,686	1,686	
	Gated Spillway C43S-11	Nov-12 Apr-16	Jul-14	1.076	3,679	1,023		4,702		2,351	2,351	
	C43S-7	Nov-12 Apr-16	Jul-14	1.076	2,065	574		2,639		1,319	1,319	
	C43S-9	Nov-12 Apr-16	Jul-14	1.076	1,304	363		1,666		833	833	
	C43S-14	Nov-12 Apr-16	Jul-14	1.076	1,552	432		1,984		992	992	
	C43S-15	Nov-12 Apr-16	Jul-14	1.076	1,909	531		2,440		1,220	1,220	
			N/A	1.000	0	0		0		0	0	
			N/A	1.000	0	0		0		0	0	
30	PE&D				46,645	8,861	0	55,505	0	27,753	27,753	
	PIR	Oct-08 Mar-09	Dec-07	1.000	11,214	0		11,214		5,607	5,607	PM Updated Based on MCASES
	P&S/EDC	Oct-07 Apr-16	Dec-11	1.089	35,431	8,861		44,291		22,146	22,146	26-Oct-09
			N/A	1.000	0	0		0		0	0	
			N/A	1.000	0	0		0		0	0	
			N/A	1.000	0	0		0		0	0	
31	CONST MNGT				29,852	7,463	0	37,315	0	18,658	18,658	
	S&A	Nov-12 Apr-16	Jul-14	1.190	29,852	7,463		37,315		18,658	18,658	PM Updated Based on MCASES
			N/A	1.000	0	0		0		0	0	26-Oct-09
			N/A	1.000	0	0		0		0	0	
			N/A	1.000	0	0		0		0	0	

Appendix C Environmental Information
No proposed edits

Appendix D Real Estate

The Real Estate Appendix is up-dated in accordance with CECW-SAD memorandum dated July 30, 2009 signed by the Director of Civil Works, U.S. Army Corps of Engineers. The current guidance for the CERP, Land Valuation and Crediting is as follows:

a. Consistent with long-standing USACE practice, and as supported by the unique land credit provision for CERP contained in Section 601 (e)(5)(A) of WRDA 2000, tracts acquired by the SFWMD that are acquired and provided in furtherance of a CERP project should be valued and credited as individual tracts regardless of whether the acquisition was prior to or after execution of the PPA for that project. This general principle would not apply where the SFWMD acquired contiguous tracts that are required for a CERP project but it acquired such tracts prior to the PPA for a reason and use other than for implementation of the CERP project. A determination that a tract was acquired "in furtherance of a CERP project" should be supported by documentation existing at the time of acquisition.

b. The unique statutory land credit provision for CERP projects is clear that the non-Federal sponsor will be afforded credit for the value of lands, or interests in lands, that it provides in accordance with a PIR "regardless of the date of acquisition." *See* Section 601 (e)(5)(A) of WRDA 2000. To effectuate the clear intent of Congress reflected in this credit provision, land use restrictions imposed in furtherance of a CERP project after acquisition of a tract by the SFWMD should not be considered in valuing that tract for crediting purposes.

c. For the same reasons as expressed in subparagraph b. above, demolition of improvements after a tract was acquired in furtherance of a CERP project should not change the approach to value from that applicable at the time of acquisition. Accordingly, the tract should be valued for crediting purposes as it was improved when acquired by the SFWMD. To accomplish this result, the contributory value of the improvements, as of the date of the SFWMD's acquisition, should be added to the market value of the land on the date it is provided for the project as appraised in accordance with its highest and best use on the date of acquisition.

3. Incidental costs. The SFWMD has requested that it be afforded credit for the costs incurred by other non-federal governmental entities incidental to acquisition of project lands by such entities. the wording of section 601 (e)(5)(a) is clear that credit may be afforded only for "incidental costs for land acquired by a non-federal sponsor." credit may be afforded for traditional incidental acquisition costs that are incurred by SFWMD (such as appraisal costs, mapping costs, or relocation assistance benefits) as well as costs actually incurred by SFWMD in obtaining the required real property rights from other non-federal governmental entities. however, to be eligible for credit to be afforded to the SFWMD for incidental acquisition costs, SFWMD must have, in fact, incurred those costs.

1. Page D-7, Paragraph D.5.1, first paragraph, first sentence change to read as follows:

The Caloosahatchee River (C-43) West Basin Storage Reservoir project area encompasses approximately 10,700 acres consisting of approximately 10,480 acres in fee, approximately

20 acres of perpetual channel easement, and 200 acres in temporary easement that lie within approximately 12,430 acres owned by SFWMD.

2. Pages D-8 and D-9, last paragraph, change to read as follows:

The Reservoir currently under consideration will be constructed on property formerly owned by J&H Grove Holdings, L.C. (Berry Groves), the Griffin Family Limited Partnership, the MG Enterprises, L.L.C and the Bryan Paul Citrus. All these lands are currently owned in fee by the SFWMD.

3. Page D-23, Section D.9, first paragraph, fourth sentence, eleventh through seventeenth line, change sentence to read as follows:

SFWMD exchanged 541.31 acres within its ownership for 600.17 acres owned by Bryan Paul Citrus and identified on the map and table as GX100-008 and GX100-009 respectively. The exchange added an additional approximately 58 acres for an estimated total of 12,430 acres for SFWMD ownership in fee and easement that is available and sufficient interest for project purposes.

4. Page D-23, Section D.9, second paragraph, first and second bullets, change to read:
   - SFWMD's total initial land acquisition consisted of approximately 12,372 acres including approximately 20 acres of easement.
   - SFWMD exchanged approximately 541 of these acres for approximately 600 acres owned by Bryan Paul Citrus for a new total of approximately 12,430 acres.

5. Page D-24 first, second, third, fourth and fifth bullets, change to read as follows and Delete Note: *Note Costs in $x1000:

   - Federal Fund contribution for approximately 7,080 acres is estimated at $27,502,294 for land cost and $64,375 for acquisition cost for an estimated total of $27,566,669.
   - Federal administrative costs for 10,700 acres is an estimated amount of $273,000 with 30% contingency.
   - Total estimated Federal cost share $27,840,000.
   - State funds contribution for both the 7,080 acres as well as the remaining 3,620 acres is an estimated amount of $54,970,000 for land cost and an estimated amount of $1,840,000 for administrative/acquisition costs with contingencies included.
   - Total estimated real estate costs for the 10,700 acres required for the project are the sum of $27,566,669 Federal + $273,000 Federal +$54,970,000 non-Federal + $1,840,000 non-Federal which amounts to $84,650,000.00 (Rounded).

6. Page D-27 fourth paragraph should read:

In accordance with CECW-SAD memorandum dated July 30, 2009 signed by the Director of Civil Works, U.S. Army Corps of Engineers. The current guidance for the CERP, Land Valuation and Crediting is as follows:

a. Consistent with long-standing USACE practice, and as supported by the unique land credit provision for CERP contained in Section 601 (e)(5)(A) of WRDA 2000, tracts acquired by the SFWMD that are acquired and provided in furtherance of a CERP project should be valued and credited as individual tracts regardless of whether the acquisition was prior to or after execution of the PPA for that project. This general principle would not apply where the SFWMD acquired contiguous tracts that are required for a CERP project but it acquired such tracts prior to the PPA for a reason and use other than for implementation of the CERP project. A determination that a tract was acquired "in furtherance of a CERP project" should be supported by documentation existing at the time of acquisition.

b. The unique statutory land credit provision for CERP projects is clear that the non-Federal sponsor will be afforded credit for the value of lands, or interests in lands, that it provides in accordance with a PIR "regardless of the date of acquisition." *See* Section 601 (e)(5)(A) of WRDA 2000. To effectuate the clear intent of Congress reflected in this credit provision, land use restrictions imposed in furtherance of a CERP project after acquisition of a tract by the SFWMD should not be considered in valuing that tract for crediting purposes.

c. For the same reasons as expressed in subparagraph b. above, demolition of improvements after a tract was acquired in furtherance of a CERP project should not change the approach to value from that applicable at the time of acquisition. Accordingly, the tract should be valued for crediting purposes as it was improved when acquired by the SFWMD. To accomplish this result, the contributory value of the improvements, as of the date of the SFWMD's acquisition, should be added to the market value of the land on the date it is provided for the project as appraised in accordance with its highest and best use on the date of acquisition.

3. Incidental costs. The SFWMD has requested that it be afforded credit for the costs incurred by other non-federal governmental entities incidental to acquisition of project lands by such entities. the wording of section 601 (e)(5)(a) is clear that credit may be afforded only for "incidental costs for land acquired by a non-federal sponsor." credit may be afforded for traditional incidental acquisition costs that are incurred by SFWMD (such as appraisal costs, mapping costs, or relocation assistance benefits) as well as costs actually incurred by SFWMD in obtaining the required real property rights from other non-federal governmental entities. However, to be eligible for credit to be afforded to the SFWMD for incidental acquisition costs, SFWMD must have, in fact, incurred those costs.

However, the national valuation and crediting policy will not apply to any lands acquired for any project utilizing Federal funds, (Farm Bill and/or Land and Conservation Act funds), provided to any non-Federal Sponsor. The actual acquisition costs of SFWMD or any other non-Federal Sponsor will be utilized in the plan formulation, cost estimating, evaluation, and crediting in accordance with the terms and conditions of any Department of Interior Grant as well as the Framework Agreement executed 3 October 1996 by and between the United States Department of Interior, the United States Department of the Army, the State of Florida, Department of Environmental Protection, and the South Florida Water Management District. This will be applicable to all lands included or described in any Department of Interior (DOI) Grant Agreement.

The approximately 3,620 acres acquired by SFWMD with only State/SFWMD funds were acquired in May and June 2003 after April 30, 1999 the date the C&SF Comprehensive Review Study, Final Integrated Feasibility Report and Programmatic Impact Statement (PEIS) - April 1999.

7. Page D-28 paragraph D.9.2.1 Certification and Crediting for Actual and Incidental Costs Acquired under the Department of Interior Grants should be changed to read as follows:

Pursuant to the terms and conditions of the Department of Interior Grant Agreement, SFWMD submitted and Department of Interior reviewed and approved the actual acquisition costs and SFWMD's administrative/incidental costs, (excluding SFWMD's staff costs) for the acquisition of J&H Grove Holdings, L.C. (Berry Grove) properties consisting of approximately 9,003 acres in the amount of $71,500,000, of which $32,800,000 were Federal funds. Of the approximately 7,080 acres of the approximately 9,003 acres required for the project, the Federal share for the lands would be approximately $27,566,669 as shown in ***Table D-2***, ***Table D-3***, and ***Table D-4***. These figures may be increased or decreased based on a more detailed analysis during the crediting review process after approval of the Project, execution of a Project Cooperation Agreement and certification of the land.

8. Page D-34, paragraphs D.20 & D.21 should be changed to read as follows:

D.20 BASELINE COST ESTIMATE (*Table D-3)* AND MCACES COST ESTIMATE (*Table D-4)*

The actual acquisition costs and administrative costs provided by SFWMD were considered in the final computation. SFWMD cost towards the land and incidental costs is estimated at $56,810,000 (Rounded) with contingency. The Federal cost is estimated at $27,840,000 (Rounded), which includes the Federal share of the land costs as well as future federal administrative costs. The total real estate cost with contingency is estimated at $84,650,000 (Rounded). These figures are subject to modification and verification during the crediting review process.

D.21 BASELINE COST ESTIMATE (*Table D-3*) AND MCACES COST ESTIMATE (*Table D-4)*

The actual acquisition costs and administrative costs provided by SFWMD were considered in the final computation. The total real estate cost with contingency is estimated at $84,650,000 (Rounded).

9. Page D-35, replace Table D-3 with the following table:

TABLE D-3: SUMMARY OF BASELINE COST ESTIMATE

PROJECT: Caloosahatchee River (C-43) West Basin Storage Reservoir

DATE: October 2009

LANDS AND DAMAGES:

ESTATE	ACRES	NON-FEDERAL COST	FEDERAL COST	TOTAL
FEE-With Federal and State funds	7080.00	$28,236,243	$27,502,294	
FEE-With only State funds	3400.00	$19,816,684		
EASEMENT				
CHANNEL	20.00	$0		
WORK AREA	200.00	$750,000		
CONTINGENCY 30% on $20,566,684 non-fed funds		$6,170,005.20		
SUBTOTAL	10700.00	$54,972,932	$27,502,294	
IMPROVEMENTS	0	$0		$0
SEVERANCE:		$0		
SUBTOTAL	0	$54,972,932	$27,502,294	$82,475,226
MINERALS				$0
TOTAL LANDS AND DAMAGES				**$82,475,226**
ACQ/ADMIN				
FED			$210,000	
FED-DOI			$64,375	
NON-FED		$1,416,271		
SUBTOTAL		$1,416,271	$274,375	
FED CONTINGENCY 30% ON $210,000			$63,000	
NON-FED CONTINGENCY 30% ON $1,416,271		$424,881		
SUBTOTAL		$1,841,153	$337,375	$2,178,528
TOTAL PROJECT COST		$56,814,084	$27,839,669	**$84,653,753**
TOTAL ESTIMATED RE COSTS (RD DOWN)				**$84,650,000**

10. Page D-36, replace Table D-4 with the following table:

TABLE D-4: MCACES PROJECT REAL ESTATE COSTS

MCACES PROJECT REAL ESTATE COSTS
PROJECT: Caloosahatchee River (C-43) West Basin Storage Reservoir
DATE: October 2009

			NON-	
01A	PROJECT PLANNING	FEDERAL	FEDERAL	TOTALS
	Other	100,000	0	100,000
	Project Cooperation Agreement	15,000	0	15,000
01AX	Contingencies (30%)	34,500	0	34,500
	Subtotal	149,500	0	**149,500**
01B	LANDS AND DAMAGES/PERMITS			
01B4 0	Acquisition/Review of PS	95,000		95,000
01B4 0	DOI Grant Funds	64,375		64,375
01B2 0	Acquisition by PS		1,416,271	1,416,271
01BX	Contingency (30%) on $95,000 Fed and (30%) on $1,416,271 non-Fed	28,500	424,881	453,381
	Subtotal	187,875	1,841,152	**2,029,027**
01F	PL 91-646 ASSISTANCE			
01F2 0	By PS		0	0
01FX	Contingencies (30%)		0	0
	Subtotal		0	**0**
01R	REAL ESTATE LAND PAYMENTS			
01R1 B	Land Payments by PS (state funds only)		20,566,684	20,566,684
01R1 B	Land Payments by PS (federal and state funds)	27,502,294	28,236,243	55,738,537
01R2 B	PL91-646 Relocation Payment by PS		0	0
01R2 D	Review of PS			0
01RX	Contingencies (30%)	0	6,170,005	6,170,005
	Subtotal	27,502,294	54,972,932	**82,475,226**
	TOTALS	**27,839,669**	**56,814,085**	**84,653,754**
	ROUNDED DOWN TO			**84,650,000**

11. Page D-36, comments below Table D-4: MCACES PROJECT REAL ESTATE COSTS should be deleted.

Appendix E Agency /Public Coordination
No Proposed edits

Appendix F Plan Formulation
No Proposed Edits

Appendix G Economic and Social Considerations

1. Page G-56, second paragraph, first line, replace $6.79 with $7.27.

2. Page G-56, second paragraph, third line, replace $359,000 with $384,700.

3. Page G-56, second paragraph, third line, replace $199,000 with $214,000.

4. Page G-56, replace Table G-31 with the following table:

TABLE G-31: SUMMARY OF RECREATION COSTS AND BENEFITS (OCTOBER 2009 PRICE LEVEL)

Recreation Construction Costs	**$2,930,000**
PED & S/A (18%)	$527,400
Total Recreation Construction	**$3,457,000**
Construction Duration	12 months
Interest During Construction Costs	$75,000
Total Recreation Investment	**$3,532,000**
Period of Analysis	40 years
Annualized Cost	$189,000
OMRR&R	$25,000
Average Annual Costs	**$214,000**
Annual Benefits	
User Day Value	$7.27
Daily Use	145
Annual Use	52,925
Average Annual Benefit	**$384,700**

5. Page G-56, replace Table G-32 with the following table:

TABLE G-32: SENSITIVITY ANALYSIS USING MULTIPLE SCENARIOS (OCTOBER 2009 PRICE LEVELS)

Scenario	Annual Users	Daily Users	Annual Benefit
Most Likely	52,925	145	$170,700
Worst Case	32,850	90	$17,800
SCORP Guidelines	464,280	1,272	$3,154,000

6. Page G-57. first paragraph, first line, replace $160,000 with $170,700.

Appendix H Recreation

1. Page H-1, third paragraph, fifteenth line, replace $2,519,000 to $2,930,000.

2. Page H-2, first paragraph, second line, change $2,972,000 to $3,457,000.

3. Page H-7, second paragraph, fourteenth line, change $504,000 to $586,000.

4. Page H-8, replace Table H-2 with the following table:

TABLE H-2: ENTRANCE AND PERIMETER CANAL RECREATION FEATURES (OCTOBER 2009 PRICE LEVELS)

Features	Quantity	Unit Cost	Total Cost
Shade Trees	200	$290	$58,000
Footbridge	1	$159,000	$159,000
Shade Shelter 10' x 20'	3	$29,000	$87,000
Canoe Launch	1	$45,000	$45,000
Information Kiosk	1	$17,000	$17,000
Parking Area Handicap Access	15 Spaces	$58,000	$58,000
Waterless Vault Toilet Facility	2 units	$52,000	$104,000
Traffic Control Fencing	Lump Sum	$58,000	$58,000
Entrance and Perimeter Canal Site Total			**$586,000**

5. Page H-9, first paragraph, second sentence, change $2,015,000 to $2,341,000.

6. Page H-9, replace Table H-3 with the following table:

TABLE H-3: LEVEE AND RESERVOIR IMPOUNDMENT RECREATION FEATURES (OCTOBER 2009 PRICE LEVELS)

Feature	Quantity	Unit Cost	Total Cost
Double-lane boat ramp (linear feet)	2	$1,161,800	$2,323,600
Finger Pier (handicapped accessible)	1	Included in boat ramp	
Vehicle Gate	1	$17,400	$17,400
Paved road from bridge up levee and down to boat ramp	LF	Included in project costs	$0
Levee and Reservoir Impoundment Site Total			**$2,341,000**

7. Page H-12, replace Table H-5 with the following table:

TABLE H-5: CONVERSION OF POINTS TO DOLLAR VALUES (OCTOBER 2009 PRICE LEVELS)

General Recreation Point Values	General Recreation Dollar Values
0	$3.59
10	4.26
20	4.71
30	5.39
40	6.73
50	7.63
60	8.30
70	8.75
80	9.65
90	10.32
100	10.77

8. Page H- 4, second paragraph, fifth line, replace 4 7/8 percent with 4 3/8 percent.

9. Page H-16, replace Table H-7 with the following table:

TABLE H-7: SUMMARY OF RECREATION COSTS AND BENEFITS (OCTOBER 2009 PRICE LEVELS)

Recreation Construction Costs	**$2,930,000**
PED & S/A (18%)	$527,400
Total Recreation Construction	**$3,457,000**
Construction Duration	12 months
Interest During Construction Costs	$75,000
Total Recreation Investment	**$3,532,000**
Period of Analysis	40 years
Annualized Cost	$189,000
OMRR&R	$25,000
Average Annual Costs	**$214,000**
Annual Benefits	
User Day Value	$7.27
Daily Use	145
Annual Use	52,925
Average Annual Benefit	**$384,700**

10. Page H-16, third paragraph, second line, replace $160,000 with $170,700.

11. Page H-17, replace Table H-8 with the following table:

TABLE H-8: SENSITIVITY ANALYSIS USING MULTIPLE SCENARIOS (OCTOBER 2009 PRICE LEVELS)

Scenario	Annual Users	Daily Users	Annual Benefit
Most Likely	52,925	145	$170,700
Worst Case	32,850	90	$17,800
SCORP Guidelines	464,280	1,272	$3,154,000

This page intentionally left blank.

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
FINAL INTEGRATED
PROJECT IMPLEMENTATION REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT
ADDENDUM B

Addendum Purpose:

The purpose of this Addendum is intended to serve as a response to comments received in May and June 2010 from the Assistant Secretary of the Army's (ASA) review of the Final Caloosahatchee River (C-43) West Basin Storage Reservoir Project Final Integrated Project Implementation Report and Environmental Impact Statement of July 2007. Comments received focus on challenges encountered with the hydrologic modeling and implications thereof on plan selection.

Project Status:

The Final Caloosahatchee River (C-43) West Basin Storage Reservoir Project Implementation Report (PIR) and Environmental Impact Statement successfully underwent a Civil Works Review Board briefing in August 2007. The project Chief's Report was signed on 11 March 2010 following a two and half year delay resulting from programmatic level decision making regarding land valuation and crediting. In April 2010, the Caloosahatchee River (C-43) West Basin Storage Reservoir Final PIR was submitted to the office of the ASA. The Final PIR was slated for transmittal to the Office of Management and Budget (OMB) for review on 16 July 2010. Transmittal is currently delayed pending resolution of ASA comments.

ASA Comments:

Initial comments were received from the ASA's office in May 2010. After an initial response, the US Army Corps of Engineers received a second round of comments from the ASA in late June 2010. This second round of comments expands upon a single remaining unresolved comment regarding challenges in the hydrologic modeling and its role in plan selection as described in the Final PIR. A summary of these comments follows:

1. The PIR lacks complete and valid feasibility-level engineering analyses to support project justification.
2. The PIR had an incomplete description of project's Hydraulic and Hydrologic (H&H) performance.
    - Failed to characterize the recommended plan's impacts on downstream flows, estuary conditions, or reservoir operations.

- The PIR did not indicate amount of storage that would likely be beneficial for this basin, i.e. a target for restoring the estuary.

3. The report does not sufficiently assure that the right plan is recommended or that the plans would achieve their respective intended outputs to warrant Federal investment.
4. There is no indication that the Corps reviewed the H&H modeling. The modeling and analyses need to be revised and subjected to ATR and model review guidance.

Project Modeling and Plan Selection:

The hydrologic modeling completed for the Caloosahatchee River (C-43) West Basin Storage Reservoir project utilized an iterative and prudent methodology compliant with USACE plan formulation guidance in place at that time (2006-2007). The initial modeling of alternatives and plan selection was completed using the MIKESHE model. MIKESHE is an industry standard model developed by the Danish Hydrologic Institute and is a USACE certified engineering model approved for use on CERP projects. During the team level QA/QC review of the MIKESHE model output, it was recognized that errors existed in the model runs. The impact of the error on the outcome of each alternative was uncertain. As a result, a determination of the impact if any on the ranking/order of the benefits (environmental lift) of the alternatives could not be ascertained. In order to validate the plan selection and address the MIKESHE output errors, the Interagency Modeling Center (IMC) developed a spreadsheet analysis. This analysis was used in addition to the MIKESHE model to calculate flow at the S-79 structure (**FIGURE 1**) (see Engineering Appendix A, Attachment A: IMC Technical Memorandum for the Caloosahatchee River (C-43) West Basin Storage Reservoir Spreadsheet Model for Alternative Evaluation, pg. 124, for detailed hydrologic output including flow frequency and duration data).

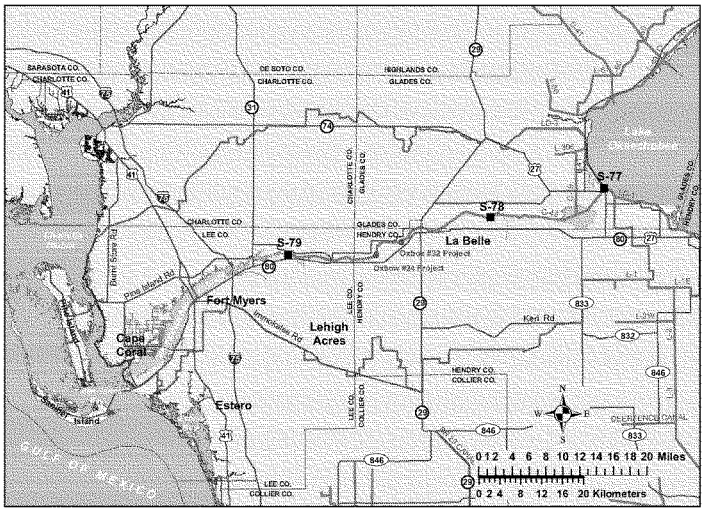


FIGURE 1: CALOOSAHATCHEE WATERSHED

The results were then used to conduct a Next Added Increment (NAI) analysis on each of the final alternatives. This Spreadsheet analysis served as a parallel alternative analysis approach to verify plan selection, although the MIKESHE model remained the model on record for use in ranking the project alternatives. A brief summary of the final alternatives is provided in the table below (**TABLE 1**).

TABLE 1: SUMMARY OF FINAL ARRAY OF COST EFFECTIVE ALTERNATIVES

Alternative 1	No Action (Future-Without Project)
Alternative 2	100,000 ac-ft reservoir, 1,500 cfs pump capacity
Alternative 3B	170,000 ac-ft reservoir, 1,500 cfs pump capacity
Alternative 3C	170,000 ac-ft reservoir, 3,800 cfs pump capacity
Alternative 4A	220,000 ac-ft reservoir, 3,800 cfs pump capacity

FIGURE 2 depicts the parallel approaches to alternative analysis. Both approaches were initiated with flow data generated by the USACE approved South Florida Water Management Model (SFWMM 2X2). In the first approach MIKESHE was then used to model flows from S-77 to S-79. MIKESHE output at S-79 was fed into a salinity regression model that was used in combination with HSI models to generate habitat units (HUs). The second approach fed SFWMM 2X2 output at S-79 into the IMC Spreadsheet tool to produce modified flow estimates at S-79. This output was then fed into the same salinity regression model and HSI models to

generate HUs using the methodology from the first approach. The IMC Spreadsheet approach does not use the MIKESHE output at any point.

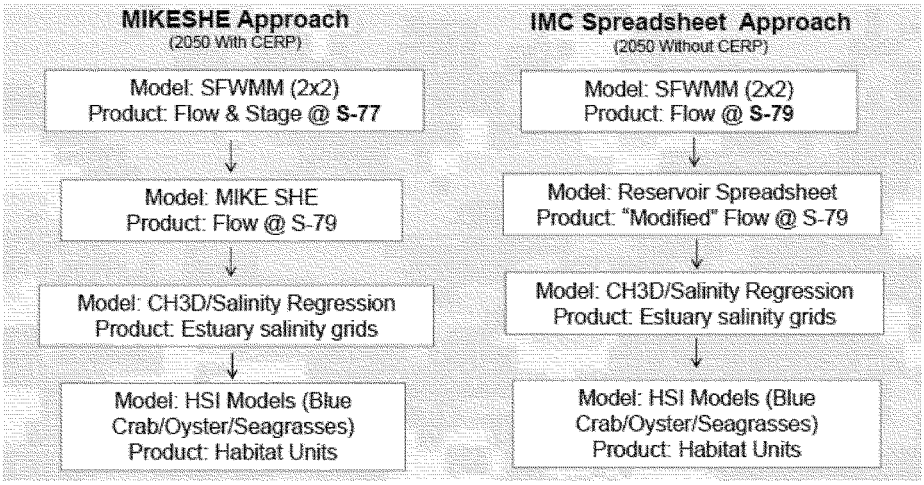


FIGURE 2: PARALLEL APPROACHES TO ALTERNATIVE ANALYSIS

TABLE 2 below presents the average annual lift (HUs) and average annual cost ($) comparison for the two approaches for each of the alternatives in the final array.

TABLE 2: SUMMARY OF NAI (SPREADSHEET) AND SYSTEM-WIDE (MIKESHE) AVERAGE ANNUAL HABITAT UNIT LIFT AND AVERAGE ANNUAL COST/AVERAGE ANNUAL HABITAT UNIT FOR EACH ALTERNATIVE IN THE FINAL ARRAY (OCTOBER 2006 PRICE LEVELS[1])

Alternative	AAHU lift (MIKESHE)	AAHU lift (Spreadsheet)	AA$/AAHU (MIKESHE)	AA$/AAHU (Spreadsheet)	Total Cost
2	10,628	13,624	$2,725	$2,126	$504,120,000
3B	12,809	15,297	$2,440	$2,043	$560,140,000
3C	16,397	17,694	$2,236	$2,072	$601,620,000
4A	15,907	18,410	$2,757	$2,382	$640,420,000

Note – The Costs presented in this analysis are planning level costs for comparison with original alternatives, as presented in Section 5 of the report. The costs have been revised based on additional engineering and design. The actual costs are presented in the updated MCACES analysis. NED costs do not include Recreation Cost for Plan Formulation.

Both the MIKESHE model approach and the IMC Spreadsheet analysis provided consistent results regarding the appropriate scale of the proposed reservoir (170,000 ac-ft storage, rather than 100,000 ac-ft or 220,000 ac-ft) as indicated in the highlighted cells in **TABLE 2**. Because the benefits per dollar achieved for alternatives 3C and 3B were close, the team selected the less

expensive alternative; Alternative 3B, which cost approximately $41 million less than alternative 3C in 2007 ($560 versus $601 million). The difference in cost is primarily associated with the smaller pump capacity in Alternative 3B.

Report Review and Approval Process

The parallel approaches to alternative analysis were presented to the USACE Vertical Team in a series of In Progress Reviews (IPRs) in early 2007 and endorsed by USACE Headquarters and the SFWMD in April of 2007. As a component of the South Florida Water Management District (SFWMD) Acceler8 program, this project had thorough engineering-level analyses included in the Final PIR. The design was completed to 90% plans and specs, which is far beyond what is typical for a standard USACE feasibility level report.

Interagency technical reviews (ITR) of the Caloosahatchee River (C-43) West Basin Storage Reservoir document were carried out through collaboration with the National Ecosystem Restoration Planning Center of Expertise (PCX) in compliance with guidance at the time of Final PIR completion (2007). Extensive external scientific peer review through the National Academy of Science (NAS) has been conducted at the Comprehensive Everglades Restoration Plan (CERP) programmatic level and will continue throughout the planning and implementation of the CERP program through the NAS biennial reports to Congress. In particular, the NAS promoted the use of traditional water storage technologies and the use of adaptive management principles within the formulation process. Both of these comments have been integrated into the formulation and design of the C-43 WBSR project. The Caloosahatchee River (C-43) West Basin Storage Reservoir Chief's Report states that no further IEPR was deemed necessary or recommended for the study. In addition, no further IEPR is needed in response to WRDA 2007, since C-43 studies had been initiated and alternatives identified more than two years prior to its enactment and the final report had been submitted for approval prior to its passage.

The MIKESHE hydrologic model used in alternative analysis and plan selection is a USACE certified engineering model approved by the USACE Science, Engineering, and Technology (SET) for use on CERP projects. The IMC Spreadsheet was a water budget analysis tool utilized for plan comparison and, unlike the MIKESHE, was not considered a hydrologic engineering model, which excluded it from the review requirements specified in the existing Engineering Model Certification guidance. The *IMC Spreadsheet Technical Memorandum for the Caloosahatchee River (C-43) West Basin Storage Reservoir Spreadsheet Model for Alternative Evaluation,* which presents the spreadsheet analysis output, is included in the Engineering Appendix of the Final PIR and underwent ITR in 2007 as part of Final PIR package. A list of significant meetings, reviews, and approval milestones are captured in the timeline below (**TABLE 3**).

TABLE 3: C-43 WBSR PROJECT TIMELINE 2006-2007

Action	Date
Evaluate Alternatives (MIKESHE)	**Summer 2006**
MIKESHE problems realized	**Oct-06**
ITR pre-AFB	**25-Oct-06**
AFB	**2-Nov-06**
QRB Guidance- abandon MIKESHE, develop spreadsheet model for plan formulation to achieve DPIR in July 2007	**1-Jan-07**
Management Guidance - use MIKESHE for plan selection, spreadsheet for assurances (IOR, NAI)	**1-Feb-07**
HQ review of PIR completion strategy	**20-Feb-07**
Spreadsheet Analysis (NAI/Alternative Analysis)	**Mar-07**
HQ/SAD **IPR**	**16-Mar-07**
2nd HQ/SAD **IPR**	**22-Mar-07**
ITR on Draft PIR	**28-Mar-07**
Management Guidance - release DPIR for public and agency review	**13-Apr-07**
DPIR **IPR**	**18-Jun-07**
ITR on Final PIR	**11-Jul-07**
CWRB	**23-Aug-07**
90% P&S Rcieved	**17-Sep-07**
Chief's Report	**11-Mar-10**

Conclusion:

In conclusion, the team feels that the Final PIR contains valid and complete feasibility level engineering analysis to support plan selection in accordance with plan formulation guidance. Both the Draft and Final PIRs met all review requirements in place at that time. The ASA is correct in stating that the underlying H&H model (MIKESHE) used in plan selection had unresolved errors. However, the team sought to address these errors by utilizing a second alternative analysis method to validate plan selection. These two approaches produced results justifying the selected alternative as a reasonable sized reservoir to benefit the Caloosahatchee Estuary. The Final PIR recognized the need for follow-on analyses and potentially additional storage to benefit the estuary, which is consistent with the principles of adaptive management and the incremental adaptive restoration approach espoused by the NAS.

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
FINAL INTEGRATED
PROJECT IMPLEMENTATION REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

Responsible Agencies: The lead agency is the U.S. Army Corps of Engineers, Jacksonville District. The South Florida Water Management District is the non-Federal cost sharing partner for the project. Other participating agencies are the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, the National Park Service, the Florida Fish and Wildlife Conservation Commission, the U.S. Geological Survey, the Natural Resources Conservation Service, and the Florida Department of Environmental Protection. The U.S. Fish and Wildlife Service, Florida Department of Environmental Protection, Everglades National Park, U.S. Environmental Protection Agency and Florida Fish and Wildlife Conservation Commission were invited to be Cooperating Agencies. None of these agencies accepted this invitation; therefore there are no cooperating agencies for this environmental impact statement (EIS).

Abstract: This report documents studies for the Caloosahatchee River (C-43) West Basin Storage Reservoir project, in accordance with the requirements of Section 601(d) of the Water Resources Development Act of 2000 (WRDA 2000) and recommends authorization of this project. This Project addresses the need to restore the ecosystem function in the Caloosahatchee Estuary by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuary system. The project also helps to maintain a desirable minimum flow of fresh water to the estuary during dry periods. These two primary functions help to moderate unnatural changes in salinity which is extremely detrimental to estuarine communities.

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to contribute to the restoration of the Caloosahatchee Estuary as part of a comprehensive plan for restoring the south Florida ecosystem. The project provides approximately 170,000 acre-feet (ac-ft) of above-ground storage volume in a two-cell reservoir with normal pool depths when the reservoir is full varying from 15 feet at the southeast corner to 25 feet at the northwest corner. Major features of the project include external and internal embankments, canals, two pump stations, internal control and outflow water control structures, and environmentally responsible design features. The project provides deepwater habitat within the impoundment cells, including refugia (created by embankment excavation) for fish and other aquatic animals during extremely dry periods. The perimeter canal may also include littoral areas which may be utilized as forage and nursery habitat by wading birds. The configuration and extent of these areas will be determined during detailed design work. Reservoir operations will also incidentally improve water quality in the Caloosahatchee Estuary, since some of the nutrient-laden runoff and lake water will be stored in the reservoir, allowing for the settling of nutrients and other pollutants within the reservoir cells prior to delivery to the estuary.

This Final Project Implementation Report and Environmental Impact Statement describes public and agency involvement in project development (including comments received and responses), explains the plan formulation and alternative evaluation and plan selection processes, and documents recommended plan features, including costs and environmental benefits.

THE OFFICIAL CLOSING DATE FOR THE RECEIPT OF COMMENT IS 30 DAYS FROM THE DATE ON WHICH THE NOTICE OF AVAILABILITY OF THIS EIS APPEARS IN THE FEDERAL REGISTER.

If you require further information on this document, contact:
Mrs. Susan Conner
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019
Telephone: (904) 232-1782
E-mail:susan.l.conner@saj02.usace.army.mil

NOTE: This report includes an integrated Environmental Impact Statement within the Final Project Implementation Report. An asterisk in the Table of Contents notes sections required for compliance with the National Environmental Policy Act.

This page intentionally left blank

FOREWORD
A note to the reader of this Final PIR/EIS

The State of Florida has developed a program called "Acceler8" for the purpose of accelerating design and construction of a number of critical restoration projects consistent with the Comprehensive Everglades Restoration Plan (CERP) prior to one or more of the following: administration approval, Congressional committee resolution, Congressional authorization, or Federal construction funding. The State anticipates the Acceler8 program will provide immediate environmental, social, and economic benefits in the south Florida region. All Acceler8 projects must be specifically authorized by Congress before becoming a part of the Federal CERP. Anticipated Acceler8 crediting is based upon future legislation which specifically provides for it, since Acceler8 efforts are performed prior to a project cooperation agreement (PCA) execution and not creditable under existing authority. The South Florida Water Management District (SFWMD) is the state agency responsible for water resources management in south Florida and acts as the non-Federal sponsor for Federal water resources projects, including the CERP. The SFWMD is also the lead State agency responsible for implementing the Acceler8 program and will need to acquire Department of the Army permits under Section 404 of the Clean Water Act prior to construction.

Of the projects that make up SFWMD's Acceler8 program, the following projects were initially authorized CERP Projects under Water Resources Development Act of 2000 (WRDA 2000): C-44 Basin Storage Reservoir, Everglades Agricultural Area Storage Reservoir-Phase I, Site 1 Impoundment, Water Conservation Areas 3A and 3B Levee Seepage, C-11 Impoundment, C-9 Impoundment, and C-111 Spreader Canal. One Acceler8 project, Acme Basin B, potentially falls under the WRDA 2000 programmatic authority provisions. Three other Acceler8 projects require separate Federal authorization: Biscayne Bay Coastal Wetlands, Caloosahatchee River (C-43) West Basin Storage Reservoir, and the Picayune Strand Restoration Project (PSRP). While Federal authorization is required for crediting purposes, it is not required for construction performed by the State.

The U.S. Army Corps of Engineers (USACE) and SFWMD anticipate that the SFWMD will accelerate construction and attainment of ecosystem restoration benefits and other benefits of certain CERP projects by obtaining required permits and initiating construction upon completion of the Final Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS) for the associated Federal CERP project.

The SFWMD proposes to initiate construction of the Caloosahatchee River (C-43) West Reservoir Acceler8 Project prior to implementation of the Federal Caloosahatchee River (C-43) West Basin Storage Reservoir project. The USACE

is proceeding with two separate and independent but related actions, the feasibility-level evaluation of the Federal project and the regulatory evaluation of the SFWMD's proposed Acceler8 project, both of which are described in this Final PIR/EIS. The SFWMD's Caloosahatchee River (C-43) West Reservoir Acceler8 project is the same as the National Environmental Policy Act (NEPA) preferred alternative or Federal Recommended Plan, described in this Final PIR/EIS. The purposes of the Federal Recommended Plan identified in this Final PIR and the SFWMD's Acceler8 project are consistent. Therefore, it is anticipated that this Final PIR/EIS will also serve as the basis for the Regulatory Division's NEPA evaluation of the SFWMD's proposed Acceler8 project.

This Final PIR/EIS is posted on the CERP website: (http://www.evergladesplan.org)

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
INTEGRATED
PROJECT IMPLEMENTATION REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE), Jacksonville District, in cooperation with its cost-sharing partner, the South Florida Water Management District (SFWMD), has prepared an Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS) for the Caloosahatchee River (C-43) West Basin Storage Reservoir project, located in Hendry County, Florida. This report describes the purpose and need for the project, location, alternatives considered, and the selected alternative plan (SAP), including plan implementation. The report also contains the evaluations conducted reaffirming that an above-ground storage reservoir in the Caloosahatchee River (C-43 Canal) basin is a cost-effective solution for achieving the benefits of the project and the goals and purposes of the Comprehensive Everglades Restoration Plan (CERP).

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to contribute to the restoration of the Caloosahatchee Estuary as part of a comprehensive plan for restoring the south Florida ecosystem. The SAP provides approximately 170,000 acre-feet (ac-ft) of above-ground storage volume in a two-cell reservoir with normal pool depths when the reservoir is full that vary from 15 feet at the southeast corner to 25 feet at the northwest corner. Project features encompass approximately 10,700 acres acquired partially with funds provided by the Federal government via Department of Interior (DOI) funds for Everglades Restoration and partially with funds provided by the State of Florida. Major features of the SAP include external and internal embankments, canals, two pump stations, internal control and outflow water control structures, and environmentally responsible design features to provide fish and wildlife habitat such as littoral areas in the perimeter canal and deep water refugia within the reservoir.

In addition, the recent recommendations of the National Research Council (NRC) of the National Academies in the final selection of the SAP were considered. The NRC has reviewed the first five years of work on CERP. Starting in 2004, 12 science and engineering experts studied CERP's progress and, after two years of study, issued their findings: *Progress Toward Restoring the Everglades: The First Biennial Review, 2006.* Biennial evaluations will continue through the 30-year lifetime of CERP. The NRC recognizes that

Everglades' restoration is a complex undertaking with many scientific uncertainties, which can slow the rate of progress. The NRC concluded that if the construction of a restoration project is delayed until all scientific uncertainties are eliminated, there will be many negative consequences including: continued decline of the Everglades ecosystem, lagging public support, and increased project costs. The NRC identified an approach referred to as Incremental Adaptive Restoration where an incremental approach using steps that are large enough to provide some restoration benefits now, while addressing critical scientific uncertainties and taking actions to promote learning that can guide the remainder of the project design. Constructing projects using a phased approach will enable assessments of benefits and impacts to the environment as each phase is constructed. Remaining phases will then be adapted to optimize performance based on actual findings from the earlier phases.

To address changing conditions, concerns and issues which have arisen since the Restudy analysis of the Caloosahatchee River Watershed, it is recommend that project use an Incremental Adaptive Restoration approach of two PIRs, in which the first PIR, the Caloosahatchee River (C-43) West Basin Storage Reservoir will address the most immediate needs of the estuary, while ensuring that it is fully compatible and consistent with the CERP. The second PIR would be a more comprehensive study that could provide a complete solution to addressing the broader needs of the entire basin.

This report has been prepared in accordance with the requirements of Section 601(d) of the Water Resources Development Act of 2000 (WRDA 2000) and Programmatic Regulations for the CERP (33 Code of Federal Regulations [CFR] Part 385) and will be circulated for public and agency review and comment in accordance with the National Environmental Policy Act (NEPA). This PIR and EIS take into consideration public and agency comments, which will be the basis for the Chief of Engineer's Report to be submitted to the Assistant Secretary of the Army (Civil Works) for transmittal to Congress.

PURPOSE AND NEED FOR THE PROJECT

The Caloosahatchee River and Estuary is at the head of a vast estuarine and marine ecosystem that includes aquatic preserves (Matlacha Pass Aquatic Preserve, Estero Bay Aquatic Preserve, Pine Island Sound Aquatic Preserve, Charlotte Harbor National Estuary, and the Caloosahatchee, Matlacha Pass and Ding Darling National Wildlife Refuges), along with numerous other Federal, state, and local parks and recreation areas. Restoration of a healthy, productive aquatic ecosystem in the Caloosahatchee River is essential to maintaining the ecological integrity and associated economic activity in these publicly owned and managed areas.

The Caloosahatchee Estuary (which is generally considered to be that portion of the Caloosahatchee River west of the W. P. Franklin Lock and Dam, Structure S-79, including the Matlacha Pass, San Carlos Bay, and Estero Bay areas at the mouth of the Caloosahatchee River, ***Figure ES-1*** and ***Figure ES-2***) encompasses approximately 80 square miles of estuarine habitat on Florida's southwest coast in the vicinity of Fort Myers, Florida. The Fort Myers area, including Cape Coral, Fort Myers Beach, Sanibel and Captiva Islands, Bonita Springs and unincorporated areas is one of the fastest growing areas in the

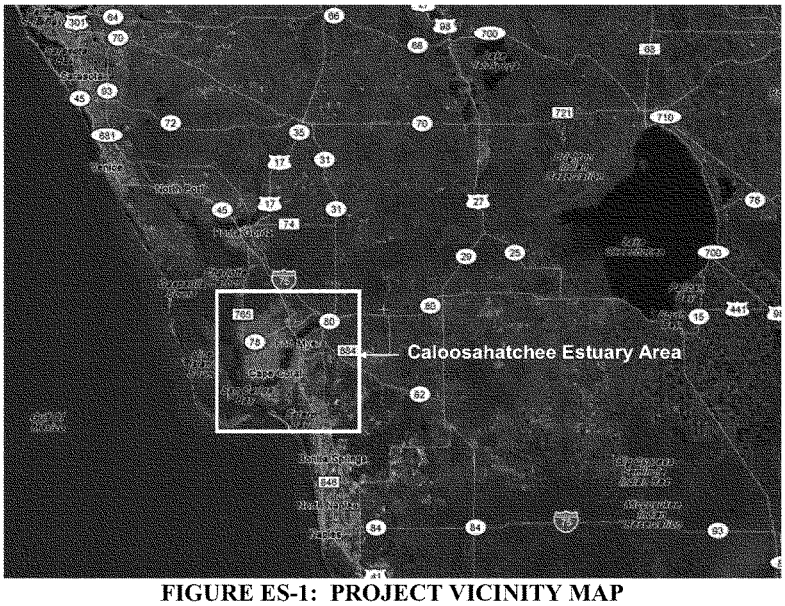


FIGURE ES-1: PROJECT VICINITY MAP

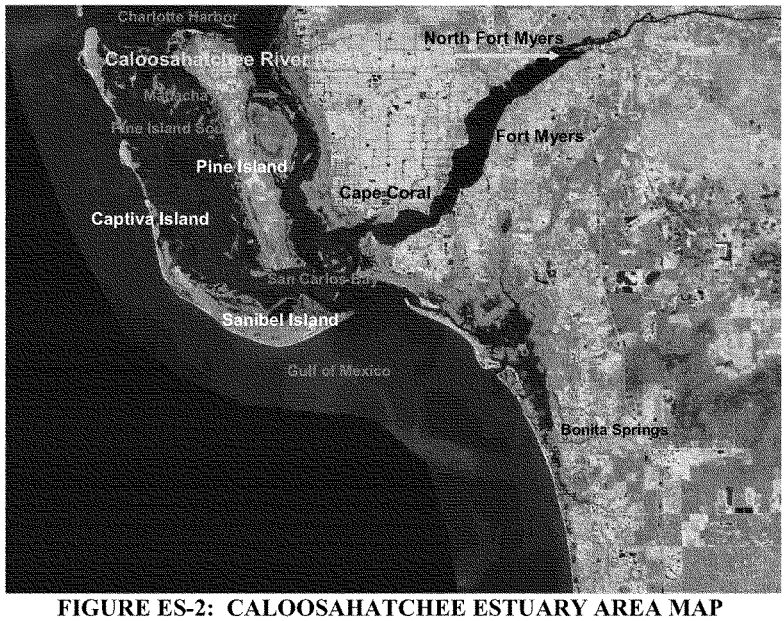


FIGURE ES-2: CALOOSAHATCHEE ESTUARY AREA MAP

Southeastern United States (2000 population approximately 440,000 according to United States [U.S.] census figures) and is an extremely popular tourist destination. The Caloosahatchee Estuary is connected to Lake Okeechobee by the Caloosahatchee River (C-43 Canal), a man-made connection to the lake originally created in the late 19th century. As part of the Central and Southern Florida (C&SF) Project for Flood Control and Other Purposes, the Caloosahatchee River has been widened and deepened to ensure that high water levels in Lake Okeechobee can be managed to prevent harmful high water levels in the lake and flooding in adjacent areas. The Caloosahatchee River is part of the federally maintained Okeechobee Waterway, and also serves to provide water supply deliveries from Lake Okeechobee to urban and agricultural areas in the basin while conveying basin runoff away from urban and agricultural areas.

Currently, there is not enough storage capacity in the regional water management system to minimize or prevent the possible harmful effects of periodic high volume discharges of freshwater to the Caloosahatchee Estuary. Conversely, during dry periods, there is sometimes not enough freshwater available in the regional system to maintain desirable salinity levels in the estuary. The combined result of too much and too little freshwater flowing to the Caloosahatchee Estuary is a degraded estuarine ecological community,

characterized by declines in the abundance and diversity of native finfish and shellfish populations and other marine and estuarine species, poor water quality, and reductions in the extent of submerged habitat suitable for sea grass and oysters (two primary indicators of healthy estuarine communities in south Florida) and other higher trophic level species, including threatened and endangered species (e.g., manatees, wood storks).

To restore ecological function and productivity in the Caloosahatchee Estuary, CERP, approved by Congress in the WRDA 2000, included an above-ground reservoir along the Caloosahatchee River to capture and store basin runoff and excess freshwater released from Lake Okeechobee. By capturing this excess water the reservoir can also serve as a source of environmental water supply to the estuary during dry periods. The need for additional storage to restore, protect, and preserve the Caloosahatchee Estuary, including Federal trust lands and other publicly owned and managed areas in and around the Caloosahatchee Estuary has also been validated by other planning efforts, including the Caloosahatchee Water Management Plan (2000) and Lower West Coast Water Supply Plan (2005-2006) prepared by the SFWMD. In accordance with Federal and state requirements for implementing CERP projects, this Final PIR was prepared to reaffirm that an above-ground storage reservoir in the Caloosahatchee River (C-43 Canal) Basin is a cost-effective solution for achieving CERP goals and Caloosahatchee River (C-43) West Basin Storage Reservoir project objectives and to present the results of evaluations required by Federal and state regulations.

WHAT WILL HAPPEN WITHOUT THE PROJECT?

Environmental conditions have declined sharply in the Caloosahatchee Estuary area due to flood control and water management actions in the study area. Additionally, since the greater Fort Myers area population has already increased considerably since the CERP was approved in 2000 and is projected to continue to increase, increasing demands for freshwater will be placed on the Caloosahatchee River and its tributaries to meet competing municipal, agricultural, and environmental water supply needs in the basin. The expected result is that undesirable high salinity levels will also continue to recur in the Caloosahatchee Estuary, and those events will likely be greater in severity and duration.

Economically, the decline in estuary functions has already had and will continue to create periodic significant adverse impacts on commercial, recreational and associated economic activities.

Without actions taken to reduce the effects of too much and too little freshwater entering the Caloosahatchee Estuary at the wrong times, the estuarine

ecosystem will continue to be degraded with the potential for some estuarine species to disappear entirely. If the recommended plan for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is not constructed, ecologically damaging discharges of basin runoff and flood control releases from Lake Okeechobee will continue during wet periods, causing periodic unnatural low salinity levels in the Caloosahatchee Estuary and adjacent estuarine and marine areas, including adjacent parks, refuges, preserves and other publicly owned and managed areas.

The net ecological effect of continued degradation of the Caloosahatchee Estuary will be further loss and limited possibility for recovery of primary and secondary productivity, including forage and nursery areas in submerged habitats and adjacent wetlands. The reduction in the abundance and spatial distribution of primary organisms such as submerged vegetation, invertebrates, small fish, and other prey organisms normally part of a healthy estuarine community will continue to be adversely impacted and be magnified in higher-level organisms such as pelagic fish, marine mammals, birds, and other aquatic-dependent wildlife (including threatened and endangered species).

PLAN FORMULATION, EVALUATION, AND SELECTION

Previous ecosystem restoration and water supply planning efforts including the C&SF Comprehensive Review Study, Final Integrated Feasibility Report and Programmatic EIS (USACE and SFWMD, April 1999) have established the need for and the beneficial effects of an above-ground reservoir in the Caloosahatchee River (C-43 Canal) Basin as part of a comprehensive plan to achieve restoration objectives for the Caloosahatchee Estuary.

The Comprehensive Review Study included two primary structural components focused on improving environmental conditions in the Caloosahatchee River and Estuary: 1) an approximately 160,000 ac-ft reservoir with associated aquifer storage and recovery (ASR) wells and 2) basin runoff backpumping and stormwater treatment facilities. Due to technical uncertainty and implementation issues, the ASR features (Part 2) originally associated with a storage reservoir in the Caloosahatchee Basin will be evaluated and implemented separately. The availability and effectiveness of storing basin runoff, treating it and returning (back-pumping) it to Lake Okeechobee will also be further evaluated as part of a future study.

For this project, plan formulation efforts involved reaffirming that an above-ground storage reservoir, as originally described in the Comprehensive Review Study, is a cost-effective means for achieving the purposes of the project consistent with the goals and objectives of the CERP. After reaffirming that the benefits of the project could be achieved with an above-ground reservoir,

formulation efforts focused on optimizing reservoir size and features on lands already acquired using DOI funds for project implementation, combined with a consideration of planning and policy constraints such as the WRDA 2000 Savings Clause.

After consideration of an initial array of alternative plans involving storage volumes ranging from 100,000 to 220,000 ac-ft with various inflow pump sizes, a final array of four alternative plans were selected consisting of:

- Alternative 2: 100,000 ac-ft storage reservoir with 1,500 cubic feet per second (cfs) pump capacity
- Alternative 3B: 170,000 ac-ft storage reservoir with 1,500 cfs pump capacity
- Alternative 3C: 170,000 ac-ft storage reservoir with 3,800 cfs pump capacity
- Alternative 4A: 220,000 ac-ft storage reservoir with 3,800 cfs pump capacity

Based on performance measures and habitat suitability indices (HSI), a system formulation evaluation was performed comparing the performance of each of the alternative plans together with the remaining components of CERP to the No-Action Alternative (future without-project condition). The system formulation evaluation examines differences in the magnitude of the alternative plan outputs to illustrate which plan performs best in a system-wide context. One of the key assumptions for the system formulation model simulations was that water supply deliveries from Lake Okeechobee to the Caloosahatchee River would be constrained to the same volumes as provided in the Comprehensive Review Study. This assumption was included in the hydrologic simulation to maintain the benefits provided by the CERP in the Everglades and other south Florida basins due to projected increased demands for water supply in the Caloosahatchee Basin subsequent to the completion of the Comprehensive Review Study. The Tentatively Selected Plan (TSP) was identified from the system formulation evaluation.

After the TSP was identified, a next-added increment (NAI) analysis was performed to show how well the TSP would perform without the effects of other CERP projects (i.e., assuming no further investment of public funds after this project, is the TSP still a good investment?). In the NAI analysis, the planning constraint on water supply deliveries to the Caloosahatchee River was removed from the model simulation, to ensure that current levels of service for water supply in the Caloosahatchee Basin could still be met with implementation of the TSP.

Although it is clear based on the evaluations performed that plans with greater storage capacity and pump sizes would produce more benefits (Alternative 3C was identified as the NER plan) for the Caloosahatchee Estuary, the increase in benefits is associated with increasing cost (including additional real estate

interest) and increasing technical uncertainties regarding canal conveyance capacity, modifications to existing infrastructure and embankment design.

Alternative 3B is recommended for implementation, rather than Alternative 3C, which has been identified as the NER alternative plan. Alternative 3B meets the policy criteria established in Corps of Engineers guidance for planning in a collaboration environment[1]. This guidance provides that any alternative plan can be selected "if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse..." Alternative 3B is clearly of less scope and cost than Alternative 3C, reduces uncertainty and financial risk to the government, and meets the Administration's policies for high priority outputs. Because Alternative 3B is an increment of Alternative 3C, this plan also supports adaptive implementation recommendations established by the NRC. The study considered various scales of reservoir storage and identified no alternative smaller than 3B which was more economical. For these reasons Alternative 3B is the recommended plan and no ASA(CW) waiver is required.

DESCRIPTION OF THE SELECTED ALTERNATIVE PLAN

The term "selected alternative plan" refers to the alternative that has been recommended for implementation. For the purposes of complying with the NEPA and in the spirit of NEPA, the plan that would be recommended for authorization is termed the "preferred alternative." For NEPA, a plan is not "selected" until it has been fully coordinated, is subject to alterations based on public involvement, and is then formally accepted by Congress or the Chief of Engineers, as appropriate, and authorized with the signing of a Record of Decision (ROD) or Finding of No Significant Impact (FONSI). Throughout this document, the analysis includes the NEPA evaluation and uses the term "selected alternative plan" or "selected plan" interchangeably as the preferred alternative. "Selected" throughout this document is meant to discern which alternative the team is recommending to Congress and the Chief of Engineers for further development and implementation

The selected plan ("preferred alternative") (***Figure ES-3***), Alternative 3B, consists of two cells and associated features totaling approximately 10,700 acres providing a normal maximum storage capacity of approximately 170,000 ac-ft surrounded by a perimeter embankment and canals. The SAP will require approximately 10,480 acres of fee and 20 acres of perpetual channel easement. Approximately 200 additional acres will be required on a temporary basis during project construction for staging areas. Major features of the SAP for the Caloosahatchee River (C-43) West Basin Storage Reservoir project include:

[1] EC 1105-2-409 "Planning in a Collaborative Environment"

- External (dam) embankments varying in height from 32-37 feet above existing grade;
- Soil-Bentonite slurry walls within and beneath the external embankments;
- An internal (dam) embankment separating the two reservoir cells with an approximate height of 31 feet above existing grade ;
- An inflow pump station consisting of diesel-powered pumps with a total pumping capacity of 1,500 cfs;
- A perimeter canal;
- A perimeter canal pump station consisting of electric-powered pumps with a total pumping capacity of 195 cfs;
- Numerous spillways, culverts, perimeter canal structures, an internal cell balancing structure, and outlet structures;

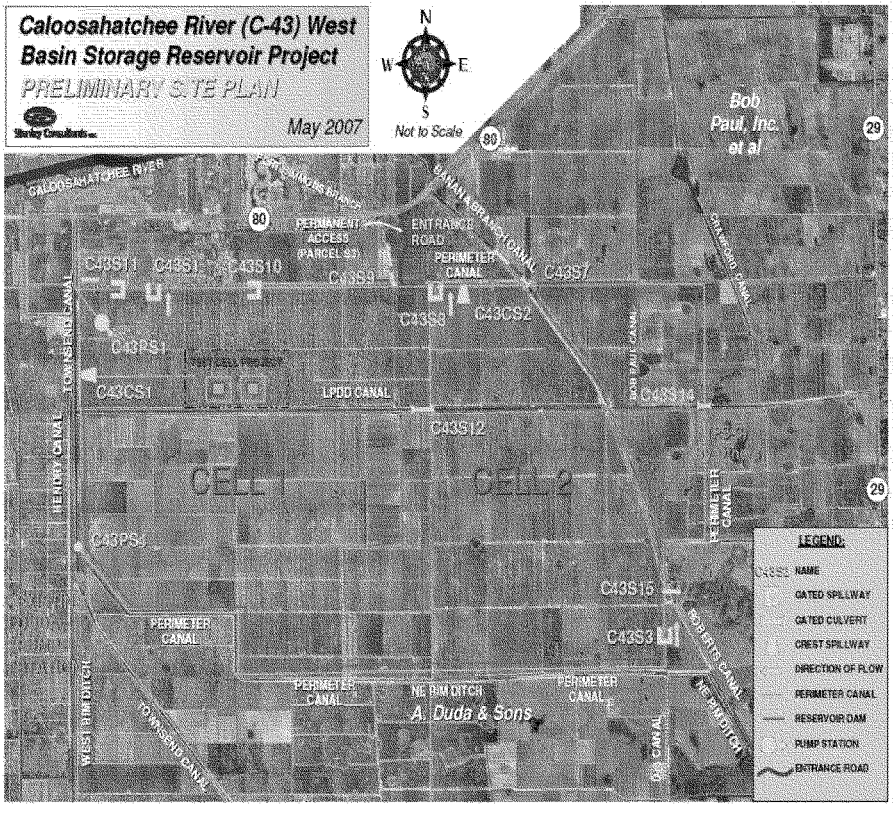


FIGURE ES-3: SELECTED ALTERNATIVE PLAN FEATURES

The external embankments include drainage features, and the top of the embankments and the upper portion of the outward side will be covered with soil-cement. The internal embankment does not include drainage structures, but will be covered on both sides with soil-cement. The reservoir is designed to withstand hurricane force winds of over 160 miles per hour (mph), as well as a combination of hurricane force winds with a rainfall event of over 54 inches in a 72-hour period.

The operation of the SAP is keyed to conditions at the W. P. Franklin Lock and Dam (structure S-79) on the Caloosahatchee River, as the flows over the dam are a good indicator of the resulting health of the estuary. The project will be operated to improve environmental conditions in the Caloosahatchee Estuary by reducing flows over S-79 during wet periods, and helping to maintain a minimum flow of 450 cfs at S-79 during dry periods. The S-79 structure is located approximately ten miles down-river (west) of the project site.

Project operations involve pumping inflows from the Caloosahatchee River (C-43) via an existing canal (Townsend Canal) into Cell 1. An internal cell balancing structure in the internal embankment will allow water in Cell 1 to enter Cell 2. Water may be released from both cells by outlet structures into the perimeter canal for delivery back to the Caloosahatchee River via the Townsend Canal and two other direct connections (Fort Simmons Branch and Banana Branch Canal) to the C-43 Canal. Other project structures help to maintain water levels in the perimeter canal and Townsend Canal, and provide water supply deliveries to adjacent lands affected by construction and operation of the reservoir.

BENEFITS OF THE SELECTED ALTERNATIVE PLAN

The SAP contributes toward the restoration of ecosystem function in the Caloosahatchee Estuary by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuary system. The SAP also helps to maintain a desirable minimum flow of fresh water to the estuary during dry periods. These two primary functions help to moderate unnatural changes in salinity that are detrimental to estuarine communities.

Based on a salinity model, the area within the Caloosahatchee Estuary system beneficially affected by the project conservatively encompasses at least 71,000 acres in the Caloosahatchee River, San Carlos Bay, and a portion of Pine Island Sound, although in all likelihood the area beneficially affected by project implementation will be much larger, including portions of Pine Island Sound, Estero Bay, and the Gulf of Mexico. These acres are within the navigable waters of the United States and within the navigation servitude of the United States.

The SAP also provides deepwater habitat within the impoundment cells, including refugia (created by embankment excavation) for fish and other aquatic animals during extremely dry periods. The perimeter canal may also include littoral areas which may be utilized as forage and nursery habitat by wading birds. The configuration and extent of these areas will be determined during detailed design work.

Though not designed specifically to provide water treatment benefits, the reservoir is expected to reduce downstream nutrient loads by retaining approximately 20 percent of the total phosphorus load that enters the reservoir. The reservoir's average hydraulic residence time of around 200 days is expected to result in substantial removal of pesticides and heavy metals through settling of suspended solids.

In accordance with the CERP Programmatic Regulations (33 CFR Part 385) and the Draft Programmatic Guidance Memoranda, the selection of plans for individual CERP projects is based on the performance of alternative plans when evaluated together with the rest of the CERP. This ensures that from a south Florida ecosystem-wide perspective, the SAP will contribute toward the achievement of system-wide restoration goals and objectives established for CERP, as well as the other water-related needs of the region. Plans must also be justified as the NAI (the next project to be added to a system of projects that includes only those that already have been approved and are likely to be implemented by the time the project being evaluated is completed). For this project, no other CERP projects were included in the NAI analysis, since other projects were not likely to be implemented by the time this project would be completed.

To evaluate the contribution of the SAP toward system-wide restoration goals and objectives, HSIs developed for the study area focused on the change in suitability of habitat in the Caloosahatchee Estuary. For analytical purposes, the area within the Caloosahatchee Estuary system beneficially affected by the project was assumed to encompass approximately 71,000 acres within the navigable waters of the United States and is within the navigation servitude of the United States. HSIs for the following key indicators of estuarine health were developed to evaluate project effects: oysters, sea grass, and *Vallisineria* ("tape grass" or "eel grass"; a submerged fresh water plant found in rivers and streams). Based on the HSIs, for the system formulation evaluation, the SAP will generate an average annual increase of approximately 12,809 habitat units within the affected area compared to without-project conditions (without any attempt to optimize system-formulation operations to further improve the Caloosahatchee Estuary). The average annual cost per average annual habitat unit for the system formulation evaluation is approximately $2,825. The cost

per acre of affected habitat (based on the total area of benefit) for this project is $8,035.

The NAI evaluation (using the same HSI and evaluation methodology as the system formulation evaluation) demonstrates that as a stand-alone project (i.e., without the benefit of other CERP water storage projects that would further reduce the harmful effects of excess fresh water on the Caloosahatchee Estuary), the SAP will generate an average annual increase of approximately 15,300 habitat units within the affected area compared to without-project conditions.

The area of benefit is recognized as significant at a local, regional, state and national level. The benefited area includes Matlacha Pass and Pine Island Sound state aquatic preserves. San Carlos Bay as well as the Caloosahatchee River are designated as a Federal Manatee Refuge. In addition, there are five national wildlife refuges in the benefits area including J.N. Ding Darling National Wildlife Refuge, Caloosahatchee National Wildlife Refuge, Matlacha Pass National Wildlife Refuge, Pine Island National Wildlife Refuge, and Island Bay National Wildlife Refuge. There has also been significant public recognition of the importance of this area through continued support of this project by the local public as well as governments.

Water for the Natural System and Other Water-Related Needs

WRDA 2000 requires that an analysis of water made available by CERP projects for the natural system be included in each PIR. This water must be reserved or allocated by the State of Florida prior to execution of a project operation agreement. PIRs must also include an analysis of water made available by the project to meet other water related needs (such as water supply and aquifer protection). An evaluation of water made available by the Caloosahatchee River (C-43) West Basin Storage Reservoir project was completed based on the requirements of draft Programmatic Guidance Memorandum 4 ("Identifying Water Made Available for the Natural System and Other Water-Related Needs").

The primary functions of the reservoir are two-fold: to capture excess basin runoff and discharges from Lake Okeechobee during periods of high volume flows, and to provide an additional source of water to maintain desirable salinity in the Caloosahatchee Estuary during periods of low flow. Since the estuarine system does not need additional fresh water during periods of excess flow, the analysis of water made available focused on the additional water delivered from the reservoir to the Caloosahatchee River and Estuary during periods when additional flows are needed to meet estuary flow targets. The additional water delivered from the reservoir to meet estuary flow targets (as measured by flows at the S-79 structure over the period of analysis) ranged from approximately

160,000 ac-ft at least ten percent of the time to approximately 27,600 ac-ft 90 percent of the time, with a median value of approximately 106,000 ac-ft per year. The State of Florida will reserve or allocate for the natural system the additional water made available by the project.

The conceptual intent of the project is that the reservoir will be operated to supply water to the Caloosahatchee River based on maintaining desirable salinity levels in the Caloosahatchee Estuary system. The project will not provide any additional water for water supply or other water-related needs in the Caloosahatchee River Basin. The Draft Project Operating Manual is consistent with the conceptual intent and this assumption. However, project operations include water supply deliveries to agricultural lands adjacent to the reservoir where water supply canals were interrupted due to the location of the reservoir and the severance of surface water connections to the Caloosahatchee River.

The Savings Clause

In addition to identifying water for the natural system and other water-related needs, Section 601(h)(5) ("Savings Clause") of WRDA 2000 also requires PIRs to include an analysis of project effects on existing legal sources of water for municipal and agricultural water supplies, the Seminole and Miccosukee Tribes, Everglades National Park (ENP), and fish and wildlife. The Savings Clause also requires an analysis of potential project impacts on the existing level of service for flood protection. These Savings Clause analyses were completed based on the requirements of draft Programmatic Guidance Memorandum 3 ("Savings Clause Requirements").

Consistent with the conceptual intent described above and the Draft Project Operating Manual, it was assumed that project operations will not reduce the quantity of water in the Caloosahatchee River Basin available for water supply, including sources for municipal and agricultural interests and fish and wildlife. Sources of water for the Seminole and Miccosukee Tribes and ENP are influenced by the regional water management system (C&SF Project, including Lake Okeechobee), and are not affected by this project.

An analysis of potential affects on water stages and elevations on lands adjacent to the reservoir was conducted with a local-scale hydrologic simulation model (MIKESHE). Differences in groundwater elevations and durations were calculated for various points in the vicinity of the reservoir site. These model results indicated that the project will not create harmful and adverse changes to water levels on adjacent lands.

ADVERSE EFFECTS OF THE SELECTED ALTERNATIVE PLAN

Several potential adverse effects of the SAP have been considered during this study. First, implementation of the SAP will impact approximately 125 acres of wetlands within the project footprint. The loss of this wetland habitat will be offset by the increase in ecosystem function and quality in the Caloosahatchee Estuary.

Second, the SAP will cause a shift in nutrient load from the wet season to the dry season; however, the SAP will decrease the frequency in which the monthly TN load exceeds the dry season, wet season, and annual targets established by F DEP (dry-season 190 tons/month, wet-season 350 tons/month, annual 3,000 tons/month).

While it is possible that nitrogen fixation within the reservoir will result in short-term increases in TN loading to S-79, the average annual TN load at S-79 will be reduced. Improvements will occur in the overall average water quality conditions at S-79 as well as downstream in the estuary. Given the uncertainty in the threshold chlorophyll-a concentration required for the restoration of the ecological function of the estuary, the degree to which the reservoir project will improve downstream water quality is unknown at this time. Based on the evidence presented here, it appears that the project will not cause or contribute to water quality degradation under future conditions. Prior to beginning operation, the State of Florida will require an application for a water quality permit to determine compliance with applicable water quality standards

Another concern raised during development of the draft report was the possibility that project operations would reduce the quantity of water available from existing sources for agricultural and urban water supply interests in the basin. Conceptually, the SAP is to be operated to capture excess basin runoff and releases from Lake Okeechobee that would be harmful if discharged to the Caloosahatchee Estuary. Storing such flows would not affect the quantities of water needed to meet water supply demands in those periods. The SAP also includes structures and operations to provide water supply to replace any existing legal source on adjacent lands that were affected by project implementation. The Project Operating Manual contains the operational intent and instructions to operators to ensure that water supply deliveries in the basin and adjacent to the reservoir are not adversely affected by project operations.

The USACE and USFWS have completed formal consultation under Section 7 of the Endangered Species Act (ESA) to identify and evaluate possible adverse impacts to the Florida panther, eastern indigo snake, and Audubon's crested caracara as a result of the Caloosahatchee River (C-43) West Basin Storage Reservoir. Potential adverse impacts to the Florida panther include the loss of

10,335 acres of panther habitat which will be compensated for through the protection and restoration of 102,129 acres off-site through implementation of Band 1/Acceler8 projects included in CERP. Potential adverse impacts to the eastern indigo snake include the direct loss of 10,264 acres of eastern indigo snake habitat resulting in the incidental take of up to 54 snakes during initial construction and operations. In addition to standard protection measures, initial and subsequent rehydrations of the reservoir will be monitored and reviewed to determine if snakes are re-populating the reservoir during drydown events. Potential adverse impacts to Audubon's crested caracara includes the incidental take of up to two adult pairs of caracara in the form of harassment, as well as up to two caracara nest sites for up to five consecutive breeding seasons. Monitoring and surveys of the birds will be conducted to minimize future impacts. The USACE has also completed informal consultation with the USFWS for the West Indian manatee. A manatee barrier will be placed at the confluence of the Townsend Canal and Caloosahatchee River to minimize potential impacts to the West Indian manatee. The USACE has concluded Section 7 Endangered Species Act (ESA) consultation with the USFWS.

In public outreach efforts to date, one potential environmental justice issue has been identified: the loss of jobs for low income and minority workers as a result of acquiring agricultural land for the construction of the reservoir. The expected loss in employment will occur to seasonal and/or temporary migrant workers. As can be noted in the future land use section, agricultural acreage in the surrounding study area and counties is expected to increase. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project provides an opportunity to somewhat alleviate the potential loss of jobs for low income and minority workers by providing jobs during construction of the project, some of which could provide seasonal and temporary employment. In addition, it is anticipated that adjacent lands will continue to support agricultural operations.

A final potential adverse effect that was studied in detail is the hazard potential. The hazard potential for a dam is defined by the possible consequences that may result from the release of stored water due to dam failure or mis-operation of the dam or appurtenances during both normal and flood flow conditions. According to the joint USACE and SFWMD Design Criteria Memorandum, DCM-1, there are three classification levels of the hazard potential for a dam: Low Hazard Potential, Significant Hazard Potential and High Hazard Potential (SFWMD, 2005).

Based upon this classification system and its criteria, the proposed C-43 West Basin Storage Reservoir has been classified as a high hazard potential impoundment. A dam break analysis indicated that a dam failure would compromise the safety of existing residents living near the proposed reservoir possibly resulting in the loss of life. In addition, the proximity of a major

highway (SR80), the anticipated future development of areas near the facility, along with the size of the facility and volume of impounded water would all likely increase the potential for loss of life and high economic and infrastructure losses.

The High Hazard Potential classification of the C-43 West Basin Storage Reservoir means that the reservoir has been designed with the most stringent safety requirements and features designed to ensure that a weather extreme event or even a dam break would not compromise the safety of nearby residents. An extensive freeboard analysis and design process has been conducted to ensure the integrity and safety of the impoundment in cases of wind and wave run-up within the reservoir. This analysis is provided in the Engineering Appendix

PROJECT COST ESTIMATES AND COST APPORTIONMENT

The total initial estimated cost of the project, including all costs for construction, lands, easements, relocations, rights-of-way and disposals (LERRD), and pre-construction engineering and design (PED) and construction management costs is $570,480,000. Project construction costs will be shared equally between the Federal government and the non-Federal sponsor in accordance with Section 601 of the WRDA 2000 to maintain a 50/50 cost share as measured cumulatively for the entire CERP Program. Operations and maintenance (O&M) costs will be cost-shared 50/50 in accordance with the O&M cost-sharing provisions of Section 601 of WRDA 2000.

Section 601 of WRDA 2000 and USACE policy requires that the non-Federal sponsor must obtain and provide certification of LERRDs necessary for project implementation. ***Table ES-1*** provides additional details on initial costs for construction and non-construction items.

TABLE ES-1: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR COSTS OCTOBER 2006 PRICE LEVELS (INITIAL COSTS ROUNDED TO THE NEAREST $10,000)

Ecosystem Restoration Elements	TOTALS
Construction	
Relocations	$1,180,000
Reservoir	$12,780,000
Reservoir (embankments, slurry wall, drains, soil cement, perimeter canal, spillways, structures, etc.)	$278,780,000
Channels and Canals	$5,180,000
Pumping Plants	$83,300,000
Recreation	$2,930,000
Floodway Control-Diversion Structures	$18,430,000
Sub-Total Construction Cost	**$402,580,000**
Non-Construction	
Lands and Damages	$84,650,000
Planning, Engineering, and Design	$51,880,000
Construction Management	$31,37000,000
Sub-Total Non-Construction Cost	**$167,900,000**
TOTAL INITIAL COST	**$570,480,000**

The estimated average annual cost for operations and maintenance is $3,100,000 (rounded to the nearest $10,000).

The costs shown above are updated, detailed costs and are not exactly equivalent to the costs that were utilized in the Economic Appendix cost/effectiveness and incremental costs analysis (CE/ICA). These updated costs were used, due to more detailed cost estimates becoming available, which warranted further justification of the original CE/ICA that was used for plan formulation and selection as can be noted in Appendix E.

SELECTED ALTERNATIVE PLAN IMPLEMENTATION

"ACCELER8"

The State of Florida has developed a program called "Acceler8" to accelerate design and construction of critical restoration projects prior to one or more of the following actions: administration approval, Congressional committee resolution,

Congressional authorization, and appropriation of Federal funds for CERP project construction and operation. Acceler8 projects are consistent with CERP projects, and are typically increments of a larger plan described in CERP PIRs. The "C-43 (Caloosahatchee River) West Reservoir" project is one of the projects included in the Acceler8 program (www.evergladesnow.org).

The State has determined that Acceler8 projects will provide immediate environmental, social, and economic benefits in the south Florida region, and has begun design and construction work in anticipation that future authority will provide for credit toward the fifty percent non-Federal cost-sharing requirements of WRDA 2000. The SFWMD is the lead agency for the State of Florida for implementing the Acceler8 program. The SFWMD proposes to initiate construction on the Caloosahatchee River (C-43) West Basin Storage Reservoir project prior to implementation of the Federal project, and has already constructed test cells at the project site to evaluate seepage and embankment design and water quality effects.

This report contains a recommendation that the non-Federal sponsor (SFWMD) receive credit toward the non-Federal cost-share for work completed prior to entering into a project cooperation agreement, provided that the work is integral to the CERP project and subject to certifications that: 1) the costs are reasonable, allowable, necessary, auditable, and allocable; and 2) that the activities were implemented in accordance with USACE design and construction standards and applicable laws.

Detailed design of the Caloosahatchee River (C-43) West Basin Storage Reservoir project will be accomplished by the SFWMD as part of the State of Florida's Acceler8 program. Design information and details will be coordinated and reviewed by the USACE pursuant to the Design Agreement between USACE and SFWMD dated May 12, 2000. Activities during the construction phase will be in accordance with the Acceler8 program and will be the responsibility of the SFWMD.

Real estate interests for LERRDs will be the responsibility of the SFWMD.

A draft Project Operating Manual is included with this report. An Interim Project Operating Manual will be completed during subsequent detailed design efforts to reflect design modifications. A Final Project Operating Manual will be prepared following completion of operational testing and monitoring which occurs at the end of the construction phase. The USACE and SFWMD will share in the responsibilities for conducting water management operations during operational testing and monitoring of the project.

In coordinating completion of the CERP PIR with Acceler8 activities, the USACE is proceeding with two separate and independent but related actions: the feasibility-level evaluation of the Federal project described in this final report and the regulatory evaluation of the SFWMD's proposed project as part of an application for a Department of the Army Section 404 (Clean Water Act) permit. The SFWMD's Acceler8 project is consistent with the SAP included in this final report. It is anticipated that the Final Integrated PIR and EIS to be prepared for this project will be considered as part of the regulatory permit application and provide the basis for the NEPA evaluation of the proposed Acceler8 project. A Section 404 permit decision will not be made until at least 30 days after the Notice of Availability of the Final Integrated PIR and EIS and execution of a Regulatory Record of Decision by the District Commander.

The scheduled construction start date for the Acceler8 project is initiation of clearing and grubbing, and embankment structure pre-loading in December 2007, and reservoir construction in February 2008, pending receipt of all required authorizations and approvals. It should be noted that the clearing and grubbing activities in uplands do not include any discharge of dredge or fill material into waters of the United States, thus there is no Department of Army permit associated with this work. Department of the Army authorization will be required prior to embankment structure pre-loading and reservoir construction.

STAKEHOLDER PERSPECTIVES

Initial public and agency comments received in response to a 2003 public notice of intent to prepare a Draft Integrated PIR and EIS focused on impacts to existing wildlife habitat in the vicinity of the reservoir site, the adequacy of habitat to be created within the reservoir, water quality impacts, recreation features to be included in the project, potential impacts to water supplies and reservoir operations, and potential impacts to a portion of State Road 80 adjacent to the reservoir.

Since 2003, several hurricanes passing over south Florida created exceptionally high volumes of fresh water entering the Caloosahatchee Estuary from local basin runoff and from Lake Okeechobee. In response to public concerns raised about impacts to both the Caloosahatchee and St. Lucie estuaries and the effect of high water levels in Lake Okeechobee on Herbert Hoover Dike, the USACE, Jacksonville District announced plans in early 2006 (during plan formulation efforts for this project) to prepare a supplemental EIS (separate from this PIR and EIS) to investigate modification of the Lake Okeechobee Regulation Schedule (LORS), or water control plan, to address these and related concerns.

Many stakeholders, local governments and representatives of non-governmental environmental organizations provided similar written comments and statements

at recent public meetings on the proposed changes to Lake Okeechobee's Regulation Schedule (LORS). The primary focus of their concern was the releases the lake would make to the Caloosahatchee River under the new regulation schedule and the effect those release would have on the health of the estuary. Some raised concerns about how the harmful effects of both excessive amounts of fresh water entering the estuary during the wet season and of insufficient fresh water to maintain desirable salinity levels in the estuary during dry periods affects the local economy. For example, in an October 2006 letter, the City of Sanibel commented:

> *"Sanibel Island's economy and its way of life depend upon the health of the Caloosahatchee River and Estuary. The Estuary provides essential habitat for fish populations that are central to the region's economy and recreational fishing economies. The City of Sanibel is particularly dependent on the health of the Caloosahatchee Estuary, as tourism generated by the diverse estuarine ecosystem in which it is located is central to the Island's economy."*

Similarly, the City of Fort Myers commented:

> *"The Caloosahatchee River and the estuary must be protected. The local economy is reliant on these waters through both the tourism industry and the fishing industry. We cannot afford to lose this most precious environmental and economic resource to the damaging effects of increased water releases from Lake Okeechobee."*

Since this Caloosahatchee River (C-43) West Basin Storage Reservoir Final PIR and EIS will be circulated for public and agency review and comment, and since it involves many of the same stakeholders and issues, it is expected that comments similar to those received on the LORS, Draft Supplemental EIS (USACE, Jacksonville District, August 2006) will be submitted for this project.

ENVIRONMENTAL OPERATING PRINCIPLES

The proposed project is consistent with the USACE "Environmental Operating Principles" (http://www.hq.usace.army.mil/cepa/envprinciples.htm), particularly with respect to the south Florida ecosystem-wide approach for plan formulation, evaluation, and selection, and a holistic consideration of water resources needs and solutions to water resources problems in the study area. The SAP incorporates monitoring, and CERP has an adaptive assessment and management program in place to ensure that projects, including the Caloosahatchee River (C-43) West Basin Storage Reservoir project, are achieving intended purposes. Project implementation, including plan formulation, involved collaborative interactions with the multiple agencies represented on the Project Delivery Team (PDT). Study area stakeholder groups and members of

the general public have had multiple opportunities to receive information on the project and to provide comments and recommendations via public meetings, internet postings, teleconferences, and interagency PDT meetings.

INDEPENDENT TECHNICAL REVIEW

An external independent technical review (ITR) was performed on both the Draft and Final PIR and EIS by a multi-disciplinary team consisting of technical staff from the USACE Wilmington, Savannah, Walla Walla, Rock Island and Mobile Districts, in accordance with recent Corps policy regarding coordination with the National Ecosystem Restoration Center of Expertise and the National Cost Engineering Directorate of Expertise. Significant comments addressed during ITR included:

- Environmental benefits quantification methodology and spatial extent;
- Use of a hydrodynamic modeling tool to evaluate salinity changes in the estuary;
- Project real estate requirements; and,
- Development of project cost estimates.

In general, the ITR Team found that the information presented in the report describing the plan formulation and evaluation supported plan selection. All concerns resulting from ITR of the Final PIR have been resolved.

UNRESOLVED ISSUES

There are no significant unresolved issues with respect to the design of features to be constructed, cost estimates, and expected project outputs.

The implementing agencies (USACE, SFWMD, and U.S. Department of Interior) agree that there are remaining water resources problems in the Caloosahatchee River Basin which were not fully addressed by the SAP, including providing additional pumping and storage capacity, the need for additional water storage and management features in the Eastern Caloosahatchee River (upper) basin, and improving basin water quality. These concerns were also clearly articulated by other Federal, state, and local agencies and stakeholder groups in the study area. To address these and other unmet needs, a subsequent PIR will be initiated upon completion of this PIR.

Related to the need to investigate additional water storage and management options in the Caloosahatchee River Basin, concerns have also been raised about the ASR features of the CERP associated with the C-43 Basin Storage Reservoir (Restudy). During the initial planning for CERP, ASR wells were formulated in association with several of the CERP reservoirs (including the C-43 Basin Storage Reservoir [Restudy]) to provide an additional source of water and to

improve the efficiency of the reservoir operations. However, at this time, a number of technical, regulatory, cost, and efficiency uncertainties remain unresolved for ASR as originally envisioned for CERP. To address these uncertainties, pilot projects have been initiated and a study is underway to more fully evaluate regional ASR performance and implementation issues. If these investigations indicate that ASR technology is a feasible and cost-effective means of achieving ecosystem restoration goals and objectives in the Caloosahatchee Basin, a third PIR (C-43 Basin ASR PIR) may be initiated to incorporate those features.

TABLE OF CONTENTS

***ABSTRACT** ..... **i**

FOREWORD ..... **iii**

***EXECUTIVE SUMMARY** ..... **v**

***TABLE OF CONTENTS** ..... **xxv**

SECTION 1–INTRODUCTION

1.1 REPORT AUTHORITY 1-4
1.2 PROJECT AREA 1-5
1.3 PROJECT PURPOSE AND SCOPE 1-7
1.4 RELATIONSHIP TO OTHER USACE/NON-FEDERAL SPONSOR EFFORTS, STUDIES, DOCUMENTS, AND REPORTS 1-12
1.4.1 CERP Components 1-12
1.4.2 Non-CERP Components 1-14
1.5 PROGRAMMATIC REGULATIONS GUIDANCE MEMORANDUM 1-15
1.6 RELEVANT DOCUMENTS AND REPORTS 1-16
1.7 CERP MASTER IMPLEMENTATION SEQUENCING PLAN 1-17
1.8 THE STATE OF FLORIDA'S ACCELER8 PROGRAM 1-18
1.9 LAND ACQUISITION ACTIVITIES 1-19

***SECTION 2–EXISTING CONDITIONS/AFFECTED ENVIRONMENT**

2.1 GENERAL ENVIRONMENT 2-1
2.2 CLIMATE 2-4
2.2.1 Sea Level Rise 2-4
2.3 PHYSICAL LANDSCAPE 2-4
2.3.1 Geology 2-4
2.3.2 Soils 2-5
2.3.3 Aquifers 2-5
2.4 HYDROLOGY 2-6
2.5 WATER MANAGEMENT 2-8
2.5.1 Water Supply 2-8
2.5.2 Water Demands 2-10
2.5.3 Water Usage 2-10
2.6 WATER QUALITY 2-11
2.6.1 Water Quality Conditions Upstream of S-79 2-12
2.6.2 Water Quality Conditions Downstream of S-79 2-13
2.6.3 Sediment Quality 2-14
2.7 PLANT COMMUNITIES 2-14
2.7.1 Exotic Species 2-15
2.8 WETLANDS 2-16
2.9 FISH AND WILDLIFE RESOURCES 2-18

2.9.1 Estuarine and Riverine Invertebrates 2-18
2.9.2 Amphibians and Reptiles 2-19
2.9.3 Fish 2-19
2.9.4 Birds 2-20
2.9.5 Mammals 2-21
2.9.6 Protected Species 2-21
2.9.7 Essential Fish Habitat 2-30
2.10 ESTUARINE RESOURCES 2-30
2.10.1 Recent Hurricane Impacts 2-36
2.10.2 Estuarine Indicators 2-38
2.11 AIR QUALITY 2-44
2.12 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE 2-44
2.12.1 Berry Groves Property 2-45
2.12.2 MG Enterprises LLC Property 2-47
2.12.3 Griffin Property 2-47
2.12.4 Brian Paul Grove Property 2-48
2.13 CULTURAL RESOURCES 2-49
2.14 SOCIOECONOMICS 2-49
2.14.1 Population 2-50
2.14.2 Economy 2-51
2.14.3 Commercial and Recreational Fishing 2-52
2.15 EXISTING LAND USE 2-53
2.15.1 Agricultural Land Use 2-55
2.16 NOISE 2-56
2.17 RECREATION AND AESTHETICS 2-56

***SECTION 3–FUTURE WITHOUT PROJECT CONDITION**
3.1 GENERAL ENVIRONMENTAL SETTING 3-1
3.2 CLIMATE 3-1
3.3 PHYSICAL LANDSCAPE 3-3
3.4 HYDROLOGY 3-3
3.5 WATER MANAGEMENT 3-4
3.5.1 C&SF Project Modifications 3-4
3.6 WATER QUALITY 3-6
3.6.1 Freshwater Caloosahatchee Sub-Basin (Upstream of S-79) 3-8
3.6.2 Caloosahatchee Estuary (Downstream of S79) 3-8
3.6.3 Summary 3-9
3.7 PLANT COMMUNITIES 3-9
3.7.1 Exotic Plants 3-9
3.8 WETLANDS 3-10
3.9 FISH AND WILDLIFE RESOURCES 3-10
3.9.1 Threatened and Endangered Species 3-11
3.9.2 Essential Fish Habitat 3-11
3.10 ESTUARINE RESOURCES 3-12
3.11 AIR QUALITY 3-12

3.12 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE 3-12
3.13 CULTURAL RESOURCES 3-13
3.14 SOCIO-ECONOMIC CONDITIONS 3-13
3.14.1 Population Projections 3-13
3.15 LAND USE 3-14
3.16 MUNICIPAL AND INDUSTRIAL WATER SUPPLY 3-19
3.16.1 Agricultural Water Demand 3-22
3.17 NOISE 3-24
3.18 RECREATION AND AESTHETIC RESOURCES 3-24
3.18.1 Commercial and Recreational Fishing Resources 3-25

SECTION 4–IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES
4.1 STATEMENT OF PROBLEMS AND OPPORTUNITIES 4-1
4.1.1 Public Concerns 4-1
4.1.2 Ecological Problems and Opportunities 4-4
4.1.3 Water Quality Problems and Opportunities 4-7
4.1.4 Economic and Social Well-Being Problems and Opportunities 4-17
4.2 PLANNING OBJECTIVE AND CONSTRAINTS 4-19
4.2.1 Goals and Objectives 4-19
4.2.2 Constraints 4-21
4.3 PROJECT EVALUATION CRITERIA AND EVALUATION METHODS AND MODELS 4-21
4.3.1 Hydrologic Performance Measures 4-22
4.3.2 Ecological Performance Measures 4-27
4.3.3 Water Quality Evaluation Criteria 4-29

***SECTION 5–FORMULATION OF ALTERNATIVE PLANS**
5.1 PRIOR FORMULATION 5-1
5.2 PLAN FORMULATION RATIONALE 5-2
5.3 PLAN FORMULATION 5-4
5.3.1 Management Measures for Reaffirmation 5-5
5.3.2 Summary of Reaffirmation of Management Measures 5-10
5.3.3 Project Siting Analysis 5-10
5.3.4 Screening of Final Array of Alternatives 5-11
5.3.5 Summary of Final Array of Alternative Plans 5-19
5.3.6 Alternatives Within the Jurisdiction of the Lead Agency 5-20
5.3.7 Evaluation of the Final Array of Alternatives 5-21
5.4 SELECTION OF THE FINAL PLAN 5-37
5.5 DISCUSSION OF MAJOR RISKS AND UNCERTAINTY 5-38
5.5.1 Engineering and Real Estate Risks and Uncertainty 5-38
5.5.2 Modeling Risks and Uncertainty 5-39
5.5.3 Ecological Response Risks and Uncertainty 5-44
5.5.4 Adaptive Management 5-46

***SECTION 6–ENVIRONMENTAL EFFECTS**

6.1 SUMMARY OF AFFECTED RESOURCES 6-1
6.2 SEA LEVEL RISE 6-2
6.3 PHYSICAL LANDSCAPE 6-2
6.3.1 "No Action" Alternative 6-2
6.3.2 Alternatives 2, 3B, 3C, and 4 6-2
6.4 HYDROLOGY 6-3
6.4.1 "No Action" Alternative 6-3
6.4.2 Alternatives 2, 3B, 3C, and 4 6-3
6.5 WATER MANAGEMENT 6-4
6.5.1 "No Action" Alternative 6-4
6.5.2 Alternatives 2, 3B, 3C, and 4 6-5
6.6 WATER SUPPLY 6-6
6.6.1 "No Action" Alternative 6-6
6.6.2 Alternative 3B 6-6
6.6.3 Alternatives 2, 3C, and 4 6-7
6.7 FLOOD PROTECTION 6-7
6.7.1 "No Action" Alternative 6-7
6.7.2 Alternative 3B 6-7
6.7.3 Alternative 2, 3C, and 4 6-8
6.8 WATER QUALITY 6-8
6.8.1 "No Action" Alternative 6-8
6.8.2 Alternatives 2, 3B, 3C, and 4 6-9
6.9 SEDIMENT QUALITY 6-9
6.9.1 "No Action" Alternative 6-9
6.9.2 Alternatives 2, 3B, 3C, and 4 6-10
6.10 PLANT COMMUNITIES 6-10
6.10.1 "No Action" Alternative 6-10
6.10.2 Alternatives 2, 3B, 3C, and 4 6-11
6.11 WETLANDS 6-11
6.11.1 "No Action" Alternative 6-11
6.11.2 Alternatives 2, 3B, 3C, and 4 6-12
6.12 FISH AND WILDLIFE RESOURCES 6-12
6.12.1 "No Action" Alternative 6-12
6.12.2 Alternatives 2, 3B, 3C, and 4 6-12
6.13 FEDERAL AND STATE LISTED SPECIES 6-13
6.13.1 "No Action" Alternative 6-13
6.13.2 Alternatives 2, 3B, 3C, and 4 6-13
6.13.3 Essential Fish Habitat 6-17
6.13.4 Estuarine Resources 6-18
6.14 LAND USE 6-19
6.14.1 "No Action" Alternative 6-19
6.14.2 Alternatives 2, 3B, 3C, and 4 6-19
6.15 AIR QUALITY 6-20
6.15.1 "No Action" Alternative 6-20
6.15.2 Alternatives 2, 3B, 3C, and 4 6-20

6.16 NOISE 6-20
6.16.1 "No Action" Alternative 6-20
6.16.2 Alternatives 2, 3B, 3C, and 4 6-20
6.17 HTRW 6-21
6.17.1 "No Action" Alternative 6-21
6.17.2 Alternatives 2, 3B, 3C, and 4 6-21
6.18 CULTURAL RESOURCES 6-22
6.18.1 "No Action" Alternative 6-22
6.18.2 Alternatives 2, 3B, 3C, and 4 6-23
6.19 SOCIOECONOMICS- REGIONAL ECONOMIC IMPACTS 6-23
6.19.1 "No Action" Alternative 6-23
6.19.2 Alternatives 2, 3B, 3C, and 4 6-23
6.20 OTHER SOCIAL EFFECTS 6-25
6.20.1 "No Action" Alternative 6-25
6.20.2 Alternatives 2, 3B, 3C, and 4 6-25
6.21 AESTHETIC EFFECTS 6-27
6.22 RECREATION 6-27
6.22.1 "No Action" Alternative 6-27
6.22.2 Alternatives 2, 3B, 3C, and 4 6-27
6.23 CUMULATIVE IMPACTS 6-28
6.24 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES 6-30
6.25 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS 6-30
6.25.1 Land Use 6-30
6.25.2 Wetlands 6-30
6.25.3 Water Quality 6-30
6.25.4 Air Quality 6-30
6.25.5 Soils 6-30
6.25.6 Wildlife 6-31
6.25.7 Threatened and Endangered Species 6-31
6.26 RELATIONSHIP BETWEEN SHORT-TERM USE AND LONG-TERM PRODUCTIVITY 6-31
6.27 COMPATIBILITY WITH FEDERAL, STATE, AND LOCAL OBJECTIVES 6-31
6.28 UNCERTAIN, UNIQUE OR UNKNOWN RISKS 6-31
6.29 ENVIRONMENTAL JUSTICE 6-31

***SECTION 7–THE SELECTED ALTERNATIVE PLAN**
7.1 DESCRIPTION OF PLAN COMPONENTS 7-1
7.1.1 General Plan Description 7-2
7.1.2 Major Project Components 7-5
7.1.2.1 Reservoir 7-5
7.1.2.2 Intake Canal 7-5
7.1.2.3 Embankments (Dams) 7-5
7.1.2.4 Pumping Station C43PS-1 7-6
7.1.2.5 Pumping Station C43PS-4 7-6

7.1.2.6 Culvert Structure C43s-7 7-7
7.1.2.7 Culvert Structure C43s-9 7-7
7.1.2.8 Culvert Structure C43s-14 7-7
7.1.2.9 Culvert Structure C43s-15 7-7
7.1.2.10 Gated Culvert Structure C43s-3 7-7
7.1.2.11 Gated Spillway Structure C43s-10 7-8
7.1.2.12 Gated Spillway Structure C43s-11 7-8
7.1.2.13 Cell 1 Main Outlet Structure C43s-1 7-8
7.1.2.14 Cell 2 Main Outlet Structure C43s-8 7-9
7.1.2.15 Balancing Outlet Structure C43s-12 7-9
7.1.2.16 Crest Spillway Structure C43cs-1 7-10
7.1.2.17 Crest Spillway Structure C43cs-2 7-10
7.2 RECREATION FEATURES 7-10
7.2.1 Recreational Costs 7-12
7.3 COST ESTIMATES 7-13
7.4 DESIGN AND CONSTRUCTION CONSIDERATIONS 7-15
7.4.1 Engineering and Design 7-15
7.4.2 Construction and Implementation of the Plan 7-15
7.5 LERRD (LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, AND DISPOSALS) CONSIDERATIONS 7-16
7.5.1 Real Estate Requirements 7-16
7.5.2 Land Acquisition 7-16
7.5.2.1 DEPARTMENT OF INTERIOR GRANT NUMBER LWCF-1, ADDENDUM 3, LAND AND WATER CONSERVATION ACT FUNDS 7-16
7.5.3 Hazardous, Toxic and Radioactive Waste 7-18
7.5.4 Relocation Assistance 7-21
7.6 OPERATIONS AND MAINTENANCE CONSIDERATIONS 7-22
7.6.1 Operations and Maintenance Costs 7-22
7.6.2 Monitoring and Adaptive Management Costs 7-23
7.7 PLAN ACCOMPLISHMENTS 7-23
7.7.1 Relationship of Other Projects in CERP to Caloosahatchee River (C-43) West Basin Storage Reservoir Project 7-24
7.7.2 Project Justification: Next - Added Increment 7-24
7.8 CONTRIBUTION TO ACHIEVEMENT OF INTERIM GOALS AND TARGETS 7-27
7.8.1 Progress toward Interim Goals 7-28
7.8.2 Progress toward Interim Targets 7-30
7.9 SUMMARY OF ECONOMIC, ENVIRONMENTAL, AND OTHER SOCIAL EFFECTS 7-32
7.9.1 Other Social Effects 7-32
7.9.2 Environmental Justice 7-32

SECTION 8–PLAN IMPLEMENTATION
8.1 DIVISION OF IMPLEMENTATION RESPONSIBILITIES 8-1

8.1.1 Schedule 8-1
8.1.2 Preconstruction Engineering and Design 8-1
8.1.3 Implementation of Project Operations 8-2
8.2 COST SHARING 8-2
8.2.1 Cost Sharing of Construction and Land Costs for Restoration Features 8-2
8.2.2 Cost Sharing of Monitoring 8-3
8.2.3 Cost Sharing of Operations and Maintenance 8-3
8.3 PROJECT DESIGN 8-3
8.3.1 Application of the Design Criteria Memorandums for Hazard Potential Classifications of Impoundments 8-3
8.4 PROJECT OPERATIONS 8-4
8.4.1 Existing Operations 8-4
8.4.2 Initial Operating Regime 8-5
8.4.3 IOR Local Water Supply Operations 8-6
8.4.4 Future Operations 8-6
8.4.5 Future Local Water Supply Operations 8-7
8.5 PROJECT ASSURANCES 8-7
8.5.1 Level of Service for Flood Protection 8-7
8.5.2 Effects on Existing Legal Sources for Water Supply 8-7
8.5.3 Identification of Water Made Available for the Natural System and Water for Other Water-Related Needs 8-8
8.6 PROJECT MONITORING PLAN 8-9
8.7 COMPLIANCE WITH ENVIRONMENTAL LAWS, STATUTES, AND EXECUTIVE ORDERS 8-10
8.8 COMPLIANCE WITH FLORIDA STATUTES 8-14
8.8.1 Permits, Entitlements and Certifications 8-15
8.8.2 Compliance with Applicable Water Quality Standards and Permitting Requirements 8-15
8.9 ENVIRONMENTAL COMMITMENTS 8-16
8.10 VIEWS OF NON-FEDERAL SPONSOR 8-18

***SECTION 9–SUMMARY OF COORDINATION, PUBLIC VIEWS AND COMMENTS**
9.1 SUMMARY OF COORDINATION, PUBLIC VIEWS, AND COMMENTS 9-1
9.2 SCOPING FOR THE C-43 BASIN STORAGE RESERVOIR 9-1
9.3 OTHER REQUIRED COORDINATION 9-2
9.4 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 9-2
9.5 ENDANGERED SPECIES ACT OF 1973 9-2
9.6 FISH AND WILDLIFE COORDINATION ACT OF 1958 9-2
9.7 NATIONAL HISTORIC PRESERVATION ACT OF 1966 (INTER ALIA) (PL 89-665, THE ARCHEOLOGY AND HISTORIC PRESERVATION ACT (PL 93-291), AND EXECUTIVE ORDER 11593) 9-3
9.8 CLEAN WATER ACT OF 1972 9-3
9.9 CLEAN AIR ACT OF 1972 9-3
9.10 COASTAL ZONE MANAGEMENT ACT OF 1972 9-4

9.11 FARMLAND PROTECTION POLICY ACT OF 1981 9-4
9.12 WILD AND SCENIC RIVER ACT OF 1968 9-4
9.13 MARINE MAMMAL PROTECTION ACT OF 1972 9-4
9.14 ESTUARY PROTECTION ACT OF 1968 9-5
9.15 FEDERAL WATER PROJECT RECREATION ACT 9-5
9.16 FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976 9-5
9.17 SUBMERGED LANDS ACT OF 1953 9-5
9.18 COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990 9-5
9.19 RIVERS AND HARBORS ACT OF 1899 9-5
9.20 ANADROMOUS FISH CONSERVATION ACT 9-5
9.21 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT 9-5
9.22 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT 9-6
9.23 RESOURCE CONSERVATION AND RECOVERY ACT OF 1976 9-6
9.24 TOXIC SUBSTANCES CONTROL ACT OF 1976 9-9
9.25 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT 9-10
9.26 E.O. 11990, PROTECTION OF WETLANDS 9-10
9.27 E.O. 13186 RESPONSIBILITIES OF FEDERAL AGENCIES TO PROTECT MIGRATORY BIRDS 9-10
9.28 E.O. 11988, FLOOD PLAIN MANAGEMENT 9-10
9.29 E.O. 12898, ENVIRONMENTAL JUSTICE 9-10
9.30 E.O. 13089, CORAL REEF PROTECTION 9-11
9.31 E.O. 13112, INVASIVE SPECIES 9-11
9.32 STATUS OF COORDINATION AND COOPERATION WITH OTHER AGENCIES 9-11
9.32.1 CERP Partnerships and Cooperating Agencies 9-12
9.33 REVIEW OF THE DRAFT CALOOSAHTCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT PIR/EIS 9-12
9.33.1 List of Agencies, Organizations and Persons to Whom Copies of the Draft PIR/EIS are Sent 9-13

SECTION 10–DISTRICT ENGINEER'S RECOMMENDATION

***SECTION 11–LIST OF REPORT PREPARERS**

***SECTION 12–INDEX**

***SECTION 13–GLOSSARY OF TERMS AND ACRONYMS**

***SECTION 14–REFERENCES**

ANNEXES

A FWCA AND ENDANGERED SPECIES ACT COMPLIANCE
B NEPA INFORMATION
C ANALYSES REQUIRED BY WRDA 2000 AND STATE LAW
D DRAFT PROJECT OPERATING MANUAL AND MONITORING PLAN
E RECOVER REPORTS
F CZM CONSISTENCY AND 404(B)(1) EVALUATIONS

APPENDICES

A ENGINEERING
B COST ESTIMATES
C ENVIRONMENTAL INFORMATION
D REAL ESTATE PLAN
E AGENCY AND PUBLIC COORDINATION
F ECONOMIC AND SOCIAL CONSIDERATIONS
G RECREATION

* Elements marked with an asterisk (*) are required for NEPA compliance according to Council on Environmental Quality (CEQ) Regulations.

LIST OF FIGURES

Figure 1-1: Location of the Caloosahatchee River & Estuary 1-4
Figure 1-2: C-43 Basin Study Area 1-7
Figure 1-3: Caloosahatchee Estuary 1-9
Figure 1-4: Timeline of Events and Milestones for the Project 1-22
Figure 2-1: Caloosahatchee River (C-43) West Basin Storage Reservoir Project Site Map 2-3
Figure 2-2: Caloosahatchee River (C-43) West Basin Storage Reservoir Project 2-9
Figure 2-3: The Caloosahatchee River, Estuary, and Southern Charlotte Harbor Watershed 2-31
Figure 2-4: Caloosahatchee Estuary Salinity Sensors and Important Landmarks 2-32
Figure 2-5: Daily Average Salinity Collected by Continuous Sensors at Two Downstream Locations (Cape Coral Bridge and Shell Point at the River Mouth) in the Caloosahatchee Estuary 2-34
Figure 2-6: Caloosahatchee Estuary SAV Monitoring Stations and General Oyster Locations 2-36
Figure 2-7: Total Discharge into the Caloosahatchee Estuary (Watershed Releases) at S-79 2-37
Figure 2-8: Freshwater Flow through S-77 and S-79 Compared to Salinity at Interstate-75 Bridge and Ft. Myers 2-39
Figure 2-9: Tape Grass (*Vallisneria americana*) Shoot Density in the Upper Caloosahatchee Estuary 2-40

Figure 2-10: Map Depicting Results of Seagrass Aerial Survey Conducted in 2004 and Processed in WY2006 2-42
Figure 2-11: Density of Seagrass: (a.) *Halodule wrightii* (shoal grass); and (b) *Thalassia testudinum* (turtle grass) in the Caloosahatchee Estuary and San Carlos Bay 2-44
Figure 2-12: Map Depicts The 2000 Land Use Map For The South West Florida Region 2-54
Figure 3-1: Projected 2050 Land Use 3-17
Figure 3-2: Differences Between 2000 and 2050 Land Use 3-18
Figure 4-1: Submerged Aquatic Vegetation in the Caloosahatchee Estuary 4-11
Figure 4-2: Percent Frequency of Mean Monthly Flows for 1966 Through 1990 4-25
Figure 4-3: Percent frequency of Mean Monthly Flows 4-26
Figure 5-1: Location of the Berry Groves Site 5-11
Figure 5-2: Typical Alternative Site Plan 5-13
Figure 5-3: Alternative 4B Site Plan 5-19
Figure 5-4: Mean Weekly Distribution of Flows from S-79 5-25
Figure 5-5: Flow Chart for the Environmental Analysis Process 5-28
Figure 5-6: Annual Habitat Unit Lift 5-30
Figure 7-1: The Selected Alternative Plan 7-4
Figure 7-2: Conceptual Recreation Plan 7-12

LIST OF TABLES

Table 2-1: Summary of 1995 Water Use Demand Based on the Integrated Surface Water/Ground Water Model for Major Agricultural Land Use Categories 2-10
Table 2-2: USGS Estimated Total Water Use, for Selected Counties, 2000 - Excluding Mining and Power Generation (MGD) 2-11
Table 2-3: Federally Listed Threatened (T) and Endangered (E) Species in Caloosahatchee River (C-43) West Basin Storage Reservoir Project Study Area 2-22
Table 2-4 Aerial Extent of Seagrass 2-42
Table 2-5: Charlotte, Glades, Lee and Hendry County 2-50
Table 2-6 Income and employment for counties and census tracts 2-52
Table 2-7 Golf Course Acreage 2-55
Table 2-8 Total Land and Farm Acreage 2-55
Table 3-1: Historic Rate of Sea Level Rise at NOAA Stations in Florida 3-2
Table 3-2: Normalized Sea Level Projections for 2025, 2050 and 2100, Compared with 1990 Levels 3-2
Table 3-3: Probability Distribution of Sea Level Rise for Fort Myers for Years 2025, 2050, and 2100 3-3
Table 3-4: Charlotte, Glades, Hendry & Lee Counties, Population Estimates 2000-2050 (1,000s) (BEBR Projections, US Census (2000)) 3-14
Table 3-5: Projected Difference between 2000 and 2050 land use 3-19

Table 3-6: USGS Estimated Total Water Use (MGD), for Selected Counties, 2000, Excluding Mining and Power Generation 3-21
Table 3-7: C-43 Study Area, M&I Conservation-Adjusted Water Use and Distribution, by County Area Most-Likely Population Scenario, 2000, 2025, and 20503-22
Table 3-8: Summary of 2020 Water Use Demand Based on the MIKESHE for Major Agricultural Land Use Categories. 3-23
Table 3-9: Demand and Facility Needs (1997 and 2010) for Selected Recreation Activities in Southwest Florida (SCORP Region 9) 3-25
Table 4-1: Public Comments and How They Were Addressed 4-2
Table 4-2: Surface Water Classification for Caloosahatchee River 4-9
Table 4-3: Number of Months of TN Seasonal Load Exceedances 4-16
Table 4-4: CERP and Project Goals and Objectives 4-20
Table 4-5: CERP performance measures for freshwater discharge at S-79 and MFL salinity criteria at Fort Myers, FL 4-23
Table 4-6: Frequency Distribution of Flows From S-79 Associated with EST05 (Without Tidal Basin Contribution) 4-27
Table 4-7: Ecological Performance Measures 4-29
Table 5-1: Description of Management Measures Considered for the Project 5-6
Table 5-2: Screening of Potential Measure for Use in Caloosahatchee River (C-43) West Basin Storage Reservoir Project 5-9
Table 5-3: Alternative 2 Design Summary 5-14
Table 5-4: Alternative 3A and 3B - Design Summary 5-16
Table 5-5: Alternative 3C - Design Summary 5-17
Table 5-6: Alternative 4A - Design Summary 5-17
Table 5-7: Alternative 4B - Design Summary 5-19
Table 5-8: Target Flow Distribution for EST05 5-23
Table 5-9: Summary of Mean Monthly Flow Events AT S-79 within Different Flow Ranges 5-24
Table 5-10: Percent Match to Target (EST05) at S-79 for Mean Weekly Flows 5-25
Table 5-11: Total Habitat Unit Calculations for System Formulation 5-29
Table 5-12: Habitat Unit Lift, System Formulation 5-29
Table 5-13: Cost of Final Array of Alternatives 5-31
Table 5-14: Costs and Outputs Used in Cost Effectiveness and Incremental Cost Analyses 5-33
Table 5-15: Results of Cost Effectiveness Analysis 5-34
Table 5-16: Results of Incremental Cost Analysis – Cost Effective and Best Buy Plans Arrayed by Increasing Output 5-35
Table 5-17: Summary of Alternative Plans 5-36
Table 5-18: P&G Evaluation Criteria 5-36
Table 5-19: Summary of Project Features and Associated Risk and Uncertainty 5-39
Table 6-1: Overall Regional Economic Impacts 6-24
Table 6-2: Regional and State Totals 6-24
Table 7-1: Summary of recreation costs and benefits 7-13
Table 7-2: Project Costs for the Tentatively Selected Plan 7-14
Table 7-3: Comparison of Yellow Book and selected alternative plan First Cost for Caloosahatchee River (C-43) West Basin Storage Reservoir Project 7-15

Table 7-4: Comparison of NAI and System Formulation Scores 7-26
Table 7-5: Summary of Raw HSI Scores 7-26
Table 7-6: Everglades Interim Goal Indicators 7-28
Table 7-7: Project Effects on Everglades 7-30
Table 7-8: Project Effects on Interim Targets Indicators 7-32

Table 8-1: Cost Apportionment Table for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project 8-2
Table 9-1: List of Active and Inactive HTRW Sites on C-43 Basin Project Lands 9-7

SECTION 1
INTRODUCTION

This page intentionally left blank

1.0 INTRODUCTION

The Comprehensive Everglades Restoration Plan (CERP or "the Plan") provides a framework for the restoration of ecological function for the diverse and significant habitats of the south Florida ecosystem, including the Everglades, which encompasses 18,000 square miles from Orlando to the Florida Reef Tract. Everglades National Park (ENP) (the largest national park east of the Mississippi River, comprising a significant portion of the greater Everglades ecosystem) is a World Heritage Site, an International Biosphere Preserve, and a Wetland of International Importance. The Everglades and the south Florida ecosystem are affected by competing demands for recreation, development, natural and commercial resources, and include 68 federally listed threatened and endangered plants and animals.

First authorized by Congress in 1948, the Central and Southern Florida (C&SF) Project expanded the existing network of canals, levees, water storage areas and water control structures in south Florida. Project objectives included flood damage reduction, regional water supply, prevention of saltwater intrusion, preservation of fish and wildlife, recreation and navigation. While fulfilling these objectives, the project has had unintended adverse effects on the natural environment that constitutes the Everglades and south Florida ecosystem by disrupting the pre-existing hydrologic regime. As a result, in 1996, the United States Army Corps of Engineers (USACE), in conjunction with the South Florida Water Management District (SFWMD), was directed to develop a comprehensive plan to restore, preserve, and protect the south Florida ecosystem while also providing for other water-related needs of the region such as water supply and flood protection. The resulting plan submitted to Congress on July 1, 1999, is called the CERP, and consists of proposed structural and operational modifications to the C&SF Project.

The CERP was approved as a framework for the restoration of the natural system in Section 601 of the Water Resources Development Act of 2000 (WRDA 2000). The Plan consists of 68 components to restore, preserve, and protect the south Florida ecosystem while providing for other water-related needs of the region. The Plan's components will be implemented over an approximately 40-year period. Together, these components will benefit the ecological functioning of more than 2.4 million acres of the south Florida ecosystem by improving and/or restoring the proper quantity, quality, timing and distribution of water made available for the natural system while also addressing urban and agricultural water supply concerns and maintaining existing levels of flood protection.

Significantly less water flows through the ecosystem today compared to the past. An average of 1.7 billion gallons of water per day that once flowed through the ecosystem is now discharged to the Atlantic Ocean or the Gulf of Mexico via

C&SF Project canals. The CERP will capture a significant amount of this water in above-ground, in-ground, and underground storage areas, retain this water and redistribute it as needed. Specifically, this water will be stored in 330 aquifer storage and recovery (ASR) wells, over 217,000 acres of new reservoirs, and wetland treatment areas. In addition, various means of seepage control along the remaining Everglades will retain more water in the Everglades ecosystem, thereby increasing the volume of water retained in the natural system. Finally, wastewater reuse facilities are included in the Plan to provide a source of additional water to meet restoration needs.

The natural alternating flooding and drying periods, termed hydroperiods, are vital to the Everglades ecosystem and have been severely altered by human activities. Restoring natural patterns of inundation and variability of water flows and levels is an integral part of the CERP. Specifically, the CERP modifies the timing of water held and released into the ecosystem so that it more closely matches historical natural patterns. Changes in water delivery schedules will be made in some areas to alleviate extreme fluctuations. Lake Okeechobee water levels will be modified to improve the health of the lake. In other areas, the rainfall-driven operational plan will improve the timing of water flows.

The final factor in the water equation is the real extent and movement of water through the system. The remaining Everglades ecosystem has been separated, or compartmentalized, by canals and levees. The CERP will remove over 240 miles of levees and canals to improve the connectivity of natural areas and restore sheetflow. In addition, excess phosphorus, mercury and other contaminants have diminished water quality in the south Florida ecosystem. The water quality of the Everglades Water Conservation Areas (WCAs), the coastal estuaries, Florida Bay and the Keys shows similar signs of degradation. The CERP will help improve the quality of water discharged to natural areas by directing flow through wetlands-based treatment areas totaling approximately 36,000 acres.

The CERP established the need for and the beneficial effects of an above-ground reservoir in the Caloosahatchee River (C-43 Canal) basin as part of a comprehensive plan for achieving restoration objectives for the Caloosahatchee Estuary. The Comprehensive Review Study included two primary structural components focused on improving environmental conditions in the Caloosahatchee River and Estuary: (1) an approximately 160,000 acre-foot reservoir with associated ASR wells and (2) basin runoff backpumping and stormwater treatment facilities. Due to technical uncertainty and implementation issues, the ASR features originally associated with a storage reservoir in the Caloosahatchee Basin will be evaluated and implemented separately (Part 2). The availability and effectiveness of storing basin runoff for

backpumping to the C-43 Canal and Lake Okeechobee will also be further evaluated as part of future CERP updates.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project will contribute to the restoration of the Caloosahatchee Estuary as part of a comprehensive plan for restoring the south Florida ecosystem. This final report has been prepared in accordance with the requirements of Section 601(d) of the WRDA 2000 and Programmatic Regulations for the CERP (33 Code of Federal Regulations [CFR] Part 385). The Caloosahatchee River (C-43) West Basin Storage Reservoir project area is shown in ***Figure 1-1***.

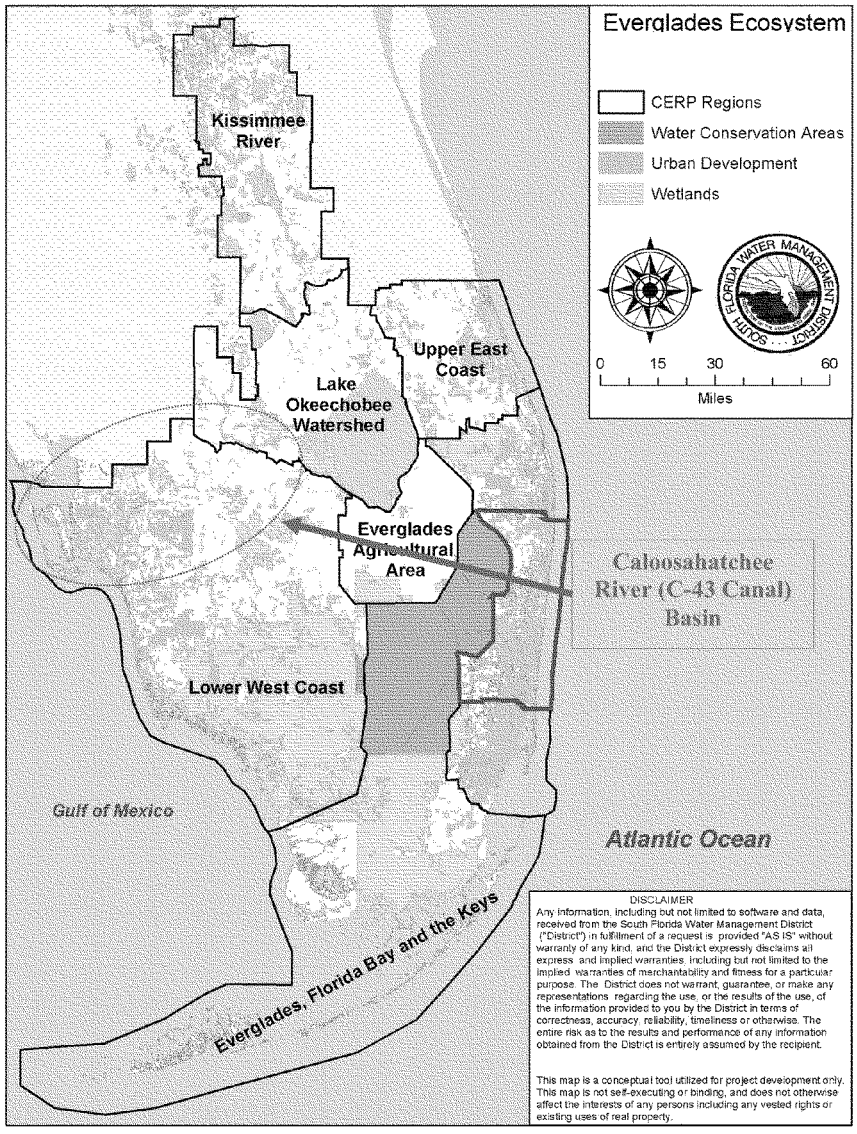


FIGURE 1-1: LOCATION OF THE CALOOSAHATCHEE RIVER & ESTUARY

1.1 REPORT AUTHORITY

The CERP was approved in Section 601 of WRDA 2000, which states, in part:

> *(b) Comprehensive Everglades Restoration Plan Approval –*
> *(1) APPROVAL*
> *(A) IN GENERAL. —Except as modified by this section, the Plan is approved as a framework for modifications and operational changes to the Central and Southern Florida Project that are needed to restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Plan shall be implemented to ensure the protection of water quality in, the reduction of the loss of fresh water from, and the improvement of the environment of the South Florida ecosystem and to achieve and maintain the benefits to the natural system and human environment described in the Plan, and required pursuant to this section, for as long as the project is authorized.*

The authority for the preparation of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Implementation Report (PIR), one of a number of site-specific projects, is contained in Section 601(d) of WRDA 2000, which states:

> *(d) AUTHORIZATION OF FUTURE PROJECTS-*
> *(1) IN GENERAL- Except for a project authorized by subsection (b) or (c), any project included in the Plan shall require a specific authorization by Congress.*
> *(2) SUBMISSION OF REPORT- Before seeking congressional authorization for a project under paragraph (1), the Secretary shall submit to Congress--*
> *(A) a description of the project; and*
> *(B) a project implementation report for the project prepared in accordance with subsections (f) and (h).*

Section 601(h)(4) of WRDA 2000 further requires that a PIR document the following:

> *(4) PROJECT-SPECIFIC ASSURANCES-*
> *(A) PROJECT IMPLEMENTATION REPORTS-*
> *(i) IN GENERAL- The Secretary and the non-Federal sponsor shall develop project implementation reports in accordance with section 10.3.1 of the Plan.*
> *(ii) COORDINATION- In developing a project implementation report, the Secretary and the non-Federal sponsor shall coordinate with appropriate Federal, State, tribal, and local governments.*
> *(iii) REQUIREMENTS- A project implementation report shall--*

(I) be consistent with the Plan and the programmatic regulations promulgated under paragraph (3);
(II) describe how each of the requirements stated in paragraph (3)(B) is satisfied;
(III) comply with the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.);
(IV) identify the appropriate quantity, timing, and distribution of water dedicated and managed for the natural system;
(V) identify the amount of water to be reserved or allocated for the natural system necessary to implement, under State law, subclauses (IV) and (VI);
(VI) comply with applicable water quality standards and applicable water quality permitting requirements under subsection (b)(2)(A)(ii);
(VII) be based on the best available science; and
(VIII) include an analysis concerning the cost-effectiveness and engineering feasibility of the project.

1.2 PROJECT AREA

Located on Florida's lower southwest coast, the Caloosahatchee River (which is also commonly referred to as the C-43 Canal) region extends approximately 70 miles from Lake Okeechobee to the lower Charlotte Harbor Basin at San Carlos Bay. The Caloosahatchee River watershed constitutes the northern portion of the SFWMD Lower West Coast planning area. The Caloosahatchee River watershed covers an area of 1,125,000 acres in parts of Lee, Glades, Charlotte, and Hendry counties. The watershed can be further subdivided into seven drainage basins based on their hydrologic characteristics, hydrologic control features, and topography. Moving from east to west these basins are the C-21, East Caloosahatchee, West Caloosahatchee, Orange River, S-236, Telegraph Swamp, and the Tidal Caloosahatchee Basin (***Figure 1-2***). The population of the four counties that make up the Caloosahatchee River Basin was 630,000 in 2000 and is expected to nearly double to 1,220,000 by 2050. Major land uses in the area include agriculture (dominated by citrus, sugar cane, vegetables, sod, and cattle production), urban and municipal development, and natural areas.

The Caloosahatchee River watershed (or C-43 Basin) drains an area of about 1,758 square miles. Originally the Caloosahatchee River was a shallow meandering river. Prior to human disturbance, water moved slowly from the uplands and wetlands to the river and then downstream to the estuary. The lower Caloosahatchee River near its convergence with San Carlos Bay supported luxuriant seagrass beds with high light transmittance to the substrate and low nutrient and suspended solids concentrations. The interior basin was dominated by seasonally flooded cypress savannas and freshwater marshes with interspersed pine-dominated uplands, while the lower tidal portion consists of a coastal fringe of mangroves with extensive beaches and numerous estuaries (SFWMD 2000).

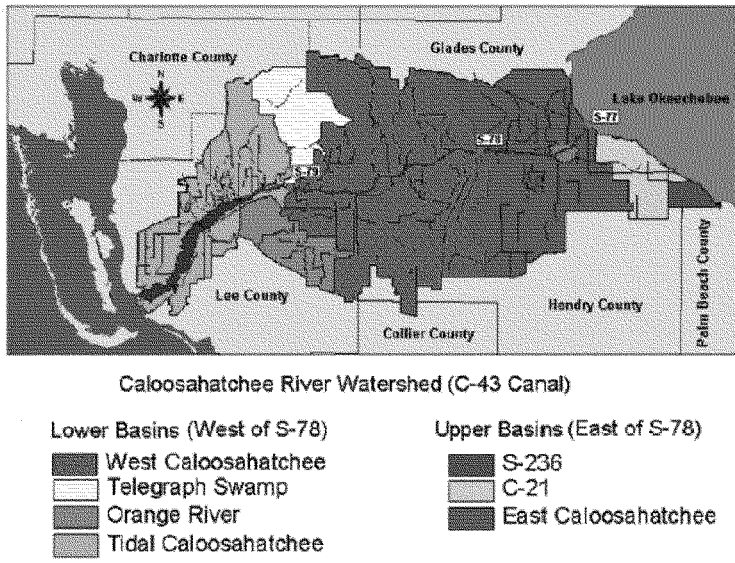


FIGURE 1-2: CALOOSAHATCHEE BASIN STUDY AREA

The Caloosahatchee River now serves as the western reach of the cross-state Okeechobee Waterway that connects Lake Okeechobee to the Gulf of Mexico at Fort Myers on the west coast. The Caloosahatchee River was hydrologically connected to Lake Okeechobee in 1881 by private interests, which resulted in the first lowering of the lake's water table. From 1910 to 1930, the canal's 65-mile course was channelized to improve navigation and flood control. Three lock-and-dam structures, (S-77, S-78, and S-79) were constructed to control flow and stage height in the lake and canal. From a hurricane gate located on the southwestern shore of Lake Okeechobee at Moore Haven (S-77), the Caloosahatchee River drains to the west for about five miles through very flat terrain into Lake Hicpochee. From Lake Hicpochee, the canal joins the upper reach of the Caloosahatchee River. The river is controlled by two navigation locks, one at Ortona (Ortona Lock and Dam or S-78), 15-miles downstream from Moore Haven and the other at Olga near Fort Myers (W.P. Franklin Lock and Dam or S-79). The S-78 aids in control of water levels on adjacent lands upstream and is the boundary that separates the Eastern Caloosahatchee Basin from the Western Caloosahatchee Basin. The S-79 is the most downstream structure and marks the beginning of the Caloosahatchee Estuary. The S-79 structure helps maintain specific water levels upstream, regulates freshwater discharges into

the estuary, and serves as an impediment to saltwater intrusion upstream of the lock.

1.3 PROJECT PURPOSE AND SCOPE

The Caloosahatchee River and Estuary is at the head of a vast estuarine and marine ecosystem that includes aquatic preserves (Matlacha Pass Aquatic Preserve, Estero Bay Aquatic Preserve, and Pine Island Sound Aquatic Preserve; the Charlotte Harbor National Estuary; and the Caloosahatchee, Matlacha Pass and Ding Darling National Wildlife Refuges), along with numerous other Federal, state, and local parks and recreation areas. Restoration of a healthy, productive aquatic ecosystem in the Caloosahatchee River is essential to maintaining the ecological integrity and associated economic activity in these publicly owned and managed areas.

The Caloosahatchee Estuary (***Figure 1-3***), which is generally considered to be that portion of the Caloosahatchee River west of the W. P. Franklin Lock and Dam, including the Matlacha Pass, San Carlos Bay, and Estero Bay areas at the mouth of the Caloosahatchee River, encompasses approximately 80 square miles of estuarine habitat on Florida's southwest coast in the vicinity of Fort Myers, Florida. The Fort Myers area, including Cape Coral, Fort Myers Beach, Sanibel and Captiva Islands, Bonita Springs and unincorporated areas is one of the fastest growing areas in the southeastern United States (2000 population approximately 440,000 according to U.S. Census figures) and is an extremely popular tourist destination.

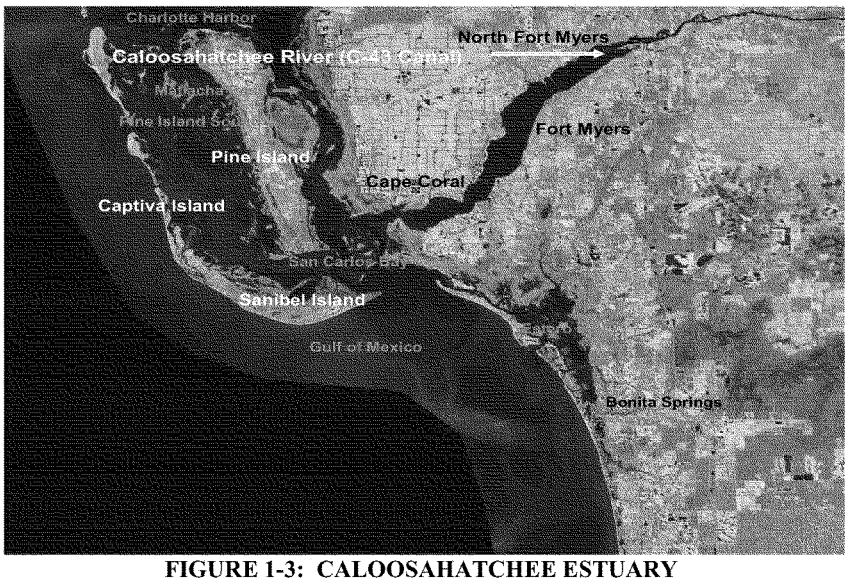


FIGURE 1-3: CALOOSAHATCHEE ESTUARY

Currently, there is not enough storage capacity in the regional water management system to minimize or prevent the harmful effects of periodic high-volume discharges of freshwater to the Caloosahatchee Estuary. Conversely, during dry periods, there is sometimes not enough freshwater available in the regional system to maintain desirable salinity levels in the estuary. The combined result of too much and too little freshwater flowing to the Caloosahatchee Estuary is a degraded estuarine ecological community, characterized by declines in the abundance and diversity of native finfish and shellfish populations and other marine and estuarine species, poor water quality, and reductions in the extent of submerged habitat suitable for sea grass and oysters (two primary indicators of healthy estuarine communities in South Florida) and other higher trophic level species, including threatened and endangered species (e.g., manatees, wood storks).

To restore ecological function and productivity in the Caloosahatchee Estuary, the CERP approved by Congress in WRDA 2000 included an above-ground reservoir along the C-43 Canal to capture and store basin runoff and excess freshwater released from Lake Okeechobee. By capturing this excess water the reservoir can also serve as a source of environmental water supply to the estuary during dry periods. The need for additional storage to restore, protect, and preserve the Caloosahatchee Estuary, including Federal trust lands and other publicly owned and managed areas in and around the Caloosahatchee Estuary has also been validated by other planning efforts, including the Caloosahatchee

Water Management Plan (CWMP) (2000) and Lower West Coast Water Supply Plan (2005-2006) prepared by the SFWMD. In accordance with Federal and state requirements for implementing CERP projects, this final PIR was prepared to reaffirm that an above-ground storage reservoir in the Caloosahatchee Basin is a cost-effective solution for achieving CERP goals and Caloosahatchee River (C-43) West Basin Storage Reservoir project objectives and to present the results of evaluations required by Federal and state regulations.

The primary restoration objective for the Caloosahatchee River (C-43) West Basin Storage Reservoir identified in the Restudy was:

> *"... to capture C-43 Basin runoff and releases from Lake Okeechobee. These facilities will be designed for water supply benefits, some flood attenuation, to provide environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary..."*

Primary system benefits would include:

(1) Improvements in salinity and
(2) Improvements in water quality in the estuary.

Secondary system benefits would include:

(1) Improvements in flood attenuation within the basin; and
(2) A possible additional water supply source for agricultural and urban uses (via runoff capture and reuse methodology) once the needs of the estuary are met.

The Restudy recommended a plan that included restoration efforts in the Caloosahatchee River (C-43) region. The CERP project scope included the following description:

> *"This feature includes above-ground reservoir(s) with a total storage capacity of approximately 160,000 acre-feet and aquifer storage and recovery wells with a capacity of approximately 220 million gallons per day and associated pre- and post water quality treatment located in the C-43 Basin in Henry, Glades, or Lee Counties. The initial design of the reservoir(s) assumed 20,000 acres with water levels fluctuating up to 8 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design. The initial design of the wells assumed 44 wells, each with the capacity of 5 million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The level and extent of treatment and*

number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project (U.S. Environmental Protection Agency, 1999)"

The plan formulated in the Restudy alternative for the Caloosahatchee Basin was to capture water in reservoir(s) to provide desirable flow volumes through the S-79 structure to achieve the appropriate salinity envelope in the Caloosahatchee estuary. Through screening and evaluation of plan components proposed in the Restudy it was determined that above ground water storage provided the most cost effective alternative for freshwater attenuation (CERP, Volume 1; Section 7.2).

As previously stated, during completion of the CERP Master Program Management Plan (MPMP) in August of 2000, the project was divided into two parts, Part I: The Caloosahatchee Basin Storage Reservoir Project, and Part II: The Caloosahatchee Basin ASR Project.

This PIR addresses formulation, evaluation, and justification of a separable reservoir project in the lower Caloosahatchee River basin by reaffirming that a reservoir in the lower basin will achieve the benefits of the Restudy Plan for the Caloosahatchee Basin in a cost-effective manner. It demonstrates that a reservoir has been optimized, and acknowledges that the project is part of a more comprehensive plan for the Caloosahatchee Basin.

Since this project located in the lower portion of the Caloosahatchee Basin is focused on estuary restoration, it has limited capability to provide additional water to meet water supply demands in the upper Caloosahatchee River basin. A subsequent study will address the water supply needs and water quality issues of the upper basin. This later study will also address any additional restoration needs and demands in the lower Caloosahatchee River basin not met by the Caloosahatchee River (C-43) West Basin Storage Reservoir project.

Storage of water within the C-43 Basin had been established as one of the primary management measures contributing to the goals and purposes of the Restudy. Based on these findings, the SFWMD originally acquired approximately 12,372 acres (including easements) using State funds and Federal funds. SFWMD is in the process of exchanging approximately 541 acres of this previously acquired land for approximately 600 acres adjacent to the property originally acquired. As the PIR development process was initiated, there was an effort to identify early opportunities to obtain system-wide benefits by utilizing readily available lands. One of these opportunities was the evaluation of a potential reservoir located in the western Caloosahatchee River Basin on lands acquired by SFWMD with both Department of Interior (DOI) and SFWMD funds (please see Real Estate Appendix D, section D1.10.2 for more information).

Draft Programmatic Regulations Guidance Memoranda #1 and #2 instruct project teams to affirm and optimize the component identified in the Restudy unless conditions or planning objectives have changed, or if the component no longer meets the purposes outlined in the Restudy, to formulate new alternatives. Additionally, for projects where the non-Federal sponsor has already acquired lands, formulation of alternative plans using other sites will be minimized if the intended project purposes can be achieved and no more cost-effective sites are identified during formulation. Additional management measures to address the new circumstances should be developed and screening should occur based on the project's evaluation criteria and performance measures. As stated in CERP Guidance Memorandum #2:

> **Reaffirmation:** If the project as described in the Plan is reaffirmed, then the Project Delivery Team's (PDT) efforts will focus on development of design alternatives and optimization of the project features, cost-effectiveness, satisfaction of programmatic regulations requirements for PIRs, Micro-Computer Aided Cost Engineering System (MCACES) cost estimates, and the integrated National Environmental Policy Act (NEPA) documentation to supplement the information contained in the Programmatic Environmental Impact Statement (PEIS) for the Plan, in accordance with the concept of tiering under NEPA.
>
> **Reformulation:** When the project described in the Plan no longer achieves the benefits of the project as described in the Plan, additional formulation will be required prior to initiating detailed design of the selected plan. However, the formulation completed and described in the Plan will provide the foundation for the PDT to formulate additional alternatives. The new or changed circumstances requiring additional formulation should be documented.

The plan formulation for this project focuses on reaffirming that an above-ground storage reservoir in the Caloosahatchee Basin continues to meet the goals, objectives, and purposes for the project as described in the Restudy. Accordingly, in reviewing the findings of the Restudy, the team has determined that based on the current conditions, the project as described in the Restudy still achieves the benefits of the project in a cost-effective manner. A summary of the events that led up to the decisions on how to approach the project is found in ***Figure 1-4*** located at the end of this section.

1.4 RELATIONSHIP TO OTHER USACE/NON-FEDERAL SPONSOR EFFORTS, STUDIES, DOCUMENTS, AND REPORTS

Listed within this section are brief descriptions of other key projects related to the Caloosahatchee River (C-43) West Basin Storage Reservoir project. Included in the description are the objectives and/or study area.

1.4.1 CERP Components

Each of the projects listed below is a CERP component as outlined in the Restudy.

1.4.1.1 C-43 Basin Aquifer Storage and Recovery Project, Part 2

The C-43 Basin ASR Project (Part 2) includes ASR wells with a capacity of approximately 220 million gallons per day and associated pre- and post- water quality treatment that is co-located with the reservoir. The initial design of the wells assumed 44 wells, each with a capacity of five million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The level and extent of treatment and number of the ASR wells may be modified based on findings from the ASR pilot project. The ASR pilot project is being conducted in parallel with a regional study on ASR.

1.4.1.2 Caloosahatchee Backpumping with Stormwater Treatment

The purpose of this project is to capture excess Caloosahatchee River Basin runoff, which will be used to augment regional system water supply. This feature as described in the Restudy includes pump stations and stormwater treatment areas (STAs) with a total capacity of approximately 20,000 acre-feet located in the Caloosahatchee River Basin in Hendry and Glades counties. The initial design of the STAs assumed 5,000 acres with the water level fluctuating up to four feet above grade. The final size, depth, and configuration of these facilities will be determined through more detailed planning and design. This project will be further evaluated under a separate PIR in the future.

1.4.1.3 Southwest Florida Feasibility Study

The Southwest Florida Feasibility Study (SWFFS) covers approximately 4,300 square miles of Florida's southern peninsula. The study area encompasses all of Lee County, most of Collier and Hendry counties, and portions of Charlotte, Glades, and Monroe counties. In the SWFFS study area, the Caloosahatchee River serves as the western outlet for discharges of stormwater and flood releases from Lake Okeechobee to the Gulf of Mexico and is a major source of surface water supply for the basin. The SWFFS will provide a comprehensive review of the water issues that faces southwest Florida, and is not limited to those related to the C&SF Project. The SWFFS will develop and address alternatives that protect and restore early wet-season and overland sheet flow conditions that provide for restoration of amphibian, reptile, macro invertebrate, and forage fish populations. The SWFFS will consider the impacts of freshwater pulsing and/or depletion of freshwater flows to estuaries, improvement of shellfish and fisheries habitat, and protection and restoration of shoreline wetlands that are unique to southwest Florida such as mangroves. Wide-

ranging federal and state-listed threaten and endangered species, such as the Florida panther, wood stork and Florida black bear, as well as migratory birds and endemic species will be prioritized in the study's alternative development and analysis. The study will look at the protection and/or restoration of existing natural resources through land acquisition and conservation easement. The study will plan for proper infrastructure before or, as development occurs, not after. It will develop a water resources plan for the entire southwest Florida area and provide for ecosystem and marine/estuary restoration and protection, environmental quality, flood protection, water supply and other water-related purposes.

Recommendations for restoration of natural areas within the Caloosahatchee River Basin, which are not consistent with the Caloosahatchee River (C-43) West Basin Storage Reservoir project purpose, will be conveyed to the SWFFS for assessment and evaluation, since restoration of natural areas is consistent with the SWFFS purpose. Environmental benefits from Caloosahatchee River (C-43) West Basin Storage Reservoir project will be based on the improved estuary conditions resulting from modifying the salinity regime as a result of changes in the flows to the estuary, and any nutrient load reductions that result from the reservoir storage features. Additional environmental benefits may result from additional features implemented by the SWFFS. The SWFFS includes as one of its objectives the increase in the spatial extent of functional wetlands. The SWFFS will study/evaluate the potential for sites to be re-hydrated within the SWFFS project study area, which includes the Caloosahatchee River Basin. The SWFFS will formulate for environmental benefits in the estuary and in the upland areas, even in the C-43 watershed. The Caloosahatchee River (C-43) West Basin Storage Reservoir project will only have environmental benefits in the estuary, not in the upland areas, unless specifically adjacent to a reservoir. However, recommendations for restoration of natural areas within the Caloosahatchee River Basin not consistent with the Caloosahatchee River (C-43) West Basin Storage Reservoir project purpose will be conveyed to the SWFFS for assessment and evaluation

1.4.1.4 Lake Okeechobee Watershed Project

Lake Okeechobee (approximately 730 square miles) is located in portions of Palm Beach, Martin, Okeechobee, Glades, and Hendry Counties. Water flows into the Lake primarily from the Kissimmee River, Fisheating Creek, and Taylor Creek/Nubbin Slough. The Lake is the principal natural reservoir in south Florida and discharges water east through the St. Lucie Canal (C-44) into the St. Lucie Estuary, west through the Caloosahatchee River (C-43) into the Caloosahatchee Estuary, and south through four major canals in the Everglades Agricultural Area (EAA) into the Water Conservation Areas (WCA). Water levels in the Lake are currently regulated by a complex system of pump stations, spillways, and locks, in accordance with a regulation schedule developed by the

South Florida Water Management District (SFWMD) and the Army Corps of Engineers Jacksonville District (USACE).

The Comprehensive Everglades Restoration Plan contained in the Restudy includes five components that make up the Lake Okeechobee Watershed Study.

North of Lake Okeechobee Storage Reservoir–This feature includes an above-ground reservoir with total storage capacity of approximately 200,000 acre-feet and a 2,500-acre stormwater treatment area located in the Kissimmee River Region, north of Lake Okeechobee.

Taylor Creek/Nubbin Slough Storage and Treatment Area–This feature includes an above-ground reservoir with a total storage capacity of approximately 50,000 acre-feet and a stormwater treatment area with a capacity of approximately 20,000 acre-feet in the Taylor Creek/Nubbin Slough Basin.

Lake Okeechobee Watershed Water Quality Treatment Facilities–This feature will attenuate peak flows and reduce phosphorus loading into Lake Okeechobee by restoring the hydrology of selected isolated and riverine wetlands in the region by plugging drainage ditches that were established for agriculture water supply, and flood control.

Lake Okeechobee Tributary Sediment Dredging–This feature will remove phosphorus in canals located in areas with high phosphorus concentrations that discharge runoff in the Lake Okeechobee Watershed.

Lake Istokpoga Regulation Schedule–This component will examine Lake Istokpoga regulation schedule in order to develop a long-term comprehensive management plan while balancing water supply and flood control needs, while providing ecological benefits in the basin.

1.4.2 Non-CERP Components

The C&SF Project was authorized by the Flood Control Act of 1948 and modified by subsequent acts, as a plan of improvement for flood control, drainage, and other purposes covering an 18,000 square mile area of C&SF. Within the C-43 Basin Storage Reservoir Project area, C&SF canals include Canals 43, 20, and 21. A number of efforts are currently underway by the USACE to modify the C&SF Project for environmental improvements are listed below.

1.4.2.1 Manatee Protection

The West Indian manatee (*Trichechus manatus*) is listed as a Federally endangered species and is one of the most endangered species in Florida. As a response to recent manatee mortality trends associated with water control

structures, this project will provide operational changes and implement the installation of a manatee protection system at seven sector gates at navigational locks near Lake Okeechobee. The beneficial outcome of this project will be the reduction of risk, injury, and mortality of the manatee. The seven sector gates include S-193 at Okeechobee and S-310 at Clewiston on Lake Okeechobee; St. Lucie Lock, and Port Mayaca Lock on the St. Lucie canal; and Moore Haven Lock, Ortona Lock, and W.P. Franklin Lock on the Caloosahatchee River.

1.4.2.2 Caloosahatchee River Oxbow Restoration

The Caloosahatchee River oxbows that are currently being investigated under the authority of the USACE's Section 206 Continuing Authorities Program are located between S-79 and the boundary between Lee and Hendry Counties. The purpose of this project is to restore degraded oxbows, which support the only remaining natural riverine habitat in the altered Caloosahatchee River system. These areas provide important habitat for the critical ecosystem functions of feeding, nesting, refuge and nursery areas for aquatic dependent species, some of which are State and Federally listed species. These areas serve as a critical link in the life cycle of many organisms, from macroinvertebrate communities to fish, birds, reptiles, and mammals. The Caloosahatchee River oxbow restoration will impact future hydrologic conditions of the Caloosahatchee River by increasing river flow through the oxbows. This will result in improved water quality by removal of anaerobic sediments and increased productivity and ecological value by providing a diversity of functioning habitats. Restoring the historic river oxbows also slightly increases the natural storage capacity of the Caloosahatchee River and attenuates the river's hydrograph below the oxbows.

1.4.2.3 Lake Okeechobee Regulation Schedule

Lake Okeechobee is regulated to provide flood control, navigation, water supply, regional groundwater and salinity control, enhancement of fish and wildlife, and recreation. The current regulation schedule, Water Supply/Environmental (WSE), was approved in July 2000 for the regulation of Lake Okeechobee water levels. Per Restoration Coordination and Verification (RECOVER) system-wide determinations for all CERP projects, the current WSE schedule described in the existing conditions section is assumed to be the same regulation schedule in place for future without project conditions. WSE incorporates tributary hydrologic conditions and climate forecasts into the operational guidelines and is used in conjunction with the Operational Guidelines Decision Tree. The operational flexibility of the WSE schedule allows for adjustments to be made in the timing and magnitude of Lake Okeechobee regulatory discharges based on conditions in the Lake tributary basins and in the extended meteorological and climate outlooks. However, in the near future, the USACE plans to complete a detailed study of the Lake Okeechobee regulation schedule similar to the Final

Environmental Impact Statement (EIS) (FEIS, USACE 31 March 2000) that was completed for the Lake Okeechobee Regulation Schedule Study (LORSS).

1.4.2.4 State Initiatives

In addition to the Federal projects, there are multiple state projects that will also have an impact on future water quality both upstream and downstream of S-79. They are:

- SFWMD Lake Okeechobee Protection Plan;
- Florida Department of Environmental Protection (FDEP) Lake Okeechobee Total Maximum Daily Loads (TMDL);
- SFWMD Caloosahatchee Minimum Flows and Levels (MFL);
- SFWMD Caloosahatchee Water Management Plan (CWMP);
- FDEP Caloosahatchee Basin TMDL;
- Florida Department of Agriculture and Consumer Services (FDACS)/FDEP Agricultural Best Management Practices (BMP) Program for the Caloosahatchee Basin;
- SFWMD Urban Irrigation and Landscape BMP Implementation Projects;
- SFWMD Stormwater Management Regulations;
- Lee and Hendry Counties Stormwater Management Projects.
- Northern Everglades Initiative, Caloosahatchee River Watershed Protection Plan
  In June 2007, the Florida Legislature passed Senate Bill 392, The Northern Everglades and Estuaries Protection Program, which expands the Lake Okeechobee Protection Act to include protection and restoration of the Lake Okeechobee watershed and the Caloosahatchee and St. Lucie Rivers and estuaries, provides a dedicated State funding source for Northern Everglades restoration.

  The South Florida Water Management District (SFWMD) announced in July 2007 the allocation of $3.4 million to support 16 projects along Florida's lower west coast that will improve water quality in the Caloosahatchee River and estuary. The local projects, ranging from neighborhood sewer system improvements to treatment marshes and sediment removal, will be completed over the next six months to provide immediate pollution-control measures.

1.5 PROGRAMMATIC REGULATIONS GUIDANCE MEMORANDA

WRDA 2000 required the development of Programmatic Regulations to provide additional guidance for the implementation of CERP. Section 385.5 of the Programmatic Regulations specifically requires the development of six program-wide Guidance Memoranda (GM) that are consistent with the Programmatic Regulations and applicable law, and establish additional procedures to achieve

the goals and purposes of the Plan. The GM are fundamental to the integrated framework; provide direction for using the tools for planning, implementation, and evaluation; and provide assurances that the goals and purposes of the Plan will be achieved. The GM address numerous topics including common methods, general procedures, and guidance to implement the Plan. The six program-wide subjects for the GM as set forth in the Programmatic Regulations are:

- GM#1: Project Implementation Reports
- GM#2: Formulation and Evaluation of Alternatives for PIRs
- GM#3: Savings Clause Requirements
- GM#4: Identifying Water Made Available for the Natural System and for Other Water-related Needs
- GM#5: Operating Manuals
- GM#6: Assessment Activities for Adaptive Management

These GM are currently in draft form and were used to develop this PIR.

1.6 RELEVANT DOCUMENTS AND REPORTS

Reservoir storage was identified in the Restudy as the key component for the restoration of the Caloosahatchee River and estuary. The Restudy analysis identified a conceptual C-43 Basin Storage Reservoir Project of approximately 160,000 acre-feet of above ground storage for environmental restoration for the Caloosahatchee River and Estuary. This storage amount was established through various previously completed modeling efforts. In the Restudy analysis of the Caloosahatchee Basin, an acceptable salinity range for the estuarine ecosystem was established that translated to mean monthly freshwater inflows of 300 cubic feet per second (cfs) to 2800 cfs at S-79. This flow target included the need for low flow augmentation and minimizing high flow discharge events to improve estuarine water quality and to protect and restore estuarine habitat and biota. This flow target at S-79 helped produce modeling results indicating the most efficient size for determining the storage capacity of reservoirs to capture local basin and Lake Okeechobee inflows.

Since the Restudy, additional information has been developed (improved modeling, improved analysis of local hydrology and water budgets, and new estimates of land use and water demands) that refines the amount of storage identified as necessary to meet the needs of the Caloosahatchee Estuary and Basin. In 1998, the SFWMD undertook a water supply planning initiative to ensure prudent management of south Florida's water resources. As a result of this initiative, the SFWMD released the CWMP in the year 2000. The CWMP analysis determined that the projected surface water needs of the Caloosahatchee River and Estuary can be met during a one-in-ten drought condition with the development of water management and storage infrastructure that effectively captures and stores surface water flows in the basin. The CWMP determined that improved management for surface water through storage could

increase freshwater availability in the region and reduce potential impacts resulting from water use. The CWMP identified that at a conceptual level a storage reservoir with a capacity of 220,000 acre-feet (ac-ft) located in the lower West Caloosahatchee Basin would be adequate for environmental restoration of the Caloosahatchee Estuary.

Although the Restudy alternative provided information on the necessary storage volume, it did not provide project-specific details such as a location for the reservoir. Unlike the Restudy, the CWMP identified a suitable location for the storage reservoir in the Caloosahatchee Basin. Based on the findings of the CWMP, the West Basin Berry Groves site, together with adjacent and separately owned land south of the Caloosahatchee River, was identified as the ideal location for placement of a reservoir to meet the needs of the estuary.

Despite differences between the Restudy and the CWMP, both planning efforts arrived at the similar conclusion that above-ground water storage reservoirs were the most cost effective and appropriate method for the attenuation of freshwater runoff and capture of Lake Okeechobee inflows in the Caloosahatchee Basin.

1.7 CERP MASTER IMPLEMENTATION SEQUENCING PLAN

Included within Section 10 of the *Final Integrated Feasibility Report and Programmatic Environmental Impact Statement* dated April 1, 1999, was the original sequencing plan for the implementation of the CERP. Section 10 described the project implementation process and the schedules developed to implement the recommended Plan. Subsequent to the completion of the aforementioned environmental impact statement (EIS), the Implementation Plan was first updated in July 2001 and was known as the Master Implementation Schedule (MIS 1.0). MIS 1.0 updated the Implementation Plan and documented the status of CERP at that time.

The Master Implementation Sequencing Plan 1.0 (MISP 1.0), dated March 2005, built on these previous efforts and incorporated new information, implementation experience to date, and changes in legislation. The new information included the requirements in WRDA 2000 and the subsequent programmatic regulations, as well as the effects of the streamlining contained in the State of Florida's Acceler8 initiative (an accelerated implementation schedule for several CERP components). Acceler8 will hasten CERP implementation while maintaining the relationship of the MISP and the partnership between SFWMD and the USACE. The MISP 1.0 identified the Caloosahatchee River (C-43) West Basin Storage Reservoir project as a Band 1 project (completion in 2010) that would be constructed by the State of Florida under their Acceler8 program. The recommendations contained in this report for

additional investigations in the Caloosahatchee Basin may lead to an update of the next version of the MISP.

1.8 THE STATE OF FLORIDA'S ACCELER8 PLAN

The State of Florida has developed a plan called "Acceler8" for the purpose of accelerating design and construction of a number of critical restoration projects consistent with the CERP but prior to one or more of the following: Administration approval, Congressional committee resolution, Congressional authorization, or Federal construction funding. The State anticipates the Acceler8 program will provide immediate environmental, social, and economic benefits in the south Florida region. All Acceler8 projects must be specifically authorized by Congress before becoming a part of the Federal CERP. The SFWMD is the State agency responsible for water resources management in south Florida and acts as the non-Federal sponsor for Federal water resources projects, including CERP. The SFWMD is the lead agency for the State on implementing the Acceler8 plan and will need to acquire the Department of the Army permits under Section 404 of the Clean Water Act prior to construction.

The Acceler8 program consists of a number of projects, including "C-43 West Storage Reservoir Project." The Acceler8's C-43 Reservoir is referred to in this PIR as the Caloosahatchee River (C-43) West Basin Storage Reservoir project (see www.Acceler8Evergladesnow.org). The USACE and SFWMD anticipate that the SFWMD will accelerate construction and achievement of benefits of certain CERP projects by obtaining required permits and initiating construction upon completion of the Final EIS for the Federal CERP project.

The SFWMD proposes to construct the C-43 West Storage Reservoir Project, prior to implementation of the Federal Caloosahatchee River (C-43) West Basin Storage Reservoir project. The USACE is proceeding with two separate and independent but related actions: the planning evaluation of the Federal project and the regulatory evaluation of the SFWMD's proposed project, both of which are described in this Final PIR/EIS. The C-43 West Storage Reservoir Acceler8 project is the same as the selected alternative plan, described in this Final PIR/EIS. Therefore, it is anticipated that this Final PIR/EIS will also serve as the basis for the Regulatory Division's NEPA evaluation of the SFWMD's proposed Acceler8 project.

Concurrent with the Final PIR/EIS, the USACE Regulatory Division is circulating a Public Notice which describes the Acceler8 project and provides additional information applicable to the regulatory evaluation and is not included in this Final PIR/EIS. The Public Notice is available for public and agency review at the same time as this Final PIR/EIS for the proposed Federal project. For details of the SFWMD's proposed Acceler8 project or a copy of the

Public Notice, the reader is referred to the USACE's Jacksonville District web site at http://www.saj.usace.army.mil/pao/hotTopics/acceler8.htm.

1.9 LAND ACQUISITION ACTIVITIES

As described previously, storage of water within the Caloosahatchee Basin has been established as one of the primary management measures contributing to the goals and purposes of the Restudy. The SFWMD and others have been very proactive in acquiring lands needed for CERP implementation. Based on the findings of the Restudy and CWMP, which both call for a storage reservoir in the Caloosahatchee Basin, the SFWMD determined the best location to use both State and Federal funds to acquire property in the Caloosahatchee Basin. The Federal funds used for this project were appropriated to the DOI and a Grant Agreement entitled Everglades Watershed Restoration-Grant Number LWCF-1 was executed to acquire south Florida ecosystem restoration project lands in the C-43 Basin. The Florida Division of State Lands, in cooperation with the staff of the SFWMD, reached an agreement that allowed the SFWMD to acquire the Berry Groves and some adjacent property as a key component for Everglades restoration (February 2000). To date the State of Florida has purchased a total of 12,372 acres in the immediate area in anticipation of reservoir construction with Federal funding provided by the DOI at a total of approximately $32,800,000, a portion of which ($27,567,669) will be credited to the Federal government towards the acquisition of lands required for this project. SFWMD is the process of exchanging approximately 541 acres of this previously acquired land for approximately 600 acres adjacent to the property originally acquired. The revised total land would be approximately 12,430 acres. Of this approximately 12,430 acres, the Caloosahatchee River (C-43) West Basin Storage Reservoir project will require approximately 10,700 acres, of which approximately 10,480 acres will be required in fee, approximately 20 acres will be required in perpetual channel easement and approximately 200 acres will be required in temporary easements for staging areas.

The amount of the Federal credit may be increased or decreased based on more detailed analysis during the crediting review process after approval of the Project, execution of a Project Cooperation Agreement (PCA) and certification of land.

This page intentionally left blank

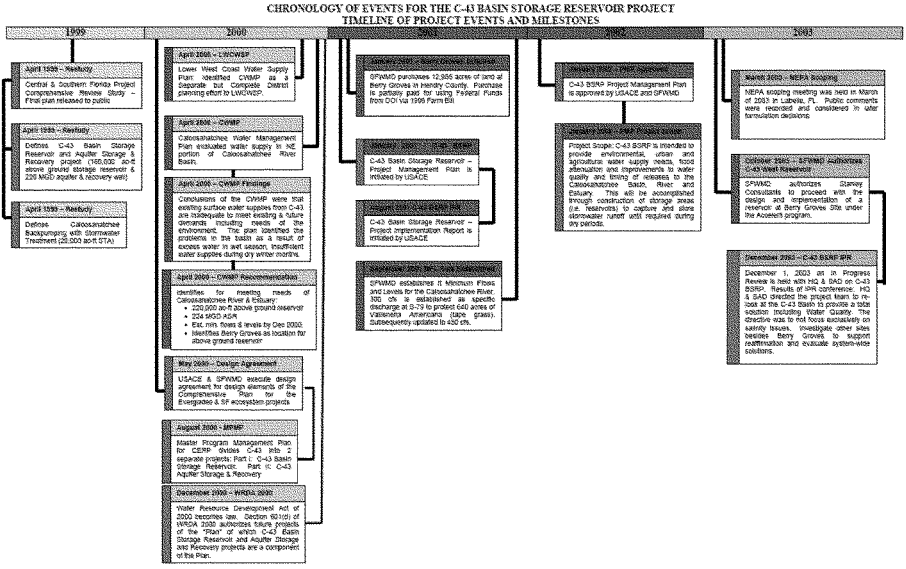


FIGURE 1-4: TIMELINE OF EVENTS AND MILESTONES FOR THE PROJECT

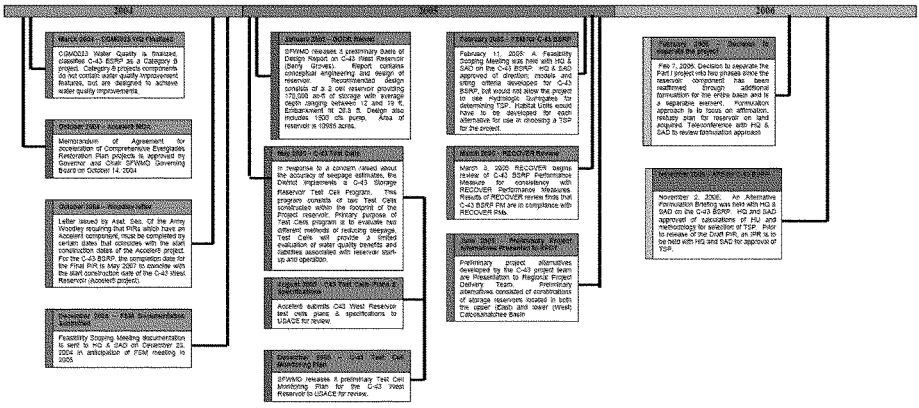


FIGURE 1-4: TIMELINE OF EVENTS AND MILESTONES FOR THE PROJECT (CONTINUED)

SECTION 2
EXISTING CONDITIONS/AFFECTED ENVIRONMENT

This page intentionally left blank

2.0 EXISTING CONDITIONS/AFFECTED ENVIRONMENT

2.1 GENERAL ENVIRONMENT

The Caloosahatchee River and Estuary extend about 70 miles from Lake Okeechobee to San Carlos Bay on Florida's southwest coast. The river basin drains an area of approximately 1,758 square miles. The Caloosahatchee River was originally a shallow, meandering river with headwaters in the proximity of Lake Hicpochee (Science Subgroup 1996). A canal was dredged to connect the Caloosahatchee to Lake Okeechobee in 1881, in order to lower the water table of Lake Okeechobee. It was first channelized to improve navigation and flood control from 1910 to 1930. Three lock-and-dam structures were added to control flow and stage height.

The most downstream structure (S-79) marks the beginning of the Caloosahatchee Estuary. Also referred to as the W.P. Franklin Lock and Dam, this structure maintains specific water levels upstream, regulates freshwater discharge into the estuary, and acts as a barrier to saltwater intrusion into the river. The Moore Haven Lock (S-77), located on the southwest shore of Lake Okeechobee, regulates lake waters. The Ortona Lock (S-78) aids in control of water levels on adjacent lands upstream and separates the Caloosahatchee River (C-43) into eastern and western basins.

Land use within the Caloosahatchee Watershed is dominated by pasture and agriculture, particularly in the upper part of the Caloosahatchee River basin. The West Coast has seen extremely high rates of urbanization in recent years. The major urban areas that occur along the Tidal Caloosahatchee watershed are Ft. Myers, on the south bank, and the large residential areas of Cape Coral and North Ft. Myers, on the north bank.

The Caloosahatchee River serves as an outlet from Lake Okeechobee to the Gulf of Mexico and is the major source of surface water supply for the lower west coast region. It provides agricultural and residential irrigation and public water supplies and is a source of drainage for private drainage systems and local drainage districts. The Caloosahatchee River makes up part of the Okeechobee Waterway, linking the Gulf of Mexico to the Atlantic Ocean through Lake Okeechobee and the St. Lucie Canal and River.

The project footprint covers approximately 10,700 acres, approximately 10,480 acres of land required in fee, approximately 20 acres of perpetual channel easement and approximately 200 acres of temporary easements for staging areas with all the land being located in Hendry County west of LaBelle. The site is a few miles south of State Road (SR) 80 and approximately two miles west of SR 29. The property is predominantly owned by the SFWMD and is under a leasing agreement with Jack M. Berry, Inc. for agricultural land use. Currently the

SFWMD is processing an exchange of 541.31 acres located north of the project boundary for the 600.1-acre Paul Property. This was necessitated by a requirement to locate the reservoir footprint away from existing power lines to the north and a need for additional lands to the east or west in order to maintain storage. The project site is currently a producing citrus grove. The site contains three major arterial canals that transport water for the purpose of irrigation and attenuation of Caloosahatchee Basin runoff waters. Two of the three canals, Roberts and Townsend, lie along the eastern and western perimeters of the footprint, respectively, The Header Canal, also called the LPDD Canal, transects the entire reservoir area and its use is primarily to cross feed water between the Roberts and Townsend Canals. These major canals are shown in ***Figure 2-1***.

Approximately 267 acres within the project site have been impacted through construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir Test Cells Project. The SFWMD initiated construction of the test cells in January 2006, in order to evaluate seepage and water quality effects and improve embankment design. The test cells are also shown in ***Figure 2-1***.

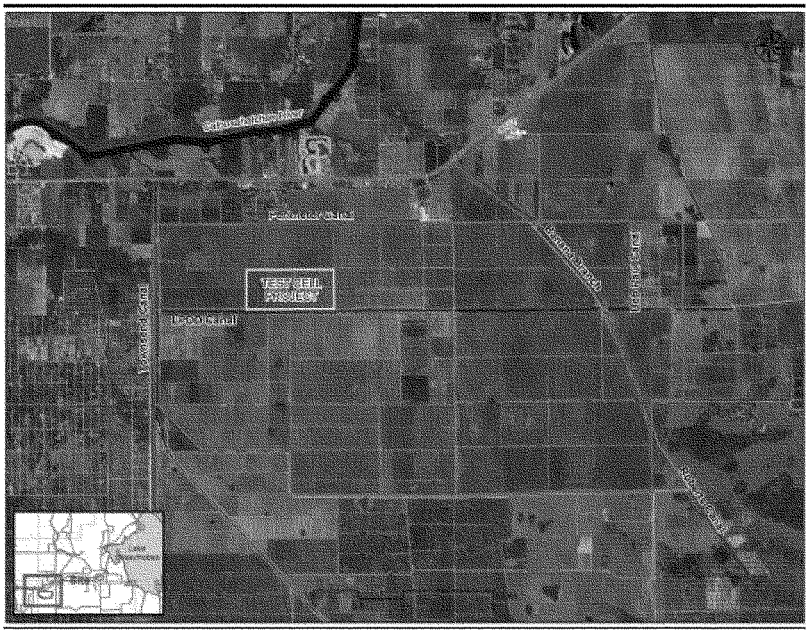


FIGURE 2-1: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR SITE MAP

2.2 CLIMATE

The climate in southern Florida is subtropical and humid, with temperatures ranging from 60°F (16°C) in midwinter to around 80°F (27°C) in summer. The summer heat and humidity is tempered by frequent afternoon and evening thundershowers, which accounts for most of the region's rainfall. The winter months are dryer.

Average yearly rainfall is approximately 52 inches within the basin, with monthly averages ranging from two to ten inches. Two-thirds of the annual rainfall occurs in the wet season from May to October. There is also a high variability in rainfall at different locations in the basin. The inland portion of the basin receives more rain than the coast during the dry season. On average the wet season rainfall is greater along the coast. Although November is usually the driest month of the year, April is the month with the greatest water demand. During the spring months, cold fronts stall to the north of southwest Florida, causing drier weather and forcing water tables to their lowest levels of the year. This time of year is prone to frequent wild fires, sparked by the dry conditions.

Since climate will influence but not be influenced by the proposed project, it will not be further discussed in the evaluation of environmental effects later in this report.

2.2.1 Sea Level Rise

Sea level rise will have the most impact on coastal canals and communities, with loss of flood protection and increased saltwater intrusion being the primary impacts. Additionally, coastal ecosystems and estuaries may be adversely affected and would require additional deliveries of fresh water to maintain desirable salinity patterns and healthy ecosystems.

Sea-level rise is one of the more certain consequences of climate change, and because it affects the land/ocean interface, it has the potential for environmental impacts on coastal areas. Sea level rise will be discussed in Section 3.2 Future Without Project Condition, but will not be discussed in the evaluation of environmental effects later in this report since it will not be influenced by the proposed project.

2.3 PHYSICAL LANDSCAPE

2.3.1 Geology

A portion of the Caloosahatchee Drainage Basin, which encompasses both Collier and Hendry Counties, lies within the physiographic region denoted as the Sandy Flatlands or Gulf Coastal Lowlands, is characterized by terraced plains.

These terraced plains largely control the topography of the area that extends northward into Glades and Charlotte counties, westward to the Gulf of Mexico, and southward into Monroe County. The sands were deposited as three marine terraces: Talbot, Pamlico, and Silver Bluff, all of which were produced during the Pleistocene Epoch. The Talbot terrace ranges from 25 to 42 feet above sea level and is considered the highest in elevation within the subject area. The Pamlico terrace ranges from eight to 25 feet above sea level, and the Silver Bluff terrace, the lowest in elevation; is less than ten feet above sea level and gradates toward the western seaboard.

2.3.2 Soils

The soils of the Caloosahatchee River Basin are dominated by somewhat poorly drained sandy soils. These soils are considered recent deposits of limestone origin, underlain by marl and/or limestone.

A geotechnical engineering evaluation performed at the project site encountered a surficial layer of sands with isolated zones of silty sand material, one to fifteen feet thick. Below this sandy deposit, a layer of interbedded zones of silty sand, clayey sand, sandy clay, and sandy silt materials, 1 foot to 20 feet thick, was encountered. Below this sand/silt/clay mix deposit, limestone material was generally encountered with a thickness ranging from 2 feet to 12 feet, with isolated areas where the limestone deposit was thicker than 30 feet. Some of the borings performed did not encounter the limestone material. Below the limestone material and until boring termination depths, clayey deposits were encountered. These clayey deposits mainly consist of sandy silt, sandy clay, and clayey sand materials.

2.3.3 Aquifers

Three major aquifers, or producing zones, and three confining beds have been identified within the sequence of rocks for the study area. The upper surficial aquifer consists of sands, shells, and limestones, within the sediments of the Ft. Thompson and Tamiami Formations that are Holocene-Pliocene age, respectively. This aquifer and the lower Tamiami/Ochopee aquifer are separated by the Bonita Springs Marl confining unit. Below the lower Tamiami aquifer lies another confining unit of the Miocene age sediments, Upper Peace River confinement. The Sandstone aquifer is sandwiched between the Upper Peace River and Basal Peace River confining unit.

The lower Hawthorn/Tampa producing zone (which includes the basal part of the lower Hawthorn aquifer of Sproul et al., 1972) and the Suwannee aquifer are considered parts of the Floridan Aquifer System (FAS).

2.4 HYDROLOGY

Water for urban and agricultural uses in the Caloosahatchee River (C-43) Basin is supplied from both groundwater and surface water systems. Surface water is used primarily for agricultural irrigation, with groundwater being used in areas that do not have access to the river. In addition, the Caloosahatchee River is a potable water supply source in Lee County. Groundwater and surface water are dependent upon rainfall for recharge.

The Caloosahatchee River (C-43 Canal) receives water from Lake Okeechobee, runoff from the basin, and base flow from the Surficial Aquifer System (SAS). The river in turn supplies water for public supply, agriculture, and the environment. This source can be unreliable during the dry season or in periods of inadequate rainfall, when releases are required from Lake Okeechobee to meet demand. The USACE manages the Caloosahatchee River (C-43 Canal) via a regulation schedule, which presently accommodates navigation, flood protection, water supply, and environmental needs.

The Lake Okeechobee Demand Service Area (LOSA), defined as the area that is or could be supplied by surface water from the Caloosahatchee River, is the primary source for agricultural irrigation and surface potable water supply in the Caloosahatchee Basin. This area extends from the Franklin Lock (S-79) eastward to the Moore Haven Lock (S-77) and includes land in Lee, Glades, and Hendry counties.

Other surface water bodies in the Caloosahatchee Basin area include lakes, rivers, and canals. These areas provide storage and allow conveyance of surface water. Lake Hicpochee is the largest lake in the area and is bisected by the Caloosahatchee River (C-43) just west of Lake Okeechobee. Numerous canals and tributaries in the basin area drain into the Caloosahatchee River. The major tributaries are the Orange River and Telegraph Slough, which drain into the Caloosahatchee River (C-43) in the western portion of the basin near W. P. Franklin Lock and Dam (S-79). The majority of the canals in the basin were constructed as surface water drainage systems rather than for water supply purposes.

Surface water flows in the basin are derived from rainfall within the basin and discharge from Lake Okeechobee. Runoff from the West Caloosahatchee Basin is slightly higher than runoff from the East Caloosahatchee Basin indicating greater flow attenuation in the eastern basin due to the flatness and thick, sandy soils (Fan and Burgess, 1983). Inflow from Lake Okeechobee is the primary flow in the river during the dry season. Water is released from the lake to meet the supplemental agricultural water demand as well as supplying water for municipal consumptive use. Water is also released to reduce lake stages before the hurricane season. High volume water releases to lower Lake

Okeechobee during high rainfall seasons may result in very high flows to the estuary. There is little water storage in the basin. The intensive drainage on the south side of the river provides little storage. The north side of the river is largely undeveloped west of Lake Hicpochee, and although there is considerable wetland water storage, it is not managed water storage.

Groundwater is an important component of the agricultural water supply in the freshwater portion of the Caloosahatchee Basin. The groundwater resources in the area include the surface aquifer, the intermediate aquifer and the Floridan aquifer system (FAS). The yield and storage of the groundwater is highly variable throughout the basin. Where ever it is possible, surface water has been used for irrigation purposes. The surface aquifer system (SAS) is used for some irrigation in eastern Hendry and Glades counties.

The intermediate aquifers are used primarily for irrigation in the western portion of Hendry County. There is local recharge to both the surficial and intermediate aquifers. The Floridan aquifer which is located in the northwest corner of the Caloosahatchee Basis is used for irrigation in northern Glades County (groundwater is mixed with surface water for irrigation use). The water from the FAS is too highly mineralized elsewhere in the basin. This deep aquifer is recharged from outside the area.

There are three structures that provide for navigation and water control in the Caloosahatchee River (C-43 Canal). These structures serve to control the water stages in Caloosahatchee River (C-43) from Lake Okeechobee and the Moore Haven Lock (S-77) to W. P. Franklin Lock and Dam (S-79). Water levels upstream of the Ortona Lock (S-78) are maintained at approximately 11 feet National Geodetic Vertical Datum (NGVD), and three feet NGVD downstream. The W. P. Franklin Lock and Dam (S-79) serves as a saltwater barrier and maintains an upstream level of approximately three feet while the downstream NGVD elevation is generally near one foot. The operation schedule for these structures is dependent on rainfall conditions, agricultural practices, the need for regulatory releases from Lake Okeechobee, and the need to provide water quality control for the Public Water Supply (PWS) facilities. Detailed operation information for structures S-77, S-78, and S-79 can be obtained from the Water Control Plan for Lake Okeechobee and the Everglades Agricultural Area (EAA), Jacksonville District, USACE, July 2000.

The project site has numerous agricultural canals that provide water control. A large, deep, east/west canal (Header Canal) bisects the north central portion of the grove and drains into the Townsend Canal along the western and southern boundaries. Other smaller east/west canals drain into north/south canals that drain into the Header Canal. In most areas, north/south ditches are spaced every 250 feet and drain beds containing nine to ten rows of citrus trees. ***Figure***

2-2, Caloosahatchee River (C-43) West Basin Storage Reservoir Wetland and Surface Water Map, shows the extensive network of canals and ditches within the project site.

2.5 WATER MANAGEMENT

2.5.1 Water Supply

The Caloosahatchee River is the major source of surface water supply for the lower west coast region. It provides agriculture and lawn irrigation, potable water supply and also provides drainage for private drainage systems and local drainage districts.

The Caloosahatchee River Estuary is a large system where the waters of the Gulf of Mexico mix with the freshwater inflows from the river, sloughs, and overland sheetflow in the basin. The area is characterized by a shallow bay, widespread seagrass beds and sand flats. Extensive mangrove forests dominate undeveloped areas of the shoreline.

Lake Okeechobee is the largest freshwater lake in the southeastern United States, covering 730 square miles. It receives significant volumes of runoff from the Kissimmee River (beginning near Orlando), the Upper Chain of Lakes, Lake Istokpoga, and numerous small inflows along its the north shore. During the predevelopment period, Lake Okeechobee discharged to the south and west, into the Everglades and occasionally into the Caloosahatchee Basin during high water periods. The USACE and the SFWMD now control outflows from Lake Okeechobee and can direct flows via an intricate canal system southward into the EAA, to the southeastern coastal urban areas, to the Atlantic Ocean via the St. Lucie River, or to the Gulf of Mexico via the Caloosahatchee River. Inflows to Lake Okeechobee are now faster than they were during the pre-development period, due to channelization of the Upper Chain of Lakes and the Kissimmee River. Additionally, Lake Okeechobee is now confined within its banks by encircling levees (the Herbert Hoover Dike [HHD]) and the historic overflows to the south can no longer occur. During unusually wet years, Lake Okeechobee levels rise until water must be released to the west and east coasts through the Caloosahatchee (C-43) and St. Lucie (C-44). Thus, the Caloosahatchee River (C-43 Canal) now carries late wet season flows that are higher than occurred prior to its connection to Lake Okeechobee. During the end of the dry season or during unusually dry years, flows in the river are lower than historic flows, due to increased water supply demand in the basin.

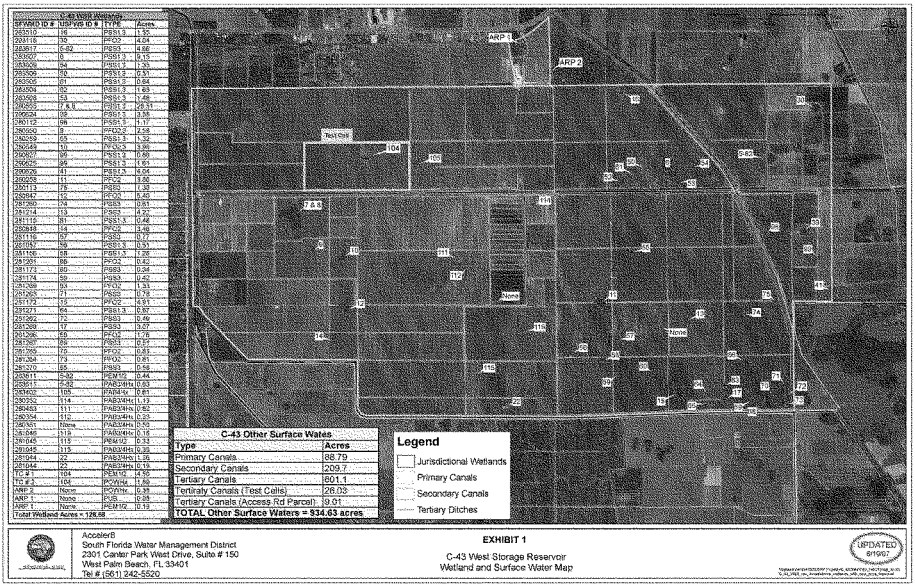


FIGURE 2-2: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR WETLAND AND SURFACE WATER MAP

2.5.2 Water Demands

Non-environmental surface water demands within the basin are primarily agricultural with some potable water supply, commercial and industrial uses. The commercial and industrial demands vary greatly by type of business. In the project vicinity, commercial and industrial demands constitute about one percent of the overall water demand. Because the demand is relatively small and difficult to generalize, an average demand is not calculated for this use category. The emphasis is placed on estimation of agricultural and potable water uses.

A thorough investigation of water use for the Caloosahatchee River and surrounding basins was conducted by the SFWMD for the CWMP. Detailed information derived from this investigation can be found in the SFWMD CWMP Planning Document, April 2000. ***Table 2-1*** summarizes the water use allocation for major agricultural land use categories for the CWMP area based on the Integrated Surface Water/Ground Water Model.

TABLE 2-1: SUMMARY OF 1995 WATER USE DEMAND BASED ON THE INTEGRATED SURFACE WATER/GROUND WATER MODEL FOR MAJOR AGRICULTURAL LAND USE CATEGORIES

Crop	Water Use (acre-feet/year)
Citrus	143,000
Sugarcane	110,000
Vegetables	36,000
Total	290,000

Note: Based on 1995 land use, MIKESHE results indicate an additional 30,000 acre-ft/year of irrigation in addition to citrus, sugarcane and vegetables.

2.5.3 Water Usage

Every five years, the U.S. Geological Survey (USGS) estimates annual water withdrawals for Florida at the county-level. The most recent publication of findings was entitled "Water Withdrawals, Use, Discharge, and Trends in Florida, 1995" (USGS, 1995). Water use estimates for 2000 were not published at the time of this analysis. However, unpublished water use estimates for 2000 for the counties included in this water use analysis were obtained from the USGS. These uses are distributed as public-supply and self-supply domestic (residential), commercial, industrial, government, and recreational water use estimates, along with unaccounted-for water loss estimates. ***Table 2-2*** presents the USGS estimate of water use, excluding mining and power generation water use, for 2000 for the four county study area. Total public-supply water use for the region is estimated at 71.85 million gallons per day (MGD), and total

municipal and industrial (M&I) water use is estimated at 115.17 MGD. The addition of the 680.63 MGD of agricultural water use increases total water use for the region to 796.24 MGD. Agricultural water use accounts for 85 percent of the total use; public-supply water use accounts for nine percent and recreational self-supply accounts for about 3 percent.

On the county level, the largest total water user in the study area in 2000 was Hendry County, mainly because of agricultural water use. Hendry County used a total of 512.11 MGD, or 64 percent, of the total regional water use. Of this amount, 503.91 MGD (or 98 percent) was agricultural use and 4.72 MGD was public-supply M&I water use. Lee County's public-supply water use was about 52 MGD. Lee County's total water use was 144.95 MGD, the third highest in the region. Lee County had the highest self-supply domestic water use in the region at 8.86 MGD. Lee County also had high recreational water use of 22.66 MGD.

TABLE 2-2: USGS ESTIMATED TOTAL WATER USE, FOR SELECTED COUNTIES, 2000-EXCLUDING MINING AND POWER GENERATION (MGD)

	Municipal and Industrial							
		Self-Supply						
County	Public Supply	Domestic	Commercial	Industrial	Recreation	Sub Total	Agriculture	Grand Total
Charlotte	14.21	3.55	0.11	0	3.48	21.35	47.19	68.54
Glades	0.55	0.61	0.04	0	0.42	1.62	69.02	70.64
Hendry	4.72	1.67	0.21	0.51	1.09	8.2	503.91	512.11
Lee	52.37	8.86	0.46	0.09	22.66	84.4	60.51	144.95
Total	71.85	14.69	0.82	0.6	27.65	115.57	680.63	796.24

NOTE: Recreation self-supply water use includes golf course irrigation.
Source: USGS unpublished data, 2002.

2.6 WATER QUALITY

The water quality conditions upstream and downstream of the S-79 structure were evaluated as part of recent Florida Department of Environmental Protection (FDEP) efforts within the Caloosahatchee River (C-43) Basin. The FDEP Verified List for the Caloosahatchee, (FDEP June, 2005) identifies impaired waters in the Caloosahatchee River (C-43) sub-basin as well as the Caloosahatchee Estuary sub-basins. The report was prepared in order to meet the requirements of the Federal Clean Water Act (CWA). Under Florida's implementation of the CWA, waters listed as impaired are then subject to the development of Total Maximum Daily Loads (TMDLs) intended to limit the future discharge of the offending pollutant by point and non-point contributors.

The FDEP has divided the Caloosahatchee Basin into five planning units. Two planning units, East Caloosahatchee and West Caloosahatchee, are the two sub-

basins that are upstream of the S-79 structure on the Caloosahatchee River (C-43 Canal). The three remaining planning units, Telegraph Swamp, Orange River, and Caloosahatchee Estuary, are downstream of the S-79 structure. To date, the EPA and DEP have developed several TMDLs within the Caloosahatchee Basin. For instance, for water body 3256 located in the East Caloosahatchee Planning Unit, TMDLs have been proposed for BOD, total nitrogen, and total phosphorus. In addition a TMDL has been developed for fecal coliform for 9-mile canal. As part of the subsequent Caloosahatchee Watershed PIR, the Corps and the SFWMD will coordinate with EPA and DEP in the ongoing development of additional TMDLs for the basin. In 2002, the FDEP performed a study to determine the relative loadings of total nitrogen and total phosphorus in the Caloosahatchee River (C-43) Basin (Janicki, 2002). This report ranks the sub-basins within the Caloosahatchee River (C-43) Basin in terms of their relative contribution of total nitrogen (TN) and total phosphorus (TP).

A third study, the Caloosahatchee Water Quality Data Collection Program" (ERD, 2002) sponsored by the SFWMD, quantifies pollutant concentrations and loads from the various sub-basins within the Caloosahatchee River (C-43) Basin. Summaries of water quality conditions for upstream and downstream of S-79 are presented below using the above referenced documents as well as other existing information.

2.6.1 Water Quality Conditions Upstream of S-79

2.6.1.1 Impaired Waters

The East Caloosahatchee and West Caloosahatchee planning units are the two sub-basins that lie upstream of the S-79 structure. While all of the East Caloosahatchee sub-basin is upstream of the planned reservoir, approximately 70 percent of the West Caloosahatchee sub-basin is upstream of the planned reservoir. The water quality conditions in these two sub-basins will have a significant impact on the reservoir water quality. The predominant land use in both of these planning units is agriculture. Water quality impairments in this sub-basin are primarily caused by non-point sources rather than point discharges from sewage treatment plants or other industrial activity. Within the East Caloosahatchee unit, six water body segments have been identified as impaired. Within the West Caloosahatchee planning unit, a total of three water body segments have been identified as impaired. The impairments are lead, coliforms, iron, dissolved oxygen, copper, and nutrients. In the West Caloosahatchee planning unit, there are three water bodies that have been identified as impaired; one is impaired for iron and lead, one is impaired for nutrients, and the third water body, the Townsend Canal (located immediately upstream of the planned reservoir intake) which has direct interest to this project, is impaired for copper and lead.

2.6.1.2 Pollutant Loading

Water quality pollutant loading upstream of the S-79 structure is composed of loading from runoff generated within the basin and from loading that results from Lake Okeechobee releases. Excluding the load from Lake Okeechobee releases, approximately 50 percent of the TN load resulting from runoff in the Caloosahatchee Basin comes from basin lands upstream of S-79. Similarly, excluding the phosphorus load from Lake Okeechobee releases, approximately 65 percent of the TP load resulting from runoff in the Caloosahatchee Basin comes from basin lands upstream of the S-79. When Lake Okeechobee flows and loads are included, more than 75 percent of TN and TP loads to the Caloosahatchee Estuary are a result of discharges at S-79 (ERD, 2002).

2.6.2 Water Quality Conditions Downstream of S-79

2.6.2.1 Impaired Waters

The three watershed planning units downstream of S-79 are Telegraph Swamp, Orange River, and Caloosahatchee Estuary. Within these three planning units, land use patterns transition from agricultural/natural areas in the east to residential in the west. In the FDEP Verified List, there are no impaired waters in Telegraph Swamp planning unit.

As the furthest downstream planning unit, the Caloosahatchee Estuary has to contend with its own pollution plus pollutants from the four upstream planning units. According to the June 2005 (FDEP) Verified List for the Caloosahatchee, the estuary-planning unit has 13 impaired water body segments, six of which are part of the main estuary and seven of which are tributary streams. All thirteen listed water body segments are impaired for coliforms (either total or fecal), seven are impaired for nutrients, six are impaired for dissolved oxygen, three are impaired for heavy metals (copper, lead), and one is impaired for specific conductivity. The FDEP Basin Status Report (FDEP 2002) states that the observed water quality violations are probably linked to urban land uses within the Caloosahatchee Estuary planning unit, poorly flushed residential tributary streams, and the effect of heavy pollutant loads discharged from upstream sub-basins.

2.6.2.2 Pollutant Loading

Within the Caloosahatchee Estuary planning unit there are a total of 31 permitted sewage treatment plants. The Caloosahatchee pollutant loading report (ERD 2002) includes pollutant-loading estimates for the four largest sewage treatment plants in the Caloosahatchee Estuary as well as for eight tributaries downstream of the S-79 structure. This report includes loading estimates for the following pollutants: ammonia, nitrate, nitrite, total kjeldahl

nitrogen, TN, orthophosphorus, TP, and total suspended solids. With the exception of ammonia, ten percent or less of the wet or dry season load of each of these pollutants to the Caloosahatchee Estuary comes from the portion of the watershed downstream of the S-79 structure. During the dry season, approximately five percent of the total ammonia load in the estuary comes from the portion of the watershed downstream of the S-79 structure; however, during the wet season, approximately 40 percent of the ammonia load to the estuary comes from downstream of the S-79 structure. A relatively large amount of the ammonia loading from downstream of the S-79 structure comes from the four large sewage treatment plants. The Caloosahatchee Estuary non-point sources of TN and TP contribute around 20 percent of the total loads delivered to the estuary.

2.6.3 Sediment Quality

Unlike the St. Lucie Estuary, a geographically extensive muck sediment layer is not present in the Caloosahatchee Estuary. This is evidenced by the presence of both freshwater and marine submerged aquatic vegetation (SAV) that usually do not coexist in areas where muck sediments are present. Scientists from the SFWMD and U.S. Fish and Wildlife Service (USFWS) have concluded that flocculent sediments are not a significant cause of water quality problems in the main channel of the Caloosahatchee Estuary.

In 1999 the USGS collected 58 sediment samples from downstream of the S-79 structure and two sediment samples from just upstream of the structure. The five sampling locations relative to the S-79 structure were downstream at mile 3.1, 9.3, 10.5, 12.2, and 23.8. Samples were tested for physical characteristics, organic content, pesticides, and heavy metals. Heavy metal results were compared with Florida Sediment Quality Assessment Guidelines (SQAG). Samples from five sites contained heavy metals (chromium, copper, lead, mercury, and zinc) at levels that exceed the Probable Effects Level (PEL) concentration published in the Florida SQAGs. Although a limited number of samples exceeded the PEL concentrations, bioaccumulation and bioconcentration studies would have to be done to quantify the impact of these sediments on in-situ biota. At present, there is no reason to believe that sediment contamination is a significant concern within the main stem of the estuary.

2.7 PLANT COMMUNITIES

The project footprint is currently an active citrus grove. Natural/biological features and land use within the Caloosahatchee River (C-43) West Basin Storage Reservoir project area were initially reviewed using the 2000 Florida Land Use, Cover and Forms Classification System (FLUCFCS) Geographic Information System (GIS) data. Citrus grove covers approximately 90 percent of the study site, more than any other land cover type. The citrus grove land use

classification includes acreage covered by citrus trees, grove maintenance roads, and small berms, brush piles, and other small features related to citrus grove operations. Open water comprises 8.9 percent of the site and includes extensive agricultural canals/ditches, classified as streams and waterways, and excavated ponds, classified as reservoirs less than 10 acres in size. Wetlands which are further discussed in Section 2.8 below comprise 1.1 percent of the site and include mixed wetland hardwoods, willow and elderberry, exotic wetland hardwoods, cypress, wetland shrub, and freshwater marsh.

Citrus groves, row crops and improved pasture with scattered cypress and mixed wetland hardwoods flank the project to the north, east, and south. The area to the north of the project site also contains some low-density residential areas. Forested uplands (parceled into low-density residential lots, various stages of development) such as pine flatwoods, longleaf pine-xeric oak, sand pine, and xeric oak are adjacent to the west of the project. At a landscape level, the Caloosahatchee River (C-43) West Basin Storage Reservoir project is surrounded by a matrix of agricultural, forested, and wetland land cover types, with pockets of urban land use. Urban areas are present to the southwest and northeast of the project area with small parcels along the Caloosahatchee River. Regions to the northwest and southeast of the project area are generally undeveloped.

2.7.1 Exotic Species

Because of its mild climate, international seaports, cultural diversity, and lenient importation laws, Florida has been the epicenter for more exotic species than almost any other region in the country. Some species have remained localized around the release sites, some have died off, and many have extended their ranges to other states. The most severe exotic species threats to the southwest Florida ecosystem come from plants, rather than animals. Therefore, the emphasis on exotics in Florida has been on flora, rather than fauna. The top seven exotic plant species include: Australian pine (*Casuarina* spp.), water hyacinth (*Eichornia crassipes*), hydrilla (*Hydrilla verticillata*), Old World climbing fern (*Lygodium microphyllum*), Melaleuca (*Melaleuca quinquenervia*), torpedo grass (*Panicum repens*) and Brazilian pepper (*Schinus terebinthefolius*) (Schmitz 1994).

Three of the exotic species found in the wetlands (Brazilian pepper, water lettuce, and water hyacinth) are classified by the Florida Exotic Pest Plant Council (EPPC) as Category I exotic species. Category I species are invasive exotics that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives. This definition does not rely on the economic severity or geographic range of the problem, but on the documented ecological damage caused.

2.8 WETLANDS

The 2000 FLUCCS GIS data set developed by the SFWMD for the Southwest Florida Feasibility Study (SWFFS) represents the most accurate wetland information available for the Caloosahatchee River Basin and was used for preliminary analyses of wetlands present in the Caloosahatchee River (C-43) West Basin Storage Reservoir Project site. Additional information on wetland location, acreage, type, and habitat function within the reservoir footprint was obtained during interagency field surveys conducted June 8 to 11, 2004, and February 21, 2007; during helicopter surveys conducted June 14 and 15, 2004; and from National Wetlands Inventory Maps and the SFWMD's November 2006 Department of the Army Permit application for the Acceler8 C-43 West Storage Reservoir Project.

In July 2004, the PDT used the Wetland Rapid Assessment Procedure (WRAP) (Miller and Gunsulas, August 1999) to assess existing wetland function within the Berry Grove property. The WRAP analysis and score sheets are further described in the Final CAR contained in ***Annex A***. IN 2007, the SFWMD, USACE, USFWS, and USEPA used the Uniform Mitigation Assessment Methodology (UMAM) Chapter 62-345 F.A.C., to reassess existing wetland function within the project area for SFWMD's Acceler8 regulatory action. The UMAM analysis was performed as a result of the State of Florida adopting UMAM as a rule in February 2004. Subsequently the USACE Regulatory Division agreed to use UMAM as the preferred functional assessment for evaluating impacts to aquatic resources for determining compensatory mitigation. See the Final CAR in ***Annex A*** for more detailed information on wetlands.

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil, for all or part of the year. Wetlands have characteristic soils, water saturation (hydrology), and plant species. The protracted inundation supports the development of distinctive wetland (hydric) soils. The hydrology largely determines the types of plant and animal communities living in and on the soil. Wetlands may support vegetation more commonly associated with water (aquatic species), land (terrestrial species), and/or facultative species that are adapted to both aquatic and terrestrial communities. Wetlands usually support the growth of plants that are particularly adapted to wet conditions (hydrophytes).

Based on the 2000 land use/cover data and maps, wetlands comprise approximately 135,277 acres (15.9%) of the land cover within the Caloosahatchee Basin. The wetland cover classes occurring in the Caloosahatchee River Basin include freshwater marsh and wet prairie, slough waters, wetland hardwood forest, wetland coniferous forest (cypress swamp and cypress/pine/cabbage palm) wetland mixed forest, mangrove swamp, and salt marsh. Other aquatic habitats

in the Caloosahatchee River Basin include streams and waterways, lakes, and reservoirs. Those habitats comprise approximately 21,682 acres (2.5%) of the land cover within the Caloosahatchee River Basin.

Based on 2000 land use/cover maps, field surveys, and additional information referenced above, 51 wetlands were identified within the reservoir footprint. Those 51 wetlands comprise approximately 112 acres (less than 1.1%) of the land cover within the reservoir footprint, and include several different land use cover classes (freshwater marsh, wet prairie mixed wetland hardwood, mixed wetland hardwood shrub, cypress, cypress/pine/cabbage palm, exotic wetland hardwood, and "reservoir less than 10 acres). Additional aquatic habitats identified include other surface waters such as agricultural ditches and canals which comprise approximately 914.5 acres (8.8%) of the land cover within the reservoir footprint. The remaining land cover within the footprint is predominantly citrus groves. These acreages were refined during a field visit by the USACE Regulatory Division on February 21, 2007, to verify the jurisdictional limits of the upland/wetland boundaries. As shown in ***Figure 2-2***, jurisdictional wetlands comprise 131.40 acres and other surface water comprises 925.62 acres of the total project area. Of these totals, 6.39 acres of wetlands and 26.03 acres of tertiary canals have already been impacted as a result of construction of the Caloosahatchee River West Basin Storage Reservoir Test Cells Project with 125 acres of wetlands and 899.59 acres of other surface waters remaining. This acreage also includes the entire limits of a wetland on the eastern perimeter of the project that is partially within the project footprint.

Development of the on-site citrus groves included perimeter ditching and regular placement of internal ditches to facilitate rapid removal of excess stormwater and control the depth of the water table. Surface water management regulations require that drainage/irrigation systems be engineered to reduce the potential for off-site flooding from increased runoff. Regulations also require that runoff from small storms be detained to prevent surface water quality degradation from fertilizers and pesticide use. Thus, efforts have been made to incorporate as many existing wetlands and flow ways into the local agricultural reservoir and wet detention system (i.e., impounded wetlands) to attenuate stormwater runoff and provide water quality treatment through sedimentation and nutrient uptake by wetland plants. Small outlying wetlands that could not be included in the reservoir system were not converted to citrus and were left in the landscape sometimes surrounded by ditches and/or dikes. Consequently, the water delivery to and the timing, depth, and duration of inundation of the on-site wetlands was altered resulting in changes to the vegetative community composition over time. For example, impounded wetlands may have become over-inundated while isolated wetlands generally have shortened hydroperiods when compared to hydrologic conditions prior to the citrus grove development.

Thus, wetlands in citrus groves are typically considered "impacted" wetlands or have been converted to reservoirs or wet detention areas.

2.9 FISH AND WILDLIFE RESOURCES

Life cycles, community structure and population densities of the fauna of south Florida are intricately linked to regional hydrology. The existing condition of fish and wildlife has been strongly influenced by the cumulative effects of drainage activities in the early 20th century, the C&SF Project, and the ensuing agricultural and urban development. A critical link in the aquatic food webs, and one that appears to have been adversely impacted by hydrologic alterations, is the intermediate trophic level of the small aquatic fauna. Small marsh fish, macro-invertebrates, and herpetofauna form the link between algal and detrital food web bases of the Everglades, and the larger fish, alligators, and wading birds that feed upon them. Aquatic fauna populations of south Florida are currently diminished due to a reduction in the spatial extent of Everglades wetlands (estimated loss of 50 percent) and changes in hydrology of the remaining wetlands.

As an active citrus grove, the proposed project site provides some limited wildlife habitat.

2.9.1 Estuarine and Riverine Invertebrates

The open bottom habitats in the estuarine and tidal Caloosahatchee are composed of mixtures of sand, mud, shell, and bedrock. Mollusks compose one the larger groups of macroinvertebrates within the Caloosahatchee ecosystems. The wedge clam (*Rangia cuneata)* and marsh clam (*Polymesoda carolineata)* are commonly found associated with mud and sandy bottoms in the Caloosahatchee Estuary. The common oyster (*Crassostrea virginica*) is the dominant species in the oyster reef community. Oyster bars serve as a food source and provide habitat for numerous estuarine species including other mollusks, polychaete worms, decapod crustaceans, and various boring sponges. The more common shrimp species include the pistol (*Alpheus* spp.), common (*Palaemonetes* spp.), grass (*Hippolyte* spp.) and broken-back (*Hippolyte pleuracantha*). The fisheries for the blue crab (*Callinectes sapidus*) are the largest, year-round fisheries in the upper and middle portion of the Caloosahatchee River. Other crab species occurring within the region are the spider (*Libinia emarginata*), fiddler (*Uca* spp.), horseshoe (*Limulus polyphemus*), stone (*Menippe mercenaria*) and hermit (*Pagurus* spp.). Sand dollar (*Echinarachnius* spp.) and starfish (*Solaster* spp., *Crossaster* spp. and *Ophioderma* spp.) are predatory invertebrates also found within the Caloosahatchee Estuary.

2.9.2 Amphibians and Reptiles

Many non-listed reptile and amphibian species are found in the Caloosahatchee Basin. These species provide recreational opportunities for residents as well as a forage base for many listed and non-listed wildlife species. Florida softshell and Florida red-belly turtles are common in the area. Southern black racers (*Coluber c. priapus*) and numerous water snakes are present throughout the waters of the basin. Other snake species likely to use these areas include the corn snake (*Elaphe guttata guttata*), yellow rat snake (*E. obsolete quadrivittata*), Everglades rat snake (*E. obsoleta rossalleni*), Florida kingsnake (*Lampropeltis getulus floridana*), Eastern coral snake (*Micrurus fulvius*), Florida cottonmouth (*Agkistrodon piscivorus conanti*), dusky pygmy rattlesnake (*Sistrurus miliarius barbouri*), Eastern diamondback rattlesnake (*Crotalus adamanteus*), coachwhip (*Masticophis flagellum flagellum*), rough green snake (*Opheodrys aestivus*), southern ringneck (*Diadophis punctatus punctatus*) and Eastern mud snake (*Farancia abacura abacura*). Alligators (*Alligator mississippiensis*) are numerous throughout southern Florida. Lizards found in the area include the six-lined racerunner (*Cnemidophorus sexlineatus*), southeastern five-lined skink (*Eumeces inexpectatus*), ground skink (*Scincella lateralis*) and green anole (*Anolis carolinensis*). Amphibians likely to be present include the southern toad (*Bufo terrestris*), spring peeper (*Hyla crucifer*), green treefrog (*H. cinerea*), Florida chorus frog (*Pseudacris nigrita verrucosa*), pig frog (*Rana grylio*) and southern leopard frog (*R. utricularia*).

2.9.3 Fish

The freshwater fishes of the Caloosahatchee River are a mix of northern freshwater species, marine species, and exotics. Among the principally marine species are the tarpon (*Megalops atlantica*), American eel (*Anguilla rostrata*), and mullet (*Mugil* spp.). These fish occasionally move far inland via canals and rivers. Freshwater fishes occupy at least nine different habitats common to the watershed. These include ponds, lakes, streams, marshes, prairies, river channels, and oxbows. These habitats may be broken down even further based on seasonal factors such as deep marsh and shallow marsh and seasonal or permanent ponds. Water quality, flora, and topographic distinctions of similar sites may also influence site suitability for certain species.

Aquatic habitats throughout the basin have been altered through channelization of river segments or are artificially created. Nevertheless, most areas support fishery resources of recreational and commercial importance. Recreational fishing is prevalent throughout the basin. Fishery resources are an economically important resource and have a large annual dollar value. Estuaries provide important habitat (i.e., nursery, escape cover, feeding grounds) for a variety of freshwater, marine, and estuarine-dependent fish and shellfish. Most economically important saltwater fishes and crustaceans spawn offshore and

then use estuarine areas for nursery habitat. Different species use the same location in different seasons, and different life stages of the same species use different locations. Some marine species have estuarine-dependent life stages, typically larval and juvenile stages, which use estuaries as nursery habitat. Larvae or juveniles immigrate on incoming tides and take advantage of the high productivity of the estuary.

Factors affecting the composition of the freshwater fish community in southwest Florida are fluctuating water levels, predation, geographic location, and habitat alteration. When water levels remain high for an extended time, larger predatory fish move into refuges previously safe from carnivores, and the smaller fish disperse into new shallows (Kushlan 1976a). The increased habitat space permits the expansion of the fish population. Continued decreases in water levels concentrate physical, chemical and biological materials and may eventually cause a fish kill or feeding frenzy. In addition to fluctuating water levels and predator-prey interactions, fish community composition differs geographically. Each aquatic habitat type exhibits a different set of physical/chemical characteristic and fish community.

Destruction of littoral zones, plant removal, channel dredging, contaminated run-off from agricultural lands and urban centers, and the drawdown of shallow aquifers are major examples of habitat alteration. Habitat alterations may also be caused by opening undisturbed water to invasion by exotic plants and fishes. Roadside ditches provide a convenient corridor for transporting species across former obstacles.

Six of the species of exotic fish currently established in southern Florida are members of the tropical secondary freshwater family Cichlidae, a highly diversified group considered to be in many ways the ecological counterpart of the centrarchids. Members of this family are generally well adapted to withstand drought. It is anticipated that the spread of cichlids will be at the expense of the native centrarchids. The future of both the exotic and native fish fauna should be a matter of concern.

2.9.4 Birds

The south Florida ecosystem is located along one of the primary migratory routes for bird species that breed in temperate North America and winter in the tropics of the Caribbean and South America. Because the south Florida ecosystem is located near Cuba and the West Indies, it draws Caribbean species that rarely appear elsewhere in North America. Fifteen species of herons, storks, and ibises nest in the south Florida ecosystem and are considered ecological indicators because of their wide foraging ranges, relatively narrow food requirements, and relatively specific habitat requirements. In addition, forested uplands and wetlands serve as important resting areas for migrating

passerine birds. Coastal Florida is often the last stop before these species cross the Gulf Stream or continue their migration south to Cuba. Development has eliminated many of the traditional forested stopover areas making remaining forested areas in south Florida more important to these species.

2.9.5 Mammals

Mammals found in the Caloosahatchee River Basin may include hispid cotton rat (*Sigmodon hispidis*), field mouse (*Peromyscus spp.*), raccoon (*Procyon lotor*), opossum (*Didelphis virginianus*), rabbit, mink, river otter, white-tailed deer (*Odocoileus virginianus*), bobcat, and black bear. Raccoon, opossum, rabbits and other small mammals provide prey items for larger mammals, including the endangered Florida panther. Deer and other fur-bearing animals provide recreational opportunities for residents through hunting, trapping, and wildlife viewing.

The bottlenose dolphin (*Tursiops truncatus*) and West Indian manatee (*Trichechus manatus*) are the only marine mammals that are likely to be found in the Caloosahatchee Estuary.

2.9.6 Protected Species

Nineteen federally listed species may potentially occur in the proposed project footprint or may be impacted by operations of the project. Although some of these species may be impacted by the loss of habitat within the project footprint, when implemented, the project has the potential to significantly contribute towards environmental restoration beyond the project footprint. For additional information on these species please refer to the Final Biological Assessment (BA) for the C-43 West Storage Reservoir Project found in ***Annex A***. The site information included in this report is based on surveys referenced in the BA. ***Table 2-3*** lists the threatened and endangered species within the Caloosahatchee River (C-43) West Basin Storage Reservoir study area. Please note that although beautiful paw-paw was originally provided by USFWS as a potential affected species for this project, once the project site was determined the beautiful paw-paw was removed from species needing consultation.

TABLE 2-3: FEDERALLY LISTED THREATENED (T) AND ENDANGERED (E) SPECIES IN THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR STUDY AREA

Scientific Name	Common Name	Status
Caretta Caretta	Loggerhead sea turtle	T
Chelonia mydas	Green sea turtle	E
Crocodylus acutus	American crocodile	E
Dermochelys coriacea	Leatherback sea turtle	E
Drymarchon corais couperi	Eastern indigo snake	T
Eretmochelys imbricata	Hawksbill sea turtle	E
Lepidochelys kempii	Kemp's (=Atlantic) ridley sea turtle	E
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E
Aphelocoma coerulescens	Florida scrub jay	T
Charadrius melodus	Piping plover	T
Haliaeetus leucocephalus	Bald eagle	T
Mycteria americana	Wood stork	E
Picoides borealis	Red-cockaded woodpecker	E
Polyborus plancus audubonii	Audubon's crested caracara	T
Rostrhamus sociabilis plumbeus	Everglades snail kite	E
Felis concolor coryi	Florida panther	E
Trichechus manatus latirostris	West Indian manatee	E
Cucurbita okeechobeensis	Okeechobee gourd	E
Pristia pectinata	Smalltooth sawfish	E

2.9.6.1 Snail Kite

The snail kite (*Rostrhamus sociabilis plumbeus*) inhabits the watersheds of the Everglades, lakes Okeechobee and Kissimmee, the upper St. Johns River, and the Caloosahatchee Basin. Critical habitat for the snail kite is present immediately adjacent to the Caloosahatchee Basin inside of the Herbert Hoover Dike (HHD) in Lake Okeechobee. The snail kite could also be found foraging in a number of native wetlands and in canals and ditches adjacent to the project area. This medium-sized raptor has a highly specific diet composed almost entirely of Florida apple snails (*Pomacea paludosa*), which are found in palustrine emergent, long hydroperiod wetlands. As a result, the snail kite's survival is directly dependent on the hydrology and water quality of its habitat (Service 1999).

One snail kite was observed on a wire and eating a snail along SR 80 during a February 2006 survey. This location was approximately 0.75 miles west of the project footprint. In addition, during several field visits 2004-2006, populations of two species of apple snails, the Florida apple snail (*Pomacea paludosa*) and the exotic ramshorn apple snail (*Marisa cornuarietis*) were observed in large ditches of the project site. The network of large agricultural ditches provides

suitable foraging opportunities but evidence of foraging/feeding (shell discards) was not observed.

2.9.6.2 Wood Stork

The wood stork (*Myctria Americana*) is primarily associated with freshwater and estuarine habitats for nesting, roosting, and foraging. They have nested, at one time or another, in every county in south Florida. Typical foraging sites include freshwater marshes and stock ponds, shallow, seasonally flooded roadside or agricultural ditches, narrow tidal creeks or shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Wood storks use a specialized feeding behavior called tactolocation, or grope feeding. A foraging wood stork wades through the water with its beak immersed and partially open (seven to eight centimeters [cm]). When it touches a prey item, a wood stork snaps its mandibles shut, raises its head, and swallows what it has caught (Kahl 1964). This unique feeding method of the wood stork gives it specialized habitat requirements; the habitats on which wood storks depend have been disrupted by changes in the distribution, timing, and quantity of water flows in south Florida. The loss or degradation of wetlands in central and south Florida is one of the principal threats to the wood stork.

The majority of the lands within the project footprint fall within the 18.6-mile core foraging area (CFA) of three wood stork colonies (see ***Annex A***). The BA only identified two colonies with a CFA that overlapped the project site but since that time a new colony has been identified. Individual wood storks have been observed foraging and loafing onsite, primarily in the tertiary and secondary canals. Within the project there are limited acres of wetlands that provide suitable wood stork foraging habitat. Wood stork foraging habitat available within the project site includes 6.72 acres of wetlands and 778.34 acres of ditches/canals as identified in ***Annex A***.

2.9.6.3 West Indian Manatee

The West Indian manatee is recognized as an endangered species by both the USFWS and Florida Fish and Wildlife Conservation Commission (FFWCC). Manatees are also protected under the provisions of the Marine Mammal Protection Act of 1972, and by Florida law. The manatee, or sea cow, is a large, plant-eating aquatic mammal that can be found in the shallow coastal water, rivers, and springs of Florida. Florida is essentially the northernmost extent of the West Indian manatee's range, though some manatees are occasionally spotted as far north as Virginia and the Carolinas (Florida Power & Light [FP&L], 1989). The endangered West Indian manatee is regularly found in the Caloosahatchee River and the Charlotte Harbor estuary. This large, aquatic mammal migrates along the Florida coast through fresh, brackish, and marine waters, with a seasonal distribution based on water temperatures. Water

depths of at least three to seven feet are preferred. Water temperatures below 20 degrees Celsius increase the manatee's susceptibility to cold-stress and cold-induced mortality. Distribution is also controlled by the availability of aquatic vegetation, proximity to channels of at least two meters in depth, and location of fresh water sources (Service 1999). During the summer months manatees range throughout water bodies of south Florida, usually in small groups. In the winter months they tend to congregate in warm water areas such as springs and electric generation facilities (FP&L, 1989).

Designated critical habitat for the manatee is located in the Caloosahatchee River Basin. Critical habitat extends downstream from the SR 31 Bridge and includes all United States territorial waters adjoining the coast and islands of Lee County.

Primary threats to manatees today consist of collisions with watercraft, degradation of seagrasses and accidents occurring at water control structures. Navigational locks along the Caloosahatchee River have a history of causing manatee mortality. Sixteen navigational lock/water control structure-caused manatee deaths have been recorded near Ortona Lock (S-78) between 1980 and 2001. Throughout those same years, six were discovered near S-77 at Moore Haven, and just one in 1999 at the Franklin Lock (S-79). Existing operational protocols for the structures and locks (unaffected by project planning for the Caloosahatchee River [C-43] West Basin Storage Reservoir) are important considerations in reducing these deaths.

Manatees have been known to utilize the Townsend Canal, which lies immediately adjacent to and west of the project footprint. During times of inflow from the Caloosahatchee River, manatees are capable of passing over the weir and traveling southward into the Townsend Canal. Individuals have been observed at the outfall area immediately west of the project boundary as well as at the mouth of the canal in the Caloosahatchee River. However, manatees cannot access the main distribution canal (i.e., Header Canal) for the grove property due to differences in elevation.

2.9.6.4 Southern Bald Eagle

The bald eagle is currently listed as a threatened species by both the USFWS and FFWCC. However, effective August 8, 2007, the bald eagle will be removed from the national list of threatened and endangered species. The bald eagle will continue to be protected by the Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act. The southern bald eagle (*Haliaeetus leucocephalus*) is considered common and known to breed throughout the state. Nest sites are usually located near large rivers, lakes, or estuaries where they feed primarily on fish and water-dependent birds. Their distribution is influenced by the availability of suitable nest and perch sites near large, open waterbodies, typically with high amounts of water-to-land edge (Service 1999). The bald eagle is the only eagle unique to

North America. It ranges over most of the continent, from the northern reaches of Alaska and Canada down to northern Mexico. Current threats to the bald eagle include habitat loss and fragmentation, collisions with cars and powerlines, and shooting (USFWS 1998).

Data obtained from the Florida Fish and Wildlife Conservation Commission (FFWCC) 2004 Eagle Nest Database indicate that the closest documented bald eagle's nest, HE002, is located 3.4 miles east of the project and east of SR 29. This nest was documented to be last active during the 2003 nesting season. No other nests were observed in the project vicinity during field efforts in the summer of 2004 or spring of 2006.

2.9.6.5 Eastern Indigo Snake

The threatened eastern indigo snake (*Drymarchon corais couperi*) is present throughout the state, but its abundance is reduced to a point where it is uncommon. Its known habitat includes pine flatwoods, scrubby flatwoods, high pine, dry prairie, tropical hardwood hammocks, edges of freshwater marshes, agricultural fields, coastal dunes, and human altered habitats. This species was listed as a result of dramatic population declines caused by over-collecting for the domestic and international pet trade as well as mortalities caused by rattlesnake collectors who gassed gopher tortoise burrows to collect snakes. Since its listing, habitat loss and fragmentation by residential and commercial expansion have become much more significant threats to this species (USFWS 1999).

Specific information on the status of this species within the project area is not available; however, indigo snakes are known to occur in the Caloosahatchee River Basin in low densities and are known to occur along roads and the banks of larger ditches and canals in citrus groves, particularly if burrows (e.g., tortoise, armadillo, small mammal, and/or land crab), debris piles, or other shelter are in close proximity. Although the eastern indigo snake was not observed during field visits, suitable habitat exists on the project site; therefore, it could potentially occur. Additionally, the species is known to utilize a variety of habitat types including citrus groves.

2.9.6.6 Florida Scrub-Jay

The Florida scrub-jay (*Aphelocoma coerulescens*), a threatened species, is present in limited areas of scrub habitat in the study area. It is a relict species of fire-dominated oak scrub habitat that occurs on well-drained sandy soils in peninsular Florida. Scrub-jays are extremely habitat-specific, sedentary, and territorial. Florida scrub-jays form family groupings; fledglings remain with their parents in their natal territory as helpers. The Florida scrub-jay is listed as a threatened species because of loss, fragmentation, and degradation of scrub habitats throughout Florida, due primarily to urbanization, agriculture, and fire

suppression. During the last 10 to 23 years, the population has declined by an estimated 25 to 50 percent, and they have been extirpated from seven counties statewide.

No individuals, nests or appropriate habitat were detected in the project footprint during site visits. The nearest documented Florida scrub jay habitat and population occurs 1.1 miles west of the project area. This colony is beyond the foraging distance for the species to access the project area.

2.9.6.7 Red-Cockaded Woodpecker

The red-cockaded woodpecker (*Picoides borealis*) was listed as threatened in 1970. The red-cockaded woodpecker is one of 22 species of woodpeckers native to North America. Its historic range encompasses the southeastern Unite States from eastern Texas to Oklahoma to New Jersey, and it was characterized as "abundant" in the 19th century literature. Throughout the 20th century, however, the species' distribution within its historic range has become fragmented, and its total population numbers have decreased dramatically due to the destruction of its habitat. Although south Florida is not a designated recovery population for the red-cockaded woodpecker, the area contains significant support populations for recovery of the species in the southeast. Additional population surveys and research on habitat requirements within the hydric pine flatwoods of south Florida are needed to assess the current status of the birds and to adapt conservation measures used elsewhere to the distinct conditions in this area. The nearest documented red-cockaded woodpecker population occurs approximately 14 miles northwest of the project area (FFWCC data).

2.9.6.8 Florida Panther

The Florida panther (*Puma concolor coryi*), a subspecies of mountain lion, is one of the most endangered large mammals in the world. The most recent population estimate for the Florida panther is a total of 87 individuals, not including denning kittens (McBride 2003). This small population in south Florida represents the only known remaining wild population of an animal that once ranged throughout most of the southeastern United States from Arkansas and Louisiana eastward across Mississippi, Alabama, Georgia, Florida, and parts of South Carolina and Tennessee. The panther presently inhabits a contiguous system of large private ranches and public conservation lands in Broward, Collier, Glades, Hendry, Lee, Miami-Dade, Monroe, and Palm Beach counties totaling more than 809,400 ha. Panthers have a strong affinity for hardwood forests and mixed swamps but also use freshwater marshes, prairie and shrub/scrub habitats, agricultural lands (i.e., wooded pasture, rangeland, citrus groves, row crops, etc.), and even urban areas. Geographic isolation, habitat loss, population decline, and associated inbreeding have resulted in a

significant loss of genetic variability and overall health of the Florida panther population. Natural gene exchange ceased when the panther became geographically isolated from other subspecies of *Puma concolor*. Population viability projects have concluded that under current demographic and genetic conditions, and without implementation of recovery actions, the panther will probably become extinct within two to four decades.

The Caloosahatchee Basin plays an important role in the recovery of the Florida panther. The USFWS has organized a multi-agency subgroup of the Multi-species/Ecosystem Recovery Implementation Team (MERIT) to produce a Florida panther landscape conservation strategy. That strategy included the identification and prioritization of habitat zones (dispersal, primary, and secondary zones) that are essential for effective Florida panther conservation. In addition to protection of habitat for adult home ranges, the strategy includes provision of corridors for dispersal of juveniles between larger areas of contiguous habitat. Dispersal across the Caloosahatchee River, between existing primary habitat south of the river and habitat that is presently only occasionally used by panthers north of the river, is considered essential for recovery of the species.

The proposed project is located within the USFWS Consultation Area and includes areas within the panther primary, secondary, and "other" zones, as identified by the Florida panther subteam of the MERIT and USFWS Consultation Area updates. The most recent available FFWCC telemetry data of radio collared Florida panthers, current through January 2004, depicts three (3) Florida panthers and one (1) Texas cougar (*Felis concolor*) within a five-mile radius of the project area. A more landscape level inspection (25-mile radius) identifies habitat utilization by several additional panthers, particularly within Okaloacoochee Slough State Forest and other conservation lands.

2.9.6.9 Audubon's Crested Caracara

Audubon's crested caracara (*Polyborus plancus audobonii*) is another federally listed species present in the Caloosahatchee Basin. It is a large, boldly patterned raptor, with a crest and unusually long legs. It is a resident, diurnal, and non-migratory species that occurs in Florida as well as the southeastern United States and Central America. In Florida, this species is found in the prairie area of the south-central region of the state. Historically, this species was a common resident in Florida from northern Brevard County, south to Ft. Pierce, Lake Okeechobee, and Hendry County. Today, the region of greatest abundance for this large raptor is a five-county area north and west of Lake Okeechobee. The preferred native habitat is dry or wet prairie with scattered cabbage palms (Service 1999). Improved and unimproved pastures are also highly utilized. Effect determinations for caracara are based mostly on potential impacts within the primary nest zone (i.e., within a radius of 985 feet from a

nest tree) or the secondary zone (a radius of 6,600 feet). Additionally, potential effects within juvenile congregation areas are also considered.

The project falls within the caracara USFWS Consultation Area. One caracara nest site was confirmed to the north of the project during spring 2006 surveys. This nest is located along the southern edge of the SR 80 right-of-way (ROW) and approximately 4,750 feet north of the project boundary. While individuals were not observed foraging in the project footprint, a portion of the project falls within 2000 meters (secondary zone) of this nest, as defined in the Standard Local Operating Procedures for Endangered Species (SLOPES). In addition, a possible nest was identified approximately 1,065 feet south of the project boundary, within a pasture of the A. Duda & Sons, Inc. property. Individuals from the possible nest site were seen flying into and out of the Caloosahatchee (C-43) West Basin Storage Reservoir project site. While the project area provides only sub-optimal foraging habitat for the species, and individuals were only observed utilizing the project area in the southeast portion of the footprint, it does fall within the home range of both the confirmed and possible nests.

2.9.6.10 Florida Grasshopper Sparrow

The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) is a subspecies of grasshopper sparrow that is endemic to the dry prairie of C&SF. This subspecies is extremely habitat-specific and relies on fire every two to three years to maintain its habitat. It is now known to occur only from Highlands, Okeechobee, Osceola, and Polk counties, but other populations may occur in Glades County, which may bring it into the study area considered in this PIR. The species is not known to occur in Hendry County but populations may occur in nearby Glades County (USFWS 4-11-02 Planning Aid Letter [PAL]). The nearest Florida grasshopper sparrow record in the 1999 Florida Natural Areas Inventory (FNAI) database is a 1984 observation located 17.3 miles north of the project. Mapping of potential Florida grasshopper sparrow habitat (Shriver and Vickery, 1999) shows marginal habitat zones to the northeast and southeast of the project, and the project area falls within the Florida grasshopper sparrow USFWS Consultation Area. However, the nearest marginal habitat zone is located approximately 2.5 miles to the southeast of the project footprint. No grasshopper sparrows were observed during field surveys and no suitable habitat exists in the project area.

2.9.6.11 Piping Plover

A wintering population of piping plovers (*Charadrius melodus*) uses the tidal area of the Caloosahatchee River. The piping plover was listed as threatened along the Atlantic coast in 1985. It is a small, migratory shorebird that breeds only in three geographic locations of North America: sandy beaches along the Atlantic Ocean: sand shorelines throughout the Great Lakes: and on riverine

systems and prairie wetlands of the Northern Great Plains. This species does not breed in Florida, but all three breeding populations winter here. Bunche Beach, at the mouth of the Caloosahatchee River, has a population of wintering piping plovers and is also designated critical habitat for this species. The USFWS established critical habitat areas for the species, which include several locations on barrier islands west of the Caloosahatchee Estuary. The nearest piping plover critical habitat zone to the project area includes Punta Rassa, a mainland location at the southwestern edge of the Caloosahatchee Estuary, and Bunch Beach.

2.9.6.12 Okeechobee Gourd

The Okeechobee gourd (*Cucurbita okeechobeensis*) is a vine that was locally common in the extensive pond apple forest that once grew south of Lake Okeechobee (Small 1922). It is a vine that is now restricted in the wild to two small distinct populations; one along the St. Johns River which separates Volusia, Seminole, and Lake Counties in North Florida, and a second around the shoreline of Lake Okeechobee in South Florida.

2.9.6.13 American Crocodile

The USFWS and the FFWCC list the American Crocodile (*Crocodylus acutus*) as endangered. This species occurs in extreme south Florida primarily in Biscayne and Florida Bays. Crocodiles have been observed as far north as the coasts of Lee and Collier counties, but these counties are not thought to support a significant resident population of crocodiles. The American crocodile has not been documented in Hendry County but is present in coastal counties of the Caloosahatchee River Basin, namely Lee and Collier counties. The nearest documented individual occurrence to the project is on Sanibel Island in Lee County. The American crocodile is known to inhabit mangrove and seagrass habitats in coastal areas of south Florida. In addition to the American Crocodile, the American alligator is listed for similarity of appearance to the American Crocodile. The American alligator is abundant throughout South Florida.

2.9.6.14 Sea Turtles

Sea turtles including the Atlantic loggerhead turtle (*Caretta caretta*), Atlantic green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), Kemp's ridley turtle (*Lepidochelys kempii*), and hawksbill turtle (*Eretmochelys imbricata*) are listed as endangered by the USFWS and FFWCC with the exception of the loggerhead turtle, which is listed as threatened. These are marine species with a presence in south Florida waters and are known to utilize bays and estuarine habitats, such as the Caloosahatchee Estuary, for feeding and resting. Sea turtles forage in the near shore waters, bays and sounds of Florida and come ashore at night to nest on the beaches above the high tide line.

Alterations in the timing and quantity of freshwater flowing through the estuary has an impact on natural biodiversity by affecting food availability, predation pressure, reproductive success, and most likely has caused chronic and acute stress to these species.

2.9.7 Essential Fish Habitat

The National Marine Fisheries Service (NMFS) website lists the Caloosahatchee estuary as essential fish habitat for juvenile Brown shrimp (*Penaeus aztecus*), juvenile Gray snapper (*Lutjanus griseus*), juvenile Pink shrimp (*Penaeus duorarum*), adult and juvenile Red drum, (*Sciaenops ocellatus*), adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile Stone crab (*Menippe mercenaria*).

Aquatic habitats within the Caloosahatchee Basin have been altered through the channelization of the river. Nevertheless, the basin continues to support fishery resources of some recreational or commercial importance. At least 70 percent of Florida's recreationally or commercially sought fishes depend on estuaries for at least part of their life histories (Harris *et al.* 1983; Estevez 1998; Lindall 1973). Seagrass communities within the Caloosahatchee Estuary provide critical refugia for juvenile fish such as red drum, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall decrease in species richness may be related to the loss of seagrass habitat and/or a result of alterations in the salinity regime and the timing of the freshwater discharges from the S-79 structure.

2.10 ESTUARINE RESOURCES

The Caloosahatchee Estuary is located on the southwest coast of Florida (***Figure*** 2-3**)**. The major source of freshwater is the Caloosahatchee River, which runs 65 kilometers (km) from Lake Okeechobee to the head of the estuary at the Franklin Lock and Dam (S-79). The estuary extends about 40 km downstream to Shell Point where it empties into San Carlos Bay (***Figure 2-4***). Major environmental concerns for the Caloosahatchee Estuary are altered freshwater inflows and extreme variation in salinity levels, eutrophication and habitat loss.

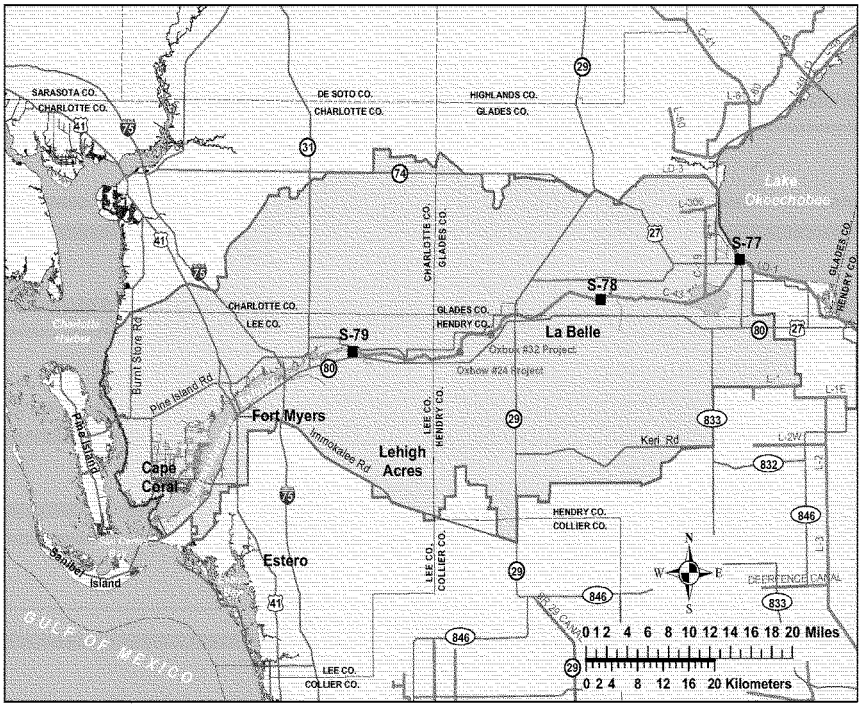


FIGURE 2-3: THE CALOOSAHATCHEE RIVER, ESTUARY, AND SOUTHERN CHARLOTTE HARBOR WATERSHED

The Caloosahatchee River historically bisected its basin and probably only rarely received water from outside its watershed or from Lake Okeechobee except during extreme regional flooding events that sent water to the marshlands at the headwater of the river. Now the river functions as a primary canal (C-43) that conveys both basin runoff and regulatory releases from Lake Okeechobee. The canal has undergone a number of alterations to facilitate this increased freshwater discharge, including channelization, bank/levee stabilization, and the addition of the three locks and dams. The last structure before the canal flows into the estuary (S-79) maintains specific water levels upstream, discharges freshwater into the estuary, and acts as a barrier to salinity and tidal action, which historically extended far upstream. Therefore, when S-79 was completed, it truncated the estuary and now spatially limits the dry season oligohaline (freshwater and low salinity brackish water) zone of the estuary, as well as the free passage of organisms seeking refuge, nursery, and breeding areas characteristic of this zone.

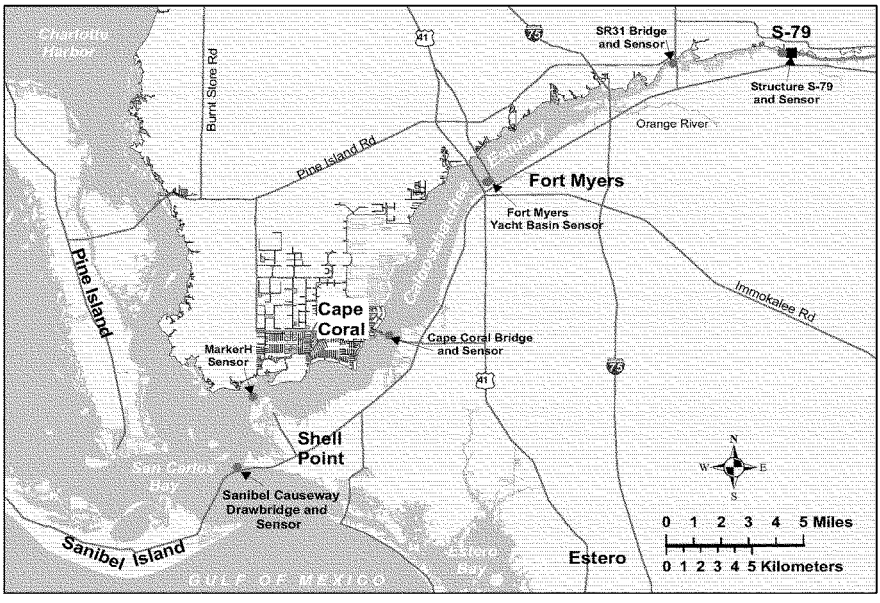


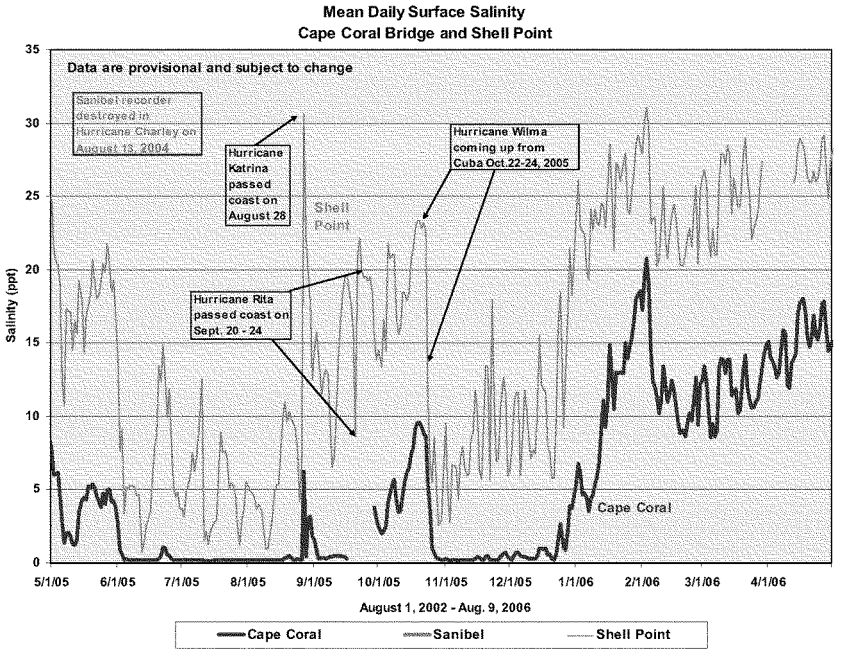
FIGURE 2-4: CALOOSAHATCHEE ESTUARY SALINITY SENSORS AND IMPORTANT LANDMARKS

The long-term mean monthly discharge measured at S-79 ranges between 300 and 3,000 cfs. However, daily and monthly flows often exceed this long term average, with prolonged flows commonly exceeding the 4,500 cfs monthly average that adversely affect the San Carlos Bay area. Flows above this threshold (occasionally exceeding 10,000 cfs) can push freshwater into Pine Island Sound and the Gulf of Mexico, thus impacting ecologically and commercially important high-salinity marine resources that historically were not directly affected by Caloosahatchee River discharges. During the dry season, the combination of limited rainfall, lack of water storage in the basin and withdrawals to meet human demands for irrigation and potable water often results in periods of no freshwater discharge to the estuary. Saline water can intrude all the way upstream to S-79 eliminating the oligohaline zone and threatening species that require low salinity to complete their life cycle (Chamberlain and Doering 1998a; 1998b, Doering et al. 2002; SFWMD 2002).

Excessive variation in discharge and salinity (***Figure 2-5***) occurs in the Caloosahatchee Estuary (Chamberlain and Doering 1998a), resulting in a constant flux of estuarine biota between those favoring higher salinity and those favoring lower salinity (Bulger et al. 1990). Optimal salinity conditions may not

last long enough for organisms to complete their life cycle and the estuary can become devoid of some populations, even keystone species that support major ecosystem components along the estuary's salinity gradient.

Environmental research by the SFWMD began in the Caloosahatchee Estuary during the mid-1980s and focused on the impacts associated with the extreme variability in freshwater inflow from S-79 (Chamberlain and Doering 1998a). The purpose of the research was to determine the proper timing and volume of freshwater inflows required to support valued ecosystem components (VECs) such as oysters and SAV, as well as the impacts of flows on general biotic indicators, such as plankton and benthic invertebrates (SFWMD 1998). This research has resulted in the development of optimum S-79 flow ranges and delivery patterns for the estuary (Chamberlain and Doering 1998b; Doering et al. 2002; Volety et al. 2003). This information forms the scientific basis for development of hydrologic performance measures for Comprehensive Everglades Restoration Plan (CERP), the SWFFS, and Lake Okeechobee, as well as meeting legislative mandates for the establishment of minimum flows and levels (MFL).



Note: The timing and influence of three hurricanes is depicted here.

FIGURE 2-5: DAILY AVERAGE SALINITY COLLECTED BY CONTINUOUS SENSORS AT TWO DOWNSTREAM LOCATIONS (CAPE CORAL BRIDGE AND SHELL POINT AT THE RIVER MOUTH) IN THE CALOOSAHATCHEE ESTUARY

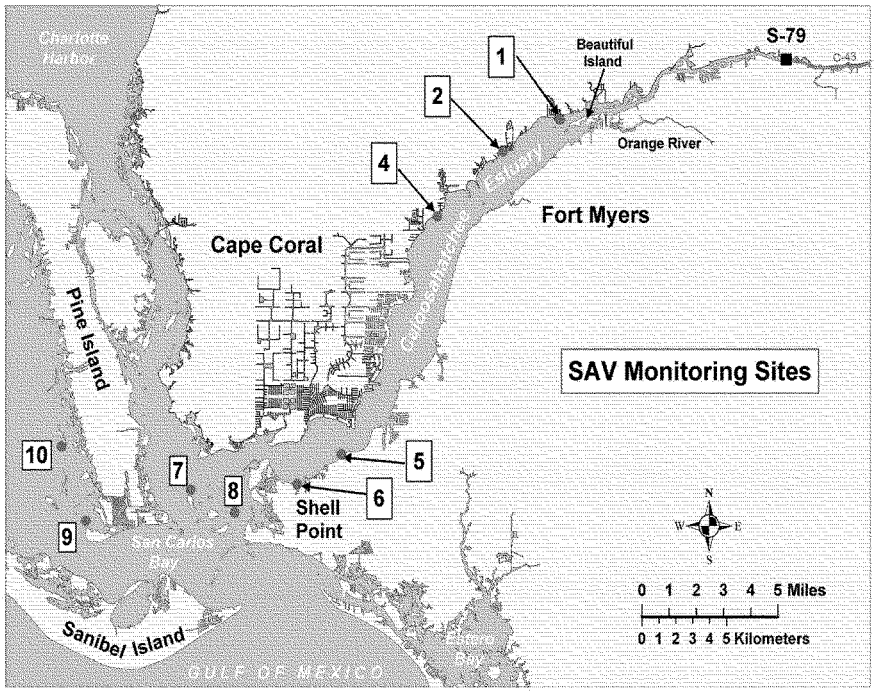
A distribution of monthly average inflows with the greatest frequency range from 300 to 1,500 cfs and a peak between 300-800 cfs was initially determined by SFWMD scientists to be the most beneficial for the species evaluated. This original frequency distribution was reported as provisional (Chamberlain and Doering 1995, 1998a, and 1998b), with the intent to update it as more information became available about the salinity requirements of key biota. This original flow recommendation was used to formulate the MFL and identified 300 cfs as the required average monthly inflow from S-79 for protecting the oligohaline zone of the estuary and the submerged plant, *Vallisneria americana*. The MFL was based on a flow-salinity relationship that was predicated on the delivery of S-79 discharges. However, salinity in the estuary is also influenced by additional inflows from creeks and groundwater downstream of S-79. On average, when flow at S-79 is 300 cfs, an additional 150-200 cfs comes from downstream sources for a total of approximately 450 cfs. However, during low

flow conditions the entire system is drier than normal and the downstream contribution is much lower than 150-200 cfs, so 300 cfs at S-79 is insufficient to achieve the MFL salinity criteria. The original basin flow optimization model used historic S-79 flow data from 1965 to 1990 to recommend a time series of basin flows (Labadie 1995: Otero et al 1995). More resent efforts use a 2000 Base and subsequent modeling related to the Restudy, the CWMP, and the Caloosahatchee River (C-43) West Basin Storage Reservoir CERP project have resulted in reconsideration of the original time series of flows to the estuary. The time series denoted as EST05 (see Section 4.3.1.1 of this report for a more detail explanation of the ESTO5 flow distribution) goes farther toward providing a higher level of protection in the upper estuary than previous time series by establishing a low flow limit of 450 cfs from S-79, which is consistent with meeting the total flow requirements associated with the MFL and its salinity criteria for protecting *Vallisneria.*

The discharge of water at S-79 also is a major determinant of macro-nutrient concentrations and other aspects of water quality in the Caloosahatchee Estuary. Influence of this discharge can be detected nearly 60 km downstream in Pine Island Sound (Doering and Chamberlain 1999). This control of water quality stems from the overwhelming dominance of the Caloosahatchee River at S-79 as a source of nutrients and other materials to the downstream estuary.

Loss of habitat has also been of concern. Hardening of the shoreline, increased freshwater discharge and oyster mining are thought to have singly or in combination reduced mangrove, seagrass and oyster bar habitats (e.g. Harris et al 1983).

Several prominent species are among those identified for long term monitoring and environmental assessment because they constitute important habitat in the Caloosahatchee, San Carlos Bay, Matlacha Pass and Pine Island Sound. In addition to tape grass (*Vallisneria americana*) that serves as an indicator of estuarine health in the upper estuary, oysters and marine seagrasses represent the more downstream, seaward portions of the system (***Figure 2-6***).



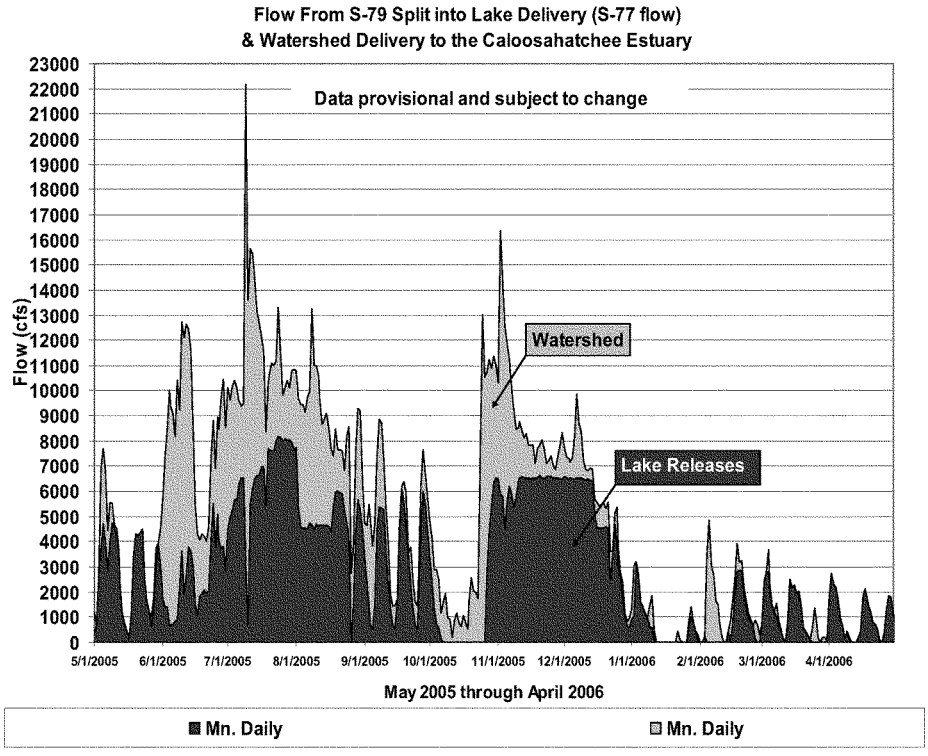
Note: *Vallisneria americana* is found at stations 1-2, *Halodule wrightii* at stations 5-10, *Thalassia testudinum* at stations 8-10. Oysters are located throughout the region downstream of station 5, but the core population is between stations 6 and 7.

FIGURE 2-6: CALOOSAHATCHEE ESTUARY SAV MONITORING STATIONS AND GENERAL OYSTER LOCATIONS

2.10.1 Recent Hurricane Impacts

In water year 2006 (WY2006) [May 2005-April 2006]), three hurricanes either directly or indirectly impacted the estuary. Hurricanes Katrina and Rita passed to the west in the Gulf of Mexico and the tidal surge associated with both caused spikes in water levels and salinity (***Figure 2-5***). During the fourth week in October 2005, Hurricane Wilma made landfill south of the region near Naples, which also caused similar spikes. Rainfall associated with Wilma brought tremendous rainfall to the basin and to Lake Okeechobee and its tributaries, which resulted in large releases from S-79 that extended to January 2006

(***Figure 2-7***). These releases drove down salinity at Shell Point (Marker H sensor) and San Carlos Bay. Salinity in the estuary upstream of Shell Point at Cape Coral was near zero parts per thousand (ppt) (freshwater) for almost two months because of the indirect impacts from Wilma.



Note: The portion of the discharge accounted for by Lake Okeechobee releases is shown in blue.

FIGURE 2-7: TOTAL DISCHARGE INTO THE CALOOSAHATCHEE ESTUARY (WATERSHED RELEASES) AT S-79

2.10.2 Estuarine Indicators

2.10.2.1 Freshwater Inflow at S-79 and Salinity at Ft. Myers

There were releases from Lake Okeechobee every month of WY2006. This was in part related to a high lake level remaining from WY2005 as a result of Hurricanes Frances and Jeanne. Therefore, Level II–III pulses were still being made to the Caloosahatchee through S-79 in October of 2005 (***Figure 2-7***). A very wet June 2005 throughout the upper district resulted in a dramatic increase in basin discharges, coupled with regulatory releases from Lake Okeechobee through August 2005. These discharges were followed by four Level III pulses, lasting into October 2005. As a result, salinity remained very low (0 ppt at Cape Coral Bridge) for four months (***Figure 2-5***). Salinities began to recover during mid-October until Hurricane Wilma (see description in the previous section). During January and the remainder of WY2006, salinities again began to recover as discharges at S-79 declined, with only Level I pulse releases being made at the end of WY2006 (April 2006). However, heavy basin rains during the 2006 wet season resulted in a single day's discharge of 21,000 cfs and average monthly discharge during September that exceeded 7,000 cfs (with no flow from Lake Okeechobee). This very wet season has been followed by a very dry season, that even with small environmental releases from the Lake Okeechobee, has resulted in violation of the MFL rule.

The long-term average discharge at S-79 is approximately 1.2 million ac-ft per year. In WY2006, discharge at S-79 was 3.6 million ac-ft, 2.2 million ac-ft of which were discharges coming from Lake Okeechobee. Most of the total annual discharge (3.3 million ac-ft or 92 %) entered the estuary through S-79 in the first eight months. WY2006 was the second consecutive year that annual discharge to the estuary was well above normal (WY2005 = 2.0 million ac-ft).

As discussed above, research and modeling conducted by the SFWMD has resulted in the identification of a preferred average monthly flow distribution between 450 and 2,800 cfs to protect and promote desirable estuarine biota and resources. In an ordinary year, flows less than 450 cfs occur for approximately 4.2 months and are greater than 2,800 cfs for 2.6 months. Thus, in an average year under current conditions, flows exceed the target about seven months per year. In WY2006, mean monthly flows were above the upper limit of the envelope, which occurred during the first eight months of WY2006 (May through December 2005). Flows exceeded 4,500 cfs during six of those eight months, which can have significant negative impacts on seagrass in San Carlos Bay. Half (4) of the flow exceedances were attributed to average monthly flows greater than 8,000 cfs, which can extend freshwater influence well into lower Pine Island Sound.

Surface salinity recorded at the Fort Myers sensor (***Figure 2-8***) during WY2006 did not exceed either of the two MFL criteria. Even though daily average salinity was greater than (>)10 ppt during three days near the beginning of February 2006 (maximum = 11.25 ppt), it did not exceed the one day limit of 20 ppt. In addition, the maximum 30 day average salinity at the same location was 6.0 ppt, well below the MFL target of 10 ppt. The period of record for salinity at Fort Myers extends back to 1992. During the 15 years of record, WY1995, WY2004, and now WY2006 are the only three years in which neither of the two criteria were exceeded (criteria: 1) moving 30-day average salinity of less than (<) 10 ppt at Fort Myers Yacht Bain; and 2) a daily average salinity of < 20 ppt). However, the dry season extending into 2007 has been extremely dry and has resulted in salinity that exceeds the monthly criteria (***Figure 2-8***).

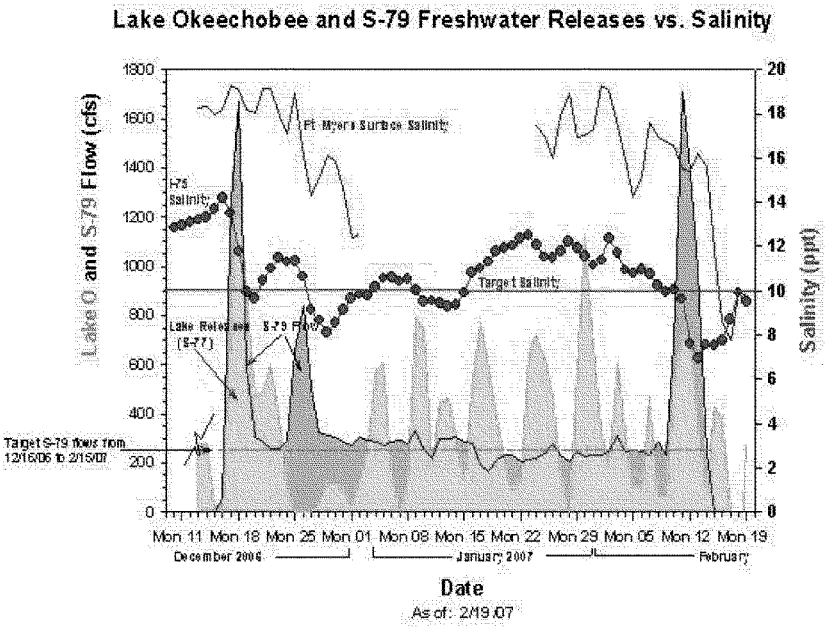


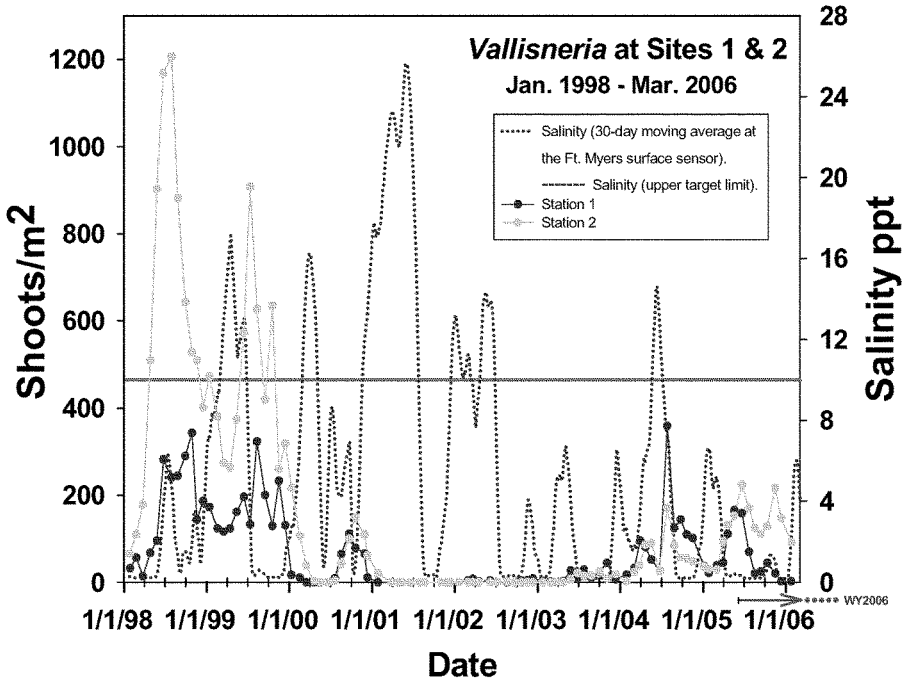
FIGURE 2-8: FRESHWATER FLOW THROUGH S-77 AND S-79 COMPARED TO SALINITY AT INTERSTATE-75 BRIDGE AND FT. MYERS

2.10.2.2 Tape Grass in the Upper Caloosahatchee

Due to high salinity experienced during the 2001 drought, tape grass beds in the upper Caloosahatchee Estuary essentially vanished, and have been in recovery since that period (***Figure 2-9***). There was an apparent slight trend toward

increasing plant density since the growing season of 2003. During WY2004, the beds began to recover in the spring-summer growing season, coinciding with favorable salinity conditions. Similar seasonal growth patterns were evident in the spring-summer growing season of 2005 (WY2006).

Before the 2001 drought, plant density was significantly greater at Station 2. WY2006 was the first time since the drought that this pattern was evident. During the high freshwater inflows in June, plant density decreased upstream at Station 1, possibly due to the associated drop in water clarity, while more plants persisted at Station 2 during November 2005 through March 2006 than in previous years since 2001. However, due to the unusually high salinity associated with the 2007 dry season (***Figure 2-9***), the plants have again almost disappeared.



(Note: Recent data are from stations monitored by the Sanibel-Captiva Conservation Foundation and Mote Marine Laboratory.)

FIGURE 2-9: TAPE GRASS (*VALLISNERIA AMERICANA*) SHOOT DENSITY IN THE UPPER CALOOSAHATCHEE ESTUARY

2.10.2.3 Oysters

Based on WY2004 aerial surveys, there are presently only 3.02 acres of Eastern oysters (*Crassostrea virginica*) in the lower Caloosahatchee Estuary and 15.04 acres in lower Charlotte Harbor. Most of these are located in the Shell Point region. This low number of oysters, especially to the east, is a result of the combination of: 1) high freshwater inflows into the estuary from the basin and Lake Okeechobee, 2) the lack of suitable substrate, and 3) shell mining in the twentieth century for construction material that decimated the live oyster population and their substrate in this region.

A preliminary target for the aerial extent of oyster reefs is 40 and 60 acres respectively in these two regions during the next 10 to 15 years. With the addition of hard substrate, this target can be increased to 200–300 acres upstream of Shell Point and 150-200 acres downstream. Eighty-seven volunteers from Florida Gulf Coast University, concerned citizens, SFWMD, and other state, Federal, and local agencies placed 200 shell-bags at two locations upstream of Shell Point (Iona Cove and Piney Point) during October and November 2005 to provide recruitment substrate for oyster reef development.

Monitoring of oysters' health and recruitment began in 2000. Results indicate that oysters in the Caloosahatchee Estuary spawn continuously from April–October, a period that coincides with freshwater releases into the estuary. High freshwater flows flush out oyster larvae and spat from upstream areas with suitable cultch and/or reduce salinities to levels that are unfavorable for spat settlement and survival. Recruitment during WY2005 was among the lowest observed (Volety; personal communication, 2005), which included the 2005 spring start-up. The high flows, which drastically increased during June 2006, resulted in another poor year for oyster survival and recruitment, especially upstream of Shell Point.

2.10.2.4 Marine Seagrass

Seagrasses have been sporadically surveyed in the Caloosahatchee by aerial photography since the 1940s. More recently, aerial surveys were conducted in 1999, 2002–2003, and 2004. No aerial surveys were conducted during 2005 or 2006. There appears to have been a dramatic increase in aerial extent of seagrass in the region between 1999 and 2002-2003 (***Table 2-4***). This increase may be due to the quality of the photography rather than a real change. Methodological and other differences between surveys preclude a reliable trend analysis (Corbett et al, 2006). However, with that said, this increase does follow the 2000-2001 drought when flows from S-79 were low and salinity in the seagrass areas were consistently in the preferred range.

Processing of the 2004 survey was completed during this WY2006 (***Figure 2-10***). The results of this survey indicate that there are approximately 38,494 acres in the combined Lower Caloosahatchee, Matlacha, San Carlos Bay and Pine Island Sound regions, with respective individual coverage of 62 acres, 7168, 3905, and 27359 acres.

TABLE 2-4 AERIAL EXTENT OF SEAGRASS

Year	Acres of Seagrass
Water Year 1999	38,197.16
Water Year 2002 and 2003	43,590.91
Water Year 2004	38,494

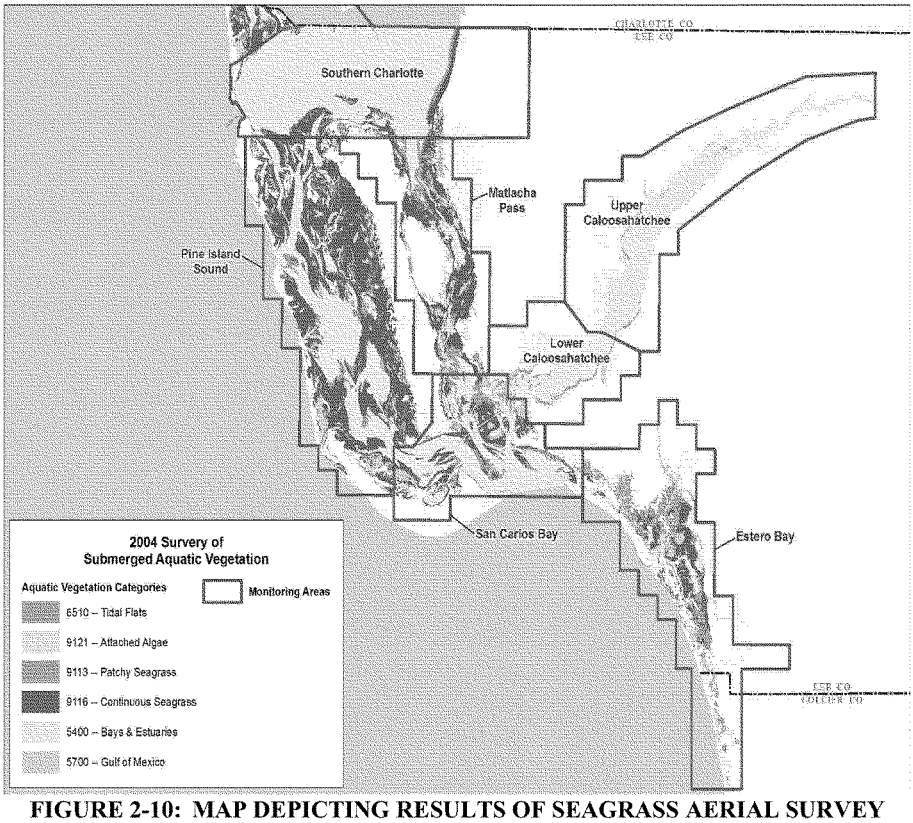


FIGURE 2-10: MAP DEPICTING RESULTS OF SEAGRASS AERIAL SURVEY CONDUCTED IN 2004 AND PROCESSED IN WY2006

Manual (in-water) seagrass monitoring by the Sanibel-Captiva Conservation Foundation Marine Laboratory indicates WY2006 was a very poor year for seagrass at all stations sampled, both upstream of Shell Point and in San Carlos Bay (***Figure 2-11***). This follows a poor WY2005 for *Halodule* upstream of Shell Point when shoot density remained below 200 m^{-2}. During WY2006, *Halodule* remained low upstream, while *Halodule* and especially *Thalassia* fell to a new seasonal low in San Carlos Bay following the large discharges that began in June 2005. These low densities persisted into the winter dry season and recent field trips indicate that *Thalassia's* percent of seagrass species composition has significantly declined.

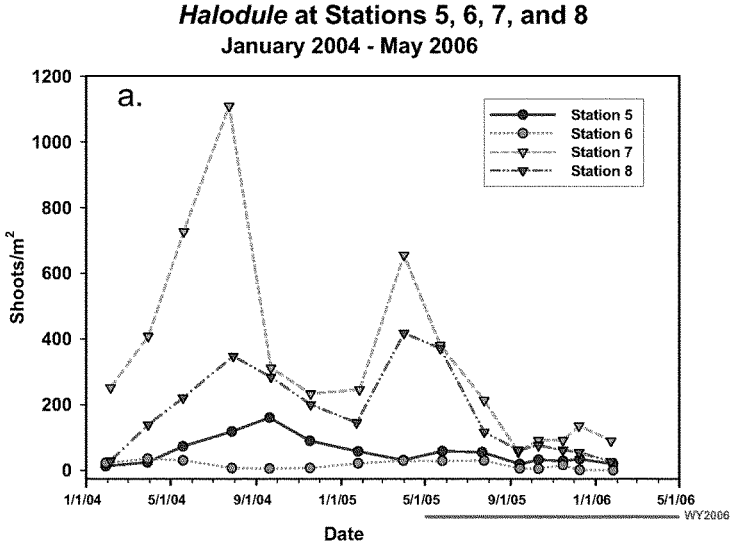


Figure A

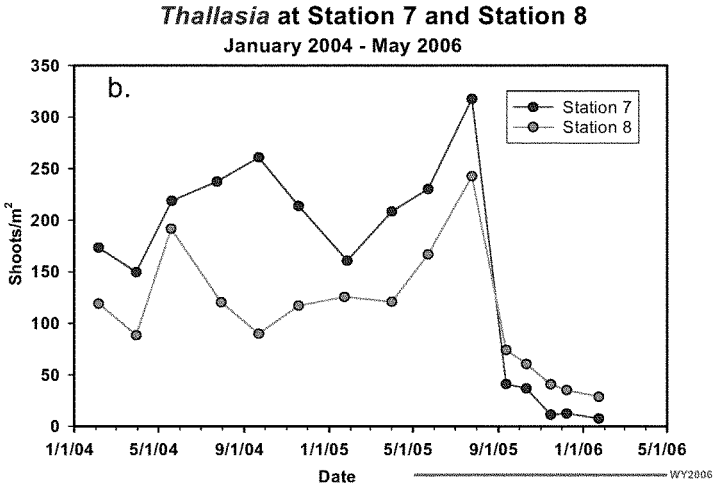


Figure B

(Note: Data collected by the Sanibel-Captiva Conservation Foundation)

FIGURE 2-11: DENSITY OF SEAGRASS: (FIGURE A.) *HALODULE WRIGHTII* (SHOAL GRASS); AND (FIGURE B) *THALASSIA TESTUDINUM* (TURTLE GRASS) IN THE CALOOSAHATCHEE ESTUARY AND SAN CARLOS BAY

2.11 AIR QUALITY

A few common air pollutants are found all over Florida. The existing air quality within south Florida is considered good, and the region attains all National Ambient Air Quality Standards. There are no non-attainment areas in the State of Florida. The current sources of air pollution are area-wide, resulting from autos in urban areas, land clearing, and partly from various licensed emitters (SWFRPC, 2002). Large industrial polluters are limited.

2.12 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

The reservoir currently under consideration will be constructed on property formerly owned by J&H Grove Holdings, L.C. (Berry Groves), the Griffin Family Limited Partnership, the MG Enterprises, L.L.C. and the Bryan Paul Citrus. All these lands are currently owned in fee by the SFWMD except the Bryan Paul Citrus parcel that will be an exchange of 541.31 acres of SFWMD ownership in exchange for 600.17 acres of the Bryan Paul Citrus property. Prior to the 1960s these lands were primarily used as unimproved pasture. For the last 30 to 40 years these four parcels have been used to cultivate citrus. Over the operating life of these groves, fertilizers, herbicides and pesticides have been applied

routinely as part of normal agricultural operations. From the 1960s to 1980s, pesticide use would have included the application of persistent organic compounds such as DDT, chlordane, and toxaphene. Use of these and other persistent pesticides has since been severely restricted by the U.S. Environmental Protection Agency (USEPA). Normal farm operations would also typically result in point-source contamination associated with maintenance areas, pesticide mixing and loading sites, and fuel storage areas. The non-Federal sponsor shall be responsible for ensuring that the development and execution of Federal, State and/or locally required HTRW response actions are accomplished at 100 percent non-project cost. No cost sharing credit will be given for the cost of response actions.

Prior to and after the acquisition of each of these land parcels, a Phase I and Phase II Environmental Site Assessment (ESA) were performed to identify and characterize contaminated sites within the properties. In addition to identifying human health impacts, the site assessments also investigated the presence of widespread residual soil contamination in the cultivated areas to determine if the level of contamination might pose a threat to wildlife inhabiting the proposed reservoir. All site assessments were performed in general accordance with the American Society for Testing and Materials Standard Practice for Environmental Site Assessments (ASTMS Practice E 1527-00). These site assessments typically focus on identifying contamination that is a threat to human health. Analytical results were compared to FDEP SQAG and the Florida Administrative Code Soil Cleanup Target Levels (SCTL) and Groundwater Cleanup Target Levels (GCTL). In those cases where contaminant concentrations were at or above the relevant guidelines, an Environmental Risk Assessment (ERA) was performed to determine if the contamination would pose a risk to affected species. The risk assessments focused on the potential for bioaccumulation of residual contaminants by avian species that might feed on fish caught from the reservoir. In particular, the USFWS identified the listed snail kite as the species at greatest risk. Short summaries of the environmental audits for each property are provided below. A detailed discussion can be found in section 9.25 of this report.

2.12.1 Berry Groves Property

The 9,000 acre Berry Grove property, only a portion of which will be utilized in the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, is owned by the SFWMD. Phase I and Phase II ESA studies as well as ERAs were performed on this parcel during the period from December 1999 through 2006. These investigations identified more than 40 potential point source contamination sites within the parcel boundaries. These point source sites typically consist of refueling sites, maintenance sheds, pesticide storage/mixing sites, and irrigation pump stations. Seventeen (17) of the 40 sites were designated as requiring no further action because further investigation

determined that contamination was not present at levels requiring remedial action. Fifteen (15) of the sites were identified as presenting a contingent hazardous, toxic, and radioactive waste (HTRW) risk because contamination has been identified and quantified but remediation has either not begun or been completed. An additional five sites were identified in March 2003 as requiring remediation. The 40 contaminated sites discussed above can be generally categorized as point source contamination sites in which the contamination is contained within an area of a few acres or less. Though most of these sites have been re-mediated as of February 2007, remediation of the remaining sites will be completed prior to transferring control of the land from the lessee to the SFWMD.

Of greater concern to the USACE and the USFWS is the widespread presence of elevated copper concentrations in the cultivated soils on the Berry Groves property. The presence of elevated copper in the soils is a result of the application of fungicides that have been applied to the citrus groves. To investigate the risk posed by copper, a Phase III ERA was conducted by the URS Corporation under contract with the SFWMD and in coordination with the USFWS. The purpose of the ERA was to determine the risk that elevated concentrations of copper in the soil posed to populations of invertebrates, fish, and birds (the listed snail kite, for instance) that would use the Caloosahatchee River (C-43) West Basin Storage Reservoir for habitat.

At the onset of this study, the 9,000 acre Berry Grove property was divided into 181 fifty-acre grids for purposes of sampling shallow soils for copper content. A total of 89 of these plots were randomly selected for sampling for residual copper in the surface soils. Copper concentrations in composite samples collected from these plots ranged from 13.1 (Grid 100) to 169 milligrams per kilogram (mg/kg) (Grid 125), resulting in a contractor calculated geometric mean of 51.9 mg/kg (95 percent upper confidence level of 56.6), which exceeds the threshold effects concentration (TEC) of 32 mg/kg for effects on benthic invertebrates. In fact, seventy-five of eighty-nine 50-acre grids exceeded the TEC. Since copper concentration in Grids 58, 124, 125, and 134 exceeded the probable effect concentration (PEC) of 108 mg/kg, discrete samples were collected in 2002 from those grids to look for potential contamination hot spots.

In 2003, the FDEP adopted a new PEC for copper (150 mg/kg) reducing the number of grids with copper concentrations exceeding the PEC to one (Grid 125). Additionally, a site-specific ecological risk assessment was performed in 2003 which concluded that impacts were likely for the benthic community. It also predicted potential risk for the Everglades snail kite if copper concentrations in soil exceed 85 mg/kg (interim screening concentration for risk to the snail kite). Contamination in Grids 56 and 145, in addition to grids 58, 124, 125, and 134, exceeded 85 mg/kg. Therefore, in 2005, discrete samples were collected from

Grids 56 and 145 to locate potential contamination hot spots. Lastly, in 2005, delineation sampling of copper contamination in the above-noted six grids was performed. The delineation sampling indicated copper exceeded 85 mg/kg in Grid 135 as well, but was less than 85 mg/kg in Grid 145. The consultant's final report recommended remediation of copper contamination in soils of Grids 56, 58, 124, 125, 134, 135, and 143.

2.12.2 MG Enterprises LLC Property

The 2,399 acre MG Enterprises LLC property is owned by the SFWMD. The entire property will be utilized in the reservoir project. The MG Enterprises LLC property is located south and west of the larger Berry Groves property. The MG Enterprises LLC property has been used to cultivate citrus for the last 30 or more years. Like the Berry Groves property, persistent pesticides such as DDT, toxaphene, and chlordane were probably widely used until the application of such chemicals was restricted by the USEPA in the 1980s. A Phase II ESA report was prepared in March 2003 by Environmental Consulting & Technology, Inc. (ECT) on behalf of the SFWMD. This report identified five areas of potential concern including the cultivated areas, canal sediments, two maintenance areas, and an exploratory oil/gas well. Grid based testing was performed in the cultivated areas such as was done on the Berry Groves property. The results of these sediment analyses indicated the presence of aldrin and aldicarb at levels exceeding the threshold concentrations. A preliminary ERA was done using a fugacity-based food chain model to determine the risk that elevated aldrin concentrations might pose to avian species. The results of this modeling indicated that at the highest detected concentration (29 ug/kg), the calculated hazard quotient ranged from 0.01 to 0.02 for birds exposed to the contamination. Two of the remaining four suspected areas, Maintenance Area A and Maintenance Area B, require corrective action. Soils samples collected in the vicinity of Maintenance Area A had high levels of endrin, copper, and zinc. No contamination of groundwater was detected at this site. Soil samples collected in the vicinity of Maintenance Area B had high levels of anthracene, flourene, and acenaphthalene. No groundwater contamination was detected at this site.

2.12.3 Griffin Property

The approximately 954 acre Griffin property is owned by the SFWMD, and all will be utilized in the Reservoir project. The Griffin property is located south and west of the larger Berry Groves property. The Griffin property (954 acres) has been used to cultivate citrus for the last 30 or more years. The Phase I and Phase II ESA report identified five areas of potential concern including the cultivated areas, canal sediments, maintenance area/chemical barn, fertilizer mix/load area, and burn area. Grid based testing in the cultivated areas was performed by dividing the property into 20 cells of 50 acres each. Discrete

samples were collected from 10 five-acre sub-grids on each larger grid and composited into one sample. The results of these sediment analyses indicated evidence of low level contamination of barium, copper, lead, mercury, zinc and paraquat. However, none of these analytes exhibited concentrations which exceeded the SQAG PEC. Aldicarb was detected in one sample grid at a concentration of 67 ug/kg which exceeds the site-specific SQAC of 1.75 uk/kg developed specifically for this site. Soils contaminated with polyaromatic hydrocarbons (PAHs) were found at the maintenance area/chemical barn. At the burn area, soils contaminated with copper were found. Seven sediment samples were collected from the drainage canal. One of these samples contained residual copper at a concentration exceeding the TEC of 32 mg/kg but not exceeding the interim screening concentration of 85 mg/kg. Another sample contained pentacholorophenol (PCP) at a concentration of 32 mg/kg which is well below the site-specific effect level of 617 ug/kg. Remediation was recommended for the maintenance area, and burn area.

2.12.4 Bryan Paul Citrus Property

The approximately 600-acre Bryan Paul Citrus property is located east of the Berry Groves property and has not been acquired by the SFWMD. It will be acquired in an exchange for approximately 541 acres of the Berry Grove property. In the 1960s the property was converted from a cattle ranch to row crops such as tomatoes, watermelons, and peppers. In 1972, the property was converted to citrus groves (see Appendix D "Real Estate Plan").

In 2004, the SFWMD conducted a Phase I and Phase II Environmental Assessment as part of a due diligence investigation prior to acquiring the lands. The Phase I assessment identified the following seven sites of environmental concern: 1) pump stations, 2) former nursery barn, 3) C-1 mixing site, 4) auxiliary tank area, 5) solid waste site, 6) burn area, and 7) grove area. To test the grove area for the presence of elevated pesticide and heavy metal residues in the soils, the 600 acres were divided into a grid composed of 119 five-acre squares. Soil samples from each of the 119 cells were collected and then composited into ten samples. The resulting 12 composite soil samples were submitted to the laboratory for analysis. The results of the analysis indicated that the soil in two grids (8 and 9) had elevated chlordane levels in excess of the recommended 100 ug/kg limit. Further testing indicated that approximately 13 acres in the vicinity of grids 8 and 9 had chlordane impacted soils.

At the solid waste area, soil samples were collected from below the buried waste. These samples indicated that the soils were not impacted though the presence of buried solid waste would have to be addressed. At the burn area, soil samples were collected to determine if concentrations of heavy metals exceed the standards. At the former pump stations, soil samples were collected and analyzed for petroleum and heavy metal contamination. The results indicate

that the visibly contaminated soils should be removed. At the burn site, the analysis of soils indicated that the surrounding soils were not impacted. However, the removal of ash was recommended by the environmental consultant. From the drainage canal, eight soil/sediment samples were collected for analysis. The results indicated that canal sediments were not contaminated; however, some canal bank soil directly adjacent to a burn area had high levels of barium, copper, and silver. The consultant's recommendation was to remove the canal bank soil that appears to be contaminated by the adjacent burn site.

2.13 CULTURAL RESOURCES

Cultural resource surveys (Florida State Department of Historic Preservation numbers 2004-8676 and 2006-07757) have been conducted for the Caloosahatchee River (C-43) West Basin Storage Reservoir site. Three isolated prehistoric artifacts, one isolated historic artifact, one prehistoric archeological site (8HN129), and four modified historic buildings were identified. All except the prehistoric archeological site were determined to lack integrity and determined not eligible for listing on the National Register of Historic Places. The prehistoric archeological site (8HB129) is located near the edge of the proposed project.

2.14 SOCIOECONOMICS

As a result of the flood protection and available supply of drinking water supplied by the C&SF project, the population of southwest Florida has grown to approximately 880,000 persons as of the year 2000. By the year 2050, the population of southwest Florida is expected to reach two million people. Lee County has one of the fastest growing populations in both south Florida and in the state. The coastal areas in these counties have become highly urbanized. As a result, this urbanization has caused development to move eastward into areas that were once agricultural or natural.

The Governor's Commission for a sustainable south Florida identified agriculture and tourism as "critical industries" for maintaining the economy in the southern part of the state. In Lee and Hendry County, agriculture is a major industry and citrus production predominates. A rapidly expanding human population demanding more developable lands and advancing agricultural development now threatens the relatively pristine natural areas. The tourism industry is also dependent upon the region's ability to sustain its economy and its quality of life through management of its resources. Agriculture and tourism depend on a system that can provide vital water supply needs and flood protection.

2.14.1 Population

Population for the four counties in the study area (Charlotte, Glades, Lee and Hendry County) increased at a high growth rate during the period from 1990 to 2000 (***Table 2-5***). Charlotte increased at 27.6 %, Lee at 31.6 %, Glades at 39.3 % and Hendry at 40.5 %. The population of Florida and the United States increased 23.5 % and 13.1 % respectively over the same period.

TABLE 2-5: CHARLOTTE, GLADES, LEE AND HENDRY COUNTY 2000 POPULATION

		Race							
	Population, 2000	**White**	**%**	**Black**	**%**	**Hispanic**	**%**	**Other**	**%**
Florida	15,982,378	12,466,255	78.0%	2,333,427	14.6%	2,685,040	16.8%	1,182,696	7.4%
Charlotte County	141,627	131,147	92.6%	6,232	4.4%	4,674	3.3%	4,249	3.0%
Census Tract 101	3,556	2,916	82.0%	525	14.8%	191	5.4%	115	3.2%
Glades County	10,786	8,305	77.0%	1,133	10.5%	1,629	15.1%	1,348	12.5%
Census Tract 1	2,018	1,975	97.9%	2	0.1%	21	1.0%	41	2.0%
Census Tract 2	5,669	4,590	81.0%	415	7.3%	1,353	23.9%	664	11.7%
Census Tract 3	2,889	1,577	54.6%	697	24.1%	220	7.6%	615	21.3%
Lee County	475,639	417,135	87.7%	31,392	6.6%	45,186	9.5%	27,112	5.7%
Fort Meyers MSA	440,888	386,598	87.7%	29,035	6.6%	42,042	9.5%	25,255	5.7%
Hendry County	36,210	23,935	66.1%	5,323	14.7%	14,339	39.6%	7,083	19.6%
Census Tract 1	6,567	4,973	75.7%	729	11.1%	2,655	40.4%	41	0.6%
Census Tract 2	7,506	3,750	50.0%	2,898	38.6%	2,007	26.7%	664	8.8%
Census Tract 3	6,926	4,222	61.0%	132	1.9%	4,256	61.4%	615	8.9%
Census Tract 4	11,066	8,503	76.8%	802	7.2%	3,738	33.8%	1,761	15.9%

Hendry County has a large percentage of people that claim Hispanic origin. Of the 36,210 residents in the county during the year 2000, almost 40% (14,339 persons) are of Hispanic origin. Glades, Charlotte and Lee counties all have lower proportions of persons of Hispanic origin than does the rest of the state. Florida's African-American population is 2,333,427, which is 14.6% of the State's total population. Hendry County has a total African-American population that is slightly higher than that of the state total. There are also three census tracts in the study area that have a higher African-American representation than that of the state.

The Native-American population of the study area represents less than one percent of the aggregate population of the study area.

2.14.2 Economy

Generally, a strong wholesale and retail trade, government and service sectors characterize Florida's economy. Florida's warm weather and extensive coastline attracts vacationers and other visitors and helps make the state a significant retirement destination for people all over the country. Agricultural production is also an important sector of the state's economy, and is especially significant to portions of the study area. Compared to the national economy, the manufacturing sector has played less of a role in Florida, but high technology manufacturing has begun to emerge as a significant sector in the state over the last decade.

The unemployment rate for Florida is 5.1 % (2003), which is greater than that of Lee (4.0%) and Charlotte (4.4%) counties. Hendry and Glades counties had unemployment rates that were much greater than the state total, with Glades' unemployment rate at 8.7% and Hendry County's unemployment rate at 11.7% (***Table 2-6***).

TABLE 2-6: INCOME AND EMPLOYMENT FOR COUNTIES AND CENSUS TRACTS

	Income					Employment	
	Median Household, 1999	**Personal Per Capita, 1999**	**Persons Below Poverty Level**	**% Below Poverty Level**	**Average Household Size**	**In Labor Force (+16 yrs old)**	**Unemployed**
Florida	38,819	21,806	1,997,797	12.5%	2.46	7,407,458	412,411
Charlotte County	36,379	21,557	11,613	8.2%	2.18	52,512	1,822
Census Tract 101	41,274	17,560	165	4.6%	2.47	1,176	27
Glades County	38,819	15,338	1,639	15.2%	2.51	3,677	357
Census Tract 1	27,604	17,216	374	18.5%	2.47	1,873	29
Census Tract 2	31,170	14,597	938	16.5%	2.72	4,268	256
Census Tract 3	34,091	15,471	175	6.1%	2.62	2,324	72
Lee County	40,319	24,542	46,137	9.7%	2.31	186,417	7,234
Fort Myers MSA	40,139	24,542	42,316	9.6%	2.31	3,120	230
Hendry County	33,592	13,663	8,727	24.1%	3.09	14,579	1,235
Census Tract 1	37,210	15,460	1,197	18.2%	2.92	3,120	230
Census Tract 2	31,760	13,047	2,034	27.1%	3.15	3,318	420
Census Tract 3	34,250	12,315	1,894	27.3%	3.55	3,512	237
Census Tract 4	33,022	15,417	2,492	22.5%	2.87	4,425	280

Personal per capita income in Florida is $21,806 (1999), but is somewhat lower in Charlotte County at $21,557, and substantially lower in Glades County at $15,338 and Hendry at $13,663. Lee County experiences higher per capita income than that of the state average. Every rural census tract associated with the study area has lower than the state average per capita income.

In 1999 it was reported that 12.5% of Florida's population lived below the poverty level, while 24.1% of Hendry County's population lived below the poverty level, and 15.2% of Glades County lived below the poverty level. Charlotte County and the census tracts associated with it are both below the state poverty level figures. All Census tracts in Hendry County are above the poverty level than that of the state.

2.14.3 Commercial and Recreational Fishing

There exists some commercial fishing in the Caloosahatchee Estuary. The Florida Statistical Abstract (FSA) contains estimates for the direct employment in fishing in Lee County. According to the FSA, the fishing industry in Lee

County involves an estimated 40 businesses (FSA, 1997), with 180 employees, and an estimated annual payroll of $3.54 million. The use of cast nets in the estuary is reported to be common. In addition, there is reported to be substantial crabbing activity in the estuary. In Lee County, there are 638 saltwater products licenses and 267 permits for blue crab fishing.

The Caloosahatchee Estuary has important ecological connections with offshore commercial fish stocks. As described in Nelson (1992), many commercial finfish and invertebrate species use estuaries for critical stages of their development. ***Appendix G*** presents commercial landings, trips, and value data collected by the FDEP for the Pine Island Sound/San Carlos Bay area. As indicated in this appendix, in 1997 the value of the commercial landings from this area was approximately $1.7 million. The finfish and bait shrimp fisheries account for most of the landings and value. Although the shrimp landings are small, there is a significant offshore pink shrimp fishery that is based on Sanibel Island. This fishery is reflected in 1997 pink shrimp landings data for Lee County, which totaled 4,033,537 pounds. The Caloosahatchee Estuary and the area affected by freshwater releases from Lake Okeechobee comprise part of the nursery habitat for this fishery. The finfish and bait shrimp poundage, trips, and value data vary widely from year to year. This is due to changes in the fish population dynamics, fishing conditions, and fishing effort.

The Caloosahatchee Estuary also supports guided sport fishing and recreational fisheries. Nelson (1992) described the following recreational species as "highly abundant", "abundant", or "common" in the Caloosahatchee Estuary: tarpon, sea catfish, snook, crevalle jack, silver perch, pinfish, spotted seatrout, red drum, black drum, and stripped mullet.

2.15 EXISTING LAND USE

The Caloosahatchee River (C-43) West Basin Storage Reservoir is proposed for construction in north-western Hendry County. This reservoir is intended to reduce the fresh water pulses into Charlotte Harbor and the Caloosahatchee Estuary, and provide water storage for meeting environmental needs. Additional water, after environmental needs are met, could be used as supplemental water to help meet the needs of agriculture and urban communities in southwest Florida. The study area includes Lee, Hendry, Glades and parts of Charlotte County. Collier County is located in the general vicinity of the study area. ***Figure 2-12*** depicts the 2000 land use map for the southwest Florida region. This map was generated for the SWFFS and includes the Caloosahatchee River (C-43) West Basin Storage Reservoir study area.

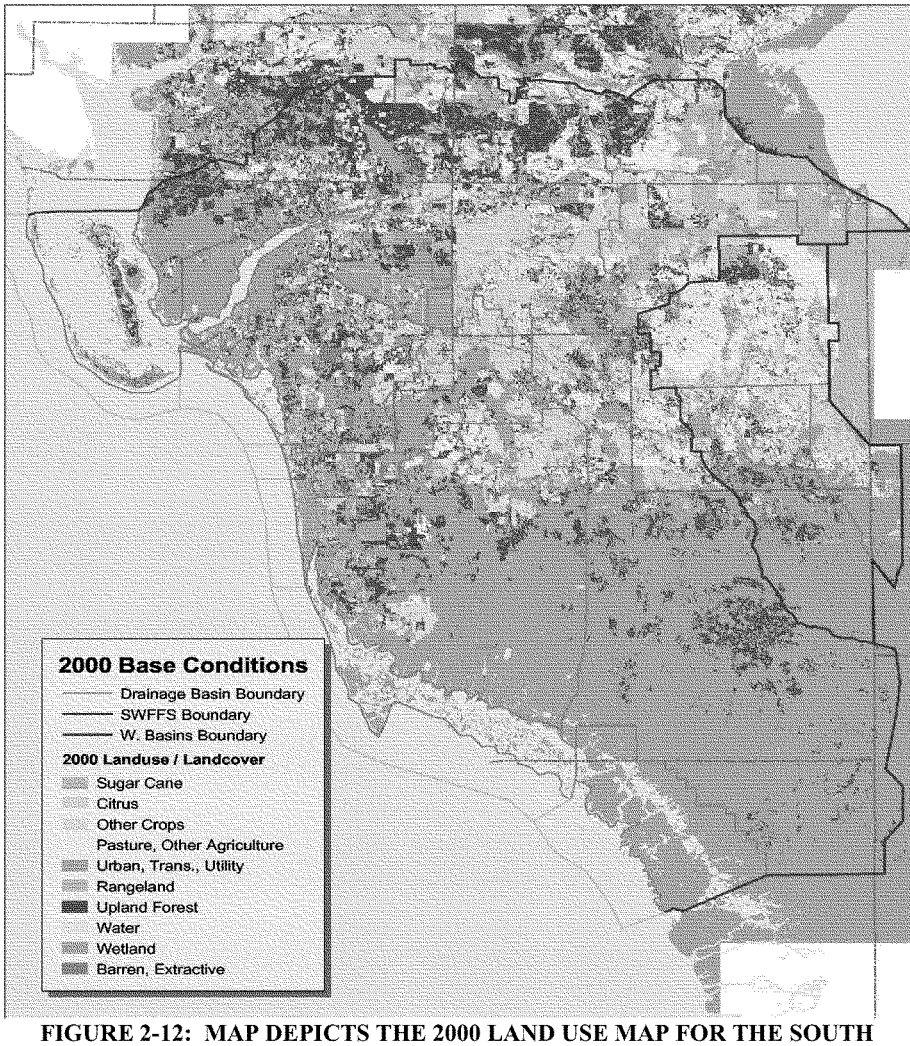


FIGURE 2-12: MAP DEPICTS THE 2000 LAND USE MAP FOR THE SOUTH WEST FLORIDA REGION

Much of the land use/cover change occurring in southwest Florida over the past several years can be categorized as either the creation of new developments in previously natural or agricultural areas, or the change in the types of agriculture practiced. Most of the new development appears to be in golf course/residential areas concentrated near Interstate 75 in Lee County. A majority of these residential areas and small reservoirs were associated with new golf course

communities. ***Table 2-7*** presents the number of acres associated with existing golf courses.

TABLE 2-7 GOLF COURSE ACREAGE

County	Year	Acreage
Lee	2000	8,962
Hendry	2000	120
Glades	2000	220
Charlotte	2000	460

The agricultural areas are inland from the urban areas and the Gulf Coast. They are being encroached upon by the urban areas and undergoing conversion within agricultural types. Much of Lee County is being converted from cattle farms to citrus, and there is a great deal of conversion year to year between pasture and row crops.

2.15.1 Agricultural Land Use

The Study Area continues to experience growth in irrigated agricultural acreage, especially citrus. The irrigated crops in this region are citrus, sugarcane, vegetables, sod, and greenhouse/nursery. Growth in citrus acreage is usually on land that was formerly pastureland. Descriptions of the agricultural acreage in each county are included ***Table 2-8.***

TABLE 2-8: TOTAL LAND AND FARM ACREAGE

Item	Florida	Charlotte	Glades	Hendry	Lee
Total Land Acreage	34,513,162	443,907	495,123	737,622	514,323
Farms	44,081	284	231	456	643
Farm Acreage	10,414,877	191,529	379,278	606,839	134,649

Source: USDA, NASS, 2002 Census of Agriculture

The following acreage by specific crop types was obtained from the Lower West Coast Water Supply Plan (LWCWSP) and pertains to acreage in 1995. The Caloosahatchee River (C-43) West Basin Storage Reservoir study area does not coincide exactly with the LWCWSP study area, but falls within the study area. Citrus is by far the dominant agricultural crop in the Lower West Coast (LWC) study area, and occupies approximately one-half of agricultural acreage in the region. Between 1968 and 1980 acreage remained at about the same level.

From about 1984 until about 1992, acreage grew rapidly, associated with the inter-regional movement of citrus acreage southward from Central Florida following several severe winter freezes in the mid-1980s. Since approximately 1992, citrus growth has slowed in the area. Tropical fruits (primarily avocados and mangos) and nuts are produced only in Lee County. In 1995, there were 1,930 acres of tropical fruits and nuts in Lee County. Vegetable crops grown in the study area include cucumbers, peppers, tomatoes, squash, eggplant, watermelons, Latin vegetables, snap beans, and potatoes. Different types of vegetables are often grown interchangeably, and in 1995 there were 44,231 acres of land used for vegetable production.

Hendry and Glades county areas are the only parts of the study area where sugarcane is produced. As a result of the cultivation practices used for sugarcane, 25 percent of the land used for sugarcane production is fallow in any given year. In 1995, a total of 35,443 acres of sugarcane were produced in the Hendry County Area. The seed corn production in southeastern Charlotte County varies from year to year, based primarily on the demand for seed corn, which in turn is dependent on seed corn production in other parts of the country. This variation in production is more a fluctuation than a trend. The estimate for seed corn production is 2,100 acres and 1,000 acres for soybeans. While fluctuations are anticipated, the magnitude of this acreage is typical. Rice in southern Glades County is grown during the summer months in rotation with sugarcane or winter vegetables, and takes place on land that would otherwise be fallow. Rice acreage in southern Glades County was assessed at 200 acres in 1995.

In 1995, there were a total of 650 acres of irrigated sod production in the LWC planning area. In 1995, there were 6,089 acres of greenhouse/nursery operations in the LWC planning area, and this is projected to increase to 10,627 acres by the year 2020.

2.16 NOISE

Within the major natural areas of south Florida, external sources of noise are limited and of low occurrence. Rural areas have typical noise levels in the range of 34-70 decibels, and urban areas may attain 90 decibels or greater. Noise generated on the project site is basically limited to agricultural machinery.

2.17 RECREATION AND AESTHETICS

Recreational opportunities in the basin include hiking, boating, fishing, and camping. Numerous recreation areas, such as Ortona Lock Recreation Area, Caloosahatchee Regional Park, and W.P. Franklin Lock Recreational Area, are extensively used by natives and visitors alike. Since the river is used for boat traffic between the east and west coasts of Florida, boat traffic is moderately

heavy and boating and fishing occurs in the area. The river banks are too steep to be useful for bank fishing. Several access points and three USACE lock structures are located along the river. Additionally, the FFWCC owns ramps at Wayside Park in Hendry County and at the intersection of SR 80 and Highland, east of Fort Myers, in Lee County. All the recreation sites along the river are well used, particularly on weekends.

Within the project footprint there are currently no recreation opportunities, as it is an active citrus grove. The visual aesthetics are characterized by limited viewsheds controlled by low topographic relief, typical of views of citrus groves, with a few remaining wetland areas scattered within the grove.

This page intentionally left blank

SECTION 3
FUTURE WITHOUT PROJECT CONDITIONS

This page intentionally left blank

3.0 FUTURE WITHOUT PROJECT CONDITIONS

The future "without project" condition describes the planning area's future if there is no federal action taken to solve the current problems. This condition is vitally important to the evaluation and comparison of alternative plans and to identify impacts (both beneficial and adverse) attributable to proposed federal actions. The without plan condition is the same as the "No Action" alternative that is required to be considered by the federal regulations implementing the National Environmental Policy Act (NEPA).

The assumption for this future without project analysis is that the project footprint would be in agricultural production as a citrus grove in 2050. Please see Section 3.15 Land Use for a more detailed description of future conditions of the project site and surrounding areas.

3.1 GENERAL ENVIRONMENTAL SETTING

The general environmental trends in the future without project condition are tied to the increase in population and decrease in quality and quantity of natural areas, as well as the continued high and low flows to the Caloosahatchee Estuary. The distribution of these high and low flows may change as increased demands on the water in Lake Okeechobee develop. Urban growth in Lee County has the potential to impact the region's environmental and water resources. Urban and industrial areas will increase, while range lands and upland forests will decrease. Wetland and aquatic habitat quality will continue to decline, as extreme flows from Lake Okeechobee will continue to cause huge variances in the salinity regime. The quantity and quality of fresh- and saltwater SAV will decline. This will generally leave less habitat for wildlife, resulting in a detriment to many threatened and endangered species as well as a decline in general ecological diversity of the region. The project site would most likely continue to be a producing citrus grove in the future without project condition.

Regulatory impacts were considered when compiling the future without project conditions. The MIKESHE model assumed no net loss of wetlands in the basin in the future without project (FWOP) scenario due to regulatory mitigation requirements. Under section 404 of the Federal Clean Water Act (CWA) permits are required for the discharge of dredge or fill material in waters of the United States including wetlands. In addition, unavoidable impacts to wetlands or other aquatic resources require compensatory mitigation. There are some exemptions under the CWA for agricultural activities. Digging ditches and farming uplands does not require a permit so this activity could occur in the basin without any USACE permit. Clearing and filling for development would likely require a permit. In that situation, mitigation may be done on site through enhancement and preservation of existing wetlands or offsite. In

addition, through the federal permit process the regulatory division of USACE evaluates compliance with other environmental laws such as Endangered Species Act (ESA).

3.2 CLIMATE

The National Oceanic Atmospheric Administration (NOAA) published historic rates of sea level rise at some NOAA stations in Florida (***Table 3-1***). The closest station to the Caloosahatchee River (C-43) West Basin Storage Reservoir Project area is Fort Myers; therefore, this station will be used to estimate sea level rise. The historic rate of sea level rise at Fort Myers is 2.29 millimeters per year (mm/yr) with a standard error of 0.452. Under current trends, it is estimated that sea level will rise 14 cm between 1990 and 2050 (2.29mm/yr x 60yr x 1/10cm/mm = 13.74 cm ≈ 14 cm).

TABLE 3-1: HISTORIC RATE OF SEA LEVEL RISE AT NOAA STATIONS IN FLORIDA

Atlantic Coast			Gulf Coast		
NOAA station name	Rate of sea level rise (mm/yr)	Standard error	NOAA station name	Rate of sea level rise (mm/yr)	Standard error
Fernandina Beach	2.04	0.12	Key West	2.27	0.09
Mayport	2.43	0.18	Naples	2.08	0.43
Miami Beach	2.39	0.22	**Ft. Myers**	**2.29**	**0.45**
-------	-------	-------	St. Petersburg	2.40	0.18
-------	-------	-------	Cedar Key	1.87	0.11

(Source: Sea Level Variations for the United States 1854-1999, NOAA, technical Report NOS CO-OPS 36, National Ocean Service, Silver Spring MD, Chris Zervas, 2001.)

Normalized sea level projections for 2025, 2050, and 2100, compared with 1990 level are shown in ***Table 3-2***. The normalized projection estimates represent the projected acceleration in sea level compared with historic trends due to the greenhouse contribution.

TABLE 3-2: NORMALIZED SEA LEVEL PROJECTIONS FOR 2025, 2050 AND 2100, COMPARED WITH 1990 LEVELS

Cumulative probability (%)	Exceedance frequency (%)	2025 (cm)	2050 (cm)	2075 (cm)	2100 (cm)
10	90	-1	-1	0	1
20	80	1	3	6	10
30	70	3	6	10	16
40	60	4	8	14	20
50	50	5	10	17	25
60	40	6	13	21	30
70	30	8	15	24	36
80	20	9	18	29	44
90	10	12	23	37	55
95	5	14	27	43	66
99	1	19	35	57	92
Mean		5	**11**	18	27
Standard deviation		6	10	15	23

To estimate sea level rise at a particular location, historic rate of sea level rise is added to the projected rise that would occur if current trends were to continue. For example, the historic rate of sea level rise at Fort Myers is 2.29 mm/yr with a standard error of 0.452 mm (***Table 3-3***). Under current trends, sea level will rise 14 cm between 1990 and 2050 (2.29mm/yr x 60yr x 1/10cm/mm = 13.74 cm ≈ 14 cm). Adding this 14 cm to the normalized values in ***Table 3-2***, the mean estimate for 2050 is 24 cm.

Since the historic rates of sea level rise in ***Table 3-1*** include the local vertical land motion, there is no need to adjust the estimated sea level rise to include historic vertical land motion unless there is strong evidence that the historical rate in vertical land motion has increased or decreased.

Table 3-3 shows the probabilities of various sea level rise amounts in the vicinity of Fort Myers for years 2025, 2050, 2075, and 2100.

TABLE 3-3: PROBABILITY DISTRIBUTION OF SEA LEVEL RISE FOR FORT MYERS FOR YEARS 2025, 2050, AND 2100

Cumulative probability (%)	Percent chance exceedance	2025		2050		2075		2100	
		cm	ft	cm	ft	cm	ft	cm	ft
10	90	7	0.2	13	0.4	19	0.6	26	0.9
20	80	9	0.3	17	.6	25	0.8	35	1.1
30	70	11	0.4	20	0.7	29	1.0	41	1.3
40	60	12	0.4	22	0.7	33	1.1	45	1.5
50	50	13	0.4	24	0.8	36	1.2	50	1.6
60	40	14	0.5	27	0.9	40	1.3	55	1.8
70	30	16	0.5	29	1.0	43	1.4	61	2.0
80	20	17	0.6	32	1.0	48	1.6	69	2.3
90	10	20	0.7	37	1.2	56	1.8	80	2.6
95	5	22	0.7	41	1.3	62	2.0	91	3.0
99	1	27	0.9	49	1.6	76	2.5	117	3.8
Mean		13	0.4	25	0.8	37	1.2	52	1.7

3.3 PHYSICAL LANDSCAPE

The lands within the project area would be developed consistent with surrounding land use patterns. The surrounding areas are predicted to still be in agricultural production in 2050. If the site remained a citrus grove, the geology and soils would not change significantly from the existing description.

3.4 HYDROLOGY

Changes to local hydrology are driven by changes in land use, water supply, water quality, and changes caused by other water resource projects in the watershed. Urban development and encroachment on previously undeveloped and low intensity agricultural lands in some areas of the Caloosahatchee Basin would be expected to increase the intensity and volume of runoff to local drainage systems and the Caloosahatchee River (C-43 Canal) during the wet season, thereby increasing flow rates and contributing to poor water quality. The increase in total area of impervious urban lands will also further decrease dry season base flows because less water infiltrates to the groundwater system, resulting in declining water table elevations.

As explained above, it is anticipated that a sea level rise of approximately 24 cm will occur over the period through the year 2050. This will impact control levels for canals within the Caloosahatchee River Basin to maintain a stable saltwater interface.

All of these factors would contribute to increasing ecological stress in the Caloosahatchee Estuary.

3.5 WATER MANAGEMENT

This section discusses the physical facilities and operational changes that are planned for the study area and are assumed to be in place for the future without plan condition.

3.5.1 Central and Southern Florida Project Modifications

The C&SF Project was authorized by the Flood Control Act of 1948, and modified by subsequent acts, as a plan of improvement for flood control, drainage, and other purposes covering an 18,000 square mile area of both central and southern Florida (C&SF). Within the Caloosahatchee River (C-43) West Basin Storage Reservoir Project area, C&SF canals include the C-43, C-20, and C-21. A number of efforts are currently underway by the USACE to modify the C&SF Project for environmental improvement. The following C&SF Project modifications are either in the planning, design, or construction phases and are included in the future without plan condition: 1) manatee protection, 2) other projects and structures, and 3) Lake Okeechobee Regulation Schedule (LORS).

3.5.1.1 Manatee Protection

The West Indian manatee (*Trichechus manatus*) is listed as a federally endangered species and is one of the most endangered species in Florida. As a response to recent manatee mortality trends associated with water control structures, the manatee protection C&SF modification project will provide operational changes and implement the installation of a manatee protection system at seven sector gates at navigational locks near Lake Okeechobee. The beneficial outcome of this modification project will be the reduction of risk, injury, and mortality of the manatee. The seven sector gates include S-193 at Okeechobee and S-310 at Clewiston on Lake Okeechobee; St. Lucie Lock and Port Mayaca Lock on the St. Lucie canal; and Moore Haven Lock, Ortona Lock, and W.P. Franklin Lock on the Caloosahatchee River. The future without plan condition for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project assumes that the automatic gate sensor devices are installed on these lock sector gates.

3.5.1.2 Other Projects and Structures

Existing projects and structures discussed in the existing conditions section of this report are assumed to remain in place and should be considered future without project conditions.

3.5.1.3 Lake Okeechobee Regulation Schedule

As part of the operation of the C&SF Project, the USACE establishes a water regulation schedule for Lake Okeechobee. A regulation schedule is a guideline for water managers to use in regulating the inflow and outflow of water through the various water control structures such as pumps, spillways and locks. Typically, a regulation schedule has water level thresholds which vary with the time of year and trigger discharges. The threshold values of regulation schedules define the release zones and are traditionally displayed graphically. Additionally, a corresponding table is typically used to identify the structure discharge rules for release zones.

Water levels are driven largely by climatic conditions across the entire watershed. One challenge of managing stage within Lake Okeechobee is that inflows to the lake frequently exceed total outflow capacity, causing the lake to rise very quickly. These sudden rises in stage may trigger discharges through the major outlets to the coastal estuaries in an effort to control excessive buildup of water in Lake Okeechobee. While the timing and magnitude of these releases is important for preserving the level of service for flood protection in the region, it also has significant impacts on the natural habitats of the downstream estuaries.

There is a need to manage Lake Okeechobee at a lower stage. Evidence of this has been clearly established for ecological reasons, such as the continued deterioration of Lake Okeechobee's littoral zone and both the Caloosahatchee and St. Lucie estuaries. The need to manage the lake lower also stems from integrity issues with the Herbert Hoover Dike (HHD) levee system that protects the surrounding communities from flood damage.

The goal of the new LORS is to implement a regulation schedule that would improve the health of Lake Okeechobee and the St. Lucie and Caloosahatchee estuaries, while continuing to ensure public health and safety, and with minimal or no impact to the competing project (lake) purposes. These goals are:

a. Ensure public health and safety
b. Manage Lake Okeechobee at optimal lake levels to allow recovery of the lake's environment and natural resources
c. Reduce high regulatory releases to the estuaries
d. Continue to meet Congressionally authorized project purposes including, flood control, water supply, navigation, fish and wildlife enhancement, and recreation

The 2007 LORS will result in water management operational guidance to be used on a daily basis in the management of Lake Okeechobee. Through the 2007LORS plan, the management of Lake Okeechobee water levels and

determination of Lake Okeechobee releases to the Water Conservation Areas (WCAs) and to tide (estuaries) is based on seasonally varying lake elevations divided into three bands. These bands include "High Lake Management," "Operational," and "Water Shortage Management." The High Lake Management Band is meant to address public health and safety, especially related to the structural integrity of HHD by providing the ability to make releases up to the maximum capacity that lake outlets will allow. The Operational Band is meant to facilitate authorized project purposes by providing the ability to make releases of various volumes, including no release; and Lake Okeechobee outlet canals should be maintained within their optimum water management elevations. The Water Shortage Management Band pertains to low lake levels which necessitate rationing water supplies. In this band, Lake Okeechobee outlet canals may be maintained below their optimum water management elevations. The water supply releases made within this band are made according to the SFWMD's draft Lake Okeechobee Water Shortage Management Plan (LOWSM).

The 2007 LORS provides the ability to make long-term, low-volume releases to the Caloosahatchee Estuary, St. Lucie Estuary, and WCAs. These releases include low-volume pulse releases and base flow releases to the Caloosahatchee and St. Lucie estuaries that allow Lake Okeechobee to be maintained at more desirable levels throughout the year. A pulse release attempts to simulate a natural rainstorm event within the basins. The receiving body would respond to the pulse release in a similar fashion as if a rainstorm had occurred in the upstream watershed. Although an average flow rate is targeted for the duration of the pulse release, daily releases vary. The pulse releases and base flow releases are intended to regulate lake levels and reduce the potential for future prolonged high-volume releases to the estuaries. The base flow releases also provide a benefit of maintaining desirable salinity levels in the estuaries. By regulating lake levels, these low-volume releases improve public health and safety performance by reducing risk to the HHD and provide improved benefits for the health of Lake Okeechobee and the estuaries.

3.6 WATER QUALITY

Future water quality conditions in the basin will be directly influenced by future land use, the operation schedule of Lake Okeechobee, and the implementation of Best Management Practices (BMPs) to control nutrient discharges. There are multiple state and Federal projects that will have an impact on future water quality loads within the freshwater Caloosahatchee Basin (upstream of S-79) as well as from the Caloosahatchee Estuary Basin (downstream of S-79). Two CERP projects, the Lake Okeechobee Nutrient Removal project and the Lake Okeechobee Sediment Removal project will result in reduced nutrient loading from discharges at S-79. Non-CERP programs that will impact water quality within the basin include:

1. USACE and SFWMD Revised LORS
2. SFWMD Lake Okeechobee Protection Plan
3. FDEP Lake Okeechobee Total Maximum Daily Loads (TMDL);
4. SFWMD Caloosahatchee Minimum Flows and Levels (MFL);
5. SFWMD Caloosahatchee River Water Management Plan (CWMP);
6. FDEP Caloosahatchee Basin TMDL
7. FDACS/FDEP Agricultural BMP Program for the Caloosahatchee Basin
8. SFWMD Urban Irrigation and Landscape BMP Implementation Projects
9. SFWMD Stormwater Management Regulations; and
10. Lee and Hendry Counties Stormwater Management Projects.

The Revised LORS is intended to decrease the frequency and severity of large volume discharges from the lake to the Caloosahatchee (C-43) and St. Lucie (C-44) rivers. The Lake Okeechobee Protection Plan and the Lake Okeechobee TMDL regulatory program will reduce nutrient loading into the lake through structural and non-structural measures. When implemented these programs should result in a reduction of nutrients contained in Lake Okeechobee discharges which in turn will reduce nutrient loading to the Caloosahatchee Estuary. The Caloosahatchee MFL program and CWMP are intended to ensure that urban, agricultural, and environmental water demands are met in the future. To the extent these projects alter the timing of river flows to the estuary, the shifting of nutrient loads from the wet to the dry season will result. The TMDL program for the Caloosahatchee will coincide with the development of numeric nutrient standards as well as the implementation of agricultural BMPs to meet those standards. Local government stormwater protection programs and projects within the basin will result in a reduction of pollutant loading from existing and future development. The net result of these programs should be a reduction of nutrient and other pollutant loads to the estuary in 2050.

Projections of future water quality in the Caloosahatchee River and Estuary are presented below. The estimates for Future Without Conditions have been developed under the assumption that non-CERP projects are successfully implemented by 2050 while CERP projects have not been implemented. In the absence of the CERP projects, the state will still be compelled by the TMDL regulations to achieve similar reductions in nutrient loads in order to meet requirements of the CWA.

3.6.1 Freshwater Caloosahatchee Sub-Basin (Upstream of S-79)

Flows at S-79 consist of runoff from the freshwater Caloosahatchee Basin as well as discharge from Lake Okeechobee. As this basin becomes more urban or more intensely cultivated, the quantity of runoff will increase which will likely result in higher nutrient loads. There are several commonly used methods to estimate the impact of land use changes on the quality of rainfall runoff. A quick and fairly standard method for calculating average annual pollutant loading is to

adapt the rational method used for estimating rainfall runoff. This load quantification methodology requires estimates for land use acreages, average annual rainfall, land use specific loading factors, and land use specific runoff factors. Loading estimates were prepared using land use specific runoff quality factors adapted from Harper (2003). The results of the analysis indicate that nitrogen and phosphorus loading from the freshwater Caloosahatchee Basin will increase by approximately eight percent. The increase in nitrogen and phosphorus loading expected under 2050 future without conditions is a reflection of the increase in the volume of runoff which will accompany urbanization of rural areas. If the implementation of BMPs to control runoff quantity and quality are moderately successful, it is likely that 2050 future without nutrient loads from this basin will be no higher than existing condition loads.

It is difficult to predict how much the average annual flow from Lake Okeechobee will change if CERP is not implemented. However, since there is a great desire to reduce the magnitude and frequency of extremely large discharge events at S-79, it is likely that 2050 without project average annual flow through S-77 will be reduced relative to the existing flow quantity. At the same time, efforts to reduce nutrient loading in Lake Okeechobee are likely to result in an improvement in the quality of water discharged from the lake. The net impact of reduced S-77 releases and improved lake water quality is a reduction in nutrient loads contributed by the lake to the estuary. Overall, nutrient loads delivered through S-79 to the estuary are expected to be no more than presently delivered to the estuary. If BMPs are implemented within the basin and are moderately effective, nutrient loads from upstream of S-79 in the future without condition should be less than the existing condition loads.

3.6.2 Caloosahatchee Estuary (Downstream of S-79)

Water quality conditions in the Caloosahatchee Estuary are influenced by nutrient loads at S-79, by runoff from the estuary sub-basin, and nutrient loads contributed by point source contributors such as wastewater treatment plants. Under the future without 2050 condition, the fraction of nutrient loads within the estuary that are contributed by flows from upstream of S-79 will continue to be between 65 percent and 75 percent as in the present condition.

Using present land use and future land use projections combined with typical runoff coefficients, it appears that the quantity of runoff from the estuary sub-basin may increase by up to 25 percent if no BMPs are implemented. The actual increase in runoff and nutrient load is likely to be significantly less than 25 percent since most of the shift in land use is to new urban development that will be required to have stormwater ponds. These ponds are effective in reducing offsite runoff as well as providing effective removal of non-nutrient pollutants such as hydrocarbons and heavy metals.

Since the 2050 population will be substantially greater than the year 2000 population, the quantity of treated wastewater effluent discharged to the estuary will increase. Regardless, with the expected implementation of TMDLs for the discharge of nutrients into the estuary, it is not unreasonable to expect that by 2050 most existing wastewater treatment plants and all future plants will incorporate tertiary treatment processes to remove nutrients. If the TMDL program is effective, the 2050 nutrient loads from wastewater effluent will be similar to or less than the present nutrient loads.

3.6.3 Summary

The overall change in nutrient loads delivered to the estuary under the future without condition will depend upon the success of the implementation of BMPs to control point and non-point discharge quality. Nutrient loads to the estuary will likely increase by ten percent or more if no BMPs or nutrient TMDLs are implemented in the Caloosahatchee Basin. If the implementation of BMPs substantially reduces non-point source nutrient loads and tertiary wastewater treatment is implemented basin wide, the 2050 future without nutrient loads may decrease by more than 25 percent as compared to the existing condition.

3.7 PLANT COMMUNITIES

The project site would most likely continue to be a producing citrus grove in the future without project condition. Consequently, the plant communities would be almost identical to those in the existing conditions.

3.7.1 Exotic Plants

Exotic plants have the potential for devastating effects to the entire south Florida ecosystem in the future. Species such as Melaleuca, Lygodium, Brazilian pepper, and Australian pine are all well established in south Florida and have the potential to drastically alter the entire ecosystem. The abundance and distribution of exotic/nuisance vegetation (e.g., Brazilian pepper) that provide little to no value for wildlife is expected to increase unless intensive control and removal efforts are successfully implemented. However, there are many efforts occurring to control exotic plants, including a CERP project entitled *Melaleuca Eradication Project and Other Exotic Plants-Implement Biological Controls*. If this occurs, the future without project would still include exotic plants but would likely include a different array of damaging plants, as controls are developed for established exotics and new exotics are introduced into the system. Because the project site is predominantly agriculture, it is not likely that exotics would be a predominant feature in the landscape. Within the project footprint, the exotic vegetation distribution along canals might change as biological controls become available for various exotics and/or new exotic plants invade the site.

It is difficult to forecast the future success of exotic control programs. Through a concerted effort across many agencies, there has been good success in controlling Melalecua in South Florida. It is still a major exotic pest, but it is now controlled rather than spreading. If similar resources are invested to control other major exotic pests in south Florida (such as those listed above), there is good reason to believe these programs would be a success. However, since there are a large number of exotic pest plants and limited resources to invest in this problem, it is hard to determine what will occur. If the programs are at least somewhat successful a more natural ecosystem will evolve due to other restoration efforts. If the ecosystem is overwhelmed with exotics and adequate exotic control programs are not implemented, exotic plants are expected to continue to spread and multiply at an alarming rate.

3.8 WETLANDS

This site would most likely continue to be a producing citrus grove in the future without project condition. Therefore the description of wetlands would be almost identical to that in existing conditions. It is likely that the quality of the wetlands may continue to decline as fluctuations in the hydrology continue and water quality declines as a result of agricultural run-off.

3.9 FISH AND WILDLIFE RESOURCES

Land use projections for 2050 predict that the acreage of natural habitats (e.g., upland forests and wetlands) and low intensity agricultural lands (e.g., unimproved and woodland pastures) in the area will decline. As these lands are developed or converted to more intensive uses, the quality of fish and wildlife habitat will likely decrease and become more fragmented. Wetland and aquatic habitat quality will continue to decline as extreme flows from Lake Okeechobee continue to cause huge variation in the salinity regime. The quantity and quality of fresh and saltwater SAV will also decline. Marshes will continue to deteriorate and convert to monocultural stands of emergent plants such as cattail, or convert to shrub/scrub habitats containing exotic or nuisance species. Both monocultures and exotic/nuisance shrub/scrub communities are low quality habitats.

Loss and degradation of habitat have generally resulted in the reduction of reptile and amphibian populations and that trend would likely continue. Populations of several furbearing animals that are dependent on higher quality habitats (e.g., muskrat, mink, and river otter) or that require large areas of contiguous habitat to survive (e.g., black bear) are also projected to decrease by 2050. Raccoons, opossums and other species that can survive in fragmented habitats with greater human presence will increase by 2050. In general seabird and shorebird populations show decreasing population trends and are projected to continue to decline into 2050. Waterfowl, wading birds, raptors, rails, coots,

and gallinules are also expected to decrease by the year 2050 as estuarine and freshwater habitat quality continues to decline under future without project conditions. The above predictions are based almost exclusively on the deterioration of wetland and forested habitats adjacent to the study area.

The project site in the future without project would not change significantly from the existing condition, although anticipated urbanization and fragmentation of surrounding natural areas will result in an overall decline in wildlife resources in the future.

Within the Caloosahatchee Estuary, salinity and proximity to SAV, mangroves, or marsh edge strongly determine the distribution of most fishes. For example, fish abundance declines dramatically with distance from marsh edge (Baltz et al. 1993). SAV, mangroves, and marsh habitats provide cover for juvenile fishes and adults of smaller species, as well as substrate for epiphytes and epifauna, which small fishes consume. Larger predatory fishes, such as spotted seatrout and red drum, forage along the edges of such intertidal habitats for small fishes, blue crab, and shrimp. Fishes that live in the open water of estuarine bays, such as bay anchovy and Gulf menhaden, gain refuge from sight-feeding predators in the turbid water. Those prey species are typically filter feeders, which eat zooplankton and phytoplankton. Demersal fishes, such as flounders, live in proximity to the bottom and are typically indistinguishable from the substrate. The deterioration of SAV and marsh habitats may temporarily benefit some estuarine-dependant fisheries, but an eventual decline in productivity will result as detrital input and SAV are significantly reduced due to extreme variations in salinity levels. The long-term loss of nursery habitat will result in population declines for many species of estuarine and marine fishes and macroinvertebrates, including those whose young of the year use fresher habitats.

3.9.1 Threatened and Endangered Species

As an active citrus grove, the proposed project site would continue to provide limited habitat value for threatened and endangered species. Direct loss of habitat, as well as fragmentation of habitat in surrounding areas, is likely to result in a continued decline in threatened, endangered, and state listed species. Section 9 of the Endangered Species Act (ESA) prohibits the unauthorized "take" of listed species on public and private lands, as a result of Federal and non-Federal actions. Future Federal actions unrelated to the proposed action but located in the study area, will require separate consultations pursuant to Section 7 of the ESA. In addition, future non-federal actions will be coordinated with USFWS through Section 10 of the ESA.

3.9.2 Essential Fish Habitat

Aquatic habitats within the Caloosahatchee Basin have been altered through the channelization of the river. Nevertheless, the basin continues to support fishery resources of some recreational and commercial importance. At least 70 percent of Florida's recreationally or commercially sought fishes depend on estuaries for at least part of their life histories (Harris et al. 1983, Estevez 1998, Lindall 1973). Seagrass communities within the Caloosahatchee Estuary provide critical refugia for juvenile fish such as redfish, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall decrease in species richness may be related to the loss of seagrass habitat and/or a result of alterations in the salinity regime and the timing of the freshwater discharges from the S-79 structure. The future without project condition would result in a loss of essential fish habitat by projected further disruptions in the distribution, timing and quantity of water flows into the Caloosahatchee Estuary.

3.10 ESTUARINE RESOURCES

Without the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, conditions in the estuary will continue to worsen between the present state and 2050. Annual variability in flow and salinity will remain high and established MFLs for the region will not be met. This will lead to salinity extremes outside of the tolerance ranges of many estuarine organisms and result in decreased species diversity. Further, there will be declines in estuarine habitat (SAV and oysters) and as a result, additional declines in the species that utilize these habitats.

Without the reduction of extreme flow and high salinity events, oyster reefs will eventually loose a large percent of the adult population and the ability to produce enough spat to reestablish previously stressed reefs. Without continued settlement, reefs (substrate) will eventually breakdown and become buried in the soft organic sediments. SAV will continue to follow current trends of spatial reduction. There will be substantial losses of *Vallisneria* and its seed bank, possibly to the point of no recovery, in the low salinity areas as it tends to be more fragile than the higher salinity species. In addition, water clarity is expected to decrease resulting in additional stress on the SAV.

3.11 AIR QUALITY

Due to increased population and urbanization, air quality in the future is expected to be degraded, while still complying with air quality standards.

3.12 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

The four major land parcels acquired or being acquired for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project are the Berry Groves tract, Bryan Paul tract, the MG Enterprises, LLC property, and the Griffin property. Over the last six years, the SFWMD has performed multiple Environmental Site Assessments as well as worked to remediate most of the point source contamination sites (a description of the findings of these assessments and completed remediation efforts are found in the existing conditions portion of this report). At present, most of this land is leased to agricultural operators who continue to cultivate the thousands of acres of citrus groves located on the properties. If the reservoir project is not constructed, it is likely that the SFWMD will either continue to lease the land to citrus farmers or sell the land to willing buyers. With no reservoir on the site, the potential for bioaccumulation of copper or other toxic substances from contaminated site soils is much less since this usually occurs when the soils are submerged. If the properties continue to be used as working groves, the application of pesticides will continue. New point source contamination sites on the properties will likely occur, but these new sites may be contaminated to a lesser extent than in the past given modern best management practice (BMPs) for the application of fertilizers, pesticides, herbicides and fungicides. Overall, since the future without condition will not include a reservoir on the site, the properties will pose only a typical HTRW risk to the environment similar to other citrus operations.

3.13 CULTURAL RESOURCES

Without the proposed project, archeological site 8HN129 may be destroyed as a result of development or expansion of citrus production. Since the site is located in the uplands, even though it is adjacent to a large wetland, it is probable that the site would be destroyed without evaluation or mitigation.

3.14 SOCIO-ECONOMIC CONDITIONS

Competition for regional water resources has intensified with the increase in population and agriculture industry growth. This places a strain on existing resources, which will eventually surpass the readily available sources. When the needs of the natural system are then factored in, demands become greater and conflicts among competing water users will become even more severe.

While most people recognize the need for a healthy ecosystem to support the region's economy and jobs, many people are concerned that restoration projects will displace farms and other businesses, limit development, reduce available water supply and reduce job opportunities. By contrast, continued degradation of the southwest Florida ecosystem will adversely affect the tourism and recreational industry that are important to the regional economy. The economic

future of the area will depend on both continued agriculture presence and new residential and commercial prospects. There is local concern that the infrastructure and services demanded by a growing residential population will exceed the means of producing the infrastructure and services.

3.14.1 Population Projections

Population for the four counties in the immediate study area (Charlotte, Glades, Lee and Hendry counties) increased at a high rate during the period from 1990 to 2000 (***Table 3-4***). Charlotte increased 27.6 percent, Lee 31.6 percent, Glades 39.3 percent, and Hendry 40.5 percent. The population of Florida and the United States increased 23.5 percent and 13.1 percent respectively over the same period.

According to the population projection derived from the Florida Bureau of Economic and Business Resources (BEBR), population in Charlotte County is expected to increase over 83 percent from 2000 to 2050; in Glades County, to increase by 74 percent; Hendry County, to increase by 96 percent; and Lee County, to grow by 97 percent. Florida as a whole is projected to grow 86 percent by 2050. The projected growth of the entire south Florida nine-county area is anticipated to be 78 percent over the same 50-year period. These estimated population increases are reflected in future without project condition water demands and land use patterns.

TABLE 3-4: CHARLOTTE, GLADES, HENDRY & LEE COUNTIES, POPULATION ESTIMATES 2000-2050 (1,000S) (BEBR PROJECTIONS, US CENSUS (2000))

Area	2000	2010	2020	2030	2040	2050
Florida	15,982.4	18,866.7	21,792.6	24,528.6	27,118.7	29,714.5
Charlotte County	141.6	169.5	198.9	225.9	242.8	259.8
Glades County	10.6	12.4	14.2	16	17.2	18.4
Hendry County	36.2	44.4	53.3	61.8	66.4	71.1
Lee County	440.9	546.8	653.3	753.9	810.3	866.9

3.15 LAND USE

Future land use projections in the Caloosahatchee Basin were updated as part of the larger regional Southwest Florida Feasibility Study (SWFFS). These regional projections will serve as a starting point for describing the C-43 project

study area's land use. These projections have been reviewed by agricultural and governmental interests in the study area and will be used as the most likely future scenario. These land use figures have been incorporated into C-43 project modeling efforts and presented in this PIR. The projections resulting from the SWFFS update apply to 2025 and 2050 conditions. For the C-43 study area, the 2025 land uses have been extended to reflect expected 2050 conditions. It is not anticipated that the agricultural acreages will increase or decrease substantially between 2025 and 2050, but the total urban acreages will increase in area and increase in density to account for the increase in population.

Land use in the Caloosahatchee Basin is split between agricultural land use, urban/metropolitan land and conservation land. In the eastern portion of the Caloosahatchee Basin, Hendry, Charlotte, and Glades counties have been predominantly agriculture and rural in nature, while in the western portion of the basin, Lee County is more urban and supports industrial and commercial development. The land use, as described by the Southwest Florida Regional Planning Council (SWFRPC), details Hendry County as remaining largely agricultural, with urbanized areas in Clewiston to the east and La Belle to the west, and intermittent preserves and wetlands throughout. Additionally there are two main industrial concerns in Hendry County, one west of Clewiston and one near the Lee County border. Like Hendry County, Glades County remains largely agricultural in 2025, with some urbanized areas (La Belle's northern reaches and Moore Haven on Lake Okeechobee) and preserves and wetlands throughout. Within the study area, Charlotte County will remain vastly agricultural with some preserves and wetlands areas.

The predominant land use in the Caloosahatchee Basin is agricultural, and is expected to remain so in the future. The study area continues to experience growth in irrigated agricultural acreage. The irrigated crops in this region are citrus (the dominant irrigated crop), sugar cane, vegetables, sod, and greenhouse/nursery. Over the past two decades, southwest Florida has had the fastest growing citrus acreage in the state. Growth in citrus acreage is usually on land that was formerly pastureland. Sugar cane closely follows citrus in dominance in terms of crops grown in the Caloosahatchee Basin. It is produced in the Caloosahatchee Basin in close vicinity to Lake Okeechobee (in Hendry and Glades counties). Sugar cane acreage has continued to increase since 1995 and is expected to continue to increase in the future. Irrigation is typically applied from the surface water sources in the Caloosahatchee Basin and consequently, subsidence is not a significant problem due to the soils being generally sandy, rather than organic.

In terms of urban and industrial development, Lee County is the most populous part of the study area. The Fort Myers/Cape Coral Metropolitan Statistical Area (MSA), unincorporated areas of Lehigh Acres, Buckingham, North Fort Myers, South Fort Myers, and East Fort Myers constitute the bulk of the population in

the western portion of the Caloosahatchee Basin (see ***Table 2-4*** in ***Section 2*** on population estimates by county). Urban growth in Lee County has the potential to impact the region's environmental and water resources. Drainage of wetlands caused by urban expansion, loss of natural surface water storage areas, and contamination from urban land use are the major water related issues in the urban areas. Growth in this part of the basin generally follows the I-75 corridor, with the greatest portion of the population being located west of S-79. The majority of projected urban growth in this part of the basin is located to the east of I-75 toward the S-79 and contains a mixture of single family/multifamily dwellings, commercial and industrial facilities, some mining operations and preserves/wetlands. ***Figure 3-1*** presents a map of the 2050 future land use conditions in the C-43 study area. ***Figure 3-2*** presents a map showing changes between existing (2000) conditions and future without project conditions. ***Table*** 3-5 shows changes to land use for the 2025 and 2050 conditions.

There are a number of areas where urban development, agriculture, and/or proposed conservation areas compete for the same land. While these competing areas are not large compared to the entire area being modeled, they are significant. There were two most likely scenarios that were determined to be applicable to the C-43 study area. The first of these scenarios corresponds to land use in 2025, the second to land use in 2050. The first scenario has agriculture out-competing or "trumping" new low-density residential urban use, agriculture develops in areas proposed for conservation (not existing conservation lands, however), and marginal urban land has not developed yet. The second scenario, or 2050 conditions, also has agriculture trumping new low-density residential urban, agriculture is allowed to develop in areas proposed for conservation, but marginal urban land has now developed. ***Figure 3-1***, ***Figure*** 3-2, and ***Table 3-5*** show the projected difference between 2000 and 2050 land use. General characterizations of the study area can be determined and forecasts that in the future, urban lands and agriculture will increase in acreage, resulting in a decrease in natural areas. Within the C-43 study area, urban lands are expected to increase from 47,000 acres in 2000 to 114,000 acres in 2025 and 127,000 acres in 2050. Sugar cane is expected to increase to 116,000 acres in 2025 and decline slightly to 113,000 acres in 2050. Acreages for citrus are 118,000 in 2025 and 110,000 in 2050. Vegetable crops and sod production are expected to increase by 10,000 acres by 2025. Given the high probability that urbanization will meet or exceed the counties' current future-growth plans within the next 20 years, it may be difficult for the agricultural community to meet its 2025 goals.

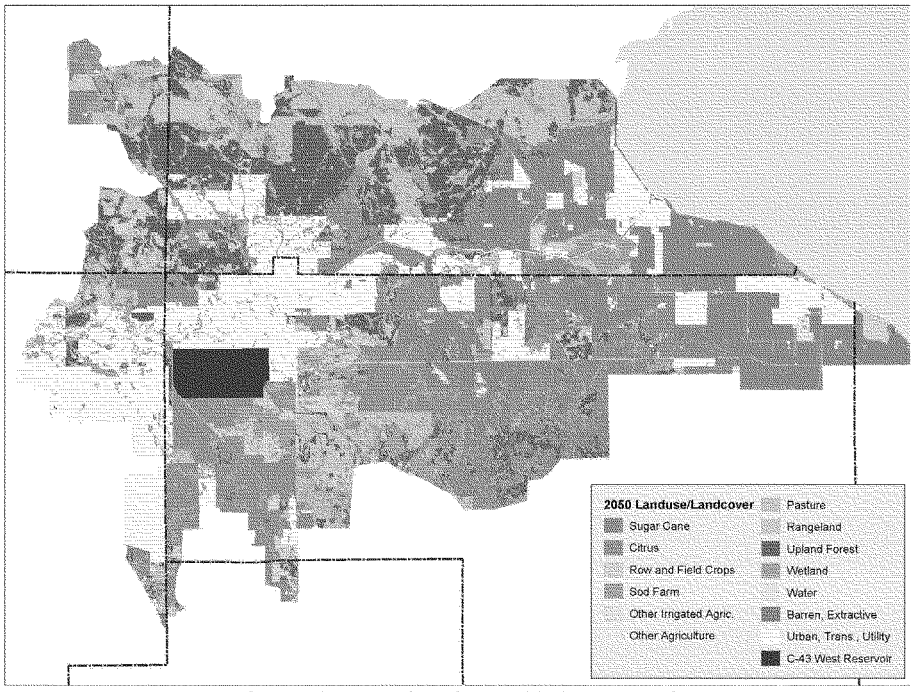


FIGURE 3-1: PROJECTED 2050 LAND USE

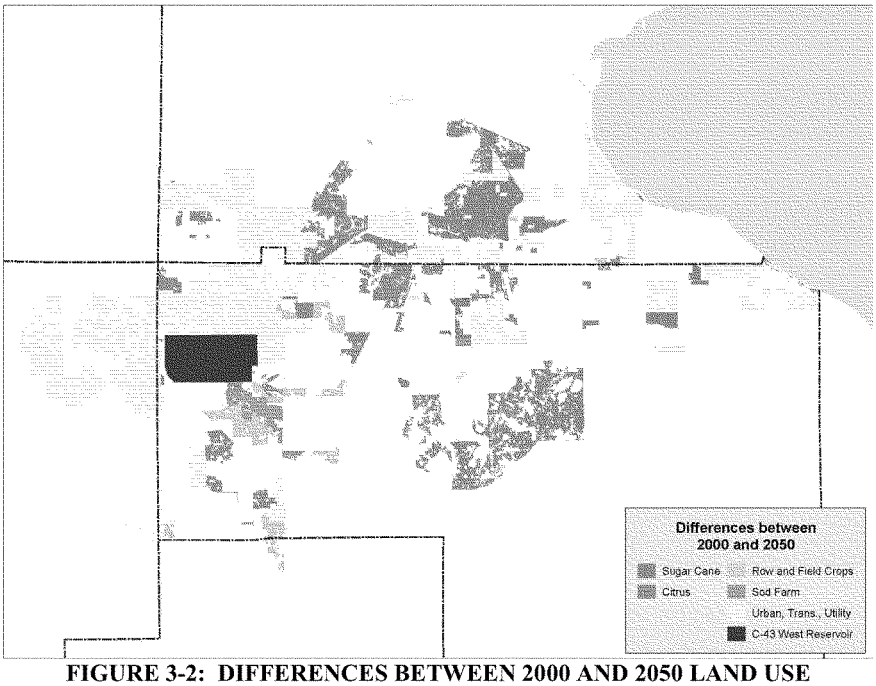


FIGURE 3-2: DIFFERENCES BETWEEN 2000 AND 2050 LAND USE

TABLE 3-5: PROJECTED DIFFERENCE BETWEEN 2000 AND 2050 LAND USE

	2000 LAND USE	2025 LAND USE	Change from 2000 to 2025	2050 LAND USE	Change from 2000 to 2050	Change from 2025 to 2050
	(Acres)					
Sugar Cane	101,513	116,105	14,592	112,970	**11,457**	(3,135)
Citrus	99,855	118,469	18,614	110,037	**10,182**	(8,432)
Row Crops, Field Crops	11,026	17,557	6,531	16,506	**5,480**	(1,051)
Improved Pasture	101,170	38,691	-62,479	38,691	**-62,479**	0
Unimproved and Woodland Pasture	28,344	16,493	-11,851	16,493	**-11,851**	0
Other Irrigated Agriculture	508	474	-34	174	**-334**	(300)
Sod	482	4,024	3,542	4,008	**3,526**	(16)
Other Agriculture	5,220	2,284	-2,936	2,098	**-3,122**	(186)
Urban, Trans., Comm., and Util.*	46,800	113,553	66,753	126,671	**79,871**	13,118
Low Density Residential	13,443	54,779	41,335	33,509	20,066	(21,269)
Medium Density Residential	4,704	31,633	26,929	61,160	56,456	29,527
High Density Residential	193	1,792	1,599	6,616	6,423	4,824
Range	31,898	20,651	-11,247	20,651	**-11,247**	(0)
Upland Forest	96,265	76,259	-20,006	76,259	**-20,006**	0
Water	5,447	5,356	-91	5,356	**-91**	(0)
Wetland	96,056	96,188	132	96,188	**132**	(0)
Barren, Extractive	6,635	5,115	-1,520	5,115	**-1,520**	(0)
TOTAL	631,218	631,218	0	631,218	**0**	0

*Residential acreage figures are included in the urban acreage total

3.16 MUNICIPAL AND INDUSTRIAL WATER SUPPLY

The Restudy recommended the development of a feasibility study to identify southwest Florida water resource conditions, and to develop potential solutions to any problems that may be identified. This municipal and industrial (M&I) water use forecast is part of the overall SWFFS, and includes Lee County, most of Collier and Hendry counties, and portions of Charlotte, Glades and Monroe counties, which encompass the Caloosahatchee River Basin and the C-43 study

area. The water demand projections for the SWFFS do not exactly coincide with the C-43 study area. Collier County is not included in the C-43 study area. The water use sectors for which forecasts were developed include public and self-supply domestic (residential), commercial, industrial, government, and unaccounted-for water loss. Water use in agriculture, mining, and power generation were not addressed as part of the M&I forecast, but are addressed under a separate agricultural water demands section. The purpose of the M&I water use forecast is to estimate existing water use and to develop water use projections for the SWFFS area.

An M&I forecast is required as input to modeling efforts which serve as the basis for planning and optimally designing the Caloosahatchee River (C-43) West Basin Storage Reservoir for both existing and future planning conditions. The planning horizon extends to the year 2050. Water use is estimated from the present to 2050 for natural area environmental purposes, agricultural irrigation purposes, M&I use, and other purposes.

The M&I water use forecasts were developed using the IWR-MAIN Water Demand Management Suite. The IWR-MAIN software allows water use forecasts to be developed based on existing water use patterns and existing or forecast socioeconomic parameters and then allows the impact of water conservation measures on those water uses to be evaluated. To maintain consistency with the water use forecasts developed for the Initial CERP Update (ICU), the water use models developed for the western portion of the study area in the ICU analysis will be used in this analysis. In the ICU, residential water use was forecast using a multiplicative forecast model and nonresidential water use was forecast using a constant use rate model.

Golf course irrigation requirements were based on a model developed by SFWMD and previously used in projecting water use in the Lower West Coast Water Supply Plan (LWC WSP). The SFWMD model consisted of using multiple regression analysis to project future golf course acreage as a function of projected population, and then applying irrigation requirements to those acreages based on the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) model. Irrigation requirements from AFSIRS, based on a representative irrigation system/rainfall station/soil type combination for each county, were then applied to the projected golf course acreage to develop projected golf course irrigation requirements.

Consistent population projections are critical to the development of M&I water use because they are used to directly project housing and employment statistics, the main drivers of the IWR-MAIN water use models. The population projections from 2000 to 2050 were based on population projections produced by the University of Florida, BEBR. BEBR generates low, medium, and high sets of population projections for each county in Florida for 2005 through 2030. The

medium population projections are believed by BEBR to most likely provide an accurate forecast of future county populations. The high and low population projections were developed to address uncertainty based on past population forecast error.

Three population projection scenarios were developed for this analysis. The BEBR medium projections were the basis for the medium or most-likely scenario for all counties, and the BEBR high and low population projections were the basis for the high and low scenarios, respectively. In order to develop projections to 2050, the growth rate exhibited in the national population projections from 2030 to 2050 was applied to the projected 2030 BEBR population for each county.

The IWR-MAIN models were calibrated to local water use patterns using the most recent data available (2000), then used to estimate water use for 2000 and project water use, in five-year intervals, to 2050. Four sets of forecasts were developed. Three were based on differing population projection scenarios, and one was based on one-in-ten year drought conditions. Projection of future water use included the implementation of all reasonable conservation measures.

According to the USGS, in 2000 estimates of annual water withdrawals (***Table*** 3-6***)*** total public-supply water use for the region is estimated at 72 MGD and from the IWR-MAIN model (***Table 3-6***) the total M&I water use is estimated at 115 MGD. The addition of 681 MGD of agricultural water use increases total water demand for the region to approximately 796 MGD. Agricultural water use accounts for 86 percent of the total use; public-supply water use, nine percent; and recreational self-supply, about four percent.

TABLE 3-6: USGS ESTIMATED TOTAL WATER USE (MGD), FOR SELECTED COUNTIES, 2000, EXCLUDING MINING AND POWER GENERATION

	Municipal and Industrial							
		Self-Supply						
County	Public Supply	Domestic	Commercial	Industrial	Recreation	Sub Total	Agriculture	**Grand Total**
Charlotte	14.21	3.55	0.11	0	3.48	21.35	47.19	**68.54**
Glades	0.55	0.61	0.04	0	0.42	1.62	69.02	**70.64**
Hendry	4.72	1.67	0.21	0.51	1.09	8.2	503.91	**512.11**
Lee	52.37	8.86	0.46	0.09	22.66	84.4	60.51	**144.95**
Total	**71.85**	**14.69**	**0.82**	**0.6**	**27.65**	**115.57**	**680.63**	**796.24**

On the county-level, the largest total water user in the study area in 2000 was Hendry County, mainly because of agricultural water use. Hendry County used a total of 512 MGD, or 64 percent, of the total regional water use. Of this

amount, 504 MGD (or 98 percent) was agricultural use and 4.7 MGD was public-supply M&I water use. Lee County's total water use was 145 MGD, the second highest in the study area, with public-supply water use accounting for 52 MGD or 36 percent. Lee County had the highest self-supply domestic water use in the region at 8.9 MGD. Lee County also had high recreational water use, with 22.7 MGD.

Table 3-7 represents the conservation-adjusted, most likely population scenario, water use forecast and the percent of total water use associated with each county or county area in the study area, for 2000, 2025, and 2050. Lee County accounted for 90.7 percent of all M&I water use in the study area in 2000, and will account for 90.4 percent of all water use by 2050. The population of Lee County is projected to increase by 97 percent over the same time period. The Glades County Area generates the smallest use, at slightly more than two percent of the total regional water use over all time periods. Due to the small population in the Charlotte County portion of the study area, the water use totals for Charlotte County are incorporated into those of Glades County and therefore the USGS 2000 baseline totals do not exactly equal the IWR-MAIN 2000 totals.

TABLE 3-7: C-43 STUDY AREA, M&I CONSERVATION-ADJUSTED WATER USE AND DISTRIBUTION, BY COUNTY AREA MOST-LIKELY POPULATION SCENARIO, 2000, 2025, AND 2050

	2000		2025		2050	
Area	MGD	Percent of Total	MGD	Percent of Total	MGD	Percent of Total
Lee County	92.7	90.7 %	129.5	90.4 %	148.0	90.4 %
Glades County Area	2.4	2.4 %	4.0	2.8 %	4.5	2.8 %
Hendry County Area	7.1	6.9 %	9.7	6.8 %	11.2	6.8 %
Total	**102.2**	**100.0%**	**143.2**	**100.0%**	**163.7**	**100.0%**

3.16.1 Agricultural Water Demand

The SFWMD calculated agricultural water demands as part of the CWMP in April 2000. These water demand calculations are the most current demands available for the C-43 study area and are a sufficient base point for demonstrating future demands and trends for the planning horizon.

The Southwest Florida Regional Planning Council (SWFRPC) has estimated that total agricultural acreage will increase between three percent and seven percent between 1995 and 2020 while citrus acreage will increase between 54 and 81 percent and sugar cane between 62 and 190 percent. The increase in

citrus and sugar cane acreage is due in a large part to conversion of existing irrigated acreage that is in other crop types to citrus and sugar cane. Based upon representation from the agricultural industry and Citrus Administrative Committee (CAC) discussion and concurrence, 2020 citrus acreage of 112,500 and sugar cane acreage of 125,000 were modeled. This represented a reduction from the SWFRPC estimate but an increase from the SFWMD District-Wide Water Supply Assessment (DWSA) completed by the SFWMD in July 1998.

The acreage for citrus and sugar cane in the 1995 CWMP does not exactly coincide with the land use update presented in this section. Upon adoption of the new land use figures, the agriculture water demand figures will be updated. A scientific procedure that considered existing land use, ownership, suitability for crop use, and proximity to existing agricultural lands was used to adjust the 1995 land use map to the 2020 land use projections. An explanation summarizing the steps involved in development of the 2020 land use coverage is included in the Land Use section of the CWMP. Based on the 2020 land use map, the MIKESHE model was used to estimate future agricultural demands.

The MIKESHE model developed for the CWMP was used to estimate the future demands by incorporating the 2020 land use information and modifying irrigated areas within the model to match the new land use. The MIKESHE model used an eight-year period (1988-1995) to simulate demand. The selected period represents a combination of wet, dry, and average years representative of variations within the Caloosahatchee Basin. The resulting demands for the 2020 Base Case using the MIKESHE methodology therefore represents probable demands based on 2020 land use and hydrologic data corresponding to an eight-year period. The resulting demands for the entire planning area, including both the Lake Okeechobee Service Area (LOSA) and non-LOSA portions of the basin, were obtained.

Table 3-8 summarizes the simulated 2020 irrigation demand for major agricultural land use categories for the CWMP area based on the MIKESHE model

TABLE 3-8: SUMMARY OF 2020 WATER USE DEMAND BASED ON THE MIKESHE FOR MAJOR AGRICULTURAL LAND USE CATEGORIES.

Crop	Water Use (1,000 acre-feet/year)
Citrus	242
Sugar cane	181
Vegetables	27
Total	450

Irrigation demands are expected to increase approximately 55 percent in the Caloosahatchee Basin between 1995 and 2020, according to the CWMP. No projected increases in irrigated acreages between 2020 and 2050 are expected, and there may potentially be a slight decline. It is expected that 2050 demands will approximate 2020 demands of 450,000 acre feet annually. After completion of the 2025 and 2050 land use projections, these new acreage figures will be modeled and new estimates of agricultural water demand will be presented.

3.17 NOISE

Noise in south Florida is expected to increase due to increased populations and urbanization. Noise levels within the project site should not change significantly in the future without project condition.

3.18 RECREATION AND AESTHETIC RESOURCES

The Florida State Comprehensive Outdoor Recreation Plan (SCORP) is the best source of information on recreation demand and supply at the state and regional scales. It divides the state into 11 planning regions, each with clusters of counties. Region 9 is the planning region that encompasses the study area and includes the following counties: Charlotte, Collier, Glades, Hendry, Lee, and Sarasota.

Recreation demands were developed for the SCORP through surveys of residents and tourists. The State of Florida's Division of Recreation and Parks conducts periodic surveys of resident and tourist participation in recreation activities to estimate outdoor recreation in Florida. The recreation participation information was derived from the 2000 surveys conducted by the University of Florida, Department of Recreation, Parks, and Tourism. Participation in outdoor recreation activities is expressed in terms of user-occasions, which occur each time an individual participates in a single outdoor recreation activity. The number of user-occasions was calculated for each planning region as well as the entire state by type of activity. Demand was estimated for 1997, 2000, 2005 and 2010 by applying the per capita participation rates to population projections.

Table 3-9 presents 1997 and projected 2010 user-occasion demands for selected recreation activities. Activities selected were those that could potentially be affected by the hydrologic changes or ecological changes associated with the alternative restoration plans. The table includes user-occasions as well as facility/resource needs. The region is expected to have significant increases in demands for the selected recreation activities with a commensurate need to increase development of the regions' recreation resources and facilities.

TABLE 3-9: DEMAND AND FACILITY NEEDS (1997 AND 2010) FOR SELECTED RECREATION ACTIVITIES IN SOUTHWEST FLORIDA (SCORP REGION 9)

Activity	Units	Demand (user-occasions)		Resources / Facility Needs	
		1997	2010	1997	2010
Hunting	Acres	108,131	139,247	0	0
RV / Trailer Camping	Camp Sites	1,501,713	2,386127	0	0
Tent Camping	Camp Sites	155,069	204,538	0	0
Hiking	Miles	1,299,375	2,011,069	223	517
Freshwater Fishing	Feet	543,125	779,561	0	0
Nature Study	Miles	2,146,713	3,073,615	10.87	56.8
Bicycle Riding	Miles	11,761,917	16,675,164	771.33	1,177.08

Source: Florida Department of Environmental Protection, 2000.

In summary, the Southwest Region (Region 9) ecosystems support a significant amount of outdoor recreation. A large portion of the expenditures comes from tourists. As can be seen from ***Table 3-9***, recreation activities for which there is an existing and increasing supply shortage include hiking, bicycle riding and nature study. With continued development and growth in southwest Florida, recreational demands are anticipated to increase and the current level of recreational opportunities will be insufficient.

The aesthetics of the proposed project site will be unchanged in the future without project condition. Surrounding areas will reflect a mixture of unchanged agricultural views as well as an increase in urbanization and population growth in some areas.

3.18.1 Commercial and Recreational Fishing Resources

Altered freshwater releases to the Caloosahatchee Estuary from Lake Okeechobee and the Caloosahatchee watershed have stressed estuarine ecosystems due to excessive salinity fluctuations, critically low benthic oxygen levels, increased turbidity that blocks sunlight to seagrass communities, algae blooms and subsequent declines in dissolved oxygen. These detrimental environmental effects can lead to commercial and recreational fishing impacts. The challenge in estimating the economic effects on commercial and recreational fishing in the Caloosahatchee Estuary is complicated by the inability to quantify the decrease in fish numbers and accurately measure the decrease in fish yields. It is reasonable to assume that as fish populations decrease due to degraded conditions in the estuary, the supply of fish will decrease, restrictions will be placed on certain species of fish, and greater distances will have to be traveled for commercial fishing vessels who in turn will realize smaller catches, all

leading to a decrease in economic activity associated with commercial and recreational fishing.

This page intentionally left blank

SECTION 4
IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

This page intentionally left blank

4.0 IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

4.1 STATEMENT OF PROBLEMS AND OPPORTUNITIES

To focus on water resources problems and opportunities in the C-43 Canal (Caloosahatchee River) basin to be addressed with this project, the project delivery team (PDT) began with the project components and purposes for the C-43 Canal basin as described in the 1999 Central & Southern Florida Comprehensive Review Study. The CERP Programmatic Regulations Draft Guidance Memoranda (GM) #1 and #2 (USACE 2004) instruct PDTs to focus on specific issues and problems identified in the Comprehensive Plan related to a given project component, and to update project-specific concerns as needed based on more current or improved information. The PDT therefore began by examining the problems and opportunities identified in the Comprehensive Plan for the Caloosahatchee River and its estuary, but also undertook a more detailed analysis of problems and opportunities in the study area in response to more recent questions and concerns expressed by the resource agencies and the public. This section describes the problems and opportunities identified in the study area and the planning goals and objectives developed by the PDT for the project.

While this section outlines the problems and opportunities identified by the PDT for the entire basin, it should be noted that the project has been split into two separate PIRs. The first of these two PIRs (Caloosahatchee River (C-43) West Basin Storage Reservoir project) will focuses on reaffirming that project goals and objectives can be achieved by constructing and operating an above-ground reservoir on lands already acquired for this purpose (Berry Groves).

4.1.1 Public Concerns

An integral component of the identification of problems and opportunities is an understanding of the public's concerns (USACE 1999). Public workshops were conducted early in the planning process for this project in order to gather public input and to document public concerns related to the problems, needs, and opportunities within the Caloosahatchee River watershed. Numerous presentations to public groups were conducted, including Lee, Collier, Hendry and Glades counties; the cities of LaBelle, Moore Haven, and Clewiston; local agencies; agricultural organizations; civic groups; business groups; clubs and neighborhood organizations.

In February of 2001 and 2002, representatives from the USACE and the SFWMD conducted two workshops/public meetings with various groups and individuals to provide a brief overview of the process for development of a PIR for the Caloosahatchee River (C-43) West Basin Reservoir Project and to obtain an understanding of the public's concerns and issues. The public meetings were held in LaBelle, Florida at the Hendry County Extension Service Building on

February 26, 2001 and at the LaBelle Civic Center on February 28, 2002. Approximately 35 people attended the meeting in 2001 and approximately 35 people attended the meeting in 2002. Information collected at these meetings was used to help inform the plan formulation process.

In addition to the earlier meetings, a NEPA scoping letter was sent out in March 2003 requesting input from the public and federal, state, and local government agencies. A public scoping meeting was subsequently held in LaBelle on May 1, 2003. By this time the team had completed some initial plan formulation and screening. The public was updated on the progress and status of the project to that point. Meetings were also held in the spring of 2003 with various stakeholders including recreational interests, agricultural interests, and local policy makers.

Table 4-1 outlines the public concerns that were brought to the PDT's attention through written correspondence, phone calls, and public meetings.

TABLE 4-1: PUBLIC COMMENTS AND HOW THEY WERE ADDRESSED

Issue Category	Public Comment-Issue, Problem, or Opportunity	Response/Action taken
Ecological	Health of the estuary	Main purpose/objective of study
	Fish health and abundance for commercial and recreational uses	Performance measures will be used to evaluated the different plan alternatives ability to improve estuarine conditions for improving fish health
	Water quality	Water quality of reservoir(s) to be evaluated as to not cause or contribute to water quality problems; also addressed in later study
	Wildlife health and abundance	Ecological performance measures
	Dredging of oxbows	Being accomplished by several other projects
	Use of water stored in reservoir	Water reservations and effects on water supply studied as part of project assurances analyses; Draft operating manual will accompany PIR
	Water allocation concerns	Water reservation studies will be completed
Ecological	Water level on the river	Project objective to deliver a more consistent water flow to estuary, which would result in a more consistent water level
	Littoral zone around reservoir to promote fishing and fish habitat	Included around seepage canal

Issue Category	Public Comment-Issue, Problem, or Opportunity	Response/Action taken
	Lake Hicpochee for natural area restoration	Lake Hicpochee will be considered for natural area restoration under later study
	Exotic/invasive plant control	Other projects are addressing this issue; proper procedures will be used to minimize this problem during construction
	Recreation and restoration as opposing uses	Restoration is the main purpose of this study, so restoration will not be sacrificed for recreational opportunities. However, recreation will be considered wherever it is viable and applicable trade-offs displayed.
Economic	Economic impacts	Socioeconomic analysis
	Tourism	Healthier estuary will promote tourism
	Water supply	Effects on water supply studied as part of project assurances analyses
	Cost of project	Cost estimates in PIR; part of alternative screening; addressed through cost effectiveness and incremental cost analyses
	Loss of tax base in Hendry County	Project will analyze impacts resulting from a reduction of agriculture land and its effect on county tax base.
	Concern that cost will outweigh benefits	Cost effectiveness/ incremental cost analyses will be performed to justify costs
	Loss of Highway 80 property for development	The State has located the reservoir a significant distance from Highway 80 so that development will not be hindered.
Engineering	Flood control	Modeling of alternatives to ensure no harm
	Questions on ASR	Separate study–see ASR pilot project Draft PIR/EIS
	Drainage problems in basin	Not a project purpose–will recommend to the SWFFS
	Suggest deeper reservoir	Geotechnical studies were conducted to determine appropriate maximum depths
	Visual aesthetics – high levee is not conducive to visual enjoyment	Due to the soils, aquifers, and topography, high embankments cannot be avoided

Issue Category	Public Comment-Issue, Problem, or Opportunity	Response/Action taken
	Water loss due to evaporation	ASRs (part of a later study) are envisioned to complement the reservoir(s), and will decrease total loss to evaporation
Other	Hurricane evacuation: route/safety issues	A meeting was held to develop safety standards for all CERP projects; local evacuation planning is not included as part of this PIR, but evacuation plans/procedures are considered in the project operating manual.
Recreation	Recreational opportunities	CERP recreation plan: Project has considered recreational opportunities compatible with restoration objectives;
	Active recreation opportunities (baseball fields, playgrounds, etc.)	Recreation plan is attached; passive recreation is most appropriate for this site.
	"Watchable" wildlife areas	These were incorporated into the Recreation Plan for the selected alternative plan (SAP)

4.1.2 Ecological Problems and Opportunities

Natural resource specialists agree that the remaining ecosystems in south Florida no longer exhibit the functions and diversity that characterized the pre-drainage system, and that key measures of ecological health will continue to decline without preventative actions. Not only is it certain that these natural systems will not recover their defining attributes under current conditions, it is unlikely that even the current, unacceptable ecological conditions can be sustained into the future (USACE, 1999).

The Caloosahatchee watershed has some ecological problems that are unique to the basin, as well as environmental problems that can also be found elsewhere in south Florida. Agricultural industry growth, urban development and the associated water management practices that accompany these activities have created undesirable conditions in the river and estuary. These problems are predicted to be magnified in the future. Some of the identified problems affecting the Caloosahatchee Basin are:

- Extreme changes in salinity in the Caloosahatchee Estuary due to either excessive or insufficient freshwater discharges over the W.P. Franklin Lock and Dam (the S-79 structure), which demarcates the division between the freshwater and tidal portions of the Caloosahatchee River.

- Loss of freshwater and marine SAV, due to salinity imbalances in the estuary.
- Truncation of estuarine extent and function due to the physical constraint of S-79 (the structure effectively blocks tidal flows upstream of that point).
- Major changes in riverine, drainage, and seepage characteristics due to excavation of 25-foot deep navigational channel in C-43.
- Reduction of oysters and blue crab habitat areas due to low salinity conditions in the lower estuary.
- Water quality problems in the river and estuary that are the result of pollutant laden (particularly nutrients) runoff from within the basin.
- Other water quality problems, including low dissolved oxygen (DO), high metals, high coliform bacteria, and diminished biological integrity.
- Increased occurrences of phytoplankton algal blooms and fish with lesions in the Caloosahatchee Estuary (FDEP2003).
- Loss of spatial extent of wetlands and associated uplands in the Caloosahatchee Basin.
- Availability of and competition for water supply for environmental, agricultural, and urban needs during dry periods.

To understand the full extent of these problems and to formulate potential solutions, it is necessary to first understand the changes that have occurred in the river and estuary.

Since the turn of the twentieth century, land reclamation, flood damage reduction and water management projects (consisting of complex networks of canals, structures and levees) have drastically altered the wetland ecosystem and hydrologic regime that once existed in the Caloosahatchee watershed. The manmade connection between Lake Okeechobee and the Caloosahatchee River (originally created in the late 1800s) has disrupted the natural pattern (quantity and timing) of freshwater flow into the Caloosahatchee Estuary. Problems in the estuary have been compounded due to the addition of water control structures on the river, the network of channelized tributaries and drainage canals in the basin connecting to the river, and associated water demands and flood protection requirements of urban and agricultural users.

The W.P. Franklin Lock and Dam structure (S-79) is the beginning of the tidal Caloosahatchee Estuary, and maintains higher water levels upstream of the structure while acting as a barrier to salinity and tidal action, which historically extended upriver as far as Fort Denaud and LaBelle (Sackett 1988). Construction of S-79 together with C-43 improvements have allowed for better conveyance of basin storm water discharge along with regulatory releases from Lake Okeechobee downstream to the estuary. This has created unnatural hydrologic and salinity regimes, and periodically causes extremely adverse effects on estuarine health and productivity. This also adversely affects the local

economy, as a significant amount of economic activity in the study area is associated with tourism and recreational and commercial fishing and related services.

Benefits obtained from the construction of the S-79 structure include the prevention of salinity intrusion into drinking water supplies upstream during dry, low flow periods. It also allowed the construction of a potable water supply intake facility upstream of the structure (the Lee County drinking water facility). In the dry season (approximately November–May), releases through S-79 are occasionally initiated to support environmental needs downstream by maintaining minimum flows.

Although S-79 has been instrumental for supporting and protecting this water supply, it has been detrimental for many estuarine organisms that historically could proceed further upstream in the dry season to find the optimum salinity and habitat. During the dry season when discharges are not occurring due to restrictions in water availability, very low or no freshwater inflow to the estuary can occur, resulting in a salinity wedge moving upstream into the upper-most reaches of the estuary, threatening fresh-water dependent species such as *Vallisneria* (tape grass), and shifting the competitive advantage to larger predatory marine fish species and adult (as opposed to juvenile) life stages. This disruption at the base trophic levels threatens the future viability of the estuarine ecosystem. Primary ecological functions (such as forage and nursery habitat) disrupted by such extreme changes in salinity do not rebound readily when more desirable salinity levels are restored, and may take several uninterrupted annual cycles to fully recover.

The amount of water available for the estuarine organisms during the dry season is constrained by at least two factors. First, the Caloosahatchee Basin has a significant amount of agriculture that depends upon surface water (and some groundwater) for its water supply. Many of the canals that discharge to the Caloosahatchee River in the wet season are used for irrigation water supply in the dry season. Second, there are several public water supplies in the basin, one of which is the Lee County drinking water facility, that rely upon surface water from the Caloosahatchee River. The net effect of increasing demands for agricultural and municipal water supply is a reduction in the amount of fresh water available to be delivered to the estuary to maintain viable ecological conditions.

Water from Lake Okeechobee has historically been released to supply water for urban and agricultural uses in the basin. The current approved LORS WSE provides for the regulation of Lake Okeechobee's freshwater discharges as a multipurpose water resource affecting the timing and volume of water available to the estuary. With the WSE regulation schedule, some water is supplied to

maintain minimum flows to the estuary when lake levels are high enough to provide those minimum flows while not endangering water supply demands elsewhere in the C&SF system. However, the historical and most predominant type of releases from Lake Okeechobee continues to be for lowering the lake when levels are too high. These regulatory releases, which can be very large and often occur in addition to basin runoff, are extremely detrimental to estuarine health. During the wet season releases (approximately June–October), the estuary can receive freshwater flows in excess of 10,000 cfs measured at S-79, significantly exceeding the historically-occurring volumes of freshwater and essentially flushing the estuary of saltwater and water column organisms, such as plankton.

To improve the problems created by high water levels in Lake Okeechobee, the USACE has also initiated a separate study to prepare a revision to the LORS. However, it should be noted that a revision to the LORS cannot by itself significantly reduce the harmful affects of excessive lake discharges and basin runoff on the Caloosahatchee Estuary. Additional storage is needed to enable management of Lake Okeechobee to minimize the frequency and severity of such harmful events.

Estuarine manifestations of the combined effects of water quantity, quality, and timing problems include the reduction and/or losses in such valued ecosystem components as SAV, oysters, and blue crab, as well as periodic declines in plankton and soft bottom benthic invertebrates. Restoring the flows and achieving hydrologic targets to maintain desirable salinity levels remains the overwhelming and overriding environmental priority within the Caloosahatchee River Basin.

4.1.3 Water Quality Problems and Opportunities

The 1999 Central and Southern Florida Project Comprehensive Review Study Final Feasibility Report and Programmatic Environmental Impact Statement (the "Restudy") reported that 14 water body segments in the Caloosahatchee River Basin and downstream coastal waters were impaired or potentially impaired, according to the FDEP in 1998. Water quality parameters of concern included excessive nutrients, coliform bacteria, biochemical oxygen demand, and depressed levels of dissolved oxygen. The Restudy report estimated that water quality conditions in the upper (eastern) and central portions of the Caloosahatchee watershed would remain unchanged through 2050, while water quality in the downstream and coastal portions would decline as a result of increased population growth and agricultural development.

The Restudy report identified the purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project as capturing Caloosahatchee Basin runoff and releases from Lake Okeechobee. The project was formulated to provide

water supply benefits, some flood attenuation, environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. It was assumed that the project might also provide significant water quality improvements depending on the location of the project and pollutant loading conditions in the watershed. According to CERP guidance memorandum-GM 23.01 "Water Quality Considerations for the PIR Phase," the Caloosahatchee River (C-43) West Basin Storage Reservoir Project falls in Category B, which means the project should be designed to achieve water quality improvements.

Because of water quality problems within the basin that were identified during the Restudy, as well as the purposes the project was designed to meet, the C-43 project team collected additional, updated water quality information for this PIR. According to the FDEP's 2003 Caloosahatchee Basin Status Report, the same water quality parameters of concern were identified for the basin as were identified in the Restudy report. In addition to problems associated with extremes in salinity levels, excessive nutrients (expressed as high chlorophyll-a concentrations), depressed levels of DO, and elevated coliform bacteria levels have been identified as problematic within the estuary. The extent of and research associated with these problems, as well as the over-arching problem of excessive salinity variations in the estuary, are discussed in the following paragraphs.

Water quality within the Caloosahatchee watershed is influenced by fresh water inflows from Lake Okeechobee, non-point pollution in local basin runoff, as well as point sources such as wastewater treatment plant discharges. Due to the geology of the region, there is also a direct interaction between the surface water and groundwater, which can affect the dissolved oxygen and iron concentrations in the surface water column. The upper Caloosahatchee River watershed from the Moore Haven Lock and Dam (S-77) to the Lee/Hendry county line has been classified by the State of Florida as a Class III water body in accordance with 62-302 Florida Administrative Code. The Class III designation establishes specific water quality standards that are intended to protect and sustain the natural attributes necessary for these waters to meet their intended use (recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife). The surface water directly upstream of S-79 east to the Lee/Hendry county line is designated as a Class I water body and must meet the standards required for use as a potable water supply (see ***Table 4-2*** for surface water classification status of Caloosahatchee River).

TABLE 4-2: SURFACE WATER CLASSIFICATION FOR CALOOSAHATCHEE RIVER

Water Class	Location
Class I Water: Caloosahatchee River	East Lee County line to SFWMD structure S-79 (Franklin Lock & Dam Spillway)
Class III Water: Caloosahatchee River	SFWMD structure S-77 (Moore Haven Lock & Spillway) at Lake Okeechobee to Lee/Hendry County line.

Several ecological functions of the Caloosahatchee Estuary are directly affected by water quality. The water quality problems negatively impacting ecological resources are primarily related to excessive variations in freshwater inflow and salinity as well as increased nutrient loads and color that result from excessive freshwater discharges in the wet season.

Water quality within this study area has been significantly altered due to the construction of the three locks and dams, excavation of the riverbed to 25 feet, increases in both urban and agricultural land use, and by the construction of an extensive network of canals and drainage ditches to accommodate this level of development. These hydrologic alterations have resulted in discharges of unnaturally large quantities of freshwater runoff into the river and eventually into the downstream receiving estuarine systems. Extensive documented research on the tidal portion of the Caloosahatchee River has shown that salinity changes in the estuary are the result of either low to no flows or too high flows of freshwater being discharged at the S-79 structure. Together, extreme flows and changes in salinity are by far the largest problem affecting the ecologic health of the estuary.

4.1.3.1 Salinity

It has long been established that freshwater inflow dynamics and salinity are major determinants of the distribution of estuarine species and those species' life stages, especially regarding their location and association with favorable habitat for rearing, protection and settlement (Gunter 1961; Pearcy and Richards 1962; Kinne 1966; Remane and Schlieper 1971; Bulger et al. 1993). Therefore, the ability of each estuary to function as a nursery differs according to its biological features, physical configuration, and inflow volume, magnitude and timing. Research by the SFWMD on the tidal Caloosahatchee began in the mid-1980s to determine the proper timing and volume of water required to support valued ecosystem components (i.e., such key estuarine species as oysters and SAV, such as *Vallisneria* spp.) and general biotic indicators (plankton and benthic invertebrates). Since the predominant source of freshwater to the tidal

Caloosahatchee (especially in the wet season) is water through the S-79 (70 percent of total flow), the research focused on issues of timing and volume of water through this structure; however, the latest models and methods do take into account the other major sources of freshwater discharged to the tidal Caloosahatchee from the "tidal" watershed. The SFWMD has focused on development of optimum S-79 flow ranges and delivery patterns for the estuary (Chamberlain and Doering, 1998b; Doering, 2002; Volety et al., 2003). As part of the state-mandated minimum flows and levels (MFLs) process, the SFWMD initially determined that a minimum dry season discharge at S-79 of 300 cfs (monthly average flow) is required to provide salinity conditions capable of supporting *Vallisneria*; however, the minimum flow target has been revised upwards to 450 cfs based on more recent scientific research by SFWMD staff. *Vallisneria* in the upper estuary is still recovering from the last drought and could suffer additional harm as the MFL requirements continue to be unmet (***Figure 4-1***).

Also as part of this research, maximum freshwater inflow limits (set at mean monthly values of 2,800 cfs and 4,500 cfs depending on frequency) and a frequency distribution of flows have been recommended that support valued ecosystem components and promote estuarine ecological benefits (Chamberlain et al. 1995, Chamberlain and Doering 1998b, Doering et al 2002, SFWMD 2003). It is these recommended flows that were used initially to determine CERP storage requirements and infrastructure changes in the Caloosahatchee Basin and Lake Okeechobee during the Restudy. These minimum and maximum flow targets have also been adopted for this PIR.

Based on the above biotic and water quality research, restoring the flows and achieving the hydrologic targets is an environmental priority within the Caloosahatchee River Basin. The estuary will remain at risk as long the quantity and timing of freshwater flows into the estuary remains unchanged. If water management practices are not changed, large releases will continue to have far reaching salinity and water quality impacts that may even influence Florida Bay (Rudnick et al. 1999).

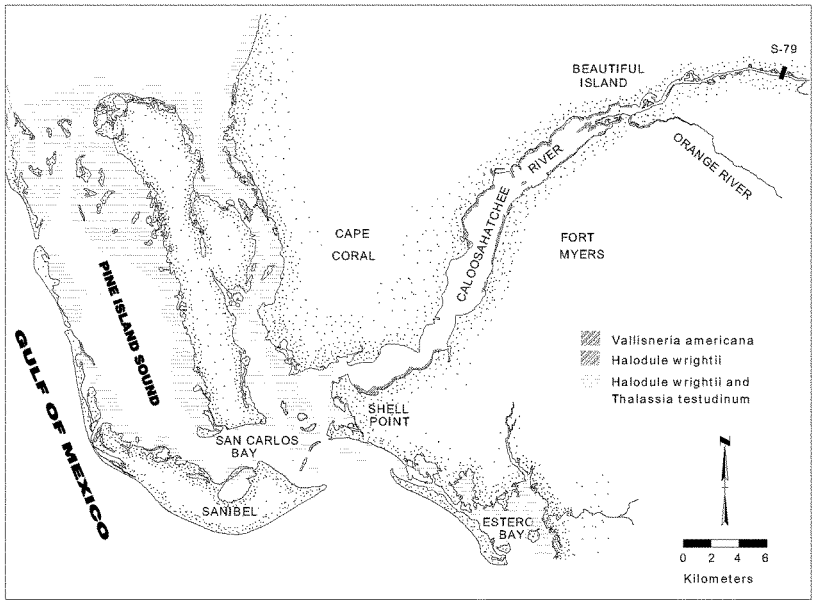


FIGURE 4-1: SUBMERGED AQUATIC VEGETATION IN THE CALOOSAHATCHEE ESTUARY

The excessive and unnatural variation in discharge and salinity that now occurs in the Caloosahatchee Estuary is due in large part to the man-made connection between Lake Okeechobee and the construction of C-43 Canal, the S-79 structure, and the network of secondary canals in the Caloosahatchee Basin (Chamberlain and Doering 1998a). Even before the S-79 was installed in 1965, a study was conducted by the University of Miami (under contract to the USACE) to determine the effects of the Lake Okeechobee releases on the St. Lucie and the Caloosahatchee estuaries (University of Miami, 1954). This study found significantly more sediment and salinity problems in the St. Lucie Canal than in the Caloosahatchee River, but the study did concluded that salinity was reduced as far downstream on the Caloosahatchee River as San Carlos Bay (downstream of Shell Point) when large releases from Lake Okeechobee occurred. According to the study, "These conditions are sufficiently severe during conditions at or near maximum release to cause temporary movements of marine life from the lower river, the southern part of Matlacha Pass, and sections of San Carlos Bay.

These conditions are also severe enough to cause the death of some forms unable to move from these areas (University of Miami, 1954)."

Subsequent biological field sampling of plants and fish by Phillips and Springer (1960), as well as Gunter and Hall (1962), before the S-79 structure was built also reported impacts on biota related to freshwater releases that extended into San Carlos Bay.

The Caloosahatchee River is the predominant source of freshwater discharges to the estuary. Bierman (1993) determined that over 90 percent of the variance in salinity in the estuary was related to discharges from S-79. The primary research on the tidal Caloosahatchee has focused on assessing the biological and water quality impacts from S-79 discharges, in order to determine optimum flow ranges, salinity, and water quality. Ideally, an estuary should provide a complete range in salinity from zero parts per thousands (ppt) (freshwater) to 35 ppt (ocean water). The long-term mean discharge through S-79 falls between approximately 300 cfs and 3,000 cfs. However, daily and monthly average inflows often exceed this long term average, with changes in salinity caused by either too little or too much freshwater being discharged over S-79. Studies conducted by the SFWMD on the Caloosahatchee Estuary indicate that discharges in excess of 2800 cfs from S-79 has caused most of the estuary above Shell Point to become oligohaline (low salinity between zero and five ppt) and inflows that commonly exceed 4,500 cfs adversely reduce salinity and water quality not only in the estuary, but also in the San Carlos Bay area and outer embayments (Chamberlain and Doering 1998a, Doering and Chamberlain 1998). During the dry season, lack of freshwater availability and subsequent low to no flow conditions can upset the salinity balance in the upper estuary and threaten the associated species, which depend on a minimum of freshwater inflow to maintain the low salinity zone that has been spatially reduced because the placement of the S-79 structure that truncated this zone (Doering et al. 2002, SFWMD 2002).

4.1.3.2 Nutrients

Although the salinity regime in the tidal Caloosahatchee has been the primary focus of much of the research, the SFWMD, FDEP, USGS and other agencies have also been examining other water quality issues in the basin and estuary. Work done by FDEP's Watershed Management Program has documented water quality impairments in the basin for several parameters and, in particular, for nutrients.

Urban and agricultural development within the drainage basin typically results in an increase in runoff and nutrient loads delivered to the downstream estuary. If excessive, the additional nutrients can cause a decrease in critical water quality when subsequent increases in phytoplankton (algae) production cause a

depletion of dissolved oxygen and a reduction in light penetration. Decreased light penetration can result in declines in SAV abundance since some of the estuary bottom that presents favorable conditions for SAV no longer obtains enough light to sustain these plants. The sediment in areas no longer supporting SAV can become mobile and increase water column turbidity which further impacts SAV viability. Excessive nutrients also trigger a thick growth of epiphytes, which can block the sunlight before it can reach the surface of the seagrass (Murray et al. 1999). In fact, in some estuaries, nutrient input has such an effect that relatively minor changes in water quality can lead to sharp reductions in the productivity of seagrasses which can lead to broad habitat changes (Livingston 1984).

Fortunately, within the Caloosahatchee Estuary, salinity swings rather than excessive nutrient loads have been identified as the primary limiting factor for SAV viability. McPherson et al. (1990) in their study of phytoplankton productivity in Charlotte Harbor determined there are three regions of productivity within an estuary that are characterized primarily by salinity and associated water quality parameters from freshwater. These regions are: (1) low salinity areas typical of the upper estuary or where high flows lowered salinity to less than approximately 10-15 ppt; (2) moderate to high salinity areas near the mouth of the major rivers or in Matlacha Pass; and (3) high salinity near the marine influence of passes to the Gulf of Mexico, well away from the influence of freshwater runoff (e.g., in Pine Island Sound). Increased phytoplankton productivity occurs when early spring temperature, light availability, and supportive water quality conditions co-occur. Typically, in Region 1, the highly-colored water from dissolved organic matter in freshwater runoff limits availability of light and is the determining factor controlling phytoplankton production and chlorophyll biomass, even when sufficient nutrients and temperature co-occur. A short residence time related to high flows also limits production. SAV (*Vallisneria* spp.) in this region of the estuary is inhibited during the wet season (high freshwater inflows) by colored water that reduces light availability. During the dry season (low freshwater inflows), low temperature and high salinity inhibit SAV.

In Region 2, nutrient-rich colored water is diluted by seawater so that the availability of light has increased and stimulates phytoplankton productivity. It is in this region of the Caloosahatchee Estuary (middle to lower estuary, western San Carlos Bay, and southern Matlacha Pass) that Chamberlain and Doering (2003) reported good statistical correlations between nutrient loading and chlorophyll concentrations. However, research by SFWMD indicates that SAV growth in shallower areas is predominately influenced by salinity, while SAV at deeper depths are impacted by a combination of salinity and light availability (Chamberlain and Doering 1997). In this region, the amount of influence on

water clarity from colored water versus chlorophyll biomass depends on the magnitude of flow and is currently being analyzed

In Region 3, even though water clarity is high, chlorophyll levels are typically low, primarily because nutrients are limited due to the distance from freshwater runoff and proximity to marine water. In this region of the estuary, SAV biomass and canopy height are high and typically extend to two meters depth.

4.1.3.3 Nutrients Impacts to the Caloosahatchee

Currently, nutrient standards for the State of Florida are narrative (non quantitative); therefore a surrogate standard for chlorophyll-a has been set at above 11 micrograms per liter (ug/l) (mg/m3) for estuaries and above 20 ug/l for freshwater. In the latest FDEP impaired water analysis for the Caloosahatchee, seven segments of the tidal Caloosahatchee River were found to be potentially impaired for nutrients. Chlorophyll-a is used as a measure of nutrient imbalance since Florida surface water quality standards do not include numerical criteria for nutrients such as nitrogen and phosphorus.

The watershed downstream of the S-79 structure that contributes directly to the tidal Caloosahatchee River is primarily urban (Cape Coral and Fort Myers). Although some of this urban area pre-dates the 1979 state rule regarding the prevention of the pollution of state waters from stormwater runoff (62-25 Florida Administrative Code), much of it was developed after this rule went into place. Although urban areas can be significant sources of nutrients and pollutants, the impact from this urban area appears to be relatively minor compared to the proportion of nutrient loads delivered to the Caloosahatchee Estuary through S-79 inflows. A study by ERD (2003) found that, discharge from S-79 contributes from 90 percent to 95 percent of the mean annual mass of total nitrogen (TN) and total phosphorus (TP) to the tidal Caloosahatchee River (for this report, the USACE has estimated that S-79 contributes more than 75 percent of the nutrient loads). The next largest contributor to the tidal Caloosahatchee River was the Orange River with 1.1 percent to 3.8 percent of the annual mass of TN and TP.

As stated above, approximately 75 to 90 percent of the nitrogen and phosphorus load sent to the Caloosahatchee Estuary comes from sources upstream of S-79. To address questions regarding the effect of reservoirs on water quality, specifically nutrients, FDEP contracted with Tetra Tech (and subcontractors Janicki Environmental and Soil and Water Engineering Technology, Inc.) to examine the potential nutrient impairment problem in the estuary. The study developed regression equations to describe two relationships: 1) between chlorophyll-a concentration and nitrogen loading and 2) between chlorophyll-a concentration and phosphorus loading. Due to the naturally occurring high levels of phosphorus in the watershed, the indication was that nitrogen was the

limiting nutrient, which is consistent with the other studies identified earlier. Thus, of the two regression equations, this study determined that the nitrogen/chlorophyll-a relationship was the best means of predicting nutrient impairment (or phytoplankton algal blooms) in the estuary. The report has identified three preliminary targets for TN loading to the estuary from releases at S-79 in order to achieve a chlorophyll-a concentration limit of 11 ug/l:

1. Maximum annual load less than 3,000 tons/year, where annual load ~ (wet season monthly load x 5) + (dry season monthly load x 7)
2. Dry season monthly load less than 190 tons/month, and
3. Wet season monthly load less than 350 tons/month.

The estimated annual TN load at S-79 is approximately 2600 tons/year at present. During the wet season an average of approximately 310 tons/month is discharged at S-79 while during the dry season an average of approximately 150 tons/month of TN is discharged at S-79. On an average basis, therefore, the nitrogen loads delivered through S-79 fall within the State's nutrient targets (i.e., TN loads associated with acceptable chlorophyll-a concentrations). The amount of nutrient loading to the estuary is mostly dependent on the magnitude of freshwater inflow (Chamberlain and Doering 2003).

During the 1996-2002 time period, the suggested annual TN target load has been exceeded three times. The exceedence years were 1998, 1999 and 2002. A dry season TN target exceedence occurred in 1998 when dry season flows from the C-43 basin along its eastern boundary with Lake Okeechobee were approximately three times higher in 1998 than the average for 1996 to 2002, probably reflecting a large controlled release from Lake Okeechobee. Wet season exceedences occurred in 1999 and 2002. These were the highest wet season flows observed at S-79 between 1996 and 2002. It should be noted that between 1996 and 2002, many of the years analyzed were wet years, resulting in high loads.

Additional documentation of the extent of the nitrogen problem in the estuary comes from research conducted as part of the Initial CERP Update (ICU). For the ICU, 22 years of TN concentrations collected just upstream of S-79 were used to calculate the average monthly concentrations at S-79 for each of 12 months. Then TN loading for each month of the 36-year period of record for CERP was calculated by multiplying each month's discharge by the average monthly TN concentration for that month. For each 36-year scenario, the number of years in which the annual TN load at S-79 exceeded 3000 tons (the load limit meeting the FDEP's estuarine standard) was calculated. Nitrogen loads were exceeded in ten of 36 years for the 2000 Base scenario (i.e., existing conditions), nine years for the 2050 Base scenario (future without project conditions), one year for the

CERP0 scenario (CERP as defined in the Restudy), and 1 year for CERP1 (updated CERP as defined in the ICU).

Similarly, ***Table 4-3*** below depicts analysis from the ICU showing results of seasonal, rather than annual TN loading. The number of months in which TN loading exceeded critical seasonal loads of 350 tons/month during the wet season and 190 tons/month during the dry season (wet season defined as June–October, dry season as November–May) are shown.

TABLE 4-3: NUMBER OF MONTHS OF TN SEASONAL LOAD EXCEEDANCES IN THE CALOOSAHATCHEE ESTUARY

Scenario	2000 Base	2050 Base	CERP0	CERP1
Wet Season	60	48	8	8
Dry Season	45	36	9	8

Under existing conditions (2000 Base) and future without conditions (2050 Base), critical seasonal loads were exceeded 28 percent (2000 Base) and 22 percent (2050 Base) during the wet season and exceeded 21 percent (2000 Base) and 17 percent (2050 Base) during the dry season. As will be discussed in greater depth under the evaluation of C-43 alternatives, TN loads under existing and future without project conditions exceed critical seasonal loads four to five times more frequently in the dry season and six to seven times more frequently in the wet season than infrastructure alternatives related to CERP0 and CERP1 (***Table 4-3***). This analysis conducted for the ICU thus demonstrates that nitrogen loadings exceeding the estuary's targets, while not a frequent problem, do occur, but are likely to be greatly improved by implementation of the Caloosahatchee River (C-43) West Basin Storage Reservoir project as described in CERP.

4.1.3.4 Nutrient Reduction Opportunities

Nutrient loads to the estuary can be reduced through treatment in stormwater treatment areas (STAs) or through the widespread adoption of best management programs (BMPs) by farmers, land developers, and urban residents. Lower nutrient loads will result in improved estuary habitat through increased light penetration and increased dissolved oxygen concentrations. The implementation of BMPs to control nutrient loads, while quite useful in the case of the Caloosahatchee Estuary, has not been considered as a central element of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project strategy. Because achievement of water quality standards is a responsibility resting primarily upon individual states, the underlying assumption of the project team has been that the State of Florida will implement state and local water quality programs necessary to achieve appropriate load reductions through actions by

the FDEP, Florida Department of Agriculture and Consumer Services (FDACS), and SFWMD.

However, the Caloosahatchee River (C-43) West Basin Storage Reservoir itself can potentially reduce and alter the timing of nutrient loads through the construction and operation of storage reservoirs. The reservoir is expected to reduce nutrient loading (particularly nitrogen) through settling and nutrient uptake.

4.1.4 Economic and Social Well-Being Problems and Opportunities

As a result of the C&SF Project, by providing flood protection and an available supply of drinking water, the population of south Florida has grown from approximately 900,000 as reported in 1950 to a population of over 5.5 million in 1995. By the year 2050, the population of south Florida is projected to grow to 11.6 million. Lee County (including Fort Myers, Cape Coral, Sanibel and Captiva Islands, Bonita Springs, and surrounding areas) has one of the fastest growing populations in both south Florida and in the state. The increased growth in population in Lee County can be attributed to net in migration and not as a result of high birth rates for this area. The coastal areas in the study area have become highly urbanized. As a result, this urbanization has caused development to move eastward into areas that were once agricultural or undeveloped.

The Governor's Commission for a Sustainable South Florida identified agriculture and tourism as "critical industries" for maintaining the economy in the southern part of the state. In the project area, agriculture is a major industry. A rapidly increasing human population demanding more developable lands and advancing agricultural development now threaten the relatively pristine natural areas. The tourism industry is also dependent upon the region's ability to sustain its economy and its quality of life through management of its resources. Agriculture and tourism depend on a system that can provide vital water supply needs and flood protection without harming the natural system upon which tourism, recreational activities, and associated services depend.

In response to the proposed modification to the LORS, the City of Sanibel commented in an October 2006 letter to the USACE:

"Sanibel Island's economy and its way of life depend upon the health of the Caloosahatchee River and Estuary. The Estuary provides essential habitat for fish populations that are central to the region's economy and recreational fishing economies. The City of Sanibel is particularly dependent on the health of the Caloosahatchee Estuary, as tourism generated by the diverse estuarine ecosystem in which it is located is central to the Island's economy."

Similarly, the City of Fort Myers also commented in 2006:

"The Caloosahatchee River and the estuary must be protected. The local economy is reliant on these waters through both the tourism industry and the fishing industry. We cannot afford to lose this most precious environmental and economic resource to the damaging effects of increased water releases from Lake Okeechobee."

Competition for regional water resources has intensified with the increase in population and agriculture industry growth. This places a strain on existing resources, which will eventually surpass the readily available sources. When the needs of the natural system are then factored in, demands become greater and conflicts among competing water users will become even more severe. While most people recognize the need for a healthy ecosystem to support the region's economy and jobs, many people are concerned that restoration projects will displace farms and other businesses, limit development, reduce available water supply and reduce job opportunities. By contrast, continued degradation of the south Florida ecosystem will adversely affect the tourism and recreational industry that are important to the regional economy.

4.1.4.1 Water Supply

While providing additional water supply for urban and agricultural users represents a potential opportunity to be addressed by the Caloosahatchee River (C-43) West Basin Storage Reservoir, providing water supply to meet the environmental needs of the estuary during dry periods is one of the primary purposes of this project. Upon meeting flow targets at the S-79 structure necessary for ecosystem restoration in the Caloosahatchee Estuary, any additional water stored by the Caloosahatchee River (C-43) West Basin Storage Reservoir could be delivered to the C-43 Canal and would be available for other water related needs.

Water supply and flood control benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir implementation will be classified as incidental. Increases to flood damage reduction benefits and water supply benefits will not be further analyzed as part of this study; however, a later PIR will investigate opportunities to increase the quantity of water available for municipal, agricultural, and other environmental interests in the basin. Analysis of area water supply is being conducted by the SFWMD in a report entitled Lower West Coast Water Supply Plan (LWCWSP) Update.

4.1.4.2 Flood Damage Reduction

While flood damage reduction is not the primary intent of this project, the evaluation of alternatives will include an analysis of their effects on the current

level of flood protection. The project will not compromise that existing level of protection, and although it was not a specific goal of the study to increase the level of protection, some incidental benefits may be achieved.

4.2 PLANNING GOALS, OBJECTIVE AND CONSTRAINTS

4.2.1 Project Goals and Objectives

The Restudy assessed some but not all of the water resource problems and issues within the Caloosahatchee River Basin. The Restudy purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir is to capture Caloosahatchee Basin runoff and releases from Lake Okeechobee as a means to meet water demands (moderate extreme damaging high and low flows) for ecosystem restoration within the Caloosahatchee Estuary, with some benefits to municipal and agricultural water supply. However, since this project is focused on reaffirming a plan to construct and operate a reservoir with approximately 160,000 ac-ft of storage, the primary goal of this project is to produce a plan that, when implemented, will meet the ecosystem restoration objectives of the Caloosahatchee Estuary. Opportunities for providing additional water to meet municipal and agricultural needs for water supply will be investigated under a subsequent study.

Based on a consideration of the Restudy purpose for the project and problems and opportunities in the study area, specific planning objectives to meet the goal of enhancing ecological values are listed below:

Goal: Enhance ecological values by restoring ecosystem function in the Caloosahatchee River and Estuary

Objectives:

- Improve the quantity, timing, and distribution of freshwater flows to the Caloosahatchee Estuary.
- Improve water quality in the Caloosahatchee Estuary by reducing nutrient inflows from the Caloosahatchee Basin.
- Improve salinity balance in the Caloosahatchee Estuary for estuarine organisms. Reduce the spatial extent and duration of occurrences of extreme low and high salinities.
- Improve the spatial extent and functional quality of habitat for estuarine biota.
- Increase plant and animal diversity and abundance, particularly increasing the spatial extent of SAV. Increase seagrass and oyster production through improved salinity regime.
- Increase spatial extent and quality of wetlands in watershed.
- Increase suitable habitat for oysters and seagrasses in estuary.

Specific planning objectives to meet the goal of restoring economic values and social well-being are listed below:

Goal: Enhance economic values and social well being

Objectives:

- Conserve and protect water resources to ensure sustainability of economic and natural resources.
- Ensure availability of ground and surface water supplies for environmental resources while protecting existing legal sources of water for agricultural and urban uses.
- Maintain existing level of service for flood protection in the project area.
- Provide recreational, tourism, and environmental education opportunities.

Table 4-4 shows the CERP goals and project specific goals and objectives.

TABLE 4-4: CERP AND PROJECT GOALS AND OBJECTIVES

CERP Goals and Objectives	Project Goals and Objectives
Enhance Ecological Values	
Increase the total spatial extent of natural areas	• Improve the spatial extent and functional quality of habitat for estuarine biota. • Increase spatial extent and quality of wetlands in watershed
Improve habitat and functional quality	• Improve the quantity, timing, and distribution of freshwater flows to the Caloosahatchee Estuary by capturing runoff from the Caloosahatchee Basin and Lake Okeechobee releases. • Improve salinity balance in the Caloosahatchee Estuary for estuarine organisms. Reduce the spatial extent and duration of occurrences of extreme low and high salinities. • Improve water quality in the Caloosahatchee Estuary by reducing nutrient inflows from the Caloosahatchee Basin. Increase plant and animal diversity and abundance, particularly increasing the spatial extent of SAV. Increase seagrass and oyster production through improved salinity regime. • Increase suitable habitat for oysters and

CERP Goals and Objectives	Project Goals and Objectives
	seagrasses in estuary.
Improve native plant and animal species abundance and diversity	• Increase plant and animal diversity and abundance, particularly increasing the spatial extent of SAV.
Enhance Economic Values and Social Well Being	
Reduce Flood Damages (agricultural/urban)	
Provide recreational and navigation opportunities	• Increased recreational opportunities are directly related to improved habitat function and quality objectives.
Protect cultural and archaeological resources and values	

4.2.2 Constraints

The C&SF Project has supported agricultural and urban development in the Caloosahatchee Basin through a variety of benefits such as water supply, flood protection, drainage control, navigation, and recreation opportunities. This economic development has, however, adversely affected ecosystem functions and values in the study area, including reductions in the spatial extent and functional quality of wetland, riverine, estuarine, and marine habitats and decreases in native animals, fish, and plant populations. While alternative plans are formulated to achieve restoration of these functions and values, to be considered for implementation, plans must also avoid violating planning constraints. All CERP projects are constrained by WRDA 2000 provisions such as avoiding the elimination or transfer of existing legal sources of water unless a new source of comparable quantity and quality is available and maintaining existing levels of service for flood protection. In addition, all USACE projects are constrained by legal requirements that seek to minimize, for example, impacts to cultural resources or impacts to threatened and endangered species or their habitats.

Planning constraints specific to the Caloosahatchee River (C-43) West Basin Storage Reservoir project include:

- Avoid or minimize impacts to navigation.
- Avoid contributing to the degradation of water quality in the estuary or any of the contributing water bodies within the basin.
- Minimize impacts that will adversely affect the tourism or recreational industries which are critical to the regional economy.

4.3 PROJECT EVALUATION CRITERIA AND EVALUATION METHODS AND MODELS

Alternatives were evaluated based on their ability to meet specific evaluation criteria and performance targets, which relate directly to the goals and objectives identified in this report. A key criterion for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is the need to capture and retain excess basin stormwater runoff and to capture excess flows discharged from Lake Okeechobee into the Caloosahatchee Estuary. The goal of the Caloosahatchee River (C-43) West Basin Storage Reservoir is to capture this excess water at times of peak or high flows and retain it for release at a later time when an increase in the freshwater flows are needed to maintain desirable salinity levels in the estuarine system. Reservoir operations were optimized to first address the environmental needs of the Caloosahatchee Estuary.

4.3.1 Hydrologic Performance Measures

The hydrologic performance measure was derived from relationships between the distribution, abundance, growth and survival of estuarine organisms and changes in salinity or freshwater discharge. Salinity tolerances of submerged grasses were initially used to identify an optimum S-79 freshwater inflow range of 300-2800 cfs (Chamberlain et al. 1995; Chamberlain and Doering 1995; Doering et al. 1999, 2001, and 2002; Doering and Chamberlain 2000; and Kraemer et al. 1999). Flows greater than 2800 cfs depress salinity in the lower estuary and threaten the marine shoal grass (*Halodule wrightii*) typical of this region (Chamberlain and Doering 1998b; and Doering et al. 2002), while flows that approach 4500 cfs have similar adverse impacts downstream in San Carlos Bay (Chamberlain and Doering 1995). Research has shown that the optimum flows for SAV are beneficial to other organisms as well.

A steady-state salinity model (Scarlatos 1988; Bierman 1993) and a statistical model of salinity (SFWMD 2000) were used to estimate mean monthly flows from S-79 that would establish a desirable salinity range in the geographic (historical) locations of SAV, without adverse impacts to benthic invertebrates, ichthyoplankton, and zooplankton (Chamberlain et al. 1995, 1999, 2001; Chamberlain and Doering 1998b; Doering et al. 2002; and Volety et al. 2003). An upgraded, fully hydrodynamic model has been developed and is under refinement. An early version of this model was used to verify and improve estimates of inflow requirements based on model prediction of salinity distribution in the estuary. For the Caloosahatchee Estuary, a mean monthly inflow of at least 300 cfs is needed from S-79 to ensure that the 30-day moving average salinity at Fort Myers (Yacht Basin) is less than ten ppt (< 10 ppt) (target maximum salinity for healthy *Vallisneria americana*) and single day maximum salinity (daily average) does not exceed 20 ppt (Doering et al. 1999, 2001, and 2002, Kraemer et al. 1999).

These MFL salinity criteria were initially designed to protect *Vallisneria americana* (tape grass) upstream of Fort Myers, but are also beneficial for other organisms that utilize this low salinity region of the estuary (Chamberlain and Doering 1998b; and SFWMD 2000 and 2002). For tape grass, this estimated MFL depends on about 200 cfs of additional flow from the tidal basin tributaries downstream of S-79. However, violations of the salinity criteria commonly occur during dryer than normal periods in the dry season when tidal tributary flows are less than 200 cfs (< 200 cfs). Additional field and laboratory research (Hunt and Doering 2005) indicates that tape grass is more sensitive to water quality conditions related to high salinity during low flows, as well as poor water clarity during excessive discharges. The last major drought constituted significant harm to the tape grass beds, which have still not fully recovered after four years. Therefore, a minimum flow of 300 from S-79 is not enough. A greater frequency of flows are needed from S-79 that are closer to a minimum of 450-500 cfs to achieve the required salinity goals associated with the MFL and prevent MFL salinity violations during these very dry conditions. Hydrologic performance measures for discharge at S-79 and MFL salinity criteria are summarized in the table below (***Table 4-5***).

TABLE 4-5: CERP PERFORMANCE MEASURES FOR FRESHWATER DISCHARGE AT S-79 AND MFL SALINITY CRITERIA AT FORT MYERS, FL

Freshwater Discharge At S-79	
Low Flow for Estuary (mean monthly)	Number of months < 450 cfs
High Flow for Estuary (mean monthly)	Number of months > 2800 cfs Number of months > 4500 cfs
Low Flow Duration	Frequency of consecutive months < 450 cfs
High Flow Duration	Frequency of consecutive months > 2800 cfs Frequency of consecutive months > 4500 cfs
Minimum Flow and Level (MFL) at Fort Myers, FL (Yacht Basin salinity sensor)	
Salinity Criteria (daily average)	Shall not exceed 20 ppt more than once in 2 years
Salinity Criteria (30-day moving average)	Shall not exceed 10 ppt more than once in 2 years

4.3.1.1 Flow Distribution Target for the Estuary

Environmental investigations done in the Caloosahatchee Estuary by the SFWMD in the 1980s and 1990s led to the initial establishment of freshwater inflow targets (average monthly flows through S-79), based on key biota, such as the freshwater-low salinity plant, *Vallisneria americana*, in the upstream portion of the estuary. As part of this analysis, the SFWMD made the initial attempts to define a preferred distribution of flows from S-79 that would best support the estuary's biotic resources. This effort began by evaluating the inflows that had occurred during the 25-year period 1966-1990 after installation of S-79. These flows were obviously skewed toward the very low end of the range (***Figure 4-2***), which routinely threatened the low salinity zone of the estuary where the submerged plant *Vallisneria* provides important habitat when allowed to flourish.

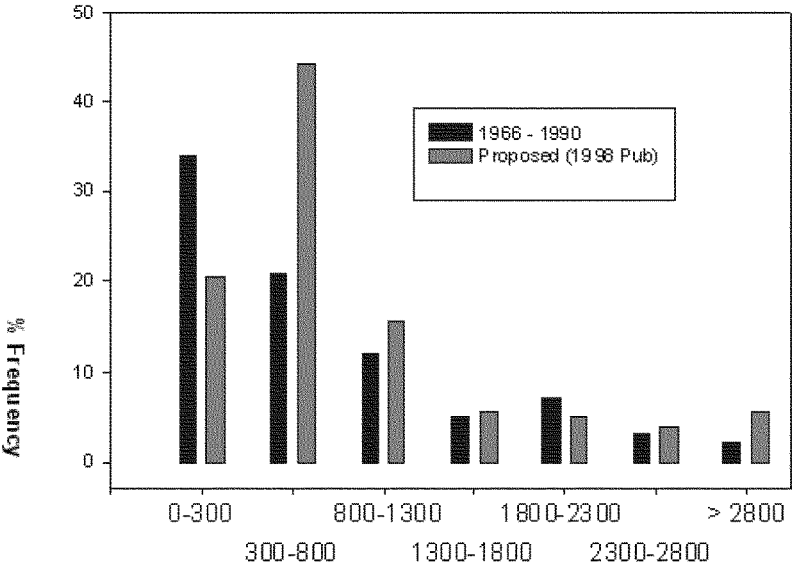
A distribution of inflows that has the greatest frequency range from 300 to 1,500 cfs, with a peak between 300-800 cfs was initially determined to be the most beneficial to the range of species evaluated. However, the SFWMD also recognized that a percentage of flows outside the preferred range (violations) may be an important component of the natural variability inherent in the estuary. An optimization program was employed as a first attempt to define the percent of acceptable violations (Labadie 1995: Otero et al 1995). The desired inflow ranges (limits for biota) were input variables to the model, along with the natural periodicity of violations of the upper and lower limits (estimated from the 1966-1990 historic data). For the Caloosahatchee, 20.5 percent violation of the low flow limit created inflows that emulated the natural variability established from the rainfall during 1966-1990. In addition to natural variation, this original frequency distribution generated by the model revealed that (1) the appropriate initial inflows limits were attained (300-2,800 cfs); and (2) the greatest frequency of inflows were within the range from 300-1,300 cfs, with a peak of inflows between 300-800 cfs. This original frequency distribution was reported and published as provisional (Chamberlain and Doering 1998), with the intent to update it as more information became available about the salinity requirements of key biota.

Instead of the original 1966-1990 base data set, more recent modeling efforts use a 2000 base condition (***Figure 4-3***), which have approximately 51 percent of the flows falling below 300 cfs (45% <150 cfs). Additional field and laboratory research since the Chamberlain and Doering (1998) publication indicates that *Vallisneria* is more sensitive to water quality conditions related to high salinity during low flows, as well as poor water clarity during excessive discharges. The last major drought constituted significant harm to the *Vallisneria* beds, which have still not fully recovered after four years.

Subsequent hydrologic modeling work (related to the Restudy, the Caloosahatchee Water Management Plan, and the development of MFL criteria) provided at least two new flow distributions that have fewer low flow violations than the original 20.5 percent and will better protect *Vallisneria*. The flow distribution known as EST02 was based on improving minimum flow deliveries at S-79. It allows fewer violations of flows below 300 cfs (seven percent) and is the best available estimate of pre-development freshwater deliveries to the estuary.

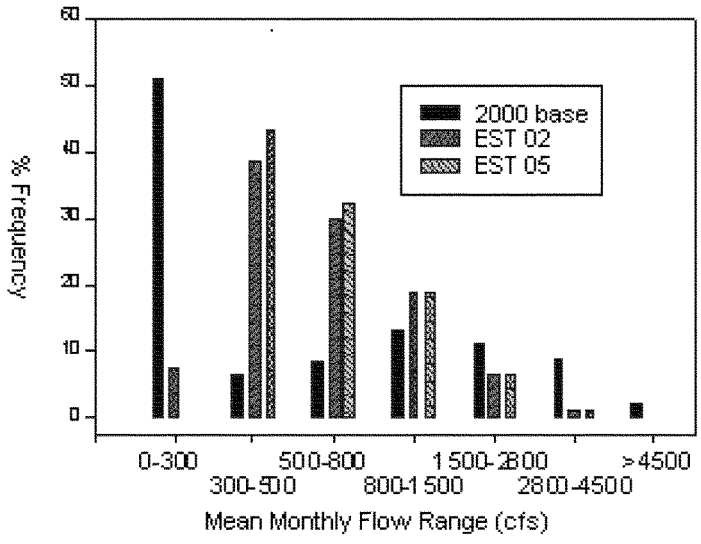
Both the earliest flow distribution estimates and EST02 assumed an average 200 cfs would be contributed by tidal basin inflows downstream of S-79, which would be adequate for meeting the *Vallisneria* salinity limits and MFL criteria. Most recently, estimates of tidal tributary inflows were added to the modeling effort to better assess total estuarine inflows related to salinity distribution targets. Assuming that 200 cfs will be contributed by the tidal basin will not achieve the MFL requirements. Also, permanent alterations have occurred in the estuary and watershed, such as the installation of S-79, which truncated the salinity gradient, preventing upstream migration of low salinity water during the dry season, thus eliminating the dry season oligohaline low salinity zone that historically existed. Therefore, a flow distribution that provides flows below 450 cfs at S-79 will not achieve the protection defined in the MFL (SFWMD 2000 and 2002) rule.

EST05 is similar to EST02, except that mean monthly inflows at S-79 are maintained above 450 cfs. Most of the EST05 flows from S-79 (75 percent) are in the ideal range of 450-800 cfs and almost all the remaining inflows are in the 800 to 2800 cfs range at S-79. Therefore, EST05 provides a slightly higher level of protection (against high salinity) in the upper estuary than other time series. This proposed frequency distribution has an estimated estuary delivery volume demand of ~524,000 ac-ft/yr and will maintain a full estuarine salinity gradient that is not unnaturally compressed.



Percent frequency of mean monthly flows from S-79 for: (a) 1966 – 1990, and (b) initially proposed during 1998 publication.

FIGURE 4-2: PERCENT FREQUENCY OF MEAN MONTHLY FLOWS FOR 1966 THROUGH 1990



Percent frequency of mean monthly flows from S-79 for:

(a) 2000 Base Condition
(b) EST 02
(c) EST 05

FIGURE 4-3: PERCENT FREQUENCY OF MEAN MONTHLY FLOWS (EST 02, EST 05 FLOW DISTRIBUTIONS)

In order to better achieve the CERP project and MFL restoration goals, scientists on the Caloosahatchee River (C-43 West Basin Storage Reservoir project team selected the EST05 flow distribution (***Table 4-6***) as the restoration target. It provides no allowances for monthly average discharges from S-79 less than 450 cfs. However, salinity violations are allowed under the MFL rule once every two years for the moving monthly average and daily salinity criteria. Therefore, the West Basin Storage Reservoir can still achieve estuarine protection and restoration success if the final selected alternative has flow occurrences beyond the distribution limits, including those below 450 cfs. The degree of achievement will be in part demonstrated by comparing performance

measure targets and habitat units (Hus) between base conditions and the alternative.

TABLE 4-6: FREQUENCY DISTRIBUTION OF FLOWS FROM S-79 ASSOCIATED WITH EST05 (WITHOUT TIDAL BASIN CONTRIBUTION)

Discharge Range (cfs) From S-79	Percent Distribution Of Flows From S-79
0 to 450	0%
450 to 500	42.8%
500 to 800	31.7%
800 to1500	19.2%
1500 to 2800	5.6%
2800 to 4500	0.7%
>4500	0%

4.3.2 Ecological Performance Measures

Estuarine ecosystem improvements will be measured as improvements to the salinity regime and water quality achieved in the river and estuary. These improvements will be measured by performance measures developed for six key indicator species:

- SAV (tape grass and seagrass)
- Oyster
- Blue crab
- Zooplankton
- Spotted seatrout

Performance measures have been established for the above biological resources in the Caloosahatchee Estuary (values are provisional and may be adjusted upon new evaluation of historic and current research efforts). These current ecological targets and supportive salinity requirements include the following:

1. SAV
   a) Tape grass–A permanent presence of tape grass beds (above the Fort Myers U.S. 41 Highway Bridges) that improve water quality and provide viable habitat for other organisms. Requires maintaining a 30-day moving average salinity < 10 ppt during the dry season at the Fort Myers continuous salinity sensor (near the surface at the Fort Myers Yacht Basin), such that tape grass in the Beautiful Island area does not decrease below 20 percent coverage and blade length is > 10 cm. Daily average salinity shall not exceed 20 ppt at Fort Myers more than

once every two years, and neither shall the 30-day moving average salinity of 10 ppt (MFL Rule: SFWMD 2000);

b) Seagrass–Return of viable seagrass that has been lost in the lower Caloosahatchee River (Iona Cove Region) and return of the 38 percent of seagrass lost in San Carlos Bay since 1982 (Harris et al. 1983). Limit the occurrence of average monthly salinity <15 ppt at the Cape Coral Bridge sensor, so salinity > 20 ppt is promoted in Iona Cove (Bierman 1993), which is supportive of minimum seagrass density (coverage > 30 percent at one meter water depth and average blade length > 10 cm). Maintain an average monthly salinity > 25 ppt, as measured at the Sanibel Causeway Bridge near-surface continuous sensor, so that historical seagrass density and coverage in the San Carlos Bay area (as determined from previous surveys, hydroacoustic monitoring, and aerial photography) is protected and restored to a previous condition (at least circa Harris et al. 1983), which includes reestablishment of continuous coverage at deeper depths in the San Carlos Bay area between Shell Point and the Sanibel Causeway.

2. Fauna

a) Oysters–A five fold increase in area coverage to approximately 100 acres and possibly 400 acres with placement of suitable substrate. Maintain daily salinity at Piney Point > 5 ppt to prevent high mortality. Consistently provide the preferred salinity of 14-28 ppt that supports the recruitment, survival, and growth of juvenile oysters upstream of Shell Point during March–October (juvenile oyster growth > 2.5 mm a month; recruitment > 3 spats per substrate shell a month; and mortality < 20 percent per month-values are based on information interpreted from Volety et al. 2003).

b)Plankton–Improve the nursery function of the estuary and better support each generation of fish recruited by improving food supply (zooplankton available). Zooplankton density spikes currently occur. Increase by 30-40 percent the occurrences of spikes that double or triple zooplankton density. Significantly reduce the occurrence (>10 percent) the frequency of total wash-out of fish eggs from the estuarine area upstream of Shell Point that result from high flows (Chamberlain and Doering 1998b; Chamberlain et al. 1999 and 2001, and SFWMD 2002)

c) Blue Crabs–Substantially (significantly) increase the blue crab population and commercial landing (catch per unit effort). Expect increase (return) of landings to 1-3 million pounds annually (assuming that fishing effort does not substantially increase or decrease).

d) Spotted seatrout-Substantially (significantly) increase the population and catch per unit effort.

Several prominent species have been identified for long-term monitoring and environmental assessment because they constitute important habitat in the Caloosahatchee, San Carlos Bay, Matlacha Pass and Pine Island Sound. In addition to tape grass that serves as an indicator of estuarine health in the upper estuary, these are oysters and marine seagrasses that represent the more downstream, seaward portions of the system. ***Table 4-7*** outlines each species chosen by the study team as a performance measure, the variables used in the habitat suitability index (HSI) for that species, and the preferred flow range identified by SFWMD research to be ideal for the Caloosahatchee estuary (Chamberlain and Doering 1998). The preferred flow ranges tend to fall in the same range as the target flow rates as outlined in EST05. Once the selected alternative plan (SAP) is identified, the ecological benefits to the Caloosahatchee estuary that accrue from achieving flow targets at S-79 will be quantified.

The ecological model which will be used to quantify benefits of the SAP relies on the HSIs to determine what conditions will make an area more suitable for each species. Each species identified as a performance measure is dependent on factors (such as flow, salinity, and temperature) that make up the variables of the HSI for that species. By plugging in each of these variables to the ecological model, a spatially explicit benefit output will be developed. Therefore, it is evident that improving the ecological conditions would be a direct result of modifying the flows. Flow will also affect other variables, most noticeably salinity. The ecological model, using the HSIs, will indicate those areas that will be most supportive of each species as a result of each alternative. The model will be able to quantify the benefits that will be provided under the chosen plan, and compare those to existing and future without project conditions.

TABLE 4-7: ECOLOGICAL PERFORMANCE MEASURES

Species	Variables in HSI	Preferred Flow Range (cfs)
SAV	Light, salinity, temperature, flow	Halodule <800 Halodule/Thalassia <2800
Oyster	Salinity, temperature, depth, substrate, flow	500-2000
Blue Crab	Substrate, salinity, temperature, flow	300-800
Zooplankton	Salinity, flow	150-600
Spotted Seatrout	Salinity, temperature, seagrass cover, proximity to seagrasses and drop offs, flow	300-1300 (general fish requirement)
Vallisneria	Previous condition, salinity, temperature, light availability	~800- 1500

4.3.3 Water Quality Evaluation Criteria

A secondary goal of the project is to improve water quality in the river and estuary. This can be accomplished by: (1) reducing high flows during the wet season, capturing, storing, and partially treating this water, then releasing it in a more environmentally sensitive manner that is beneficial to estuarine resources during the dry season; and (2) eliminating regulatory (non discretionary) discharges from Lake Okeechobee to the Caloosahatchee Estuary.

In addition, an evaluation of project-related water quality impacts is necessary to determine if the alternative plan under consideration would meet the FDEP's requirement that the project not contribute to the degradation of water quality and also to determine any benefits the project might create by improving water quality conditions both upstream and downstream of the S-79. The primary means of assessing the water quality benefits of the project will be to determine the net change in annual average nitrogen and phosphorus loads at S-79. An increase or decrease in nutrient loading will affect other water quality constituents such as dissolved oxygen, light penetration, and chlorophyll which are all critical to the quality of the estuary habitat that lies downstream of S-79.

Regional and sub-regional models will be used to simulate historical, current, and predicted flows to the estuary with and without the Caloosahatchee River (C-43) West Basin Storage Reservoir and CERP features for each alternative considered. Output (flows) from the above model runs in conjunction with water

quality analyses will be used to assess the extent of project effects on water quality.

SECTION 5
FORMULATION OF ALTERNATIVE PLANS

This page intentionally left blank

5.0 FORMULATION OF ALTERNATIVE PLANS

This section describes the plan formulation and evaluation process necessary to achieve the goals and purposes of the project and maximize the achievement of the system-wide benefits of the Plan. The Caloosahatchee River (C-43) West Basin Storage Reservoir project is an integral part of the Comprehensive Everglades Restoration Plan (CERP). The main purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to provide for the retention and management of excess water within the natural system that is lost to tide (to the ocean), then release it back into the natural system when needed to help moderate extreme salinity changes in the estuary which are detrimental to estuarine communities. Captured excess water is made up of regulatory releases from Lake Okeechobee, basin runoff from storm events passing through the Caloosahatchee Watershed, and irrigation runoff from agricultural fields.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project is needed primarily to perform two functions: (1) reduce high-volume flows to the Caloosahatchee Estuary during the wet season by capturing and storing excess surface water runoff and (2) supplement water for the natural system by increasing the availably of water to be delivered to the estuary during the dry season. Thus, a project in the lower Caloosahatchee River Watershed will increase the amount of water made available for the restoration of the Caloosahatchee Estuary.

5.1 PRIOR FORMULATION

The plan formulation and evaluation process employed during the Restudy utilized a base set of management measures identified during the reconnaissance phase of the study from which comprehensive plan alternatives were formulated in a "building block" fashion to achieve desired objectives. To address problems in the Caloosahatchee River Watershed, the Restudy recommended plan, Alternative D-13R, called for the use of above-ground reservoir(s) with a total storage capacity of approximately 160,000 ac-ft to capture excess water being lost to tide, then return this water back to the Caloosahatchee Estuary during low flow conditions Captured water in the reservoir(s) would then be released during dry periods to provide the desirable flow volumes through the S-79 structure to achieve the appropriate salinity envelope in the Caloosahatchee Estuary, thereby restoring the salinity balance to promote estuarine restoration (refer to Section 1 for more detail information on the evaluation of the project).

In 1997, significant amendments were made to the Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes) regarding regional water supply planning. These changes required the SFWMD to prepare a District-wide Water Supply Assessment (DWSA) and to prepare water supply plans for regions that

were anticipated to have the potential of demand outstripping available supply by the year 2020. In 1998, the SFWMD began a water supply planning initiative to ensure prudent management of south Florida's water resources. As a result of this initiative, the SFWMD released in 2000 the Caloosahatchee Water Management Plan (CWMP) whose findings determined that the improved management of surface water through storage containment, could increase freshwater availability in the region and reduce potential impacts resulting from water use.

In building alternative plans, the Restudy PDT considered cost effective means to achieving the desired output. The conclusion drawn in the Restudy determined that above ground water storage provided the most cost effective alternative for freshwater attenuation (CERP, Volume 1; Section 7.2). Additionally, this same conclusion was also reached in the Caloosahatchee Water Management Plan (CWMP). Both the Restudy and the CWMP concluded that above ground water storage areas are the most cost affective and appropriate method for capturing and storing excess water in the Caloosahatchee River Basin project area resulting from regulatory releases from Lake Okeechobee and freshwater runoff.

5.2 PLAN FORMULATION RATIONALE

Draft Programmatic Regulations Guidance Memoranda (GM) #1 (Project Implementation Reports) and GM #2 (Formulation and Evaluation of Alternatives Developed for Project Implementation Reports) instruct project teams to affirm and optimize the component identified in the Restudy unless conditions or planning objectives have changed or if the component no longer meets the purposes outlined in the Restudy. Additionally, for projects where the non-Federal sponsor has already acquired lands, formulation of alternative plans using other sites will be minimized if the intended project purposes can be achieved and no more cost-effective sites are identified during formulation. Additional management measures to address the new circumstances should be developed and screening should occur based on the project's evaluation criteria and performance measures.

The plan formulation for this project focuses on first reaffirming that above-ground storage reservoirs in the Caloosahatchee River (C-43) Basin continue to meet the goals, objectives, and purposes for the project as described in the Restudy (Refer to Section 1 for more detail on Reaffirmation versus Reformulation). The project team then optimized the reservoir reviewing smaller and larger alternatives (including increased/decreased footprints, increased/decreased depths, varying infrastructural features such as numbers of pumps and pumps sizes and different cell configurations) in addition to the State's Acceler8 alternative referred to as the C-43 West Storage Reservoir. This

project implementation report (PIR) will also identify any additional unmet needs in the study and a process to address them.

Once a TSP is identified through system-wide formulation analysis, a next-added incremental (NAI) analysis evaluates the effects, or outputs, of the TSP as the next project added to the group of already approved CERP projects. This analysis helps illuminate the beneficial effects of the selected alternative plan (SAP) contributions without regard to future CERP projects as well as the importance of the project in the sequence of implementing CERP and dependence of other CERP projects on the project under evaluation. This analysis also helps to ascertain whether sufficient benefits attributable to the SAP can justify the cost, if no additional CERP projects (other than those already existing or authorized) are implemented.

Studies conducted for this report will confirm that the problems, opportunities, objectives, and constraints remain consistent with the Plan; the existing and future without project conditions identified in the Plan remain consistent; and the plan as described in the Restudy remains a viable alternative.

In addition the PDT considered the recent recommendations of the National Research Council (NRC) during the formulation of alternative plans and ultimately in the final selection of the TSP. The NRC has reviewed the first five years of work on CERP. Starting in 2004, 12 science and engineering experts studied CERP's progress and, after two years of study, issued their findings: *Progress Toward Restoring the Everglades: The First Biennial Review, 2006.* Biennial evaluations will continue through the 30-year lifetime of CERP. The NRC recognizes that Everglades' restoration is a complex undertaking with many scientific uncertainties, which can slow the rate of progress. They concluded that if the construction of a restoration project is delayed until all scientific uncertainties are eliminated, there will be many negative consequences including: continued decline of the Everglades ecosystem, lagging public support, and increased project costs. The NRC identified an approach referred to as Incremental Adaptive Restoration where an incremental approach using steps that are large enough to provide some restoration benefits now while addressing critical scientific uncertainties and to take actions that promote learning that can guide the remainder of the project design. Constructing projects using a phased approach will enable assessments of benefits and impacts to the environment as each phase is constructed. Remaining phases will then be adapted to optimize performance based on actual findings from the earlier phases.

The primary purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to provide water supply to meet environmental needs, with surplus water being used as a potential opportunity to meet additional water

supply demands for urban and agricultural users in the area. Additionally, Stakeholders in the basin have expectations that the Caloosahatchee River (C 43) Basin project will address water quantity problems while providing water quality improvement features. The ability of the project to address these needs is affected by at least two factors:

- Agriculture in the area depends upon surface water and groundwater for water supply to meet irrigation needs, especially in the East Caloosahatchee River (upper) basin; and
- Several public water supplies sources in the basin rely on surface water withdrawals from the Caloosahatchee River (C-43 Canal) to meet urban water demands.

Taking into consideration all of the issues, constraints and expectations for this project, formulating and evaluating larger-scale alternatives that take into consideration all of the issues and problems in the basin while trying to meet the public's expectation for the project will be technically complex due to modeling requirements, requiring additional time to conduct the analysis of the watershed. Additionally, cost estimates for potential solutions will be costly and considerably over the Caloosahatchee River (C-43) Basin Storage Reservoir cost estimate from the Restudy. The basin-wide approach to restoration in the Caloosahatchee Basin remains consistent with the approach and issues identified in the Restudy, but require further investigation, will be more complex and time consuming, and will taking longer periods of time to complete and implement. The Caloosahatchee Estuary is in need of immediate help and cannot wait until a holistic approach is developed to address all of the issues of the entire basin.

In order to address these changing conditions and other issues and concerns that have arisen since the Restudy analysis of the project, it is recommended that the project use an Incremental Adaptive Restoration approach in which the basin study is divided in to two separate PIRs. This first PIR, the Caloosahatchee River (C-43) West Basin Storage Reservoir, will address the most immediate needs of the estuary, while ensuring that it is fully compatible and consistent with the CERP. A subsequent PIR will then provide a more comprehensive solution to the broader needs of the entire basin.

5.3 PLAN FORMULATION

The Restudy identified that above ground storage is the most cost effective means for capturing, storing and distributing excess water in the Caloosahatchee Watershed. The Restudy also realized that further in-depth analysis would result in project refinements, resulting in a more realistic and implementable design.

The refinement of the Restudy Plan for the Caloosahatchee River Watershed is known as the Caloosahatchee River (C-43) West Basin Storage Reservoir. The first major step of the plan formulation process for this project consists of reaffirming an above ground impoundment or storage reservoir with associated features such as a pumping station and seepage management system meets the goals and objectives as outlined in the Restudy. The refinement of the Restudy Plan is known as Alternative 3. To complete the plan formulation analysis, alternative plans with different storage volumes and pump sizes were then compared to determine cost-effectiveness and implementability of the selected plan.

5.3.1 Management Measures for Reaffirmation

Both structural and non-structural management measures were developed to ensure the achievement of an overall CERP goal that the proposed project would provide environmental restoration benefits as outlined in the Restudy.

In developing an initial set of management measures for the Caloosahatchee River (C-43) West Basin Storage Reservoir, the team looked at both structural and non-structural management measures. ***Table 5-1*** provides a description of management measures considered and how they could meet the planning objectives.

In order to develop and select a plan that will reasonably maximize ecosystem restoration benefits while addressing the water supply issues and opportunities in the basin, restoration of estuarine and riverine health were sought by improving hydrologic conditions. This could be done by evaluating two objectives: 1) providing additional water to augment low or no flows over S-79 during the dry season/dry periods, and 2) reducing damaging peak flows by providing adequate storage during high flow conditions.

Informal methods of analysis were used in the development of the screening process for initially selecting management measures. This consisted of an interactive process used to identify the significant differences between the management measures, to evaluate each measure utilizing best professional judgment, and to narrow down the number of measures to those that achieved the planning objectives and goals of the project (while taking into consideration constraints and environmental needs and requirements).

TABLE 5-1: DESCRIPTION OF MANAGEMENT MEASURES CONSIDERED FOR THE PROJECT

Management Measures Type	Management Measure Name	Description	Comments
Structural	Above Ground Reservoir Storage Areas	Large water storage areas surrounded by perimeter levees constructed from excavating soil from the interior of the reservoir adjacent to the levee locations. Would allow storage of water during extreme high runoff periods for release during low flow periods.	**Advantages:** Cost effective way of storing water, can be a secondary source of agricultural and urban water supply. **Disadvantages:** As the dry season's end approaches, water levels in the reservoir may drop to near the existing ground surface. **Water Quality**: Potential to improve water quality of water stored in the reservoirs somewhat through settling. Could also be combined with implementation of an STA to provide additional treatment. **Increased Habitat:** Improving habitat quality in the river and estuary by better meeting flow and associated salinity targets.
Structural	Restoration of Natural Areas	Natural areas that capture and provide natural storage & retention of stormwater runoff.	**Advantages:** Introduces an opportunity to re-hydrate and restore historic wetland and lacustrine areas and upland areas that have been altered due to urban and agricultural encroachments. **Disadvantages:** Few locations available to provide natural storage. Introductions of large amounts of water could be detrimental to the health of the existing wetlands by altering hydro-periods. **Water Quality:** Reduces the amount of stormwater reaching the canal systems, river, and estuary through the natural retention of stormwater runoff **Increased Habitat:** Improving habitat quality in the estuary, also increasing spatial extent of watershed wetlands and lake habitats.
Structural	Stormwater Treatment Areas (STAs)	Shallow water bodies created through the construction of small levees, generally ranging from one to three feet in depth. Divide vegetated cells (in which the water depth and rate flow can be controlled) are designed to uptake nutrients and remove suspended sediments from the water column.	**Advantages:** Designed and built to capture and treat stormwater runoff from the drainage basin, then release it back to the receiving water body **Disadvantages:** Due to the naturally occurring high levels of phosphorus in the watershed, nitrogen, rather than phosphorus, was the limiting nutrient, and high nitrogen loads were responsible for the elevated chlorophyll-a concentrations in the

Management Measures Type	Management Measure Name	Description	Comments
			Caloosahatchee Estuary. STAs recently constructed in South Florida have been designed to optimize phosphorus removal, but are not as effective at the removal of nitrogen. **Water Quality:** Vegetated STAs are designed to remove at least 80% of the incoming phosphorus load in water captured by the reservoirs **Increased Habitat:** Increased acreage for fish and wildlife. STAs often provide excellent areas for many migratory and threatened and endangered bird species.
Structural	Backpumping with Stormwater Treatment (STAs)	When a series of conditions are met, a series of pump stations could backpump excess water from reservoir(s) and from the Caloosahatchee River (C-43) Basin, to Lake Okeechobee after treatment through a STAs	**Advantages:** Unused water captured in reservoir(s) could be treated and returned to Lake Okeechobee. **Disadvantages:** Potentially insufficient water supply to meet all future environmental, agricultural, and urban demands in Caloosahatchee River (C-43) Basin. Series of conditions must be met before water can be sent to Lake Okeechobee. **Water Quality:** Stormwater treatment could address to small degree phosphorus loading in Lake Okeechobee **Increased Habitat:** Increased acreage for fish and wildlife. STAs often provide excellent areas for many migratory and threatened and endangered bird species.
Structural	Aquifer Storage and Recovery (ASR)	Water pumped from the storage reservoir into an ASR well for storage (at a specific capacity) in the aquifer.	**Advantages:** Provide additional water through subsurface storage to meet water needs in the Caloosahatchee River (C-43) Basin (44 ASRs) wells within the Caloosahatchee Basin, each having an injection or withdrawal capacity of five million gallons per day). It was assumed for the Restudy that the recovery efficiency would be 70% of water injected. **Disadvantages:** Water needed for ASR would be pumped from reservoir. Lack of information on the specific water quality characteristics of water to be injected, the specific water quality characteristics and the amount of water recovered from the aquifer, and the water quality

Management Measures Type	Management Measure Name	Description	Comments
			characteristics of water within the receiving aquifer. **Water Quality:** Chlorination for pre-treatment of water taken from reservoir prior to injection, and aeration for post-treatment of water recovered from ASR well prior to release. **Increased Habitat:** Improve habitat quality in the river and estuary by better meeting flow and associated salinity targets.
Structural	Oxbow Restoration	A crescent shape lake that forms in an abandoned meandering river channel, when the course of the river changes over a period of time, sedimentation builds up and closes the bend off from the river.	**Advantages:** 35 of these oxbows located along the Caloosahatchee River from the S-79 structure to the City of LaBelle. Could provide habitat within the river. **Disadvantages:** Water quality is poor in all of the oxbows; all have dissolved oxygen problems due to decaying vegetation and sediment buildup. Oxbows offer little storage value. **Water Quality:** Provides no water quality advantages. **Increased Habitat:** Increase wetland habitat. Could provide both riverine and wetland habitat improvements for many fish and wildlife species.
Nonstructural	Operation of Reservoirs	Focus on the capture and release of basin runoff through the timing of releases from the reservoir(s) that will alter the timing and quantity of nutrients delivered to the estuary through S-79 Structure.	**Advantages:** Depending upon the design and operation of the reservoir system, settling and some biological uptake will remove between 20% and 30% of the TN load captured by the reservoirs. **Disadvantages:** Will alter the timing and quantity of nutrients delivered as a result of changing discharge rates to the estuary. **Water Quality:** A nutrient loading analysis of reservoir operations conducted by FDEP determined that with an available storage of 228,000 acre-feet of storage, the project would capture approximately 500 tons/year of TN. **Increased Habitat:** Improving habitat quality in the river and estuary by better meeting flow and associated salinity targets.
Nonstructural	Best Management Practices (BMPs)**	The focus of the BMP effort is to reduce the pollutant load for a variety of water quality	**Advantages:** FDACS BMP program adopts BMPs developed by growers through workshops as the most

Management Measures Type	Management Measure Name	Description	Comments
		constituents contained in runoff from all major agricultural commodity groups (i.e., citrus, sugarcane, cattle, and row crops) and from urban land uses.	effective and practicable on-location means to improve water quality from agricultural discharges. Benefits of participation include a mechanism for "presumption of compliance" with state water quality standards and a waiver of liability. **Disadvantages:** Participation is self-implementing in that a grower chooses to participate. **Water Quality:** Reduction in nutrient and pollutant content of runoff from all major agricultural commodity groups through self imposed practices. SFWMD will expand its Urban BMP Program into the urban areas within the next year. The concept behind the BMP program is to identify and establish effective measures to prevent polluted stormwater from entering the receiving water bodies. **Increased Habitat:** Could benefit system by reducing algae blooms and other adverse affects of poor water quality.

**Note: The BMP programs described above are considered as part of the future without project conditions for the West Basin Storage Reservoir project and will not be considered as management measures in the formulation of alternative plans.

After a thorough review of the different structural and nonstructural management measures developed for the project, all but two were screened out based on the screening criteria described above. The results of the screening are shown in ***Table 5-2***. Above ground storage reservoirs (structural management measure) and operation of above ground storage reservoirs (non-structural management measures) were the selected features that the team determined were best able to meet the planning goals and objectives, opportunities, constraints, and environmental needs of the project.

TABLE 5-2: SCREENING OF POTENTIAL MEASURES FOR USE IN THIS PROJECT

Measure	Selection for First PIR	Reason
Above Ground Reservoir Storage Areas	Yes	Primary focus of Caloosahatchee River (C-43) West Basin Storage Reservoir project is to evaluate various reservoir storage areas.
Restoration of Natural Areas	No	This measure was deferred for further consideration in later study
STAs	No	This measure was deferred for further consideration in later study. STAs may not be needed. STAs most effectively treat phosphorus, and nitrogen loading is key issue in the basin.
Backpumping with Stormwater Treatment	No	This measure was deferred to later study. However, this option is less likely, since current modeling shows insufficient water supply to meet all future demands.
Aquifer Storage and Recovery	No	This measure was deferred to later study.
Oxbow Restoration	No	This measure is currently being evaluated as part of a Continuing Authorities Program - Section 206 study. Areas not addressed by the 206 study were deferred to a later study or separate SWFFS
Operation of Reservoirs	Yes	Primary focus of Caloosahatchee River (C-43) West Basin Storage Reservoir project is to evaluate various reservoir storage areas, and operational approaches
BMPs	No	Considered part of the future without project condition - will not be considered a measure in the formulation of alternative plans

5.3.2 Summary of Reaffirmation of Management Measures

The above analysis of management measures reaffirmed that above ground reservoir storage areas and operations of reservoirs meet the goals and objectives as outlined in the Restudy. These management measures will now be further optimized to meet those goals and objectives in a cost effective manner.

5.3.3 Project Siting Analysis

After screening of management measures concluded that above ground reservoir storage areas and operations of reservoirs meet the CERP-wide and project specific goals and objectives, an alternative site analysis was conducted to determine the most feasible and productive location. Previous studies such as the CWMP examined areas in existence that could be utilized for the proposed project.

Originally, an in-depth site analysis was performed for both the Eastern Caloosahatchee River (upper) basin and Western Caloosahatchee River (lower) basin to identify potential reservoir sites prior to the splitting of the project into two PIRs, see Plan Formulation Appendix for complete Siting Analysis. The siting criteria used to rank the potential reservoir sites included threatened and endangered species, wetlands, cultural resources, basin locations, effects to natural tributaries, potential seepage and flooding, and compatibility with enterprise zone. Sites with significant wetlands were eliminated from this level 1 screening.

For the West Caloosahatchee Basin, seven sites were further investigated as possible locations for placement of storage reservoirs. The seven sites included lands currently in agriculture i.e., citrus, pasture, etc. and were therefore similar with respect to type and quality of wetlands present. As a result of the in-depth screening analysis, six of the seven sites were eliminated either due to impacts to threatened or endangered species or due to geotechnical concerns with seepage rates of the soils on site. Based on this analysis a site referred to as the "Berry Groves" site was selected (***Figure 5-1***), since it represented the most promising site given the location, land use, geology, and soils (see Appendix F for more information on siting analysis).

Based on the findings of the Restudy and CWMP, which both require a storage reservoir in the Caloosahatchee River (C-43) Basin, the SFWMD determined the best location to use both State and Federal funds to acquire property in the Caloosahatchee River (C-43) Basin. The Federal funds used for this project were appropriated to the Department of Interior (DOI) and a Grant Agreement entitled Everglades Watershed Restoration-Grant Number LWCF-1 was executed to acquire south Florida ecosystem restoration project lands in the Caloosahatchee River (C-43) Basin. The Florida Division of State Lands in cooperation with the SFWMD staff reached an agreement that allowed the SFWMD to acquire the Berry Groves property as a key component for Everglades restoration (February 2000). To date the State of Florida has purchased a total of 12,372 acres in the immediate area in anticipation of reservoir construction with Federal funding provided by the DOI at a total of approximately $32,800,000, a portion of which will be credited to the Federal government towards the acquisition of lands for this project. It was determined

that the currently identified site was the most practicable location for the proposed project without incurring exorbitant costs of purchasing lands in the basin. Additionally, where the non-Federal sponsor has already acquired lands, formulation of plans using other sites will be minimized if the intended project purposes can be achieved and no more cost effective land sites are identified in plan formulation.

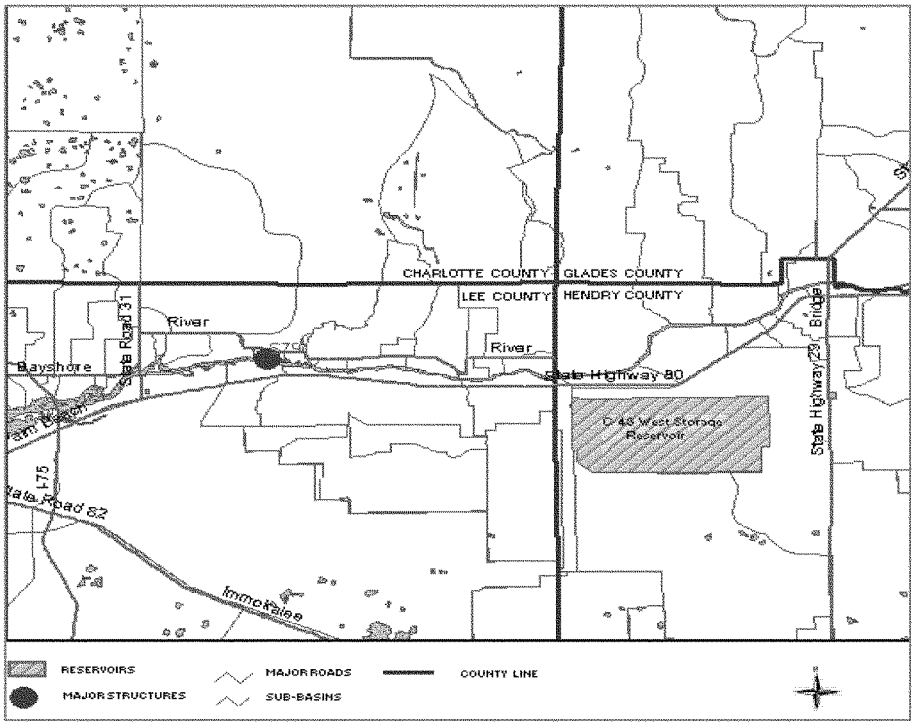


FIGURE 5-1: LOCATION OF THE BERRY GROVES SITE

5.3.4 Screening of Final Array of Alternatives

With the reaffirmation of the management measures (above ground reservoir storage areas and operations) identified in the Restudy and the selection of a cost effective site for its implementation, the PDT focused on the optimization of the management measures in identifying a cost effective and implementable alternative. The alternatives noted below were subjected to a screening process described in ***Section 5.3.1***. Also included within all these analyses was the "No Action" Alternative.

The alternative described in the Restudy used the Everglades Screening Model to identify approximately 160,000 acre-feet of storage volume as the targeted amount of storage necessary to capture wet season flows and to meet dry season minimum flows in order to provide desired salinity levels in the Caloosahatchee Estuary. The project team used the Restudy alternative (construction of above ground storage reservoirs totaling approximately 160,000 ac-ft) as a starting point for the basis of developing project alternatives.

5.3.4.1 Alternative 1

Alternative 1 is the No Action Plan, which is also the Future Without Project Condition described in ***Section 3*** of this report. This alternative was developed from the existing hydrology with modifications for anticipated changes in the watershed due to land use changes, water supply changes, water quality changes, and changes caused by other water resource projects in the watershed.

5.3.4.2 Alternative 2 (100,000 ac-ft Reservoir with 1,500 cfs Pumping Capacity)

Alternative 2 was developed as a smaller restoration alternative for the Western Caloosahatchee River (lower) Basin. This alternative is consistent with the CERP recommendation for a reservoir in this area, but it should be noted that this alternative's total storage volume of 100,000 ac-ft is significantly reduced from the 160,000 ac-ft of storage CERP estimated would be needed in this sub-region.

Alternative 2 is a two-cell reservoir with a "normal pool" storage capacity of 100,000 ac-ft (***Figure 5-2*** shows the configuration of this alternative and is applicable to the other alternatives). The design details of this alternative are outlined in ***existing on-site*** material and have a low permeability core. A graded filter is to be provided on the exterior side of the dam to direct seepage. Soil cement protection would be included on the interior side of all reservoir slope faces. A freeboard of 15 feet was used based on detailed analysis of wind and wave height run-up.

Table 5-3. The two-cell design was selected based on the fact that an internal embankment reduces wind set-up and wave-run up helping to reduce the embankment size and cost and it also allows for independent dewatering for unscheduled maintenance if necessary. The reservoir design includes a pump station (1,500 cfs capacity) to pump water from the C-43 Canal through the Townsend Canal to fill the reservoir. While a two pump station design was considered, the single pump station option was found to be most cost effective. Locating the pump station in the northwest corner minimizes improvements necessary for the Townsend Canal.

The water surface elevation of 35 ft North American Vertical Datum of 1988 (NAVD88) at "normal pool" is constant within the cells, with the depths ranging from 10-15 feet based on the elevation of the existing land surface. Dam heights for Alternative 2 will range from 29-34 feet. The maximum water depths and dam heights will occur in Cell 1, due to lower land surface elevations. The exterior and interior dams are to have a top width of 15 feet. The side slopes are 3 Horizontal: 1 Vertical (3H:1V). The exterior dams are to be constructed from

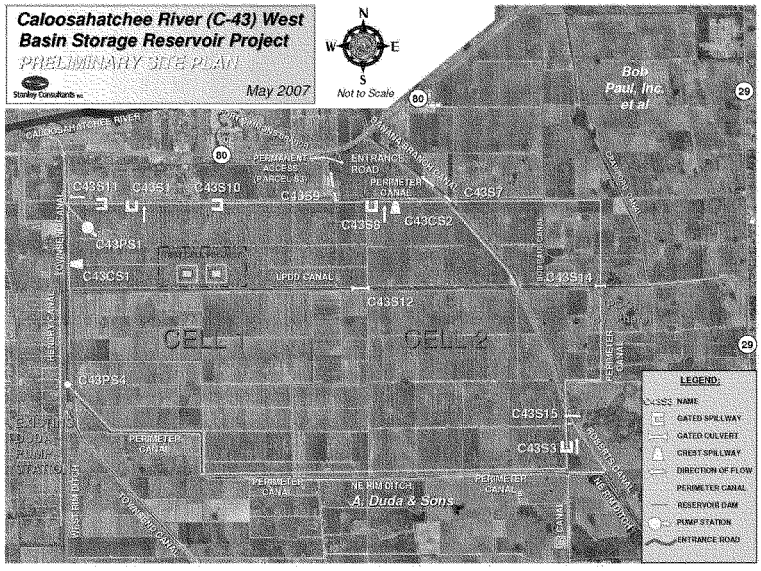


FIGURE 5-2: TYPICAL ALTERNATIVE SITE PLAN

existing on-site material and have a low permeability core. A graded filter is to be provided on the exterior side of the dam to direct seepage. Soil cement protection would be included on the interior side of all reservoir slope faces. A freeboard of 15 feet was used based on detailed analysis of wind and wave height run-up.

TABLE 5-3: ALTERNATIVE 2 DESIGN SUMMARY

Design Parameters	Parameter Values
Storage Volume (ac-ft)	100,000
Storage Area/Reservoir (acres)	9,220
Project Footprint-Staging, O&M, etc. (acres)	10,500
Normal Pool Elevation/ Average Pool Depth	35 ft NAVD88/ 10-15 ft
Dam Elevation/Dam Height	54 ft NAVD88/29-34 ft
Total Fill Rate–Pump Capacity (cfs)	1,500
Time to Fill (days)	33

A perimeter canal (seepage canal) is provided on the south, east, and north sides of the reservoir. The existing Townsend Canal will act as a seepage canal on the west side of the reservoir. In addition to seepage collection, the perimeter canal will also convey discharges from the reservoir; convey surface runoff from the south and east of the reservoir including improved drainage for SR 29; provide flows to the Crawford Canal, Banana Branch and Fort Simmons Branch; and maintain the surface water elevation in the expanded northeast rim ditch that provides irrigation for the A. Duda and Sons (Duda) citrus operations, located to the south of the reservoir. A 17-foot cutoff wall along the perimeter of the dam embankment has also been included.

Improvements to the Townsend Canal are based on the necessary capacity to meet maximum pumping requirements to fill the reservoir. Pre-storm and post-storm event flows have been simulated to evaluate flows in the Townsend Canal and other local canals and tributaries. Storm event flows in the Townsend Canal will be decreased over existing conditions with the construction and operation of the reservoir.

Each cell in the alternative is designed to discharge independently through separate discharge structures. Cell 1 discharges via S-1 into the Townsend Canal. Cell 2 discharges via S-8 into the perimeter canal. These structures will be designed for incremental operation allowing required flows to be released to the Caloosahatchee River (C-43 Canal) during periods of low flow. These structures could also serve as design storm control structures for releases prior to and during a storm event. The storm releases must be balanced with the targeted maximum flow allowed over S-79, which is 4,500 cfs. An emergency spillway with a crest elevation based on retaining the 25-year, 72-hour storm

event is to be provided within each cell's discharge structure. The 25-year, 72-hour storm captured in the reservoir would be a "control release" after the storm event in order to restore the water surface to the normal pool elevation while not exceeding the maximum flow of 4,500 cfs at S-79. The final design of the emergency spillway(s) will be in accordance with the requirements of Design Criteria Memorandum 3 (DCM-3).
Within the reservoir, structure S-12 hydraulically connects the reservoir cells and is designed to be gated so that either cell can be "isolated" for operational or maintenance purposes. A number of other culverts, weirs, and spillways are included to operate the reservoir and maintain appropriate water levels in existing canals and the perimeter canals.

5.3.4.3 Alternative 3 (A and B)–170,000 ac-ft Reservoir with 1,500 cfs Pumping Capacity

This alternative comes closest to approximating the Restudy-recommended volume of approximately 160,000 ac-ft for the West Basin storage reservoir and is the size evaluated and recommended in the Acceler8 planning process. Alternative 3 is a two-cell reservoir with a "normal pool" storage capacity of 170,000 acre-feet. The reservoir design includes a pump station with 1,500 cfs capacity to pump water from the Townsend Canal to fill the reservoir. The site layout would remain unchanged. This alternative was subdivided into a Alternatives 3A and 3B for evaluation purposes. The key distinction between Alternatives 3A and 3B is the operational methodology related to filling and draining the reservoir, rather than any structural differences. In general, Alternative 3A, the original plan identified by the State's Accler8 program attempts to maintain very specific flow rates at S-79 at all times while Alternative 3B attempts to meet the dynamic flow targets supplied by the ecological sub team (EST05).

Further in the formulation process these two alternatives were merged to fully meet the goals and purposes as identified in this report. For Alternatives 3A and 3B, the water surface elevation would be 42 feet at "normal pool" (NAVD88), with the average depth ranging from 17-19 feet. Dam heights for Alternatives 3A and 3B range from 32 -37 feet. The maximum water depths and dam heights will occur in Cell 1 due to lower land surface elevations in that cell. The exterior and interior dams are to have a top width of 14 feet. The side slopes are 3 Horizontal to 1 Vertical (3H:1V). The exterior dams are to be constructed from existing on-site material and have a low permeability core. A graded filter is to be provided on the exterior side of the dam to direct seepage. Soil cement protection would be included on the interior side of all reservoir slope faces. A freeboard of 15 feet was used based on detailed analysis of wind and wave height run-up. The design details of this alternative are outlined in ***Table 5-4***.

TABLE 5-4: ALTERNATIVE 3A AND 3B - DESIGN SUMMARY

Design Parameters	Parameter Values
Storage Volume (ac-ft)	170,000
Storage Area/Reservoir (acres)	9,220
Project Footprint Staging, O&M, etc. (acres)	10,500
Normal Pool Elevation/ Average Pool Depth	42 ft NAVD88/17-19 ft
Dam Elevation/Dam Height	57ft (NAVD88)/32-37 ft
Total Fill Rate–Pump Capacity (cfs)	1,500 cfs
Time to Fill (days)	57

The perimeter canal, improvements to the Townsend Canal, and construction of culverts, weirs, and spillways is essentially unchanged from Alternative 2. Because this alternative has a larger storage volume yet maintains the same pumping capacity, the amount of time required to fill the reservoir is approximately 24 days longer.

5.3.4.4 Alternative 3C–170,000 ac-ft Reservoir with 3,800 cfs Pumping Capacity

Alternative 3C is very similar to Alternatives 3A and 3B. The only difference is a larger pumping capacity and the associated modified reservoir operations to optimize storage performance with greater pumping flexibility. Alternative 3C is a two-cell reservoir with a "normal pool" storage capacity of 170,000 acre-feet. The reservoir design includes a pump station (3,800 cfs pumping capacity) to pump water from the Townsend Canal to fill the reservoir. The water surface elevation of 42 feet (NAVD88) at "normal pool" is the same for both cells, with depths ranging from 17-19 feet. Other structural elements would be the same as described in the previous Alternative 3B.

The inclusion of the larger pump allows for greater operational flexibility. In particular, the reservoir can be filled approximately 34 days faster than under Alternatives 3A and 3B and ten days faster than Alternative 2. This allows the reservoir to capture more water during the relatively short duration high flow events. Within this alternative there is uncertainty regarding the amount of retrofitting that may be required to the Townsend Canal and roadways. These uncertainties would not be known until additional engineering and design could be completed in the planning, engineering and design phase. For the purposes of this analysis it was assumed that no additional retrofitting would be required. The design details of this alternative are outlined in ***Table 5-5***.

TABLE 5-5: ALTERNATIVE 3C - DESIGN SUMMARY

Design Parameters	Parameter Values
Storage Volume (ac-ft)	170,000
Storage Area/Reservoir (acres)	9,220
Project Footprint-Staging, O&M, etc. (acres)	10,500
Normal Pool Elevation/ Average. Pool Depth	42 ft NAVD88/17-19 ft
Dam Elevation/Dam Height	57 ft NAVD88/32-37 ft
Total Fill Rate–Pump Capacity (cfs)	3,800 cfs
Time to Fill (days)	23

5.3.4.5 Alternative 4A–220,000 ac-ft Reservoir with 3,800 cfs Pump

Alternative 4A is a two-cell reservoir with a "normal pool" storage capacity of 220,000 ac-ft with dam heights of 41-46 feet and water depths of 22-27 feet at "normal pool." The pump station capacity is 3,800 cfs. The reservoir location and other associated features are the same as Alternative 3C.

The major difference is that by increasing the storage capacity and maintaining the same foot print normal pool elevations and levee elevations would be approximately five feet higher. In addition, by maintaining the same pump capacity as Alternative 3C approximately six additional days would be required to fill the reservoir. The design details of this alternative are outlined in ***Table*** 5-6. The selection of the upper bound 220,000 acre-feet reservoir matches findings of the SFWMD CWMP that recommended a storage reservoir with a capacity of 220,000 ac-ft located in the Western Caloosahatchee River (lower) basin at Berry Groves. The CWMP concluded that a 220,000 ac-ft reservoir would provide for environmental restoration of the Caloosahatchee Estuary.

TABLE 5-6: ALTERNATIVE 4A - DESIGN SUMMARY

Design Parameters	Parameter Values
Storage Volume (ac-ft)	220,000
Storage Area/Reservoir (acres)	9,220
Project Footprint-Staging, O&M, etc. (acres)	10,500
Normal Pool Elevation/Average Pool Depth	47 ft NAVD88/22-27 ft
Dam Elevation/Dam Height	66 ft NAVD88/ 41-46 ft
Total Fill Rate–Pump Capacity (cfs)	3,800
Time to Fill (days)	29

5.3.4.6 Alternative 4B–220,000 ac-ft Reservoir on Expanded Footprint with 3,800 cfs Pumping Capacity

Alternative 4B maintains the same storage volume as Alternative 4A; however, an approximately 5,610 acre larger footprint would be utilized allowing for an approximately eight foot lower dam height and pool elevation. Alternative 4B would also be a two-cell reservoir with 220,000 ac-ft of storage. Dam heights would range from 32-37 feet and water depths from 14-19 feet at "normal pool." The pump station location and capacity is the same as Alternative 3C and 4A. The exact locations of other culverts, weirs, and spillways would be similar to Alternative 4A. The general site plan and design details can be found in ***Figure*** 5-3 and ***Table 5-7*** respectively.

Although Alternative 4B was carried into the final array of alternatives, it was screened from further consideration at this point. Alternative 4B provides the same level of ecosystem output as Alternative 4A, however, the cost estimates indicated that while construction costs would be lower, total land costs would increase by approximately $150 million resulting in a roughly $80 million higher cost. The real estate costs for the additional land area associated with Alternative 4B were estimated to be considerably higher than previous purchases based on increasing development pressures in the area. In addition, the larger surface area of this alternative would result in greater evapotranspiration of water. Based on these findings, Alternative 4B was removed from further consideration.



FIGURE 5-3: ALTERNATIVE 4B SITE PLAN

TABLE 5-7: ALTERNATIVE 4B - DESIGN SUMMARY

Design Parameters	Parameter Values
Storage Volume (ac-ft)	220,000
Storage Area/Reservoir Footprint (acres)	15,140/16,610
Project Footprint-Staging, O&M, etc. (acres)	18,910
Normal Pool Elevation/ Average Pool Depth	39 ft NAVD88/14-19 ft
Dam Elevation/Dam Height	57 ft NAVD88/32-37 ft
Total Fill Rate–Pump Capacity (cfs)	3,800
Time to Fill (days)	29

5.3.5 Summary of Final Array of Alternative Plans

The final array of alternatives consists of seven alternative plans, including the No Action Alternative and variations on three reservoir capacities of 100,000, 170,000 and 220,000 ac-ft. Alternative 4B would require the purchase of approximately 5,610 additional acres to support an expanded footprint and lower dam heights. This array of alternatives would serve the needs of the Caloosahatchee River (C-43) Basin through the creation of a single reservoir in a location that would capture water from Lake Okeechobee and basin runoff from a majority of the Caloosahatchee River (C-43) Basin. The Berry Groves location also provides for efficient and flexible management of the stored water. The final array of alternatives is summarized in ***Table 5-8***.

TABLE 5-8: SUMMARY OF FINAL ARRAY OF ALTERNATIVES

Alternative 1	No Action (Future-Without Project)
Alternative 2	100,000 ac-ft reservoir, 29-34 feet dam, 10-15 feet average pool depth, and 1,500 cfs pump capacity
Alternative 3A	170,000 ac-ft reservoir, 32-37 feet dam, 17-19 feet average pool depth, and 1,500 cfs pump capacity • Restudy/Acceler8 design and operations
Alternative 3B	170,000 ac-ft reservoir, 32-37 feet dam, 17-19 feet average pool depth, and 1,500 cfs pump capacity • Restudy/Acceler8 design with alternate operations
Alternative 3C	170,000 ac-ft reservoir, 32-37 feet dam, 17-19 feet average pool depth, and 3,800 cfs pump capacity • Restudy design with larger pump
Alternative 4A	220,000 ac-ft reservoir, 41-46 feet dam, 22-27 feet average pool depth, and 3,800 cfs pump capacity
Alternative 4B	220,000 ac-ft reservoir, (expanded footprint) 32-37 feet dam, 14-19 feet average pool depth, and 3,800 cfs pump capacity

Note: Range in height is due to site elevations which vary by approximately 5 feet over the reservoir area.

5.3.6 Alternatives within the Jurisdiction of the Lead Agency

The Caloosahatchee River (C-43) West Basin Storage Reservoir project contains one component that is a part of the CERP, and is authorized in WRDA 2000. The measures considered in this study fall within the jurisdiction of the USACE and its sponsor the SFWMD. The implementation of this plan by the Federal government is being led by the USACE along with its non-Federal partner, the SFWMD. All alternatives being evaluated for the Caloosahatchee River (C-43)

West Basin Storage Reservoir project are consistent with CERP and within the USACE's jurisdiction. No measures considered were outside the jurisdiction of the USACE or its sponsor.

5.3.7 Evaluation of the Final Array of Alternatives

The next step was to evaluate the final array of alternatives using ecological output measured in habitat units (HUs) and costs. The following sections summarize the tools used for this evaluation and how they were used.

5.3.7.1 Analytical Tools Used to Evaluate the Final Array of Alternatives

In formulating and evaluating project alternatives, operational effects of proposed management measures on the existing ecosystem must be considered. To do this, computer simulation models and spreadsheets were used to evaluate the proposed operational criteria for each alternative in terms of its hydrologic influences on potentially affected natural areas.

A description and interpretation of all model results, including a review of the reliability and accuracy of the assumptions and data used in the model as well as risks and uncertainties associated with their use, is provided in ***Appendix A***.

5.3.7.1.1 South Florida Water Management Model

The most commonly used integrated model in South Florida is the South Florida Water Management Model (SFWMM). The model simulates the hydrology and the management of the water resources system from Lake Okeechobee in the north to Florida Bay in the south, covering an area of 7,600 square mile with a mesh of 3.2 km (2 miles) by 3.2 km (2 miles) cells. The SFWMM incorporates current or proposed water management protocols and operational rules and has the ability to simulate water management practices and policies that affect urban, agricultural, and environmental water uses in south Florida in one of its major strengths. Since the boundary of the SFWMM does not extend into the Caloosahatchee River (C-43) West Basin Storage Reservoir project area, the SFWMM model can only provide boundary conditions at the point where Lake Okeechobee discharges into the Caloosahatchee River (C-43 Canal), at Structure S-77. Therefore, a sub-regional model will be needed to simulate the hydraulics and hydrology of the project area.

5.3.7.1.2 MIKESHE Model

For this PIR, hydrologic indicators and hydraulic models were used to evaluate potential affects that could occur in the watershed for average wet season water levels (July 1 to October 1), average dry season water levels (April 1 to May 15), and hydroperiods. The MIKESHE modeling platform was used to develop sub-

regional models of the Caloosahatchee River (C-43) Basin to simulate the hydraulics and hydrology for purposes of showing hydrographs and stage duration curves, water level fluctuations and hydroperiods for selected indicator regions within natural areas associated with each of the alternative plans. These modeling results provide a comparison between Pre-Development, Existing (2000) conditions, 2050 Without Project conditions, and With Project conditions for each of the proposed alternatives for the system-wide analysis (with CERP) to identify the SAP.

5.3.7.1.3 Spreadsheet Analyses

The intent of this project is to help maintain desirable salinity levels in the Caloosahatchee Estuary System as measured by flows calculated for the S-79 structure. As an additional verification of modeling results used in selection of the SAP, a spreadsheet analysis will calculate flow data for the S-79 structure for use in a Next Added Increment (NAI) analysis of each alternative to verify environmental benefits achieved by each plan evaluated.

The source of Caloosahatchee River (C-43 Canal) flow data for the spreadsheet analyses for the Existing Conditions Baseline (2000) and Future Without Project Condition (2050 with no-CERP projects in place) is derived from South Florida Water Management Model (SFWMM) version 5.4.2 base model simulation 2000RD, for the Existing Conditions Baseline and 2050RD model simulation for the year 2050 with no CERP projects in place. Listed below are key assumptions utilized in these analyses, and which are consistent with this conceptual intent.

- The spreadsheet will take into consideration the evapotranspiration (ET) losses from the reservoir due to evaporation. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, reservoir seepage (assumed to be zero based on results of the C-43 Test Cell Pilot Project– July 2006), ET losses (based on area volume relationship), and reservoir direct precipitation.
- No agricultural or urban water supply deliveries will be supplied by the reservoir. These demands continue to be supplied from Lake Okeechobee or existing groundwater sources.
- The eastern Caloosahatchee Basin (east of the S-78 structure) will not be affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary downstream of S-79, there will be no impacts on the Western Caloosahatchee Basin.

5.3.7.2 Hydrologic Modeling Evaluation of Alternatives

As previously discussed, the reservoir's design utilizes the selected site to its fullest capacity in order to capture the greatest volume of water needed to meet

the flow targets (EST05) just downstream of S-79 at the start of the Caloosahatchee Estuary. To determine the appropriate size and performance of the reservoir at the area known as the Berry Groves, hydrologic data was compiled and analyzed to determine if the reservoir was designed to meet the flow and salinity targets.

Average daily flows between January 1988 and June 1999 were approximately 500 cfs. Low flows of 0 cfs and flows as high as 17,283 cfs were recorded during the same period (CWMP, April 2000). Therefore, in order to mimic natural fluctuations in flows to the estuary, other flow ranges and their frequency of occurrence needed to be determined. To do this, the SFWMD evaluated average monthly flow data for a period of 36 years (1965 to 1999), and developed the following flow distributions (EST05) shown in ***Table 5-9***.

TABLE 5-9: TARGET FLOW DISTRIBUTION FOR EST05

S-79 Freshwater Discharge (Mean monthly flow range)	Frequency -Mean Monthly Flow (36 Year Period of Record)
Number of months < 450 cfs	0.0%
Number of months between 450 cfs and 1500 cfs	74.5%
Number of months between 1500 cfs and 2800 cfs	24.8%
Number of months > 2800 cfs	0.07%
Number of months > 4500 cfs	0.0%

For each of the alternatives evaluated for this project, comparisons were made between the flow frequency distribution performance of the alternative and the target frequency distribution of the combined monthly and weekly average freshwater inflows through S-79 from the watershed and Lake Okeechobee for the nine year period of record (9 years out of the 36 year period of record containing three wet, three dry and three normal years on record).

The resulting flow frequency distributions from the analysis of Alternatives 1, 2, 3A, 3B, 3C and 4A were compared against the EST05 target distribution to determine the top performing plan. Based on this analysis, all alternatives show an increase in hydrologic performance. As the size of the project increases the performance also increases. Of the alternatives analyzed, Alternatives 3C and 4A came closest to matching the EST05 flow frequency distribution at S-79 (providing the desired number of months where the flows at S-79 were in the 450 cfs to 2800 cfs flow range) as they are the largest projects. These results are reflected in ***Table 5-10***.

The result of the analysis for each alternative was to show either an increase or decrease in the number of events where the mean monthly flows at S-79 were either above, below or within the flow envelope as compared to the future without project condition (***Table 5-10***).

TABLE 5-10: SUMMARY OF MEAN MONTHLY FLOW EVENTS AT S-79 WITHIN DIFFERENT FLOW RANGES

Alternative	Number of Months <450 cfs	Number of Months 450 – 800 cfs	Number of Months 800 – 2800 cfs	Number of Months 2800 – 4500 cfs	Number of Months >4500 cfs
Target (EST05)	0	79	29	0	0
2050FWO	43	27	28	7	3
Alternative 2 (2050)	33	46	27	2	0
Alternative 3A (2050)	33	56	17	2	0
Alternative 3B (2050)	30	26	49	3	0
Alternative 3C (2050)	19	60	29	0	0
Alternative 4A (2050)	19	60	29	0	0

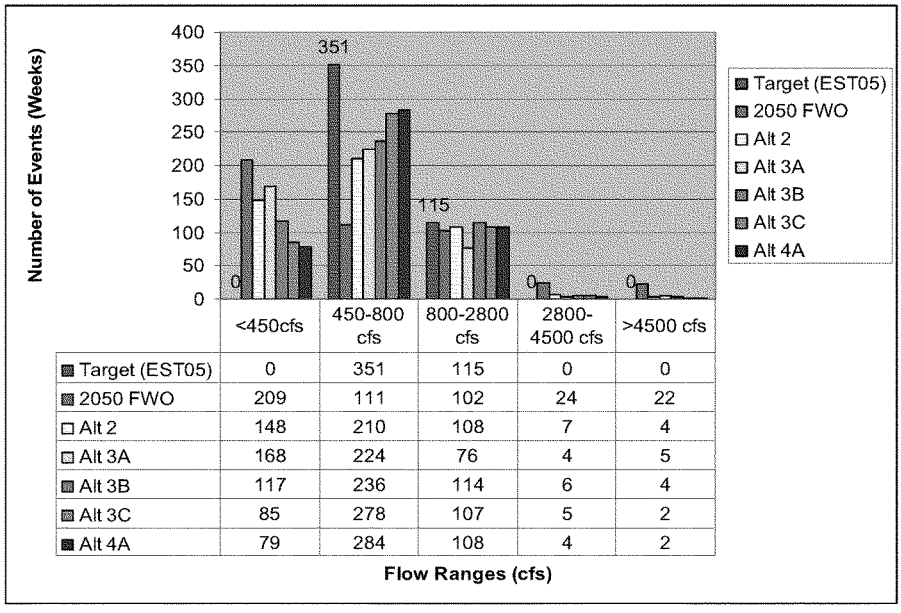
It is anticipated that project benefits will see additional lifts in benefits over those currently predicted using available ecologic and hydrologic models.

5.3.7.3 Evaluating the Ecological Significance of Hydrologic Change

Because all of the species indicators are also somewhat dampened by the effect of averaging over months, seasons, and spatially, it was determined that it would be beneficial to have at least one benefit stream that depicts a more accurate picture of how well each alternative is matching the hydrologic target flow at S-79. EST05 is the hydrologic target used for a suite of estuarine organisms but, because it represents a time series/flow range necessary for an ecological balance within the estuary, it may not reflect the optimal hydrology for any one species.

As stated above, species indicators were dampened by the effect of averaging over months, seasons, and spatially. In reviewing the flow data for each

alternative, it was determined that by looking at the monthly values of flows over S-79 for each alternative, not all of the flow events that were greater than 2,800 cfs were being captured due that the averaging of data for monthly periods. Extreme short duration events that occurred over a few days rather than an entire month were not being accounted for in the habitat analysis. Additionally, weekly data were available which did capture these shorter duration extreme events so the results are not as diluted as the monthly averages. The alternatives were then evaluated based on mean weekly flows through the S-79 structure. Using this method, the relative ranking of alternative performance remained unchanged across alternatives. Alternative 3C and Alternative 4A again provide the best performance at 84 percent of the period of record respectively (***Table 5-11***). Percentages used for calculating HUs were then calculated based upon weekly averages as to how well each alternative came close to matching the EST05 frequency distribution at S-79. These analyses are summarized in ***Figure 5-4*** and ***Table 5-11***. What these evaluations continue to show is that as storage and pump size are increased, the resulting benefits also increase.



	<450cfs	450-800 cfs	800-2800 cfs	2800-4500 cfs	>4500 cfs
Target (EST05)	0	351	115	0	0
2050 FWO	209	111	102	24	22
Alt 2	148	210	108	7	4
Alt 3A	168	224	76	4	5
Alt 3B	117	236	114	6	4
Alt 3C	85	278	107	5	2
Alt 4A	79	284	108	4	2

FIGURE 5-4: MEAN WEEKLY DISTRIBUTION OF FLOWS FROM S-79

TABLE 5-11: PERCENT MATCH TO TARGET (EST05) AT S-79 FOR MEAN WEEKLY FLOWS

Alternative	450-800 cfs	800-2800 cfs	%POR in Desired Envelope
Target	75.0%	24.6%	99.6%
2050FWO	23.7%	21.8%	45.5%
Alt2	44.9%	23.1%	67.9%
Alt3A	47.9%	16.2%	64.1%
Alt3B	50.4%	24.4%	74.8%
Alt3C	59.4%	22.9%	82.3%
Alt4A	60.7%	23.1%	83.8%

5.3.7.4 Ecological Benefits Evaluation of the Final Array of Alternatives–System-Wide Perspective

In practice, USACE's ecosystem restoration studies typically measure the ecosystem benefits of alternative plans in terms of physical dimensions (number of acres of wetlands, for example), or population counts (number of wading birds, for example), or various habitat-based scores ("habitat unit (HUs) based on the USFWS's Habitat Evaluation Procedures, or [HEP], for example). The next step was to evaluate the final array of alternatives using ecologic output measured in HUs and costs

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to develop a plan that will help moderate flows: i.e., reduce flows during high flow periods and augment flows during low flow periods. Therefore, in order to present benefits of each plan, the impacts must be determined during those critical flow events. Once benefits are determined for each of the final alternatives, they will be compared to determine the differences between plans for basis of selection of the tentatively selected plan (TSP). Benefits of each plan are measured in terms of HUs. A HU is a measure of how a particular species responds to changes in its environment as a result of contributions of a particular plan. More detailed information on the calculation of HUs for this project can be found in ***Appendix C***. Species selected for evaluation (focal species) are ecologically, recreationally or economically important and have a well established linkage to stressors of management interest. They may also make good focal species because they engage the public in caring about the outcome of restoration projects. To measure the responses of these indicator species to the different alternatives, Habitat Suitability Indices (HSI) models were developed by choosing specific life stages of particular species with the most limited, restricted, or tightest range of suitable conditions, to capture the highest sensitivities of the organisms to the environmental changes associated with the planned restoration activities. The intent of the habitat suitability model is not to simulate the life-cycles of the species. Rather, it is to estimate the number of HUs to serve as a relative basis for comparing management

alternatives. HSI models were developed with each stressor variable portrayed spatially and temporally across the study area at scales appropriate to the organism or community being portrayed. The HSI models have been incorporated into a Geographic Information System (GIS) to portray responses spatially and temporally to facilitate policy decisions. That is, the model describes a response surface of habitat suitability values that vary spatially according to stressor levels throughout the estuary and temporally according to temporal patterns in stressor variables (see ***Appendix C***).

The project team originally decided to use seven species–eastern oysters, blue crabs, *Vallisneria,* seagrass (*Halodule and Thalassia)*, spotted seatrout, decapod larvae, and zooplankton. Once all models were run on all alternatives, the team decided to narrow the full analysis to three species–oysters, *Vallisneria* and seagrass. It was useful to run all of the species models, as they affirmed that all species showed an improvement over base conditions. However, it was determined that some species would be dropped for purposes of quantification for the final analysis because:

- they were less sensitive to changes between alternatives
- they were redundant and added little additional value
- the team decided to focus on habitats rather than individual species

The chosen species also cover a full range of both temporal and spatial attributes. Oysters are found in the middle estuary and are impacted by both wet and dry season flows. Seagrass are found in the lower Caloosahatchee River Estuary and are most impacted by the wet season flows. *Vallisneria* is found in the upper Caloosahatchee River Estuary and is most impacted by the dry season flows. Benefits were calculated using the appropriate period of record to reflect when species are most affected. Wet years analyzed include 1979, 1982, and 1983. Dry years include 1980, 1981 and 1985. The wet season was defined as July through November and the dry season was defined as December through May. June was not included, because for some years June is dry and for some years it is wet, therefore it causes inconsistency in the benefits calculations. However, in practice benefits will be realized in June based on the current recommended operations.

This project is expected to primarily benefit the Caloosahatchee Estuary. However, because CERP projects are required to be selected and justified based on their system-wide benefits, the following analysis conducted for the plan selection process is based on a system approach in which the Caloosahatchee River (C-43) West Basin Storage Reservoir project benefits would coincide with the rest of CERP being constructed. For system formulation analyses, the environmental evaluations were based on five attributes:

1) Average HSI for oyster–based on all seasons of dry years and all seasons of wet years
2) Average HSI for *Vallisneria*–based on dry seasons of dry years
3) Average HSI for seagrass–based on wet seasons of wet years
4) Extreme Events–Average HSI of oyster, *Vallisneria*, and seagrass during the three driest months and three wettest months in the period of record.
5) EST05–This attribute reflects the percentage of weeks each alternative matches our target flow (EST05). EST05 is a time series of flow developed to maximize beneficial conditions for a suite of organisms in the Caloosahatchee River Estuary. EST05 was adopted as the system-wide performance measure for the Caloosahatchee Estuary (NE-03) by the RECOVER team.

Upon review of the data, there is little value in averaging all habitat suitability index (HSIs) for all seasons of all years. The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to help moderate flows; reducing flows during high flow periods and augmenting flows during low flow periods. Therefore, in order to present benefits, the impact must be determined during those periods of time. Thus the benefits were calculated using the appropriate seasons to reflect when species are most impacted. Wet years analyzed include 1979, 1982, and 1983. Dry years include 1980, 1981, and 1985. The wet season was defined as June through November. The dry season was defined as December through May.

5.3.7.4.1 HSI Assumptions

The following is a list of assumptions for the HSI models:

- Linear relationship between the index and individual habitat parameter
- Positive relationship between the index and habitat carrying capacity
- Time scales are appropriate to capture change
- Spatial scale appropriate to capture change
- Variables strongly correlates with habitat quality and can be quantified by the model
- Habitat quality for selected species is a good indicator of habitat quality for other estuarine species
- Input data used to create HSI curves are reliable
- Where local data is lacking, data from other regions/estuaries are applied to models

5.3.7.4.2 HSI Background

The forecasting model used to evaluate alternatives for the Caloosahatchee River (C-43) West Basin Storage Reservoir project consisted of a set of stressor-response (habitat suitability) models for individual species. These Habitat

Suitability Indices (HSI) models were developed from scientific literature, expert knowledge, and available field data. The HSIs portray each stressor variable spatially and temporally across the study area at a scale appropriate to the organism or community being portrayed. HSI models were incorporated into a Geographic Information System (GIS) to describe responses spatially and temporally for the selection of restoration alternatives for each project.

Each HSI model describes a response surface of habitat suitability values between 0 (unsuitable) and 1 (most suitable) that varies spatially according to stressor levels throughout the estuary and temporally according to temporal patterns in stressor variables. Much of the temporal variation is a result of temporal cycling of important stressor inputs, such as salinity. The models calculate habitat suitability monthly as the weighted geometric mean of the environmental variables identified as important for each model. The geometric mean is derived from the product of the variables rather than the sum (as in the arithmetic mean), and has the appropriate property that if any of the individual variables are unsuitable for species success (i.e., the value of the variable is zero) then the entire index goes to zero. This HSI value was then multiplied by the area within each grid cell and the grid cell values added to calculate habitat units for each species. ***Figure 5-5*** represents how the various HSI's were combined to generate habitat unit scores and support the cost effectiveness/ incremental cost analysis (CE/ICA) effort.

Scoring each of the attributes above resulted in a quality index number (HSI or percent) for each alternative. Those quality index numbers were then combined using a Habitat Unit Combination Method (HUCM) in order to arrive at one total HU number for each alternative. ***Figure 5-5*** outlines the process for the environmental analysis.

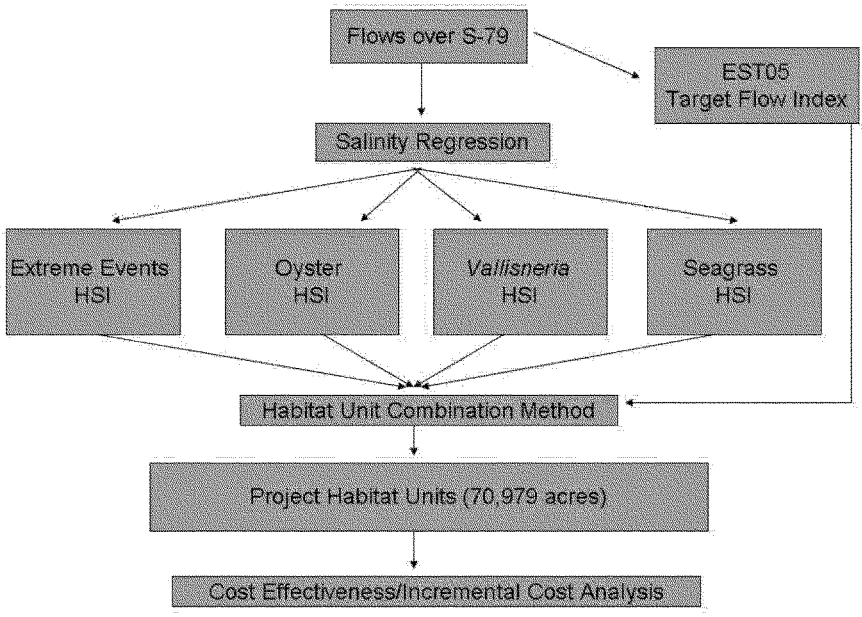


FIGURE 5-5: FLOW CHART FOR THE ENVIRONMENTAL ANALYSIS PROCESS

Table 5-12 summarizes the five attributes and quality index calculations for the 2000 base case, 2050 future without project, and each of the alternatives.

TABLE 5-12: TOTAL HABITAT UNIT CALCULATIONS FOR SYSTEM FORMULATION

Condition	Oyster	*Vallisneria*	Seagrass	Extreme Event	EST 05
2000 Base (Existing)	.48	.16	.51	.28	.38
2050 Future Without Project	.52	.20	.54	.30	.43
Alternative 2	.60	.31	.59	.42	.64
Alternative 3B	.60	.33	.59	.43	.70
Alternative 3C	.61	.35	.59	.45	.80
Alternative 4A	.61	.35	.59	.45	.79

5.3.7.5 Water Quality Analysis of Final Array of Alternatives

Under the conservative assumption that no water quality treatment occurs in the reservoir, the project alternatives in the system formulation condition (which include the rest of CERP) will reduce TP and TN loads at S-79 by approximately 28% to 34% in comparison to the future without condition. This reduction in nutrient loads at S-79 is largely the result of the reduction in discharges from Lake Okeechobee. All of the selected alternatives will cause a shift in nutrient load from the wet season to the dry season; however, all of the alternatives will decrease the frequency in which the monthly TN load exceeds the dry season, wet season, and annual targets established by DEP (dry-season 190 tons/month, wet-season 350 tons/month, annual 3,000 tons/month).

While it is possible that nitrogen fixation within the reservoir will result in short-term increases in TN loading to S-79, the average annual TN load at S-79 will be reduced. Each of the alternatives results in an improvement in overall average water quality conditions at S-79 as well as downstream in the estuary. Given the uncertainty in the threshold chlorophyll-a concentration required for the restoration of the ecological function of the estuary, the degree to which the reservoir project will improve downstream water quality is unknown at this time. Based on the evidence presented here, it appears that the project will not cause or contribute to water quality degradation under future conditions.

5.3.7.6 Planning Level Cost Estimates of Final Array of Alternatives

The cost estimate for the alternatives includes construction, lands, easements, right-of-ways, relocation, and disposal (LERRD), pre-construction, engineering and design (PED) costs, and construction management. Data for initial construction/implementation, land acquisition, monitoring, and periodically recurring costs for operation, maintenance, repair, replacement, and rehabilitation (O&MRR&R), have been developed through engineering design and cost estimation, and real estate appraisal efforts (See Appendix B: Cost Estimates for details of data development for cost estimates).

For purposes of this report and analysis, national economic development (NED) costs, as defined by USACE, are expressed in October 2006 price levels, and are based on costs estimated to be incurred over a 40 year period of analysis. Costs of a plan represent the value of goods and services required to implement and operate and maintain the selected plan. These costs are included in ***Table 5-13*** and were used in the cost effectiveness analysis of the alternatives. Based on additional engineering and design that would be performed in the planning, engineering and design phase, Alternative 3C may require modifications to the Townsend Canal and a major road downstream of the impoundments. For this purposes of this planning level cost estimate these costs were not included.

The costs in this section of the main report are updated, detailed costs and are not exactly equivalent to the costs that were utilized in the Economic Appendix cost/effectiveness and incremental costs analysis (CE/ICA). These updated costs were used, due to more detailed cost estimates becoming available, which warranted further justification of the original CE/ICA that was used for plan formulation and selection as can be noted in Appendix E. The result of this analysis verifies the conclusions of the original CE/ICA and the results seen in ***Table 5-18*** are consistent for both CE/ICA evaluations.

TABLE 5-13: COST OF FINAL ARRAY OF ALTERNATIVES (ROUNDED TO THE NEAREST 10,000)

	Alternative 2	Alternative 3B	Alternative 3C	Alternative 4A
Cost Component*				
Construction	$319,200,000	$355,170,000	$395,100,000	$425,500,000
S/A	$25,500,000	$27,000,000	$31,600,000	$34,000,000
PED	$31,900,000	$44,660,000	$39,500,000	$42,500,000
Lands	$80,420,000	$80,420,000	$80,420,000	$80,420,000
Initial Cost	$457,020,000	$507,240,000	$546,620,000	$582,420,000
Interest During Construction				
Construction	$33,600,000	$39,400,000	$42,000,000	$45,000,000
Lands	$13,500,000	$13,500,000	$13,000,000	$13,000,000
Total IDC	$47,100,000	$59,900,000	$55,000,000	$58,000,000
Total Project Investment	$504,120,000	$560,140,000	$601,620,000	$640,420,000
Average Annual Cost				
Interest & Amortization	$28,900,000	$32,100,000	$34,500,000	$36,700,000
Operation & Maintenance	$3,000,000	$3,000,000	$3,930,000	$3,930,000
Total Average Annual Cost	$31,900,000	$35,100,000	$38,430,000	$40,630,000

*Note – Final Costs of Selected Alternative Plan will be revised based on additional engineering and design
NED cost do not include Recreation Cost for Plan Formulation

5.3.7.7 Cost-Effectiveness/Incremental Cost Analyses for Final Array of Alternatives

Cost effectiveness analysis begins with a comparison of the costs and outputs of alternative plans to identify the least cost plan for every level of output considered. Alternative plans are compared to identify those that would produce greater levels of output at the same cost, or at a lesser cost, as other alternative plans. Alternative plans identified through this comparison are the cost effective alternative plans. Next, through incremental cost analysis, the cost effective alternative plans are compared to identify the most economically efficient alternative plans. Cost effective plans are compared by examining the

additional (incremental) costs for the additional (incremental) amounts of output produced by successively larger cost effective plans. The plans with the lowest incremental costs per unit of output for successively larger levels of output are the "Best Buy" plans. The results of these calculations and comparisons of costs and outputs between alternative plans provide a basis for addressing whether the additional outputs are worth the costs incurred to achieve them.

The final arrays of alternative plans for this project consisted of an aboveground reservoir (a single management measure) of varying storage volumes and pump sizes. All other management measures were screened from further consideration as a result of prior studies. Since all of the plans in the final array of alternative plans consisted of the same cost effective management measure, an incremental cost analysis was performed to determine the incremental costs of the benefits produced by the remaining four structural plans. Incremental cost analysis of the system-wide effects of the final array of plans was performed using IWR Plan software for the remaining alternative plans.

This analysis is based on and follows guidance from the USACE's Institute for Water Resources publication, Evaluation of Environmental Investment Procedures Manual, Interim: Cost Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1. Costs are based initially on a rough order of magnitude (ROM) and include PED and construction costs, interest during construction, as well as O&M costs after construction.

5.3.7.8 Average Annual Benefits

The analysis of ecological response times for large, diverse ecosystems is extremely difficult to calculate. For example, when analyzing an estuarine system, certain attributes will have to be examined when predicting the response to changes in salinity. While some species will generally provide responses within a year of salinity change towards normal conditions, others will respond fairly quickly, but are difficult to measure due to changing conditions. To account for this, a linear approach to predict ecological response time was used and it resulted in:

- 80% of the benefits would be realized by three years from start of construction,
- 90% within five years after that,
- 100% of the lift would be realized within ten years of construction.

If nothing was done to improve the conditions in the estuary, the project team determined that eventually the ecosystem would stabilize in a severely degraded condition.

In ecosystem restoration projects, cost effectiveness and incremental cost analyses require a comparison of average annual costs and average annual benefits. In an ecosystem restoration project, the analyses compare the alternative plans' average annual costs against the appropriate average annual HU estimates. ***Table 5-14*** summarizes the four alternatives and their respective project HU lift totals. The average annual outputs were calculated as the difference between with-plan and without-plan conditions over the period of analysis (through year 2050). Costs used for CE/ICA and outputs used for CE/ICA are displayed in ***Table 5-15***.

TABLE 5-14: HABITAT UNIT LIFT, SYSTEM FORMULATION

Alternative	Average Annual Project Habitat Units
Alternative 2	10,628
Alternative 3B	12,809
Alternative 3C	16,397
Alternative 4A	15,907

Note that the output values shown reflect the differences between without project and with project on an average annual basis (i.e., ecological "lift" provided by each of the alternatives). For increases in oyster population under the future with project condition, recycled and fossil oyster shell and stabilizing mesh (where needed) could be used to establish suitable substrate for oyster recruitment (Oyster Reef Construction). Although this oyster reef restoration is not a part of the recommended plan, a description is included in this document as a recommendation for enhanced restoration of the estuary. A full description of the oyster reef restoration plan can be found in ***Appendix C*** (C.8 Oyster Reef Restoration Plan). ***Figure 5-6*** graphically represents a plot of the average annual benefits for the combined habitat streams for the future with and future with-out conditions. Any year on the graph can be picked to represent the HUs created in any particular period. The analysis used a 40 year period for benefit annualization, with the base year (first year benefits) beginning to accrue in 2010. Each alternative that took longer periods for benefits to begin accruing, had their costs annualized over 39 years and the 2010 present worth of the annualization calculated. In order to account for discrepancies in the annual benefit period of analysis, the benefits were annualized over 40 years (which is consistent with the cost annualization); with a year of zero lift being included in the average. The average annual HUs lift is then calculated as subtracting the future without project HUs from the future with project HUs for each year and averaging over the life of the project, which in this case is 40 years.

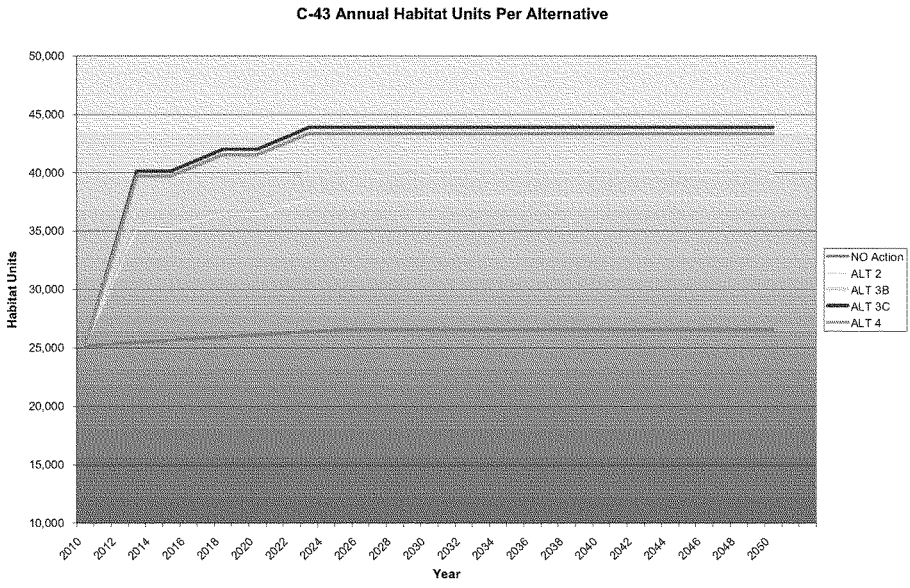


FIGURE 5-6: ANNUAL HABITAT UNIT LIFT

TABLE 5-15: COSTS AND OUTPUTS USED IN COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES

	Alternative 2	Alternative 3B	Alternative 3C	Alternative 4A
Annual Cost	**$31,900,000**	**$35,100,000**	**$38,400,000**	**$40,600,000**
Average Annual Habitat Units	**10,628**	**12,809**	**16,397**	**15,907**

Note: Values assume system benefits (ecosystem outputs that would accrue to the Caloosahatchee River (C 43) West Basin Storage Reservoir study area if rest of CERP is constructed). Values for Alternatives are Differences Between "Without" Plan and "With" Plan (on an average annual basis)

5.3.7.9 Cost Effectiveness Analysis

Cost effectiveness and incremental cost analyses (CE/ICA) were conducted for each of the Caloosahatchee River (C-43) West Basin Storage Reservoir alternative plans. The analyses compared the alternative plans' average annual costs against the appropriate average annual HU estimates. The average annual outputs were calculated as the difference between with-plan and without-plan conditions over the period of analysis (through year 2050). CE/ICA

was performed using a combination of the following five metrics to represent various ecosystem outputs of the C--43 alternatives:

- *Vallisneria*
- Oyster
- Seagrass
- EST05
- Extreme Event

The total cost of CERP is not included in this CE/ICA. The cost of the balance of the CERP features, those not included in the West Basin Storage alternatives, is the same for all the alternatives. As such, including it in this analysis does not bring any additional insight or differentiation between alternatives. For this analysis, the difference between the alternatives can be shown through a display of the outputs and costs of each alternative without the cost of the "other CERP" features.

All of the environmental outputs were calculated on an average annual basis to account for the fact that several years may be required for full attainment of the functional capacities to be realized. This was performed for the expected future with and without project HUs, which were used to calculate the average annual benefits for each ecosystem output. A summary of the average annual lift calculations and average annual costs used in the CE/ICA analysis are provided in ***Table 5-16***, ***Table 5-17***, and ***Table 5-18*** show that for Alternatives 2, 3B and 3C; are all cost effective alternatives. Alternative 3C provides the greatest habitat lift of all the alternatives, and this alternative also has the lowest average cost per unit of output.

TABLE 5-16: RESULTS OF COST EFFECTIVENESS ANALYSIS

Alternatives	Average Annual Cost ($1,000)	Output	Average Cost Per Output	Cost Effective?
Without Plan	$0	0	N/A	
Alternative 2	$31,900	10,628	$3,002	YES
Alternative 3B	$35,100	12,809	$2,740	YES
Alternative 3C	$38,400	16,397	$2,344	YES
Alternative 4A	$40,600	15,907	$2,554	NO

Note: Freshwater Wetland Habitat Units (HU). All plans and cost effective plan arrayed by increasing output for each output category.

5.3.7.10 Incremental Cost Analysis

Typically, cost effective plans are arrayed by increasing outputs to clearly demonstrate changes in costs (i.e., increments of cost) and in outputs (i.e., increments of output). For comparison purposes, each cost effective alternative plan is compared to the without plan condition to determine which of the alternative plans has the lowest incremental costs per unit of output of all plans. This plan is then considered the National Ecosystem Restoration (NER) plan. After the NER plan is identified, all larger cost effective plans are compared to the NER plan in terms of increases in (increments of) cost and increases in (increments of) output. The alternative plan with the lowest incremental cost per unit of output (for all cost effective plans larger than the NER plan) is then considered the second best buy plan. ***Table 5-17*** presents the results of the ICA of the different alternative plans for the Caloosahatchee River (C-43) West Storage Reservoir project (for the respective ecological zones). The results of the analysis show that there is only one best buy plan for the Caloosahatchee River (C-43) West Basin Storage Reservoir project. From the analysis of incremental cost for all of the alternatives, Alternative 3C provides the greatest HU lift while having the lowest cost per unit of output and is considered the NER plan for the project.

TABLE 5-17: RESULTS OF INCREMENTAL COST ANALYSIS–COST EFFECTIVE AND BEST BUY PLANS ARRAYED BY INCREASING OUTPUT

	Average Annual Cost ($1000)	Output	Average Cost Per Output ($1,000)	Incremental Average Annual Cost ($1,000)	Incremental Output	Incremental Cost Per Output	Best Buy?
				(Habitat Units)			
Without Plan	$0	0	N/A	N/A	N/A	N/A	
Alt 3C	$38,400	16,397	$2,344	$38,400	16,397	$2,344	Best Buy

While the CE/ICA of the various alternatives in obtaining habitat outputs is the primary evaluation technique in the selection of the NER plan. Engineering Circular (EC) 1105-2-409 states that in regards to plan selection: Any alternative plan may be selected and recommended for implementation if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse, in the four Principles and Guidelines (P&G) evaluation accounts: NED, Environmental Quality (EQ), Regional Economic Development (RED), and other social effects (OSE).

This section provides a full discussion and display of the beneficial and adverse effects of each plan, and a comparison of costs and effects among plans as well as cumulative effects.

5.3.7.11 National Economic Development (NED)

NED benefits are defined as increases in the economic value of the goods and services that result directly from a project. These are benefits that occur as a direct result of the project but are national in perspective.

The P&G states: "the alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment (NED plan) is to be selected (paragraph 1.10.2)." There is no similar rule for plan selection where outputs are not measured in dollars, as in the case of ecosystem restoration analyses. While the CE/ICA does not provide a discrete decision rule for plan selection, it does provide the types of information to support an informed decision regarding ecosystem restoration (see ***Table 5-18***). Information about the acceptability, completeness, efficiency and effectiveness can also provide valuable support in making an informed decision in answering the question: "Is it worth it?"

TABLE 5-18: SUMMARY OF ALTERNATIVE PLANS

Alternative 2	Alternative 3B	Alternative 3C	Alternative 4A
Cost Effective	Cost Effective	Cost Effective and Best Buy	Not Cost Effective

Using the P&G evaluation criteria, the final array of alternatives were evaluated for:

- Acceptability: the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public. The alternatives are evaluated for compatibility with existing laws, regulations, and public policies
- Completeness: the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
- Efficiency: the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment

- Effectiveness: the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities

Each plan (except the No Action Alternative), was rated on a scale of 0 to 2 on the ability of each plan to meet the specified criteria (0 = does not meet; 1 = partially meets; 2 = fully meets) (***Table 5-19***).

TABLE 5-19: P&G EVALUATION CRITERIA

	Alternative 2	Alternative 3B	Alternative 3C	Alternative 4A
Acceptability	1	2	1	1
Completeness	1	1	1	1
Efficiency	1	1	2	0
Effectiveness	1	2	2	1

5.4 SELECTION OF THE FINAL PLAN

This section of the report began with a brief overview of the findings of the NRC that stated that they recognize that Everglades' restoration is a complex undertaking with many scientific uncertainties, which can slow the rate of progress. The NRC concluded that if the construction of a restoration project is delayed until all scientific uncertainties are eliminated, there will be many negative consequences including: continued decline of the Everglades ecosystem, lagging public support, and increased project costs. The NRC identified an approach referred to Incremental Adaptive Restoration where an incremental approach using steps that are large enough to provide some restoration benefits now while address critical scientific uncertainties and to take actions that promote learning that can guide the remainder of the project design. Constructing projects using the suggested NRC phased approach will enable assessments of benefits and impacts to the environment as each phase is constructed. Remaining phases will then be adapted to optimize performance based on actual findings from the earlier phases.

While utilizing a basin-wide approach to plan formulation remains consistent with the Restudy, formulation of comprehensive restoration plans for the entire Caloosahatchee River Watershed will necessitate further investigations of the basin, is more complex, and will require more time to complete the study and implement a recommended plan. The Caloosahatchee Estuary cannot wait on a larger study to address all basin wide issues; the estuary is in need of immediate action now if restoration efforts are to be successful.

To address the immediate issues of the estuary, an Incremental Adaptive Restoration approach (as suggested by the NRC) in which the basin study is

divided in to two separate PIRs is recommended. The first PIR (the Caloosahatchee River (C-43) West Basin Storage Reservoir project) will address the most immediate needs of the estuary, reaffirm the reservoir component in the Comprehensive Review Study, and ensure that it is fully compatible and consistent with the CERP. To address the overall needs and issues of the Caloosahatchee River Watershed, a subsequent PIR will address a more complete solution to the broader needs of the entire basin.

This first PIR focuses on the formulation and evaluation of a reservoir located in the lower West Caloosahatchee River basin to address the immediate restoration needs of the Caloosahatchee River Estuary. Through the formulation process, Alternative 3C is identified as the NER plan and is also identified as the Best Buy Plan in the CE/ICA analysis of project alternatives.. Although identified as the NER and Best Buy Plan, Alternative 3C does carry with it greater uncertainty, such as the potential to require more extensive modification to numerous structures downstream of the reservoir,, resulting in possible additional costs and time delays to the project. Delays in implementing the project will ultimately result in a loss of time for the estuary to realize potential ecological benefits. Alternative 3B is a variation of Alternative 3C, with the only difference between plans being the major pump station size (Alternative 3B uses a 1500 cfs pump while Alternative 3C uses a 3800 cfs pump). Alternative 3B is a cost effective plan, it is implementable, it achieves estuarine benefits, it does not carry as much uncertainty as Alternative 3C, and it received a high score based on the P&G selection criteria. While Alternative 3B is not a Best Buy Plan it ultimately may become one if Alternative 3C should require more extensive modifications to downstream features in order to meet project objectives.

Alternative 3B is recommended for implementation, rather than Alternative 3C (identified as the NER alternative plan). Alternative 3B meets the policy criteria established in Corps of Engineers guidance for planning in a collaboration environment[1]. This guidance provides that any alternative plan can be selected "if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse..." Alternative 3B is clearly of less scope and cost than Alternative 3C, reduces uncertainty and financial risk to the government, and meets the Administration's policies for high priority outputs. Because Alternative 3B is an increment of Alternative 3C, this plan also supports adaptive implementation recommendations established by the National Academy of Science. The study considered various scales of reservoir storage and identified no alternative smaller than 3B which was more economical. For these reasons Alternative 3B is the recommended plan, and no ASA (CW) waiver is required.

[1] EC 1105-2-409 "Planning in a Collaborative Environment"

Therefore, the recommendation is to select Alternative 3B as the SAP (preferred plan) and adaptively monitor and manage implementation of the project.

As part of the second PIR for the Caloosahatchee River Watershed, the PDT will evaluate if additional pump capacity is required and the feasibility of making modifications to the 1500 cfs pump station. The design of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project does take into consideration the potential future addition of pumps to provide additional pumping capacity if it is determined necessary in the second PIR analysis. Additional pumps can be added to the pumping station but would require additional construction (building on to the pump station) to accommodate the new additional pumps. A new operations plan would also be needed to account for the additional pumping capacity. The addition of pumps would allow the reservoir to capture additional flows from the Caloosahatchee River and to be filled in a shorter period of time, but it would not add any additional volume for water storage.

This decision will be based on real time data collection and engineering and ecological analysis and adaptive management while the SAP is functioning and benefits are being realized in and around the estuary.

5.4.1.1 Next Added Increment Plan Selection Verification

The intent of a system-wide analysis is to demonstrate how an alternative plan will function in conjunction with all CERP projects in place. However, potential benefits achievable by each alternative plan may not be realized due to differences in water budgets resulting from the implementation of additional CERP projects that have the Lake Okeechobee Regulation Schedule (LORS) shifting water away from the Caloosahatchee River (C-43) Basin in order to meet the demands of these projects under the system-wide analysis. To verify additional environmental benefits achievable by each plan, a NAI analysis was performed on all of the alternatives.

The NAI analysis does not include other CERP projects; therefore additional benefits achievable by each plan are more than likely resulting from the differences in additional water being released into the Caloosahatchee River (C-43) Basin under a water budget that is not influenced by CERP. A NAI analysis yields greater HUs and shows a larger lift in HUs calculated for each alternative over those calculated in the system-wide analysis. Additionally the NAI analysis can provide a better representation of the ranking of alternatives, thereby providing a validation of the plan rankings based on MIKESHE modeling results used in the selection of the SAP.

To validate the plan selection and address concerns with the MIKESHE modeling results, a spreadsheet analysis will calculate flow data for the S-79 structure for use in conducting a NAI analysis of each alternative (see

Engineering ***Appendix A*** for a detail discussion of the spreadsheet analysis used in the NAI analysis). The HSI models calculated HU for each alternative utilizing flow results from the spreadsheet analysis. ***Table 5-20*** and ***Table 5-21*** show the results of the HU benefit analysis of the different alternatives along with the system-wide analysis results providing a comparison of achievable HU lift from the NAI and system-wide analysis to validate selection of the SAP.

TABLE 5-20: TOTAL HABITAT UNIT CALCULATIONS FOR NAI FORMULATION

Metrics	2000	2050	ALT 2	ALT 3B	ALT 3C	ALT 4A
Vallisneria	0.03	0.08	0.58	0.60	0.59	0.59
Seagrasses	0.49	0.51	0.52	0.52	0.52	0.52
Oysters	0.52	0.52	0.23	0.23	0.33	0.34
Extreme Events	0.22	0.24	0.24	0.24	0.26	0.27
EST05	0.20	0.21	0.65	0.71	0.76	0.78

TABLE 5-21: SUMMARY OF NAI AND SYSTEM-WIDE AVERAGE ANNUAL HABIT UNITS LIFT FOR EACH ALTERNATIVE EVALUATED

Alternative	System-wide AAHU lift (MIKESHE)	NAI AAHU lift (spreadsheet)
2	10,628	13,624
3B	12,809	15,297
3C	16,397	17,694
4A	15,907	18,410

As would be expected, under the NAI analysis, alternatives increase in benefit as the pump size and reservoir capacity increases.

Increased Benefits

The NAI analysis demonstrates that there are increased benefits for all of the alternatives, compared to system formulation. This is mainly due to the change in flows that the basin will be receiving from Lake Okeechobee in the system formulation condition compared to the NAI condition. In the system-wide formulation analysis, the basin will be receiving reduced flows, sometimes occurring during periods when the estuary demands increased freshwater flows. However, under the NAI analysis, there are fewer competing demands on Lake Okeechobee water, resulting in more lake water being made available to the Caloosahatchee Basin.

Alternative 3C versus Alternative 4A

In the system formulation, Alternative 3C provided more habitat units than Alternative 4A. This is counterintuitive to the assumption that a larger reservoir should provide more benefits. The NAI analysis using spreadsheet data does reflect Alternative 4A providing more benefits than Alternative 3C. In this case, issues with water budgets in the MIKESHE model may not realistically reflect the reservoir benefits. The NAI analysis is a better representation of the relative ranking of alternatives.

Alternative 3B versus Alternative 3C in the NAI Analysis

The relative difference in benefits between Alternatives 3B and 3C is less in the NAI analysis than in system formulation analysis. If there is more water in the Caloosahatchee Basin in the NAI, as stated above, all alternatives will perform better in the dry season. The dry season is where the reservoir feature provides most of its benefits, and these benefits during the dry season do not depend on pump size, since the pump is not used to release water to the estuary. Alternatives 3B and 3C are the same size reservoir, so they would provide roughly the same benefits during the dry season. In the wet season under NAI, the relative difference in benefits may be less than system formulation because there is so much more water available in NAI, that the larger pump of Alternative 3C still does not have much of a beneficial impact. There would be more flows that would be greatly over the target than in the system formulation scenario. So the added benefits of the larger pump in Alternative 3C would be less under NAI wet season than system formulation wet season. .

5.5 DISCUSSION OF MAJOR RISKS AND UNCERTAINTY

The primary focus areas for the risk and uncertainty evaluation are engineering and real estate considerations, modeling, and ecological response. This assessment includes evaluations of engineering and construction issues, such as project and construction scheduling, construction cost estimates, land availability, and technology. In addition, the reliability and accuracy of the assumptions and tools used to forecast with- and future without project conditions are evaluated. Finally, project performance and ecological response is discussed.

5.5.1 Engineering and Real Estate Risks and Uncertainty

The risk and uncertainty associated with the construction and operation of these features of the proposed project should be minimal. All features have been designed and constructed through established and applied technology. No experimental design was necessary for any component of the proposed impoundment. Additionally, both the USACE and the SFWMD have extensive

and reputable credibility in the design, construction and O&M of the proposed features from previous water resources planning efforts.

A cutoff wall along the perimeter of the dam embankment is being considered and will be further investigated as the project proceeds to design. For estimating purposes, a 17-foot cutoff wall was included. These features use standard technology and should pose minimal risk.

Soil cement protection was included for armoring. This will be further investigated as the team proceeds with the design. Armoring generally uses standard technology and should pose minimal risk.

A freeboard of approximately 15 feet was used in preparing the rough order of magnitude cost estimates. This value for freeboard was developed by Acceler8 and presented in their March 2006 Draft Technical Memorandum detailing their design assumptions and calculations for freeboard. Based on interagency review (USACE, SFWMD, USFWS, USEPA, USGS, FDEP, FFWCC, Hendry County, and Lee County) of the draft memorandum, it is expected that the final freeboard design will be somewhat less than the initial 13-foot assumption. The freeboard design will be further refined in accordance with applicable CERP DCM. These DCMs were developed to provide consistent working level guidance for impoundment design by the Acceler8 teams. The DCMs consolidate and incorporate design criteria from various agency regulations and guidelines including USACE, U.S. Bureau of Reclamation, Federal Energy Regulatory Commission, Florida Building Code, and the American Society of Civil Engineers. The DCMs do not supersede USACE's regulations. Freeboard designed in compliance with the DCMs, and thusly USACE regulations, should result in minimal risk of embankment failure due to overtopping (refer to DCM-2 for additional detail).

Through the Caloosahatchee Watershed plan, lands necessary for the construction and O&M of the West Basin Storage Reservoir have already been acquired by the SFWMD using funds appropriated to the DOI in Section 390 of the Federal Agricultural Improvement and Reform Act of 1996 together with State funds. As such, there is no uncertainty associated with land availability and acquisition.

A summary of project features and associated risks and uncertainties is provided in ***Table 5-22***.

TABLE 5-22: RISKS AND UNCERTAINTIES

Feature	Risk	Uncertainty
Reservoirs • Armoring • Cutoff Walls • Freeboard	Minimum	Minimum- established and applied technology
Pump Stations	Minimum	Minimum- established and applied technology
Spillways • Emergency Overflow • Vertical Lifts	Minimum	Minimum- established and applied technology
Drawdown Structures	Minimum	Minimum established and applied technology
Culverts	Minimum	Minimum established and applied technology
Canals	Minimum	Minimum- established and applied technology
Earthwork • Filling canals • Plugging culverts	Minimum	Minimum-established and applied technology
Manatee Barrier	Minimum	Minimum- established and applied technology

5.5.2 Modeling Risks and Uncertainty

5.5.2.1 Hydrologic Modeling

To formulate, evaluate, assess and adaptively manage the CERP and individual CERP projects, regional hydrologic simulation models, such as the SFWMM and the Natural Systems Model (NSM) are utilized by project teams and RECOVER. Both models use two-mile (2 mile by 2 mile) square grids with resolution based on available spatially distributed data. These models have been peer reviewed and represent the best available science. They are considered reliable for current decision-making processes (and have been used repeatedly to support decision-making). However, these models depict general hydrologic conditions that are assumed to be representative throughout the individual four-square mile area (2,560-acre) grid cells that comprise the model. Therefore, the models may not be fine enough in their resolution to simulate minor hydrologic changes that would result from variations in topography, soils, and vegetation within the grid cells, but which may be significant in terms of ecological response. The SFWMM was developed during the late 1970s and early 1980s and has served as the primary regional simulation model in south Florida for nearly two decades.

New initiatives such as the Everglades Restoration and Water Supply Planning have placed new demands for information on regional simulation models. This has led to the development of the next generation of the 2x2 model referred to as the Regional System Model (RSM). The RSM is the next generation SFWMM developed using recent advances in computer technology-in particular, GIS, databases, and object-oriented model development. The RSM makes use of the

more realistic, accurate, and efficient numerical algorithms to simulate hydrology and water management in south Florida. It uses a variable mesh structure capable of simulating the region at differing spatial resolutions. It is expected that the RSM will eventually replace the existing SFWMM, although years of development and testing will be needed before RSM becomes fully operational for the entire system.

While the hydrologic models can illustrate effects of alternative plans in relationship to hydrologic targets, it is often difficult to discern the ecological magnitude of the relative differences between alternatives (e.g., a small slope change in a stage duration curve). Furthermore, the simulation models are not sensitive to small changes in hydrology at the cell boundaries. As such, the effects of individual projects may be negligible or may not even be discernable using the regional modeling tool, particularly when their influence on the regional water management system is relatively small. This particular problem creates a lack of scientific certainty with respect to the spatial extent of a project's effects.

The uncertainties in using these models to predict reservoir function relate to the use of historical data, including:

1. Failure of the reservoir to be filled by the time of commissioning.
2. Mean flows in the watershed below what has been predicted/simulated.
3. Clustering of wet and dry years, especially the occurrence of a prolonged dry period.
4. Faster reservoir sedimentation than expected.

The risks due to this project are:

1. Risk to downstream settlement and environmental resources due to dam breach.
2. Higher than expected downstream damages during release of major floods due to infrastructure encroachment on flood plains.

The regional hydrologic simulation model is designed for regional, long-term applications. Although scalable, performance constraints may impose practical limits on the time and space scales. This regional model is not intended for local-scale decision-making support. Even if the hydrologic model shows differences in alternative plans in relationship to hydrologic targets, it is often difficult to discern the ecological magnitude of the relative differences between alternatives. Also, the relative size difference between the reservoir and the affected areas (Caloosahatchee Estuary) is such that even large changes in volume of water stored within the reservoir cannot be easily seen when water is spread over such a large area. To minimize these risks, the project team will use

a sub-regional model to determine seepage rates and the probability of spillover. The reservoir operations manual will include management measures such as:

1. Developing a reservoir regulation schedule
2. Creating flood storage prior to predicted storm
3. Design of outlet structures to handle release water after a major storm in preparation for a subsequent storm

5.5.2.2 Modeling of the Various Alternative Plans

The MIKESHE modeling platform was used to develop a subregional model to simulate the hydraulics and hydrology of the Caloosahatchee River (C-43) Basin in order to simulate the integral connection between groundwater and surface water interaction within the basin for existing and future conditions. For formulation purposes, the hydrologic outputs from the modeling analysis of the final array of alternatives are useful for determining and comparing the effects of alternative plans for plan selection.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project was formulated to keep water in the regional system without adversely affecting existing legal uses of water. Excess water is captured and stored in the reservoir for later releases for meeting estuarine demands. The volume of water that could be retained by a reservoir for delivery to the estuary is likely limited to the volume of damaging Lake Okeechobee releases that can be captured and pumped to the reservoir and the volume of excess runoff captured by the reservoir from the Caloosahatchee River (C-43) Basin (largely agricultural and un-developed lands with some urban areas intermixed). To evaluate the performance of different reservoir sizes, modeling output data of the with project conditions (obtained from the MIKESHE/MIKE 11 analysis of the alternatives modeled) was compared to the CERP system-wide performance measure "NE-3" (Caloosahatchee salinity envelope (EST05)) to determine which alternative plan came closest to achieving the hydrologic performance targets set for the project.

In order to characterize the risk and uncertainty issues that are inherent in developing a model to simulate a natural and/or managed system, an assessment of the risk and uncertainty specific to the modeling of existing condition, future without condition and the final array of alternatives for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project must be considered. These assessments included a review of the reliability and accuracy of the assumptions and data used in the MIKESHE/MIKE 11 modeling platform to simulate existing conditions and for forecasting the future with and without project conditions. During a review of the sub-regional modeling results for all of the alternatives, several issues became apparent resulting in a level of uncertainty in calculating habitat units for the alternatives.

Analysis of the modeling results indicated a significant water budget discrepancy. It was determined that the source of this water budget error was in the MIKESHE irrigation routines. Within a given MIKESHE model, the irrigated areas are discretized into "irrigation command areas" which represent individual farms or groups of farms that draw from an individual source of water. These sources of water can be withdrawals from locations within a surface water canal, withdrawals from groundwater wells, or water introduced from an external source. This external source could represent water from sources outside or below the model domain (a deep aquifer), from a feature not modeled at all such as a water reclamation facility, or as in the case of this MIKESHE model application, it was used to represent irrigation demands that are unmet by the surface and groundwater systems. Within the irrigation module, this external source is treated as an infinite source of water. Each irrigation command area can also use multiple sources within each time step and a prioritized list is developed for each irrigated area based on currently permitted or projected irrigation operations. For example, a given command area can try to get its water from a canal source, then if the quantity of water available from that source is insufficient, then that command area will go to the next source which could be another surface water location or a groundwater source. If all preceding sources of water are insufficient, then the irrigation command area will receive the remaining unmet balance of its demand from the infinite external source.

In the development of the Freshwater Caloosahatchee MIKESHE model, it was decided to allow all the irrigated areas to use this infinite external source as a final source of water as a method of quantifying "demands not met" or the shortage in the amount of water that is required by an irrigation command area. It was anticipated that this quantity of water would be very small in relation to the remainder of the irrigation volumes and insignificant in relation to the total model water budget.

Upon analysis of the model outputs, specifically the irrigation outputs, it was discovered that this volume of water coming from external sources was significantly greater than anticipated. The quantity of water coming from external sources also varied significantly among the various model runs. The average-annual volume of water coming from external sources ranges from 125,100 ac-ft for the 2000 without-project run to 260,500 ac-ft for one of the with-project runs. For some model runs this equates to more than half of the total irrigation volume coming from an artificial external source of water. When compared to the volumes of the reservoirs being tested, this is a significant error in the water budget.

After consultation with the developer of the MIKESHE code, the Danish Hydraulic Institute, it was determined that there was a limitation in the

conceptualization of the irrigation routines. Essentially, the model grossly underestimated the available volume of water from existing sources of water such as canals and groundwater and prematurely resorted to the theoretically infinite external water source. At times when sufficient irrigation water was available in the canals, the model pulled in water from external water sources, producing this significant water budget error.

While this water budget error produces some level of risk and uncertainty, it is not anticipated that there will be a change to the ranking of environmental benefits for the alternatives. It is still reasonable to assume that alternatives with larger component features (pumps and reservoir sizes) will perform better than alternatives with smaller components. In the wet season, a larger pump will always be able to shave off more damaging flows than a smaller pump and a larger reservoir will always provide more storage volume than a smaller reservoir. That extra water that is stored in the wet season will always translate to a larger source of water carried over into the dry season.

This water budget error could also affect the various alternatives differently, changing the relative differences in project benefits between alternatives. As a result, it is possible that the final quantity of habitat units for each alternative will change (increase or decrease). This means that there could be changes in the number of habitat units achieved by each alternative as a result of the water budget error, but the ranking of the order of plans based on the number of habitat units achieved will remain the same.

Although there is a level of risk and uncertainty associated with the modeling results, for purposes of plan selection, the modeling data developed to date will be used in selecting the recommended plan for the project (SAP). Additionally, the CERP Programmatic Regulations require the evaluation of a tentatively selected plan (TSP) using a "next-added increment" (NAI) analysis to helps illuminate the amount of benefits the plan contributes without regard to future CERP projects prior to the selection of the SAP. The TSP must also demonstrate that it does not negatively impact existing levels of flood protection (saving clause) to meet the intent of the level of service analysis for flood protection contained in the WRDA 2000, the CERP Programmatic Regulations as well as Florida State law regarding the implementation of CERP. To minimize the risks and uncertainties resulting from the issues with the MIKESHE/MIKE11 modeling platform, the project team will use alternative methods for showing TSP compliance with CERP Programmatic Regulations, WRDA 2000 and Florida State law. A separate spread sheet analysis which utilizes modeling output from the SFWMM regional hydrologic simulation model will be used in the NAI analysis of the TSP. To demonstrate compliance with saving clause requirements concerning flood levels, a revised MIKESHE/MIKE11 model will

look at the localized areas around the reservoir to demonstrate that the project does not have an impact to flood levels on lands adjacent to the reservoir.

5.5.3 Ecological Response Risks and Uncertainty

5.5.3.1 Evaluating the Ecological Significance of Hydrologic Change

Hydrologic performance measures are useful for determining and comparing the effects of alternative plans. However, to determine a plan's outputs for purposes of depicting NER benefits, the assumption is made that the hydrologic performance measures fully characterize all of the attributes of ecosystem functions, since the analytical tool for system-wide effects is a hydrologic simulation model. This assumption results in some uncertainty with respect to the evaluation of system-wide ecological responses because not all ecological attributes can be simply reduced to hydrologic terms. However, to reduce some levels of uncertainty, the hydrologic performance measures have been related to certain ecological attributes by the ecological sub-team.

Additional uncertainty exists in the correlation between small hydrologic changes seen in the outputs of a regional model, and the ecological significance of those changes. The hydrologic change in a model grid cell, indicator region, or geographic sub-region that may result from individual projects is typically small in relative magnitude. Therefore, there is uncertainty in predicting the extent of system-wide change in ecological attributes due to relatively small differences in the hydrologic changes associated with incremental implementation of individual CERP projects.

Hydrologic performance measures illustrate the degree of attainment of specific hydrologic targets in specific areas (e.g., releases at the S-79 structure). However, the significance of change in a hydrologic performance measure with respect to the ecological attribute to which the performance measure applies is uncertain, especially when evaluating the effects of individual CERP projects. This is because the hydrologic change in a model grid cell, indicator region, or environmental sub-region that may result from individual projects is typically small in relative magnitude. Although target conditions are usually established for hydrologic performance measures, scientists on project teams usually have difficulty determining the meaningfulness of the relatively small differences between plans, including base conditions indicative of the degree of attainment of target condition. Typically, a more-or-less-is-better analysis is performed, and can be expressed as a percentage of the degree of attainment of the target. However, when the effects of all plans are relatively equal, it can be difficult to state the meaningfulness (in terms of the ecological response of the attributes affected by the performance measures) of relatively small differences between plans (e.g., 60, 61, and 63 percent attainment). Therefore, there is some uncertainty in predicting the extent of system-wide change in ecological

attributes due to relatively small differences in the hydrologic changes associated with incremental implementation of individual CERP projects.

5.5.3.2 Spatial Extent of System-Wide Effects of Alternative Plans

While the hydrologic models used for CERP project plan formulation and evaluation may effectively demonstrate meaningful changes between alternatives in hydrologic performance measures and where those changes occur (in terms of the model's four-square mile grid cells), describing ecological responses to those hydrologic changes over precise areas has proven to be difficult for many projects which are "invisible" to the hydrologic model. For example, a species may be sensitive to topographic, vegetation, and soil conditions, which would in turn affect habitat quality. Thus, determining the differences in the spatial extent of effects resulting from each alternative plan in an array of plans (for a given ecological attribute) has proven to be difficult to estimate with scientifically defensible certainty. This in turn makes the estimation of the spatial extent of the benefit units uncertain.

Determining the individual variable spatial response to hydrologic change of each attribute that is evaluated during plan formulation is also uncertain. Each of the Conceptual Ecologic Models (CEM) that are the basis for the system-wide hydrologic performance measures encompass multiple ecological attributes (for example, oysters, *Vallisneria*, and seagrass are all attributes of the Caloosahatchee CEM). Each attribute may vary independently in the spatial extent of response to differences in hydrology. These variations in area make the assignment of "spatial extent" affected by an alternative plan all the more difficult to determine. If "areas affected" for each attribute were simply summed, the issue of double-counting HUs could arise as multiple attributes could overlap in the same area affected by multiple projects, and thus the same benefit units could be counted more than once. Similarly, without fully understanding how each attribute responds independently to variations in hydrology (and without a sensitive enough hydrologic modeling tool to depict the spatial extent of the attribute response), it is equally likely that not enough benefit units (expressed as HUs) would be counted, thereby understating the beneficial effects of plans.

5.5.3.3 Ecological Response Time Risks and Uncertainty

There are no existing models that can be utilized to predict ecological response time. Although ecological response can be fairly well predicted for smaller restoration projects, it is difficult to address the effects of such a large restoration project as the Caloosahatchee River (C-43) West Basin Storage Reservoir project. Therefore, the natural system sub-team utilized current scientific knowledge and best professional judgment to predict responses within the natural system.

5.5.4 Adaptive Management

Adaptive management (AM) consists of an active strategy for dealing with the considerable uncertainties that characterize management of large natural ecosystems, which are complex and difficult to predict. The overall purpose of AM is to maximize the chance of success and includes methods, such as proactive approaches to dealing with uncertainties, the use of modern ecosystem science and scientific practices, active collaboration, and the use of open, inclusive, and integrative processes.

Five key principles help implement this approach to adaptive management (AM):

1. Anticipate future uncertainties and contingencies
2. Employ science-based approaches to build knowledge
3. Design robust projects that can be adapted to changing conditions
4. Build a shared understanding through collaboration and conflict resolution
5. Reconcile competing objectives to benefit both nature and society

The Caloosahatchee River (C-43) West Basin Storage Reservoir project is a component of the CERP, which consists of sixty-eight (68) major components. The uncertainty associated with a program of this magnitude was recognized during the Restudy, which led Congress to address the necessity of AM in the WRDA 2000.

As such, a fundamental implementation principle for CERP is to utilize adaptive assessment and management in order to continually refine and improve the performance of CERP projects so that planned benefits are attained. Incremental revisions of optimal project designs and project operations throughout the planning and implementation process will lead to improved performances. The use of the adaptive assessment policy minimizes the effects of uncertainty with respect to the effects of CERP projects on the natural system and other water-related needs of the region related to the design and implementation of the CERP.

The measurement of benefits attributable to CERP projects must consider individual outputs as well as system-wide interdependencies among projects. This evaluation methodology applies to hydrologically linked projects that operate optimally in a synergistic fashion. Therefore, until other CERP projects are implemented, some benefits may not be realized. Moreover, interim and long-term impacts will be largely determined by implementation of CERP components and operational strategies. Regional evaluations will be used to improve information necessary to predict and assess shortfalls attributable to sequencing issues versus shortfalls in performance.

The project team considered the uncertainty in the estimation of HU values for the various alternatives and how would ecological outputs respond over time, and how do continued high Lake Okeechobee inflows and runoff volumes affect outputs over time. Consideration of "if" and "when" other CERP components were constructed were also considered in the estimate of ecological outputs, demonstrating the sensitivity of Caloosahatchee Estuary outputs to the construction of other CERP components.

As part of the AM process, careful flow monitoring will occur to evaluate the ability of any implemented features to meet the performance measures. In addition, biological response data will be collected for use in further refining the performance measures, project operations, and system understanding. The NAI analysis showed that essentially all of the estuary outputs would still be produced by the Caloosahatchee River (C-43) West Basin Storage Reservoir project even if other CERP projects were never constructed. This same analysis also indicated that no other alternative performed more cost effectively than the recommended alternative (Alternative 3B) when other CERP project were not constructed. Furthermore, cost effectiveness analysis indicated that the various alternatives were sufficiently separate and distinct so that relatively large changes in either cost or output would be required before an alternative would appear to be the superior.

This page intentionally left blank

SECTION 6
ENVIRONMENTAL EFFECTS

This page intentionally left blank

6.0 ENVIRONMENTAL EFFECTS

6.1 SUMMARY OF EFFECTS

Table 6-1 is a summary of the environmental effects of the final array of alternatives. More detailed descriptions of these effects can be found in the remainder of this section.

This page intentionally left blank

TABLE 6-1: IMPACT TABLE

Resource	"No Action"	Alt. 2	Alt. 3B	Alt. 3C	Alt. 4A
Physical Landscape	No impact	Dam height of 29-34 feet; no impact to aquifers, surficial sands removed for embankments; loss of ~10,500 acres of unique farmland	Dam height of 32-37 feet; no impact to aquifers, surficial sands removed for embankments; loss of ~10,500 acres of unique farmland	Dam height of 32-37 feet; no impact to aquifers, surficial sands removed for embankments; loss of ~10,500 acres of unique farmland	Dam height of 41-46 feet,; no impact to aquifers, surficial sands removed for embankments; loss of ~10,500 acres of unique farmland
Hydrology	45.5% of flows in desired envelope; Continued extreme flow events to the estuary	67.9% of flows in desired envelope; Rerouting of local canals; perimeter canal will serve to maintain groundwater levels in vicinity of reservoir;	74.8% of flows in desired envelope; Rerouting of local canals; perimeter canal will serve to maintain groundwater levels in vicinity of reservoir	82.3% of flows in desired envelope; Rerouting of local canals; perimeter canal will serve to maintain groundwater levels in vicinity of reservoir	83.8% of flows in desired envelope; Rerouting of local canals; perimeter canal will serve to maintain groundwater levels in vicinity of reservoir
Water Management	Large volume releases to Caloosahatchee River continue; it is also likely that harmful low flows in the dry season would continue.	82% reduction in weekly high flows >4500 cfs; Changes in local canal operations; changes to S-79 operations to maximize reservoir usage for estuarine benefits; 100,000 ac/ft of storage	82% reduction in weekly high flows >4500 cfs; Changes in local canal operations; changes to S-79 operations to maximize reservoir usage for estuarine benefits; 170,000 ac/ft of storage	91% reduction in weekly high flows >4500 cfs; Changes in local canal operations; changes to S-79 operations to maximize reservoir usage for estuarine benefits; 170,000 ac/ft of storage	91% reduction in weekly high flows >4500 cfs; Changes in local canal operations; changes to S-79 operations to maximize reservoir usage for estuarine benefits; 220,000 ac/ft of storage
Water Supply	Existing water supply conditions would be maintained	There will be no elimination or transfer as a result of this project on existing legal sources; transfer of source for the Bob Paul property	There will be no elimination or transfer as a result of this project on existing legal sources; transfer of source for the Bob Paul property	There will be no elimination or transfer as a result of this project on existing legal sources; transfer of source for the Bob Paul property	There will be no elimination or transfer as a result of this project on existing legal sources; transfer of source for the Bob Paul property
Flood Protection	Existing levels of flood protection would be maintained.	There will be no adverse affects on existing levels of service for flood protection in the vicinity of the reservoir.	There will be no adverse affects on existing levels of service for flood protection in the vicinity of the reservoir.	There will be no adverse affects on existing levels of service for flood protection in the vicinity of the reservoir.	There will be no adverse affects on existing levels of service for flood protection in the vicinity of the reservoir.
Water Quality	Nutrient loads to the estuary will likely increase by 10% or more if no BMPs or nutrient TMDLs are implemented in the Caloosahatchee basin. If nutrient reduction	Reduction in TP loads at S-79 by approximately 30% in comparison to the FWO condition; Reduction in TN loads at S-79 by approximately 29% in comparison to the FWO condition. The load	Reduction in TP loads at S-79 by approximately 29% in comparison to the FWO condition; Reduction in TN loads at S-79 by approximately 28% in comparison to the FWO condition. The load	Reduction in TP loads at S-79 by approximately 32% in comparison to the FWO condition; Reduction in TN loads at S-79 by approximately 31% in comparison to the FWO condition. The load	Reduction in TP loads at S-79 by approximately 34% in comparison to the FWO condition; Reduction in TN loads at S-79 by approximately 32% in comparison to the FWO condition. The load reductions are due for the most part to

	programs are successful, the 2050 Future Without nutrient loads may decrease by more than 30% as compared to the existing condition.	reductions are due for the most part to reduced flows from Lake Okeechobee that result from other project elements of the CERP program.	reductions are due for the most part to reduced flows from Lake Okeechobee that result from other project elements of the CERP program.	reductions are due for the most part to reduced flows from Lake Okeechobee that result from other project elements of the CERP program.	reduced flows from Lake Okeechobee that result from other project elements of the CERP program.
Sediment Quality	Sediment quality in the estuary is expected to continue to slowly degrade.	The reduction in sediment load will be on the order of 5% to 10% relative to existing without project conditions and approximately 30% relative to future without project conditions.	The reduction in sediment load will be on the order of 5% to 10% relative to existing without project conditions and approximately 30% relative to future without project conditions.	The reduction in sediment load will be on the order of 5% to 10% relative to existing without project conditions and approximately 30% relative to future without project conditions.	The reduction in sediment load will be on the order of 5% to 10% relative to existing without project conditions and approximately 30% relative to future without project conditions.
Plant Communities	Very little change from existing conditions	Construction will largely replace existing plant communities with aquatic habitat (water-covered reservoir areas) or maintained uplands (embankments, roads, berms); 7,970 acres of citrus trees will be removed and burned	Construction will largely replace existing plant communities with aquatic habitat (water-covered reservoir areas) or maintained uplands (embankments, roads, berms); 7,970 acres of citrus trees will be removed and burned	Construction will largely replace existing plant communities with aquatic habitat (water-covered reservoir areas) or maintained uplands (embankments, roads, berms); 7,970 acres of citrus trees will be removed and burned	Construction will largely replace existing plant communities with aquatic habitat (water-covered reservoir areas) or maintained uplands (embankments, roads, berms); 7,970 acres of citrus trees will be removed and burned
Wetlands	The 125 acres of wetlands scattered throughout the project site would likely remain; expansion of citrus operations could result in direct removal of some of these wetlands areas.	Loss of 125 acres of wetlands through discharge of dredge or fill material, excavation, and/or flooding	Loss of 125 acres of wetlands through discharge of dredge or fill material, excavation, and/or flooding	Loss of 125 acres of wetlands through discharge of dredge or fill material, excavation, and/or flooding	Loss of 125 acres of wetlands through discharge of dredge or fill material, excavation, and/or flooding
Fish and Wildlife	Continues to provide limited fish and wildlife habitat.	The reservoir will likely harbor fish typical of nearby canals. Amphibians and aquatic reptiles including frogs, turtles, snakes, and alligators will use the reservoir; limited foraging habitat for osprey, bald	The reservoir will likely harbor fish typical of nearby canals. Amphibians and aquatic reptiles including frogs, turtles, snakes, and alligators will use the reservoir; limited foraging habitat for osprey, bald eagle, terns, cormorant, and	The reservoir will likely harbor fish typical of nearby canals. Amphibians and aquatic reptiles including frogs, turtles, snakes, and alligators will use the reservoir; limited foraging habitat for osprey, bald eagle, terns, cormorant, and	The reservoir will likely harbor fish typical of nearby canals. Amphibians and aquatic reptiles including frogs, turtles, snakes, and alligators will use the reservoir; limited foraging habitat for osprey, bald eagle, terns, cormorant, and other aquatic birds that feed on fish

		eagle, terns, cormorant, and other aquatic birds that feed on fish	other aquatic birds that feed on fish	other aquatic birds that feed on fish	
Federal and State Listed Species	No immediate impacts to threatened or endangered species	Beneficial impacts to many T&E species. Impacts to most species would be same under all alternatives because the footprint is identical. The project may adversely affect the eastern indigo snake, Audubon's crested caracara, and the Florida panther	Beneficial impacts to many T&E species. USACE determined the project may adversely affect the eastern indigo snake, Audubon's crested caracara, and the Florida panther	Beneficial impacts to many T&E species. The project may adversely affect the eastern indigo snake, Audubon's crested caracara, and the Florida panther	Beneficial impacts to many T&E species. The project may adversely affect the eastern indigo snake, Audubon's crested caracara, and the Florida panther
Essential Fish Habitat	Essential fish habitat (EFH) in the Caloosahatchee estuary would continue to be adversely impacted by extreme high and low flows to the Caloosahatchee Estuary	Average Annual Habitat Unit Lift: 10628. AAHUs are based on estuarine species and a good indicator of improvement to EFH. This reservoir is expected to vastly improve the extent and health of essential fish habitat.	Average Annual Habitat Unit Lift: 12809 AAHUs are based on estuarine species and a good indicator of improvement to EFH. This reservoir is expected to vastly improve the extent and health of essential fish habitat. The USACE has determined that implementation of the project would not have an adverse impact on EFH or federally managed fisheries.	Average Annual Habitat Unit Lift: 16397 AAHUs are based on estuarine species and a good indicator of improvement to EFH. This reservoir is expected to vastly improve the extent and health of essential fish habitat.	Average Annual Habitat Unit Lift: 15907 AAHUs are based on estuarine species and a good indicator of improvement to EFH. This reservoir is expected to vastly improve the extent and health of essential fish habitat.
Estuarine Resources	Habitat Suitability Model results: Oyster HSI: .52 *Vallisneria* HSI: .20 Seagrass HSI: .54 Extreme Event: .30	Habitat Suitability Model results: Oyster HSI: .60 *Vallisneria* HSI:.31 Seagrass HSI:.59 Extreme Event: .42 Improved estuarine environment	Habitat Suitability Model Results: Oyster HSI: .60 *Vallisneria* HSI:.33 Seagrass HSI:.59 Extreme Event: .43 Improved estuarine environment	Habitat Suitability Model Results: Oyster HSI: .61 *Vallisneria* HSI:.35 Seagrass HSI:.59 Extreme Event: .45 Improved estuarine environment	Habitat Suitability Model Results: Oyster HSI: .61 *Vallisneria* HSI:.35 Seagrass HSI:.59 Extreme Event: .45 Improved estuarine environment
Land Use	SFWMD could continue to lease the lands for citrus production, sell the lands, or consider	All alternatives include the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir within the same	All alternatives include the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir within the same	All alternatives include the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir within the same	All alternatives include the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir within the same project

	another project; however, approval from DOI would be required	project footprint.	project footprint.	project footprint.	footprint.
Air Quality	Air quality is expected to be slightly degraded (due to regional increased populations and urbanization) while still complying with air quality standards.	Construction activities would temporarily increase dust within the proposed project area; The operation of pumps and other equipment associated with the proposed action may have some impact upon local air quality, primarily in the form of elevated particulates, nitrogen oxides, and volatile organic compounds.	Construction activities would temporarily increase dust within the proposed project area; The operation of pumps and other equipment associated with the proposed action may have some impact upon local air quality, primarily in the form of elevated particulates, nitrogen oxides, and volatile organic compounds.	Construction activities would temporarily increase dust within the proposed project area; The operation of pumps and other equipment associated with the proposed action may have some impact upon local air quality, primarily in the form of elevated particulates, nitrogen oxides, and volatile organic compounds. Larger pumps would result in a marginal increase in the air quality impacts.	Construction activities would temporarily increase dust within the proposed project area; The operation of pumps and other equipment associated with the proposed action may have some impact upon local air quality, primarily in the form of elevated particulates, nitrogen oxides, and volatile organic compounds. Larger pumps would have more impact. Larger pumps would result in a marginal increase in the air quality impacts.
Noise	No impact	Diesel pump PS-1 would be a 1500 cfs pump. Housing of pump station would minimize noise effects.	Diesel pump PS-1 would be a 1500 cfs pump. Housing of pump station would minimize noise effects.	With a larger pump station, more pumps would be needed which could result in more noise; however, housing of the pump station will minimize noise effects.	With a larger pump station, more pumps would be needed which could result in more noise; however, housing of the pump station will minimize noise effects.
HTRW	Site will pose only a typical HTRW risk to the environment similar to other citrus operations	Over 50 point source sites with potential HTRW contamination were identified. Most if not all of these potential contamination sites have either been remediated or further investigated to characterize the sites and prepare remediation plans.	Over 50 point source sites with potential HTRW contamination were identified. Most if not all of these potential contamination sites have either been remediated or further investigated to characterize the sites and prepare remediation plans.	Over 50 point source sites with potential HTRW contamination were identified. Most if not all of these potential contamination sites have either been remediated or further investigated to characterize the sites and prepare remediation plans.	Over 50 point source sites with potential HTRW contamination were identified. Most if not all of these potential contamination sites have either been remediated or further investigated to characterize the sites and prepare remediation plans.
Cultural Resources	The existing cultural resource site that may be potentially eligible for listing in the National Register of Historic Places would likely be adversely affected by expansion of the existing citrus	Three isolated prehistoric artifacts, one isolated historic artifact, one prehistoric archeological site (8HN129), and four modified historic buildings were identified. All except the prehistoric archeological site were	Three isolated prehistoric artifacts, one isolated historic artifact, one prehistoric archeological site (8HN129), and four modified historic buildings were identified. All except the prehistoric archeological site were determined to lack integrity	Three isolated prehistoric artifacts, one isolated historic artifact, one prehistoric archeological site (8HN129), and four modified historic buildings were identified. All except the prehistoric archeological site were determined to lack integrity	Three isolated prehistoric artifacts, one isolated historic artifact, one prehistoric archeological site (8HN129), and four modified historic buildings were identified. All except the prehistoric archeological site were determined to lack integrity and

	operations	determined to lack integrity and determined not eligible for listing on the National Register of Historic Places, the prehistoric archeological site (8HB129) is located near the edge of the proposed project and will be avoided by project design.	and determined not eligible for listing on the National Register of Historic Places, the prehistoric archeological site (8HB129) is located near the edge of the proposed project and will be avoided by project design.	and determined not eligible for listing on the National Register of Historic Places, the prehistoric archeological site (8HB129) is located near the edge of the proposed project and will be avoided by project design.	determined not eligible for listing on the National Register of Historic Places, the prehistoric archeological site (8HB129) is located near the edge of the proposed project and will be avoided by project design.
Socioeconics	Under "no action", no regional impact will be realized from project expenditures. The local economy would continue to realize revenue stemming from the continued agricultural operation of the property	Although the expenditures for the various alternative plans are quite large, and are expected to result in fairly large, regional economic impacts, these impacts are very small, relative to the regional economy in which they will take place (on the order of less than one percent).	Although the expenditures for the various alternative plans are quite large, and are expected to result in fairly large, regional economic impacts, these impacts are very small, relative to the regional economy in which they will take place (on the order of less than one percent).	Although the expenditures for the various alternative plans are quite large, and are expected to result in fairly large, regional economic impacts, these impacts are very small, relative to the regional economy in which they will take place (on the order of less than one percent).	Although the expenditures for the various alternative plans are quite large, and are expected to result in fairly large, regional economic impacts, these impacts are very small, relative to the regional economy in which they will take place (on the order of less than one percent).
Aesthetics	No impact	Dams (dam elevation of 54 feet) will be an abrupt landscape transition; The top of the enclosing levees, however, will provide wide panoramas of the Caloosahatchee River landscape, and should also offer good observation points	Dams (dam elevation of 57 feet) will be an abrupt landscape transition; The top of the enclosing levees, however, will provide wide panoramas of the Caloosahatchee River landscape, and should also offer good observation points	Dams (dam elevation of 57 feet) will be an abrupt landscape transition; The top of the enclosing levees, however, will provide wide panoramas of the Caloosahatchee River landscape, and should also offer good observation points	Dams (dam elevation of 66 feet) will be an abrupt landscape transition; The top of the enclosing levees, however, will provide wide panoramas of the Caloosahatchee River landscape, and should also offer good observation points
Recreation	No impact	Wildlife viewing, boating, hiking, and horseback riding provide recreation benefits.	Wildlife viewing, boating, hiking, and horseback riding provide recreation benefits.	Wildlife viewing, boating, hiking, and horseback riding provide recreation benefits.	Wildlife viewing, boating, hiking, and horseback riding provide recreation benefits.

This page intentionally left blank.

6.2 SUMMARY OF AFFECTED RESOURCES

Under the No Action Alternative, the Caloosahatchee Estuary would continue to be degraded due to excessive high and low flows. These episodes of abnormal flushing and hypersalinity would continue to adversely affect the overall health of the estuary. The project site would likely continue to operate as a citrus grove.

The project alternatives (Alternatives 2, 3B, 3C, and 4A) would all cause similar effects on resources within the project footprint and immediately adjacent to the project site since they utilize the same project footprint. ***Therefore some of the resources in this chapter are impacted by all four alternatives equally.*** The difference among alternatives, in the cases where they do differ, would be of magnitude rather than type of impact, as the alternatives represent a graduated series of reservoir storage, pump size, and embankment heights from smallest (Alternative 2) to largest (Alternative 4A) while the location and footprint size of all alternatives is nearly the same.

The most significant beneficial effects of the proposed project would be achieved in the Caloosahatchee Estuary. Generally, estuary benefits would increase directly as storage/pumpage volume increases. All alternatives provide a significant benefit to the estuary. All alternatives can store water during the wet season for release when needed during the low flow periods. Removal of the highest peak flows and supplementing the low flow periods to the estuary will improve the salinity regime and result in a healthier estuarine environment.

Flows in the lower Caloosahatchee River will be improved during dry periods, when water is available in the reservoir for release into the river. These releases can supplement releases from Lake Okeechobee and avoid conversion of the upper estuary to a fully saline environment, which is detrimental to the growth of *Vallisneria,* a plant species of brackish water SAV. The majority of benefits accrued by this project would be a result of this supplement during the dry season. The project will provide limited benefits attributable to catching and storing high flow events during unusually wet years, when the storage capacity of Lake Okeechobee may not be enough to avoid high volume discharges of fresh water to the estuary, causing blow-outs or flushing of brackish water loving species.

None of these alternatives are capable of completely resolving the problems of the Caloosahatchee Estuary and Caloosahatchee River (C-43) Basin. None of the alternatives provide enough storage or pumping capacity to truly alleviate all extreme events. However, they all move towards restoration of the estuary by lowering the number and severity of extreme events and they all provide significant improvement to the health of the estuary. Based on a salinity model, the area within the Caloosahatchee Estuary system beneficially affected by the

project conservatively encompasses 70,979 acres in the Caloosahatchee River, San Carlos Bay, and a portion of Pine Island Sound, although in all likelihood the area beneficially affected by project implementation will be much larger, including portions of Pine Island Sound, Estero Bay, and the Gulf of Mexico. These acres are within the navigable waters of the United States and within the navigational servitude of the United States.

6.3 PHYSICAL LANDSCAPE

6.3.1 No Action Alternative

The No Action Alternative would not change the proposed reservoir site's operation as a citrus grove, nor would it affect other aspects of the physical landscape.

6.3.2 Alternatives 2, 3B, 3C, and 4A

With the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir under all alternatives, topography within the proposed project area would change significantly due to construction of the embankment and excavation of the perimeter canal. Impacts are anticipated to be similar with all of the reservoir alternatives; however, since the alternatives share the same footprint, increasing the reservoir storage capacity also increases the dam height. This in turn necessitates additional excavation of materials to form the larger, higher embankment. These elevations are significantly different and represent a significant change to the existing landscape. The dam elevations are listed below:

- Alternative 2: 54 feet
- Alternative 3b: 57 feet
- Alternative 3c: 57 feet
- Alternative 4A: 66 feet

Groundwater modeling completed for project assurances has predicted there will be no impact to the surficial aquifer. All of the deeper aquifers are below a confining layer; therefore no impact is expected to the lower aquifers.

Surficial sands (approximately upper three feet) in the footprint of the perimeter canal and portions of the reservoir would be removed on site for use as construction material for embankments. Excavation of the perimeter canal would result in removal of surficial sands, sandy clay material, and limestone. Material unsuitable for use in the embankments would be spread over the interior of the reservoir. The underlying regional geology would not be affected.

After the citrus trees are removed from the site, the areas formerly covered by citrus trees would be disced (one pass using a disc with a diameter of at least twelve inches). Exterior areas (near the embankments) would be excavated for embankment materials. Internal areas that are not covered by citrus trees (such as wetlands, canals, ditches, roads) may be left unaltered.

The soils on the project site are classified as unique farmland by the NRCS. Coordination was completed with U.S. Department of Agriculture (USDA)/NRCS and a determination was made that 13,300 acres of unique farmland would irretrievably be lost through conversion of the project site to an open water reservoir. Further design refinements reduced the potentially affected area to about 10,500 acres, which was confirmed with NRCS. This is a little less than five percent of the unique farmland in the county to be converted. Refer to the Pertinent Correspondence Annex B, correspondence with NRCS for details.

The project site includes 267 acres impacted by construction of reservoir test cells. These test cells would be incorporated into the interior reservoir. Portions of the embankments of both test cells would be breached with mounds of embankments left in place.

6.4 HYDROLOGY

6.4.1 No Action Alternative

The No Action Alternative does not improve hydrologic conditions in the Caloosahatchee Estuary and may lead to further estuarine habitat degradation. Extreme events of high flow periods during the wet season and low flow periods during the dry season would continue to occur.

6.4.2 Alternatives 2, 3B, 3C, and 4A

All of the alternatives improve hydrologic conditions by varying degrees dependent upon project components in the Caloosahatchee Estuary. Alternative 2 provides the least benefit, with Alternative 3B providing more and Alternatives 3C and 4A providing the most benefit. In general, the larger the alternative (both pump size and reservoir storage capacity), the more benefit the alternative provides to the estuary. A larger pump allows more flexibility in operations and is able to capture more of the high volume flows, while a larger capacity reservoir stores more water to augment flows in the dry season and allows more of the large flows to be stored in the wet season. The difference in ability of each alternative to match the desired flow envelope is significant. All alternatives would reduce damaging Lake Okeechobee releases of large volume flows to the estuary through the S-79 by capturing some of these flows in the reservoir. This water would then be available to supplement flows during the dry season when minimal flows for estuarine health can often not be met. The

table below summarizes the percentage of time each alternative matches the desired envelope within the preferred flow target (EST05) (***Table 6-2***):

TABLE 6-2: PERCENTAGE OF TIME EACH ALTERNATIVE MATCHES THE DESIRED ENVELOPE WITHIN THE PREFERRED FLOW TARGET (EST05):

Alternative	% Flows in Desired Envelope
2050 FWO	45.5%
Alt 2	67.9%
Alt 3B	74.8%
Alt 3C	82.3%
Alt 4A	83.8%

Within and immediately surrounding the proposed project site there would be some minor impacts to hydrology. The Roberts Canal would be re-routed around the reservoir through the perimeter canal. This would result in the Banana Branch Canal (north of the reservoir) and Ft. Simmons Branch receiving its flows from the perimeter canal. When cell two of the reservoir is dry, pump station four will be used to pump out of cell one and around the perimeter canal in order to maintain levels in the Banana Branch Canal.

The Roberts Canal would serve as a water source for the perimeter canal. The local reservoir MIKESHE Modeling (for the SAP, Alternative 3B) groundwater level analysis included the Okaloacoochee Slough (***Annex C Figure 1***, Location 7). The model results show that with the project there would be no difference to existing conditions (***Annex C, Figure 2-G***). The project footprint, project operations, and project purpose would be the same with all of the reservoir alternatives; therefore, Alternatives 2, 3C, and 4 are not anticipated to adversely affect water levels in the Okaloacoochee Slough. However, under all of the alternatives, monitoring would be required to ensure that no impacts to existing groundwater levels occur.

Currently groundwater seeps from the project site north towards the river. All of the reservoir alternatives include a slurry wall within the embankment to effectively prevent this seepage. Due to a higher embankment under Alternative 4A, it may not be possible to construct a continuous slurry wall that could extend from the subsurface clay layer to the top of the embankment. Alternative seepage control would be necessary for Alternative 4A. Once constructed the perimeter canal will provide this groundwater flow to the areas north of the project. In order to minimize the disturbance to the natural groundwater flow, the perimeter canal will be kept at levels adequate to maintain existing levels of groundwater in the area.

Another potential hydrologic change may occur as a result of removing the siltation structure at the union of the Townsend Canal and Caloosahatchee River. This structure is being removed in order to increase flow velocities. However, the removal of this structure will allow free flow to occur between the Townsend and Caloosahatchee River and would result in the northern portion of the Townsend Canal being at the same stage as the river. This is not expected to cause any negative impacts but is noted since it will change hydrology in the immediate area.

6.5 WATER MANAGEMENT

6.5.1 No Action Alternative

Lake Okeechobee releases would continue as dictated by the current LORS. Without additional water storage in the Caloosahatchee River (C-43) Basin there will be insufficient capacity in Lake Okeechobee to retain storage during the wettest months or years without large volume releases to both Caloosahatchee River and St. Lucie estuaries, and it is likely that large pulse releases would continue to affect the estuary at least during extreme years. In addition, it is likely that harmful low flows in the dry season would also continue. Additional demands on Lake Okeechobee may decrease the magnitude of large pulses being released. However, increased watershed runoff due to an increase in urban areas would likely result in continued events which may effect the estuarine habitat.

6.5.2 Alternatives 2, 3B, 3C, and 4A

The proposed Caloosahatchee River (C43) West Basin Storage Reservoir in all alternatives would be designed as a storage area which could receive water from the following sources:

- Caloosahatchee River (C-43 Canal) water via Townsend Canal
- Drainage water from southwest of the reservoir via Townsend Canal
- Drainage water from southeast of the reservoir via Roberts Canal

Management measures included as part of all alternatives include canal improvements, culverts and culvert enlargements, pumping stations, inlet and outlet structures, levees, and seepage canal. These all serve to divert water to the reservoir in times of high flow and release water from the reservoir in times when the estuary would benefit from additional flows. Water can only go into and out of the reservoir via the perimeter canal

If there is more drainage coming from the Roberts Canal during the wet season than the Banana Branch, Fort Simmons Branch, and Townsend Canal can take, and the reservoir pump station is on at that time, these flows may be "indirectly"

picked up by the reservoir when the reservoir has capacity. The same holds true for the drainage from the Townsend Canal back to the Caloosahatchee River. If the reservoir pump station was on at the same time, this flow would be picked up along with the water pulled in from the Caloosahatchee River.
The storage capacities and pump sizes of the alternatives are outlined below:

- Alternative 2 100,000 ac/ft, 1500 cfs pump
- Alternative 3B 170,000 ac/ft, 1500 cfs pump
- Alternative 3C 170,000 ac/ft, 3800 cfs pump
- Alternative 4A 220,000 ac/ft, 3800 cfs pump

The reservoirs with the larger storage capacity would allow the water managers greater flexibility in operations, due to the ability to both capture and release more often. This is a significant improvement over the no action alternative. This flexibility is apparent in the reduction of weekly average flow events >4500 cfs over S-79 compared to the No Action Alternative:

- Alternative 2 82% reduction
- Alternative 3B 82% reduction
- Alternative 3C 91% reduction
- Alternative 4A 91% reduction

The S-79 gate would be operated to mimic EST05, which is a time series of flow derived from biological indicators in the Caloosahatchee Estuary (see Section C.6 in the Environmental Appendix.). Operations of this gate are currently and will continue to be discussed on a weekly basis between the SFWMD and USACE to discuss the state of the estuary and what flows would be most appropriate.

The existing water management system in the Caloosahatchee River (C-43) basin will be modified by the proposed reservoir to enhance water storage. The LORS may be adjusted to take advantage of additional off-lake water storage capacity as it is constructed and becomes operational.

It is possible that this reservoir may extend periods of full storage capacity as well as little to no storage capacity being used. The basic operational scenario is as follows (See ***Annex D***):

- Beginning of dry season– conservatively release water from reservoir
- End of dry season– aggressively release water from reservoir
- Beginning of wet season conservatively pump water into reservoir
- End of wet season aggressively pump water into reservoir

These operational constraints will be balanced with the needs of the estuary in order to best manage the water in the basin.

6.6 WATER SUPPLY

6.6.1 "No Action" Alternative

Lake Okeechobee releases would continue as dictated by the current LORS. Without additional water storage in the Caloosahatchee River (C-43) Basin there will be insufficient capacity in Lake Okeechobee to retain storage during the wettest months or years without large volume releases to both Caloosahatchee and St. Lucie estuaries, and it is likely that large volume releases would continue during wet years. In addition, it is likely that insufficient low flows in the dry season would also continue. Additional demands on Lake Okeechobee may decrease the magnitude of high volume releases. However, increased watershed runoff due to an increase in urban areas would likely result in continued events which may affect the estuary in some cases.

Existing water supply conditions would be maintained. Undesirable low flows and insufficient water for lower watershed operations will continue to occur during some very dry years.

6.6.2 Alternative 3B

The operations for this project focus on reducing high volume flows from S-79 and provide supplemental flows across S-79 to the Caloosahatchee Estuary to achieve restoration targets. Sources of water to meet agricultural and urban demand in the Caloosahatchee Basin will remain the same as before the project. Sources of water for the Seminole and Miccosukee Tribes and Everglades National Park (ENP) are influenced by the regional water management system (C&SF Project, including Lake Okeechobee), and will not be affected by this project. Therefore, there will be no elimination as a result of this project on existing legal sources of supply for:

- Agricultural or urban water supply
- Allocation or entitlement to the Seminole Indian Tribe of Florida under Section 7 of the Seminole Indian Land Claims Settlement Act of 1987 (25 U.S.C. 1772e)
- Water supply for Miccosukee Tribe of Florida
- Water supply for ENP
- Water supply for fish and wildlife

With the project in place, portions of the Roberts Canal and Header Canal will become part of the project footprint. To continue to provide an irrigation source to the Bob Paul property, which currently pumps irrigation water from the Header Canal and the Crawford Canal, pump station #3 was included in the reservoir perimeter canal to pump water to the east down the remaining Header canal assuring the same volume of water is available compared to existing

conditions. This will result in a partial transfer of water. The Crawford Canal will still be available to the Bob Paul property and is not affected by the project.

6.6.3 Alternatives 2, 3C, and 4A

The project footprint for Alternatives 2, 3C and 4 will remain the same with only embankment height and pump size changes as described in Section 5.4.1. While the updated system-wide spread sheet analysis and local reservoir level MIKESHE model was applied to the TSP and to date has not been applied to the alternatives, operations and project purpose remain the same as described in the TSP. Therefore, it is expected that sources of water to meet agricultural and urban demand in the Caloosahatchee Basin will remain the same as before the project. Sources of water for the Seminole and Miccosukee Tribes and ENP are influenced by the regional water management system (C&SF Project, including Lake Okeechobee), and will not be affected by this project. Therefore, there will be no elimination or transfer as a result of this project on existing legal sources of supply for:

- Agricultural or urban water supply
- Allocation or entitlement to the Seminole Indian Tribe of Florida under Section 7 of the Seminole Indian Land Claims Settlement Act of 1987 (25 U.S.C. 1772e)
- Water supply for Miccosukee Tribe of Florida
- Water supply for ENP
- Water supply for fish and wildlife

6.7 FLOOD PROTECTION

6.7.1 No Action Alternative

With the No Action Alternative existing water supply conditions would be maintained. Undesirable low flows and insufficient water for lower watershed operations will continue to occur during some very dry years.

Existing levels of flood protection would be maintained. There will be no significant impact on flood protection for any alternative.

6.7.2 Alternative 3B

The intent of the level of service analysis for flood protection, required by WRDA 2000 and the CERP Programmatic Regulations as well as Florida State law regarding the implementation of CERP, is to ensure that CERP components do not negatively impact existing levels of flood protection.

The operations of this project will not change the operations of the Caloosahatchee River (C-43) Canal based on the key assumptions outlined in the Federal Assurances and Savings Clause Analysis, Section 8.4. Therefore, there will be no system-wide effects on flood protection as a result of the project.

The MIKESHE model was used to evaluate flood protection by evaluating groundwater levels to determine if they were altered due to reservoir operations. A significant change in groundwater levels could signify a potential impact to flood protection. The results from the local reservoir-level MIKESHE modeling indicate a boundary slurry wall within the embankment will prevent seepage out of the reservoir and impacts to groundwater levels. In addition, optimization of the operating levels of the seepage canals and canal structures surrounding the reservoir will maintain existing groundwater levels adjacent to the project.

Of the eleven locations evaluated using the MIKESHE model, the only location where simulated groundwater elevations increased compared to the without-project conditions was north of the project. Simulated "with project" groundwater elevations increased slightly compared to the "without project" condition. The greatest difference was during the dry period (e.g., 1981) not the wet periods. This minor effect can be addressed through further optimization of perimeter canal control structure operations for the project. The remaining ten locations show practically no differences in groundwater elevations.

Therefore, there will be no adverse affects on existing levels of service for flood protection in the vicinity of the reservoir.

6.7.3 Alternative 2, 3C, and 4A

As described above, the project footprint for Alternatives 2, 3C and 4 will remain the same with only embankment height and pump size changes as described in Section 5.4.1. The cut-off slurry wall included in the SAP embankment to attenuate seepage will also be included in the alternative embankments for Alternative 2 and 3C. Due to construction equipment constraints and embankment height, a continuous slurry wall would not be practicable under Alternative 4A; however, alternate seepage control methodologies would be investigated. While the local reservoir level MIKESHE model groundwater analysis was applied to the SAP and to date has not been applied to the alternatives, operations and project purpose remain the same as described in the SAP.

Therefore, it is anticipated there will be no adverse affects on existing levels of service to flood protection in the vicinity of the reservoir.

6.8 WATER QUALITY

6.8.1 No Action Alternative

Future water quality conditions in the basin will be strongly influenced by future land use, the operation schedule of Lake Okeechobee, and the implementation of BMPs to control nutrient discharges. In the immediate vicinity of the project, the Townsend Canal will likely continue to be impaired for copper as long as citrus is cultivated on the project lands. Since the 2050 population will be substantially greater than the year 2000 population, the quantity of treated wastewater effluent discharged to the estuary will increase. However, with the expected implementation of TMDLs for the discharge of nutrients into the estuary, it is reasonable to expect that by 2050 most existing wastewater treatment plants and all future plants will incorporate tertiary treatment process to remove nutrients. If the TMDL program is effective, the 2050 nutrient loads from wastewater effluent will be similar to or less than the present nutrient loads.

Future water quality conditions will depend upon the overall change in nutrient loads delivered to the estuary from upstream of S-79 as well as below this structure. Nutrient loads to the estuary will likely increase by ten percent or more if no BMPs or nutrient TMDLs are implemented in the Caloosahatchee Basin. If the implementation of BMPs substantially reduces non-point source nutrient loads, discharges from Lake Okeechobee are significantly reduced, and tertiary wastewater treatment is implemented basin wide, the 2050 Future Without nutrient loads may decrease by more than 30 percent as compared to the existing condition. This scenario would result in fewer violations of water quality standards at least for nutrients and coliforms. The number of water bodies in the basin listed as impaired for other pollutants such as heavy metals is likely to increase as the basin becomes more developed.

6.8.2 Alternatives 2, 3B, 3C, and 4A

Under the conservative assumption that no water quality treatment occurs in the reservoir, the project alternatives would show the following reduction in TP and TN loads at S-79 in comparison to the future without condition (***Table 6-3***).

TABLE 6-3: REDUCTION IN TP AND TN LOADS AT S-79 IN COMPARISON TO THE FWO CONDITION

Alternative	TP% Reduction	TN% Reduction
FWO 2050	0	0
Alt. 2	30%	29%
Alt. 3B	29%	28%
Alt. 3C	32%	31%
Alt. 4A	34%	32%

The difference in load reduction between alternatives is not significant. Although the size of the reservoir and the pump have some influence on the S-79 pollutant load, the reduction in nutrient loads at S-79 is largely the result of the reduction in discharges from Lake Okeechobee. In other words, the majority of load reduction shown in ***Table 6-3*** will result from project elements of CERP other than the C-43 Basin Storage Reservoir project itself. All of the selected alternatives will cause a shift in nutrient load from the wet season to the dry season; however, all of the alternatives will decrease the frequency in which the monthly TN load exceeds the dry season, wet season, and annual targets established by the FDEP (dry-season 190 tons/month, wet-season 350 tons/month, annual 3,000 tons/month). While it is possible that nitrogen fixation within the reservoir will result in short-term increases in TN loading to S-79, the average annual TN load at S-79 will be reduced. Given the uncertainty in the threshold chlorophyll-a concentration required for the restoration of the ecological function of the estuary, the degree to which the reservoir project will improve downstream water quality is unknown at this time. However, each of the alternatives results in an improvement in overall average water quality conditions at S-79 as well as downstream in the estuary.

Section 303(d) of the CWA requires states to develop a list of waters not meeting water quality standards or not supporting their designated uses. Those waters not meeting water quality standards are designated as "impaired". TMDLs are required for the waters determined to be impaired. A summary of the current list of impaired water bodies in the Caloosahatchee Basin is included in the existing conditions section of this report. Using the current list as a baseline, the impact of the project on future compliance with state water quality standards can be estimated. Under the with project condition, the Townsend Canal will likely no longer be impaired for copper and lead since the much of the farmland in this sub-basin will be within the reservoir footprint. Several of the downstream estuary bodies that are presently impaired for nutrients will likely no longer be impaired since the project will significantly decrease nutrient loads to the estuary. Estuary water bodies that are currently impaired for heavy metals will likely continue to be impaired for these pollutants since this contamination is a result of the urbanization of the estuary sub-basin. Similarly, impairments of sub-basin water bodies not directly affected by S-79 discharges will not be influenced by the construction of the project. Based on the evidence presented here, it appears that the project will not cause or contribute to water quality degradation and will likely reduce the number of and intensity of violations of water quality standards.

6.9 SEDIMENT QUALITY

6.9.1 No Action Alternative

Under the No Action Alternative, the sediment quality in the estuary is expected to continue to slowly degrade. The conversion of farms and pastures to urban developments over the next 50 years will increase the concentrations of heavy metals and hydrocarbons in stormwater runoff. Many of these pollutants will become entrained in the estuary sediments despite the requirement to include stormwater treatment facilities in all new developments. Unless additional stormwater control such as retrofitting existing development is implemented, the rate at which the estuary sediments degrade may increase somewhat since the overall quantity of stormwater and sediment load to the estuary will increase.

6.9.2 Alternatives 2, 3B, 3C, and 4A

The with project total load of sediments transported to the estuary from the freshwater Caloosahatchee sub-basin will be reduced relative to future without conditions since some fraction of the available sediment load will be retained within the reservoir. Additionally, since construction of the reservoir will reduce the total area of farmed land by some 10,500 acres, sediment transport associated with farming this acreage will also no longer be transported to the estuary. The reduction in sediment load will be on the order of five percent to ten percent relative to existing without project conditions and approximately 30 percent relative to future without project conditions. The difference between alternatives would be minimal. This reduction in sediment delivered to the estuary should result in a slight improvement in sediment quality relative to without project conditions. However, since urbanization of the basin will continue over the next 50 years, non-project related anthropogenic impacts will likely result in the continued degradation of estuary sediment quality over time.

6.10 PLANT COMMUNITIES

The impacts described below are applicable to plant communities within the project site. Estuarine plant communities (such as SAV) are addressed in Section 6.12.4, Estuarine Resources. *Plant communities would be impacted by all four alternatives equally.*

6.10.1 No Action Alternative

The lands within the project area would be developed consistent with surrounding land use patterns. The surrounding areas are predicted to be in agricultural production, as at present, in 2050. If the site remained a citrus grove, there would be very little change to the plant communities under the No Action Alternative. There may be a slight change in the density and distribution

of exotic species along the perimeters and canals. The areas in production are controlled for noxious species. However, along the canals and perimeter there is a variety of exotic species. These may change due to biological control of existing noxious plants as well as the introduction of new exotic species into the south Florida ecosystem.

6.10.2 Alternatives 2, 3B, 3C, and 4A

Under all alternatives, an above ground reservoir with associated seepage canals and embankments would be constructed. Most existing plant cover within the project footprint would be removed. This is a significant impact to existing plant communities and would be equally significant among all alternatives.

Preparation for construction of the reservoir includes the removal and burning of all citrus trees within the project footprint. The total area of tree removal is approximately 7,970 acres. Only trees located in the cultivated citrus areas of the project will be removed. No other trees or vegetation within the project area will be removed. The remaining vegetation, including vegetation found in irrigation and drainage ditches, swales, canals, jurisdictional wetlands, and areas noted as contaminated soils within the project footprint will not be removed.

In general, construction will largely replace existing plant communities with aquatic habitat (water-covered reservoir areas) or maintained uplands (embankments, roads, berms). The construction of the reservoir and seepage canal may provide some deepwater refugia and/or littoral habitat for use by fish and amphibian species when the reservoir is drawn down. The operational plan for the reservoir, in order to meet the project objectives, constrains the ability of the project site (either reservoir or seepage canal) to be optimized for management as habitat for fish and wildlife. The reservoir would likely experience wide-ranging depth and duration fluctuations throughout the year ranging from complete dry down to full capacity i.e., 15-25 feet above soil surface, on an annual basis. This would potentially impact the survival of any wetland species and provide limited benefits to opportunistic plants that could adapt to such environmental dynamics.

The interior of the reservoir will lack much productive littoral zone because of the necessity to construct relatively steep sides to maximize water storage capacity. The design for the perimeter canals, however, includes littoral areas in the corners and along some of the banks.

Exotic plant species are not expected to be a problem under any of the alternatives, as appropriate construction and maintenance procedures would be established to deter and control exotic establishment at the project site.

6.11 WETLANDS

6.11.1 No Action Alternative

If the project site remained a citrus grove, the 125 acres of wetlands scattered throughout the project site would likely remain. (An additional 6.39 acres of wetlands present within the project site were previously impacted by discharge of fill material during construction of the C-43 Test Cell Project.) The function and value of the existing wetlands would continue to deteriorate due to infestation by exotic plant species and due to reduced hydroperiod from agricultural operations. Additionally, expansion of citrus operations could result in direct removal of some of these wetlands areas.

6.11.2 Alternatives 2, 3B, 3C, and 4A

Construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir will result in the loss of 125 acres of wetlands through discharge of dredge or fill material, excavation, and/or flooding. This includes the total acreage of a wetland on the eastern portion of the project that will be bifurcated and partially impacted by construction activities. This acreage does not include wetlands previously impacted by the C-43 Test Cell Project. *This loss would be the same for all reservoir alternatives since the project footprint is nearly identical.* Operation of the reservoir to meet the project water storage and release objectives constrains its management for wetland function and habitat. Therefore, it is assumed that all wetlands within the project area will be eliminated. Currently, the design for the reservoir perimeter canals includes approximately 109 acres of littoral areas in the corners and along some of the banks.

E.O. 11990, Protection of Wetlands, was created to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. The area proposed for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is mostly farmland with a few disturbed wetlands. The reservoir design will include areas of littoral shelf along the seepage canal. This littoral shelf will create some new habitat which will help to minimize the impact of the loss of wetlands due to construction of the reservoir. There will be no mitigation for wetlands as a result of the federal project. Overall, CERP projects are expected to have a net positive lift of wetland function. The C&SF Project Comprehensive Review Study ("Yellow Book") states in Section 9.6 that "...construction features of the Comprehensive Plan will be designed to first avoid and then minimize unavoidable impacts to wetlands or other aquatic sites and natural upland habitats. Unavoidable impacts to these habitats are expected to be offset by the ecological improvement throughout the south Florida ecosystem that results

from the overall restoration achieved by the Comprehensive Plan. Accordingly, separate compensatory mitigation features are not included in the recommended Comprehensive Plan for these impacts." The state's Accler8 program may have separate wetland mitigation requirements for this project as a result of their permitting process. A wetland rapid assessment procedure (WRAP) was performed in 2004 to determine impacts of wetland function related to the proposed project. Additional information on wetlands can be found in the Final CAR in *Annex A*.

6.12 FISH AND WILDLIFE RESOURCES

This section will discuss the fish and wildlife impacts at the reservoir footprint, as well as all threatened and endangered species impacts. Impacts to the estuarine fish and wildlife resources are addressed in Section 6.12.4. *Impacts to fish and wildlife resources at the project site would be impacted by all four alternatives equally.* There will be significant, mostly beneficial, impacts to fish and wildlife resources.

6.12.1 No Action Alternative

The agricultural operation associated with the No Action Alternative would continue to provide some level of fish and wildlife resources, similar to existing conditions.

6.12.2 Alternatives 2, 3B, 3C, and 4A

Small areas of existing open water habitat would be lost under the construction footprint. Once the reservoir is filled aquatic (open water) habitat will substantially increase. The open water reservoir will likely harbor fish typical of nearby canals. Water would be conveyed to the reservoir by these canals which also act as conduits for the introduction of many aquatic organisms, including fish. Due to the operation of the pumps there will likely be some entrainment and impingement of fish and other aquatic organisms. The larger pumps (alternatives 3C and 4A) will likely increase the impingement and entrainment impacts. Species that will likely inhabit the reservoir include: largemouth bass, black crappie, red ear sunfish, shad, bluegill, and mosquitofish, among others. A high population of invertebrates is not expected, due largely to a lack of emergent vegetation. Shallow water fish bedding and rearing habitat will be limited to the margins of the reservoir. The design of the reservoir perimeter canal, however, includes littoral areas for fish and wildlife use.

Amphibians and aquatic reptiles including frogs, turtles, snakes, and alligators will likely inhabit the deepwater reservoir. Limited emergent vegetation in the reservoir will also affect these organisms by reducing available forage, cover, and reproductive habitat. The reservoir will likely create limited foraging habitat for

osprey, bald eagle, terns, cormorant, and other aquatic birds that feed on fish. Ducks may also use the reservoir, but low cover of submergent and emergent vegetation may limit the habitat value. Mammals in the reservoir will likely be limited to river otter.

Flooding a large area may create insect or rodent problems. If such problems occur, the SFWMD operations and maintenance staff will address these issues on an as-needed basis.

Additionally, the project site contains 899.59 acres of primary, secondary, and tertiary ditches. (Construction of the test cells has resulted in loss of 26.03 acres of tertiary ditches not included in this acreage). Ditches underlying the footprint of the open water portion of the reservoir will provide deepwater refugia to aquatic invertebrates, fish, and wading birds during periods when the rest of the reservoir is dry.

Prior to flooding of the reservoir, portions of the test cells embankments will be demolished in a few locations leaving some embankment mounds in place for wildlife when the reservoir is full.

Threatened and endangered species would be impacted by all four alternatives equally unless otherwise noted.

6.13 FEDERAL AND STATE LISTED SPECIES

6.13.1 No Action Alternative

Under the No Action Alternative, there would be no immediate impacts to threatened or endangered species. Use of the site by federal and state listed species would continue. Under the "No Action" Alternative including future without, continued degradation of marine seagrasses and *Vallisneria sp.* in the estuary would be harmful to the survival of the endangered West Indian Manatee.

6.13.2 Alternatives 2, 3B, 3C, and 4A

The USFWS has been an active member of the project team for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project and has provided guidance through informal consultation during plan formulation and evaluation. The USFWS provided a Biological Opinion on November 30, 2005, for construction of the Caloosahatchee River (C-43) West Basin Storage reservoir test cells, an area of approximately 267 acres. This area is not included in the ongoing Section 7 evaluation for the reservoir since consultation has been completed; therefore, the 267 acres associated with the test cells are not discussed in this section.

The USACE Regulatory Division's January 10, 2007, letters to the USFWS and NMFS transmitted the Final Biological Assessment for the Caloosahatchee River (C-43) West Basin Storage Reservoir (see Annex A). These documents describe the potential effects of the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir project on federally listed threatened and endangered species. The USACE determined that the Caloosahatchee River (C-43) West Basin Storage Reservoir Project would not affect the bald eagle (de-listed effective August 8, 2007), Florida scrub jay, Florida grasshopper sparrow, red cockaded woodpecker, Okeechobee gourd, or the beautiful pawpaw because they do not occur within or adjacent to reservoir footprint, nor would there be direct or indirect impacts to those species. The USACE determined that the proposed project may affect, but is not likely to adversely affect the smalltooth sawfish, wood stork, West Indian manatee, Everglade snail kite, American crocodile, piping plover, or the green, hawksbill, leatherback, Kemp's ridley or loggerhead sea turtles. The American crocodile, piping plover, or the green, leatherback, Kemp's ridley and loggerhead sea turtles do not occur within or adjacent to the reservoir footprint and indirect effects resulting from operation of the reservoir are expected to be negligible, discountable or beneficial to those species. Additionally, wintering piping plover critical habitat will not be adversely modified by the proposed project. Additionally, the USACE determined the project may adversely affect the eastern indigo snake, Audubon's crested caracara, and the Florida panther and requested initiation of formal consultation for these species in the January 10, 2007 letter. Formal consultation for all species was completed per a Biological Opinion (BO) transmitted from the USFWS to the USACE dated July 20, 2007. A copy of the BO is located in *Annex A*.

The following is a summary of the effects on the remaining federally-listed species not already discussed in this section. These impacts are considered significant (although largely beneficial) but would be similar for all alternatives.

6.13.2.1 Wood Stork

The Caloosahatchee River (C-43) West Basin Storage Reservoir project area is within the CFA of three wood stork rookeries as discussed in Section 2.8.7.2. Construction of the reservoir will result in the loss of approximately 785 acres of potential wood stork foraging habitat within the reservoir footprint. This includes wetlands and secondary and tertiary drainage canals. The proposed project would improve salinity conditions during the dry season for 4,130 acres of *Vallisneria* beds in the upper Caloosahatchee estuary. Two of the wood stork rookeries are located on mangrove islands within the upper estuary and would directly benefit from the proposed project. Additionally, the proposed project is not expected to alter the hydroperiod of freshwater wetlands outside of the project footprint but within the wood stork CFAs as recommended in the USFWS' Habitat Management Guidelines for the Wood Stork in the Southeast

Region. The reservoir may intermittently provide foraging habitat for wood storks during the dry season if/when water releases for the estuary are great enough to create optimal shallow-water foraging areas with concentrated prey in the reservoir. Thus, the USACE has made the determination that construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir may affect, but is not likely to adversely affect, the wood stork.

6.13.2.2 Everglade Snail Kite

No known snail kite nesting locations are documented within or adjacent to the reservoir site, and no designated critical habitat occurs within or adjacent to the project area. Snail kites have a specific diet comprised almost entirely of apple snails. Snail kite use of the site is low at present with apple snails having been documented only in the larger canals near the test cell project. Citrus operations in the project area and elsewhere have routinely applied heavy copper treatments as a fungicide for many years, resulting in extensive copper contamination in the soil. Potential copper risk to the endangered snail kite may occur due to copper accumulation in the kite's primary food item, the apple snail (URS 2003). Copper concentrations in the soils within the project area range from 13.1 to 169.0 mg/kg (URS Corporation 2003). Approximately nine percent of the sample concentrations within the project area exceed the interim effects level of 85 mg/kg agreed upon by the USFWS and SFWMD until a study to evaluate that value for the snail kite is completed. Those areas will be remediated before project construction. Construction of the reservoir would infrequently provide habitat for the snail kite as water levels would experience wide-ranging depth and duration fluctuations from complete dry down to 15 - 25 feet above soil surface, potentially impacting the survival of most wetland species. However, such widely fluctuating water levels are unlikely to provide suitable habitat for apple snails, and thus snail kite use is not expected. However, the perimeter canal may provide wetland vegetation for survival of apple snails in littoral areas created from uneven edges. The perimeter canal could potentially attract or increase usage of snail kites, providing foraging habitat but this use would be dependent on the presence of apple snails and appropriate perching sites. The USACE has therefore determined the project may affect, but is not likely to adversely effect, the Everglade snail kite and its' critical habitat.

6.13.2.3 West Indian Manatee

Manatees are known to use major inland freshwater waterways and canals, including the Caloosahatchee River from Lake Okeechobee to the Gulf of Mexico (i.e., Glades, Hendry, and Lee Counties). They are highly mobile and may be found in all waters accessible to them, including the Townsend Canal on the western side of the project footprint. When water levels are high in the Caloosahatchee River, manatees are capable of passing over the existing weir or

through a flap gate into the Townsend Canal and have been observed at the Berry Groves main pump station. However, manatees cannot access the main distribution canal (i.e., Header Canal) on the project site due to differences in elevation.

The Townsend Canal will serve as the intake canal for the reservoir. The weir will be removed, portions of the canal will be widened and armored, and two new pump stations will be constructed. In order to reduce the likelihood of thermal stress to manatees (due to warmer water from the reservoir being released into cooler canal and river water), the weir will be replaced with a structure that serves either as a permanent barrier or a seasonal barrier which restricts manatee access to the Townsend Canal only during the winter season (November 1 through March 31). A monitoring plan (described in the BO) will also be implemented when needed during the winter months. Thus, manatees in the river may continue to have seasonal access to the Townsend Canal where the two reservoir intake pump stations (i.e., C-43PS-1 and C-43PS-4) will be located. However, both intake pumps will include bar screens and trash rake systems that will prevent manatees from becoming trapped in the intake pipes as well as from entering the reservoir through C-43PS-1 or the perimeter canal through C-43PS-4, and reduce the likelihood of injury to manatees by the rake systems. The USFWS' manatee requirements for culverts, *Guidelines for Culverts Located in Manatee-Accessible CERP Projects* (USFWS 2006) and the *Standard Manatee Conditions for In-Water Work* (FWC 2005) will be followed. Manatee access to the pump intake will be blocked. Manatees feed on a variety of emergent, submergent, and floating vegetation. With implementation of the project, food sources for the manatee in the lower river and estuary will improve. Section 6.1.13.2 includes a discussion of estuarine resources that will improve as a result of the project. Therefore, the USACE has determined that the project "may affect but is not likely to adversely affect" the manatee.

6.13.2.4 Florida Panther

The proposed reservoir is within the current range of the Florida panther and will result in the conversion of approximately 10,335 acres of habitat suitable for use by the panther for foraging and dispersal to open water habitat. This acreage includes uplands i.e., agricultural lands, agricultural roads and embankments, as well as wetlands within the project area. (This acreage does not include suitable panther habitat within the test cells project area.) The project site is located within the Florida panther consultation area according to the USFWS' *Final Interim Standard Local Operating Procedures for Endangered Species for the Florida Panther* (USFWS 2000) and overlaps with the Florida panther "Primary", "Secondary", and "Other Habitat Zones" as defined in the report *How Much Is Enough? Landscape-scale Conservation for the Florida Panther* (Kautz et al. 2006) and in the *CERP Landscape Level Project Planning/Siting Map for Panther Conservation* (USFWS and FWC 2004:

Figure 15). A Biological Assessment (BA) including a panther cumulative impact analysis for a 25-mile radius action area around the project was prepared in December 2006, in order to evaluate the effects of the project on the Florida panther (See Annex A for a copy of the BA). Based on the BA, the USACE determined that the Caloosahatchee River (C-43) West Basin Storage Reservoir Project "may affect" the Florida panther and requested initiation of formal consultation with the USFWS on January 10, 2007.

In February 2007, the USACE and USFWS implemented a revised Panther Key and Panther Focus Area Map for use in determining effects to the Florida panther. In June 2007, the USACE and SFWMD provided the USFWS with an updated panther cumulative impact analysis based on the new information. On July 23, 2007, the USFWS terminated formal consultation for the Florida panther with a Biological Opinion (BO). The USFWS is using a system-wide approach for assessing impacts and benefits to panther habitat associated with the CERP Band 1/Acceler8 Projects. This includes maintaining a panther habitat mitigation ledger that shows individual projects that cause some habitat loss may be offset by habitat gains or improvements attributable to another project. The direct and indirect loss of 10,335 ac of panther habitat associated with this project as well as direct and indirect loss of panther habitat associated with other CERP Band 1/Acceler8 Projects will be offset through the preservation and restoration of approximately 102,129 ac of lands associated with implementation of the CERP Band 1/Acceler8 Projects (primarily Picayune Strand Restoration Project). This includes 63,099 ac, 5,290 ac, and 33,740 ac of habitat used by the panther within the Primary, Secondary, and Other Zones, respectively, to benefit the Florida panther and its prey. These lands, most of which have already been acquired for CERP, are located in the core area of occupied habitat. Acquisition of these lands for CERP has resulted in preservation of important lands that may otherwise be used for development. The majority of these lands are adjacent to other large tracts of natural and preserved lands (e.g., Picayune Strand State Forest), and are consistent with the USFWS' goal to locate, preserve, and restore sets of lands containing sufficient area and appropriate land cover types to ensure the long-term survival of the Florida panther south of the Caloosahatchee River.

The USFWS does not anticipate construction of this project will result in the direct mortality or injury of any Florida panthers. The USFWS does however, anticipate indirect take of the panther in the form of harm and harassment because of potential increases in interspecific aggression within the 25-mile radius action area. Based on their analysis, the USFWS believes this level of take is not likely to jeopardize the continued existence of the Florida panther. The complete habitat loss and other project effects including the panther mitigation ledger are addressed in the biological opinion (BO) prepared by the USFWS (*Annex A*).

6.13.2.5 Eastern Indigo Snake

Specific information on the status of the eastern indigo snake within the project area is not available. However, indigo snakes are known to occur in the Caloosahatchee River Basin in low densities and are known to occur along roads and the banks of larger ditches and canals in citrus groves, particularly if burrows (e.g., tortoise, armadillo, small mammal, and/or land crab), debris piles, or other shelter are in close proximity. The network of ditches and canals also provide prey items. Therefore, the USACE assumes that eastern indigo snakes occupy the site, and are more prevalent where habitat and prey items are more plentiful. Potential impacts to indigo snakes may occur due to project-related activities including citrus tree removal and burning, habitat destruction and degradation, earthmoving, construction of the reservoir and associated structures and canals, and operation and maintenance of the project. This action may cause individuals to leave the area, abandon den sites, and miss foraging and/or mating opportunities. Snakes fleeing the area could be more vulnerable to predation. Potential direct impacts to the eastern indigo or its habitat include direct injury or mortality and loss of available habitat for foraging, breeding, and dispersing.

The USFWS' *Standard Indigo Snake Protection Conditions* will be implemented during construction to minimize potential adverse effects to indigo snakes (USFWS 2002). Those measures include: 1) providing indigo snake educational materials to construction employees prior to project initiation; 2) if a live indigo snake is found, construction activities will cease until the snake has left the project area on its' own accord and the location of sightings will be reported to the USFWS; and, 3) if a dead indigo snake is found, the snake will be frozen as soon as possible and the USFWS will be contacted immediately for further instructions. With these conservation measures in place the USACE determined the proposed reservoir project "may adversely affect" the eastern indigo snake and by letter dated January 10, 2007, requested initiation of formal consultation with the USFWS. The USFWS terminated consultation with a BO on July 23, 2007. Terms and conditions of the consultation require a slow initial hydration rate for the reservoir in order to allow the snakes sufficient time to move to other habitats. Subsequent rehydration after the first extended drydown event will be monitored and the rate will be re-evaluated based on results of that monitoring. The USFWS anticipates that the direct permanent loss of approximately 10,264 ac of eastern indigo snake habitat will occur through conversion of citrus grove to reservoir and associated embankments, canals, and other infrastructure. The USFWS anticipates up to 54 eastern indigo snakes will be taken incidental to the initial project construction and operations. Complete details of the habitat loss and other project effects are addressed in the BO prepared by the USFWS (*Annex A*).

6.13.2.6 Audubon's Crested Caracara

The reservoir footprint occurs with the secondary (6,600-foot radius from the nest tree) protection zones of two known caracara nest sites. Caracara have been observed foraging in the southeast portion of the project footprint that overlaps with the secondary zone of one nest. However, no construction activities or habitat loss would occur within the primary zone (985-foot radius from the nest tree) of either nest. Since it is anticipated that construction within the secondary zone would occur all year round including during the nesting season, the USACE determined that the proposed project "may adversely affect" the crested caracara and requested initiation of formal consultation with the USFWS by letter dated January 10. 2007. The USFWS terminated consultation with a BO on July 23, 2007. Terms and conditions of the consultation require that the Caracara pairs proximate to the C-43 site will be monitored during land cover conversion and construction of reservoirs associated with this project. The USFWS anticipates that the proposed action will incidentally take the federally listed caracara, though the level of incidental take may be difficult to detect and quantify. The USFWS anticipates that up to two adult pairs of caracaras could be taken as a result of this proposed action. This incidental take for adult birds is expected to be in the form of harassment. No direct killing or injuring of adult caracaras is anticipated. The USFWS also anticipates that disturbance may cause the loss of productivity (eggs or young) associated with up to two caracara nest sites for up to five consecutive breeding seasons. The USFWS anticipates that up to six caracara eggs or young (a maximum of three per nest) could be incidentally taken per year during the construction of the project. This take would be in the form of mortality. The complete habitat loss and other project effects are addressed in the BO prepared by the USFWS (*Annex A*).

6.13.3 Essential Fish Habitat

6.13.3.1 No Action Alternative

Under the No Action Alternative, essential fish habitat (EFH) would continue to be adversely impacted by extreme high and low flows to the Caloosahatchee Estuary. Decline of marine and estuarine grasses would continue as a result of alterations in the salinity regime and the unsuitable timing of the freshwater discharges from the S-79 structure.

6.13.3.2 Alternatives 2, 3B, 3C, and 4A

The intent of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to improve the quantity and timing of flows to the Caloosahatchee Estuary by reducing high flows during the wet season and augmenting low flows during the dry season. This reservoir is expected to vastly improve the extent and health of EFH predicted for the "without project" condition. Reducing

salinity and nutrient fluctuations caused by large, pulsed freshwater flows would improve seagrass and mangrove habitat conditions in the downstream estuaries. With these improvements in water quality, the appropriate conditions for sensitive estuarine biota, such as species dependent on this habitat for egg, larval, and juvenile stages, are anticipated to benefit or rebound. These impacts are largely beneficial and are significant, and do vary in degree of improvement between alternatives.

The NMFS website (http://www.nmfs.noaa.gov/habitat/habitatprotection/efh/) lists the Caloosahatchee Estuary as EFH for juvenile Brown shrimp (*Penaeus aztecus*), juvenile Gray snapper (*Lutjanus griseus*), juvenile Pink shrimp (*Penaeus duorarum*), adult and juvenile Red drum, (*Sciaenops ocellatus*), adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile Stone crab (*Menippe mercenaria*).

All of the construction features of the alternatives are well upstream of EFH and any juvenile or adult habitat for the listed species. Standard BMPs to reduce erosion and downstream turbidity will be included in the construction specifications. Construction should have no impact on EFH in the Caloosahatchee Estuary. The USACE requested that NMFS review the draft EIS and concur with the determination stated as required by the Magnuson-Stevens Fisheries Conservation and Management Act. The USACE has determined that implementation of the project would not have an adverse impact on EFH or federally managed fisheries. The NMFS agreed with this determination per an email dated 30 May 2007.

6.13.4 Estuarine Resources

6.13.4.1 No Action Alternative

Under the No Action Alternative, the estuarine habitat would continue to be degraded as described in the existing conditions due to altered freshwater inflows and extreme variation in salinity levels, and eutrophication. Some areas of habitat may be so badly degraded that it would no longer serve as suitable habitat for important estuarine species.

6.13.4.2 Alternatives 2, 3B, 3C, and 4A

All alternatives would improve the estuarine environment. These impacts are largely beneficial and are significant, and do vary in degree of improvement between alternatives. As already described, the larger alternatives and pumps (Alternative 3C and 4A) provide the largest benefit to the estuary, as they are able to capture more of the high flows as well as hold more water in storage to augment the low flows. Specifically, salinity at Ft. Myers would be expected to fluctuate less than at present, and less than under the smaller alternatives.

Vallisneria sp. would be expected to increase in density and spatial extent. Most importantly, *Vallisneria*.cover would be more consistent year to year. Under existing conditions, the *Vallisneria* is in an almost constant state of recovery. This reservoir may stabilize conditions enough to allow the *Vallisneria* to establish and maintain consistent beds in the estuary. Oysters are currently limited in their recruitment due to high flow events. The reservoir would allow oysters to better maintain their populations and reduce the loss of live oysters and spat. This would also be expected to increase their spatial cover. Marine seagrasses would also be expected to increase in density and spatial extent. These gains would be seen both horizontally and vertically. The vertical improvement (grasses present at deeper depths) would be due to the increased clarity of the water. This improvement to seagrasses would be most beneficial in the San Carlos Bay area and upstream of Shell Point.

6.14 LAND USE

6.14.1 No Action Alternative

The SFWMD owns most of the lands within the 10,700 acre project site. (Currently the SFWMD is exchanging 541.31 acres north of the reservoir boundary for the 600.1 acres of Bryan Paul Property.) The project lands are commonly referred to as Berry Groves and were purchased in 1999 using DOI's Federal funds and State funds for Everglades restoration purposes. The DOI, USACE, FDEP, and the SFWMD are parties to a Framework Agreement under which all interim uses of lands acquired with these funds must be consistent with the ultimate use of the property in a Congressionally authorized federal project for Everglades restoration. Under the No Action Alternative the SFWMD could continue to lease the lands for citrus production, sell the lands, or consider another project; however, approval from DOI would be required.

6.14.2 Alternatives 2, 3B, 3C, and 4A

All alternatives include the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir within the same project footprint. As stated above, the lands were purchased for Everglades restoration. Implementation on any of the alternatives would be consistent with the Framework Agreement. This is a significant impact to land use and would be comparable across all alternatives.

6.15 AIR QUALITY

6.15.1 No Action Alternative

The air quality for this area is considered good and the region attains all National Ambient Air Quality Standards. In the future under the No Action Alternative, air quality is expected to be slightly degraded (due to regional

increased populations and urbanization) while still complying with air quality standards.

6.15.2 Alternatives 2, 3B, 3C, and 4A

Construction activities associated with implementing all alternatives would temporarily increase dust within the proposed project area. BMPs to control dust would be implemented during construction. All alternatives include the burning of citrus trees which may necessitate a local or state burning permit which the contractor would coordinate. Impacts to air quality are not expected to be significant and would not be significantly different across alternatives.

The operation of pumps and other equipment associated with the proposed action may have some impact upon local air quality, primarily in the form of elevated particulates, nitrogen oxides, and volatile organic compounds. Reservoir pumps and associated equipment would be powered by diesel engines or additional electric power with appropriate backup generators. The larger pumps associated with Alternatives 3C and 4 would result in a marginal increase in air quality impacts compared to the smaller pumps in Alternatives 2 and 3B.

Every Federally funded project must be consistent with state plans for implementing the provisions of the Clean Air Act Amendments (State Implementation Plans). This project is in conformance with the State Implementation Plan because it would not cause violations of the National Ambient Air Quality Standards.

6.16 NOISE

6.16.1 No Action Alternative

Within the major natural areas of south Florida, external sources of noise are limited and of low occurrence. With the No Action Alternative, noise is expected to be similar to the existing condition, which is mostly limited to agricultural machinery and a 300 cfs pump station that is exposed.

6.16.2 Alternatives 2, 3B, 3C, and 4A

Noise impacts associated with all alternatives would not increase over what presently exists within the project area. Noise impacts would not be significant and would be similar across all alternatives. Temporary increases in noise levels would be expected during construction of any of the alternatives; however, this would be limited to the immediate area of construction. This noise would mostly consist of typical construction equipment which generates an average of 80-88 dBA at 50 ft. This impact should be minimal as the area within and

surrounding the construction is mostly rural. The estimated construction timeline (during which construction noise impacts would occur) is 38 months. Although all of the reservoir alternatives include construction of two pump stations, PS-4 and PS-1, both pump stations would be housed to minimize noise. PS-4 is an electrical 195 cfs pump station that would be used only for filling the perimeter canal and therefore would not operate as frequently as PS-1. PS-4 is the same for all of the reservoir alternatives. PS-1 is a larger pump station with diesel pumps that would be used to fill and empty the reservoir. PS-1 would be of 1500 cfs capacity for Alternatives 2 and 3B and 3800 cfs capacity under Alternatives 3C and 4A. With a larger pump station under these latter alternatives, more pumps would be needed which could result in more noise; however, housing of the pump station will minimize noise effects.

6.17 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

6.17.1 No Action Alternative

The four major land parcels acquired for the project are the Berry Groves tract, Bryan Paul tract, the MG Enterpise, LLC (aka Winthrop) property, and the Griffin property. Over the last six years, the SFWMD has performed multiple Environmental Site Assessments as well as worked to remediate most of the point source contamination sites. (A description of the findings of the assessments and the remediation efforts completed to date are found in the existing conditions portion of this report.) At present, most of this land is leased to agricultural operators who continue to cultivate the thousands of acres of citrus groves located on the properties. If the reservoir project is not constructed, it is likely that the SFWMD will either continue to lease the land to citrus farmers or sell the land to willing buyers. With no reservoir on the site, the potential for bioaccumulation of copper or other toxic substances from contaminated site soils is much less since this usually occurs when the soils are submerged. If the properties continue to be to be used as working groves, the application of pesticides will continue into the future. New point source contamination sites on the properties will likely occur. However, these new sites may be contaminated to a lesser extent than in the past given modern environmental management practices. Overall, since the future without condition would not include a reservoir on the site, the properties will pose only a typical HTRW risk to the environment similar to other citrus operations.

6.17.2 Alternatives 2, 3B, 3C, and 4A

The HTRW impacts of all of the project alternatives are essentially identical since they all use the same real estate footprint. In general, all project related HTRW audits and remediation plans have been coordinated with state (FDEP) and federal (USFWS) agencies when necessary. The existing conditions portion of this document includes a summary of the Phase I/II Environmental Site

Assessment studies done on the four properties acquired for the reservoir project. In the course of these studies, over 50 point source sites with potential HTRW contamination were identified. At this time, most if not all of these potential contamination sites have been either remediated or further investigated to characterize the sites and prepare remediation plans. The project's non-Federal sponsor, SFWMD, has made a commitment to the USACE and USFWS that after it takes control of the properties from the present lessees and begins construction of the reservoir, all of the outstanding point source remediation efforts will be completed. In addition to the point source contamination sites, the SFWMD also identified distributed soil contamination in portions of the cultivated areas on all of the acquired properties. The remediation of the cultivated soil sites involves the placement of these soils into the core of the reservoir dam. This will isolate the contaminated soils from benthic organisms that serve as food for higher level organisms and thus reduce the potential for bioaccumulation of contaminants by fish and wildlife. In accordance with USACE policy, costs incurred by the non-Federal partner to characterize and remediate environmental contamination will not be cost-shared.

The USFWS has reviewed all of the SFWMD's remediation plans and indicated that they believe that the efforts will sufficiently reduce the risk of harm to fish and wildlife in those areas where the remediation will be performed. The USFWS has also stated that moderate levels of copper and other contamination of the cultivated areas are believed not to pose a direct threat to species of concern; however, they believe that an indirect effect may occur since widespread low-level soil contamination may reduce the population of benthic organisms upon which the species of concern normally feed.

Despite the diligent work performed by the SFWMD and USFWS to reduce the risk to environmental resources, it is possible that once the reservoir is built, bioaccumulation of soil contaminants does result in harm to one or more species of interest. If this does happen, additional remediation efforts, such as more extensive removal of the reservoir bottom sediments, could be done to further reduce the exposure of benthic organisms to near surface soil contamination at the end of a dry season. The cost of additional remediation, if necessary, would be the responsibility of the non-Federal sponsor. If such remediation is necessary, this remediation effort may be scheduled in one cell at a time, possibly during the late dry season, thereby keeping the reservoir somewhat operational.

6.18 CULTURAL RESOURCES

6.18.1 No Action Alternative

Under the No Action Alternative, the project site would continue to be an active citrus grove. Therefore, the existing cultural resource site that may be potentially eligible for listing in the National Register of Historic Places would likely be adversely affected by expansion of the existing citrus operations.

6.18.2 Alternatives 2, 3B, 3C, and 4A

Cultural resources would be impacted by all four alternatives equally. Cultural resources impacts are not considered significant for this project. Cultural resource surveys have been conducted for the Caloosahatchee River (C-43) West Basin Storage Reservoir. Three isolated prehistoric artifacts, one isolated historic artifact, one prehistoric archeological site (8HN129), and four modified historic buildings were identified. All except the prehistoric archeological site were determined to lack integrity and determined not eligible for listing on the National Register of Historic Places, the prehistoric archeological site (8HB129) is located near the edge of the proposed project and will be avoided by project design. The USACE has determined that the project will not affect historic properties eligible for listing on the National Register of Historic Places. The Florida State Historic Preservation Officer (SHPO) concurred with this determination (Florida State Department of Historic Preservation numbers 2004-8676 and 2006-07757). This determination and concurrence is the same for all alternatives since they utilize the same project footprint. The project has been reviewed by the SHPO and complies with the requirements of Section 106 of the National Historic Preservation Act.

6.19 SOCIOECONOMICS-REGIONAL ECONOMIC IMPACTS

The purpose of this section is to estimate the regional economic consequences of the project. The main impacts on the regional economy as a result of implementation of the project are expected to result from expenditures on construction and real estate.

6.19.1 No Action Alternative

In the event that the C-43 reservoir is not constructed, no regional impact will be realized from project expenditures. The local economy would continue to realize revenue stemming from the continued agricultural of the property.

6.19.2 Alternatives 2, 3B, 3C, and 4A

Although the expenditures for the various alternative plans are quite large, and are expected to result in fairly large, regional economic impacts, these impacts

are very small, relative to the regional economy in which they will take place (on the order of less than one percent).

Expenditures on project construction, non-construction and real estate, represent an influx of money into the local economy. Spending has a ripple, or multiplier, effect throughout the economy that can be estimated using multipliers that have been calculated using IMPLAN®. IMPLAN multipliers have been used to estimate the impacts on employment, earnings and output (sales) during the estimated three year construction period. The results of the expenditures resulting from construction of the SAP are presented in the table below. If the construction costs of the other alternatives are greater, the regional impacts will be greater, likewise it they are smaller, the impacts will be smaller.

At first glance the figures in ***Table 6-4*** look like enormous impacts resulting from the spending required to implement the project. However, these effects generally represent a very small percentage of the total economic activity in this region.

TABLE 6-4: OVERALL REGIONAL ECONOMIC IMPACTS

Alternative	Impacts			Project Costs
	Output	Earnings	Employment	
3B	$306,400,000	$79,990,000	2,258	$507,240,000

The construction of a reservoir of this size is not a one-year injection into the regional economy, but will be broken up over a number of years. The effects of the annual spending on the regional economy will prove even less significant than viewing the expenditures in total. Since the impacts are likely to occur in varying magnitude over time, the summary effects given in ***Table 6-4*** represent the upper limit if all these impacts were to occur simultaneously. In reality, the impacts of construction last only as long as those activities are carried out. The impacts represent the effects resulting from expenditures during project implementation that is expected to last three years beginning in 2008.

Table 6-5 contains the labor employment and earnings for Florida's South Region. The gross state product (GSP) for Florida is presented for a comparison to the output (sales) created by the construction projects.

When comparing the impacts of construction, as shown in ***Table 6-4*** to the actual total figures for the south region and state, it is important to recognize that the latest earnings data available were from 2000 census data. These figures have increased since 2000, but are considered sufficient for this analysis.

It can be seen that the impact on the region from the construction of the alternatives would be similar. There would be no major long-term impact and the short-term impacts would be insignificant compared to the economy of south Florida.

TABLE 6-5: REGIONAL AND STATE TOTALS

Region	Earnings (2003) ($millions)	Employment (2000)	Output (2003)*** ($millions)
Southwest Region	$320,000	9,391,709	**$910,000**
Florida	$ 10,000	357,914	**$30,000**

6.20 OTHER SOCIAL EFFECTS

The purpose of this section is to examine the social and community consequences of the project.

6.20.1 No Action Alternative

In the event that the reservoir is not constructed, the project footprint and immediate surrounding area is expected to remain a predominantly agricultural community, with earnings lower and unemployment slightly higher than that of the Florida in general. The overall outlook of the areas economic future is positive and an increase in population and residential development can be expected, while maintaining a rural community.

6.20.2 Alternatives 2, 3B, 3C, and 4A

The OSE account considers the effects of alternative plans in areas that are not already contained in the NED and RRED accounts. The categories of effects contained within the OSE account include:

- Urban and community impacts
- Life, health, and safety factors
- Displacement
- Long-term productivity
- Energy requirements and energy conservation

The alternative plans could result in both beneficial and adverse OSE within the study area. The alternative plans could have positive or adverse OSE impacts on the study area associated with (1) plan implementation, including land acquisition, project construction, and O&M activities, and (2) operation of the modified C&SF system. As in the case of the NED effects, the OSE account is

concerned with the net effects of the alternative plans (i.e., the differences between the with- and without-project future conditions).
Some of the potential OSE impacts would occur primarily at the regional scale, and others would have more localized effects. At both scales, there may be some individuals and communities that are positively affected by the alternative plans, some that are adversely affected, and many that are not affected at all. Relative to the size of the regional or local economies, the OSE effects may be minimal. However, if these effects occur predominantly within a limited geographic area, or affect a relatively small or vulnerable population, then the impacts can be disproportionately large. Therefore, the purposes of OSE analysis include not only determining the total magnitude of potential impacts, but also identifying the population (and its characteristics) that would be affected by any proposed action.

Some of the categories of effects typically included in the OSE account do not pertain to the alternative restoration plans. For example, the alternative plans are not expected to affect energy use or energy conservation in the study area.

An urban and community impact is the principal category of potential OSE impacts associated with the alternative restoration plans. This category of impacts includes effects on income distribution, employment distribution, population distribution and composition, and quality of community life. Regional income effects and fiscal impacts were discussed in the RED analysis. In addition, the impacts of agricultural water supply and M&I water supply were discussed in detail in earlier sections. The OSE assessment of urban and community impacts considers both the potential for exposure to the effects of the alternative restoration plans and the degree of vulnerability to potential impacts. Exposure refers to whether an individual or community is subject to the other social effects of the alternative plans. Vulnerability refers to the ability of that individual or community to respond or adjust to those effects.

Potential urban and community impacts of the alternative restoration plans could result from: (1) land acquisition and potential relocation of populations for reservoir and other project construction features, (2) reduced agricultural activity associated with taking the impoundment lands out of cultivation, and (3) construction activity associated with plan implementation. In general, construction activity is considered to have positive impacts. At the local scale, construction and O&M activities associated with the alternative restoration plans can have positive effects to local residents and communities by providing jobs, increasing local wages, increasing local sales, increasing tax revenues, increasing tourism and generally benefiting the local economy.

There are a variety of social and economic factors that are important determinants of an individual's or community's ability to cope with adversity.

One of the most important economic factors in the ability of individuals and groups to respond is the number of employment alternatives available locally. The ability to find another job depends on the education and training of the work force as well as the needs of local economic concerns, such as other farms, agricultural-related services, or some other local business. The socio-economic makeup of the community is also an important consideration of the ability of individuals and the community at large to cope with the adverse effects of large-scale agricultural land conversion. Some groups in society are recognized as having less opportunity to respond to adversity. These groups include ethnic and racial minorities, the elderly, and the poor.

The surrounding counties have a wide range of ethnic compositions, proportions of elderly population, unemployment rates, and per capita incomes. These socio-economic characteristics suggest that the rural counties of the study area – those that are expected to provide locations for new storage reservoirs – are areas that are least able to accommodate the associated economic and social effects on local communities. However, in these rural areas the affected populations should be relatively small.

6.21 AESTHETIC EFFECTS

6.21.1 No Action Alternative

The aesthetics of the project site would remain basically unchanged under the No Action Alternative.

6.21.2 Alternatives 2, 3B, 3C, and 4A

Aesthetic effects refer generally to impacts on the visual qualities of the environment. The area proposed for the Caloosahatchee River (C-43) Basin Storage Reservoir project is now overwhelmingly flat, rural and agricultural, with a mixture of pastures, citrus groves and other crops. The land slope is very gradual; thus long-distance viewsheds are hard to observe. The high walls of a large reservoir will present an abrupt landscape transition, which may initially be a visual shock. This will be a significant impact to aesthetics of the area and will be significantly different across alternatives due to the progressive dam elevations. The top of the enclosing levees, however, will provide wide panoramas of the Caloosahatchee River landscape, and should also offer good observation points for the surroundings. This man-made viewshed could be a good observation point for bird watching over the surrounding countryside. The main aesthetic difference between the alternatives will be in the dam elevations which are listed below:

- Alternative 2 54 feet
- Alternative 3B 57 feet

- Alternative 3C 57 feet
- Alternative 4A 66 feet

6.22 RECREATION

6.22.1 No Action Alternative

The No Action Alternative would not result in an improvement nor degradation of recreation resources. The continued operation of a citrus grove would not provide any additional recreational opportunities to the region.

6.22.2 Alternatives 2, 3B, 3C, and 4A

All of the alternatives would offer comparable recreational opportunities. These beneficial recreation impacts are considered significant. The recreation plan in ***Appendix G*** outlines wildlife viewing and hiking along the perimeter of the reservoir. Boating within the reservoir is also included in the plan. These recreational opportunities would help to fill the deficit in recreational facilities expected due to high population growth in south Florida. It is important to note, however, that recreation must be a secondary benefit of the reservoir. The reservoir must be operated to benefit the estuary in order to obtain the benefits outlined in this document. There will be times when the reservoir is predominantly dry. During those times boating may be limited or not possible within the reservoir. If the reservoir were to be operated to allow boating at all times, benefits being claimed by this project would be lost.

6.23 CUMULATIVE IMPACTS

Cumulative impact is the "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR 1508.7)."

The Caloosahatchee River (C-43) West Basin Storage Reservoir will increase water storage in the Caloosahatchee River (C-43) Basin resulting in long-term benefits for the estuary. This storage function is essential to the overall restoration of the Caloosahatchee estuary. This project along with other CERP projects would cause some adverse consequences to agricultural land use, permanently removing thousands of acres from agricultural production. These impacts may be felt locally and/or regionally as the economic base derived from agriculture is incrementally reduced relative to other sectors of the economy.

There will be some loss of wetlands on the site. 125 acres of wetlands were identified on the proposed project site. (This acreage does not include a small wetland area within the project site that has already been impacted by

construction of the C-43 Test Cell Project.) Most of the existing wetlands have been impacted by surrounding agricultural activities, including reduced hydroperiod, ditching, and exotic plant species infestation. These relatively low-functioning wetlands would be converted to open water habitat. However, the overall benefit to the estuarine system which consists primarily of high value mangrove wetlands, coastal marshes, tidal flats, and aquatic and estuarine habitats such as streams, ponds, bays and SAV beds would be greater than the local wetland loss.

Other CERP projects which might directly affect this basin include the SWFFS and a subsequent Caloosahatchee River (C-43) Basin study. The SWFFS is currently in the PIR development stage and includes many alternatives in this watershed. The subsequent Caloosahatchee River (C-43) Basin study, at the time of this writing, is not yet in the PIR development stage but is planned to begin in late 2007. This subsequent study will evaluate building additional storage features in the eastern portion of the basin. These features might result in removal of additional lands from agricultural production. However, additional storage in the basin would also result in a greater ability to control flows to the estuary, potentially improving conditions in both the wet and the dry season. Indicator species such as oysters and SAV as well as species such as manatees which feed on the SAV and wading birds which forage on the estuarine fisheries would benefit. The cumulative effect of these projects in the Caloosahatchee River (C-43) Basin would be a great reduction in the large damaging flows during the wet season as well as augmentation of the low flows during the dry season.

Other state and local projects may have impacts on this basin. Immediately adjacent to and east of the reservoir, the SFWMD may work with Hendry County to provide some additional flood alleviation to SR 29, which captures drainage from a basin area east of SR 29. A series of culverts, located in the LaBelle Private Drainage District (LPDD) Canal to direct water away from the SR 29 west ditch towards the perimeter canal, may potentially be constructed. This initiative is not a part of the Caloosahatchee River (C-43) West Basin Storage Reservoir project, but may in the future be hydraulically linked to the C-43 reservoir project's perimeter canal. The impacts to the drainage area east of SR 29 would need to be determined and analyzed. The SR 29 west ditch flood alleviation project would be separately coordinated with the USACE and FDEP through permitting.

In early 2007 the Florida Legislature passed Senate Bill 392, The Northern Everglades and Estuaries Protection Program, which expands the Lake Okeechobee Protection Act to include protection and restoration of the Lake Okeechobee watershed and the Caloosahatchee and St. Lucie rivers and estuaries. This program includes development of a technical plan to identify the

storage and water quality treatment requirements for the Lake Okeechobee watershed by February 1, 2008. This plan is currently scheduled to include development of the Caloosahatchee and St. Lucie Rivers Watershed Protection Plans to identify watershed storage projects and water quality targets by January 1, 2009. The Caloosahatchee and St. Lucie River Watershed Protection Programs will include goals for salinity envelopes and freshwater inflow targets for each estuary. The goals of the program are to :

- Meet Lake Okeechobee Watershed Total Maximum Daily Loads
- Manage Lake Okeechobee levels within an ecologically desirable range
- Manage flows to meet desirable salinity ranges for the St. Lucie and Caloosahatchee Estuaries.
- Identify opportunities for alternative surface water supply sources in the watershed

This program has potential to benefit the watershed and would help to maximize the benefit of the reservoir by developing a comprehensive watershed plan for storage as well as water quality.

In addition to the above projects, many of the storage features of the CERP would affect the water levels in Lake Okeechobee, which will in turn affect how much water is released to the estuary. This could represent both positive and/or negative impacts. Reducing the water levels in Lake Okeechobee would be an improvement during the wet season by reducing the damaging high flows to the estuary. However, lower lake levels might also result in less water available to release during the dry season. Ideally the storage reservoirs would then have water available to release to the estuary.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project is a proposed part of the CERP. Large areas north of Lake Okeechobee, within the EAA, around the lake, in the Caloosahatchee River (C-43) Basin, and on the Upper East Coast will be used to increase water storage for the overall gain and long-term benefit of the regional system. This will result in the conversion of lands to reservoirs. This will cause some adverse consequences to agricultural land uses permanently removing tens of thousands of acres from agricultural production. These impacts may be felt locally and/or regionally as the economic base derived from agriculture is incrementally reduced relative to other sectors of the economy. As these water storage features occur disparately across the landscape within different hydrologic basins, and as distinct units rather than multiple features within a single watershed, they will not likely result in a significantly detrimental cumulative effect. These project features will provide important storage functions and are essential to the overall restoration of the freshwater marshes and the estuaries of the area. The CERP contains 68 components that total approximately 217,000 acres of new reservoirs and

wetlands-based water treatment areas. This plan increases the supply of fresh water for the Everglades and south Florida ecosystem and improves the quantity, quality, timing, and delivery of water to the natural system.

A number of operational components have also been identified in the CERP and will, in most cases, occur in conjunction with related construction features. The operational features in the CERP include: a modified LORS; environmental water supply deliveries to the Caloosahatchee and St. Lucie estuaries; modifications to the regulation schedules for WCAs 2A, 2B, 3A, 3B, and the current rainfall delivery formula for ENP; modified Holey Land Wildlife Management Area Operations Plan; Modified Rotenberger Wildlife Management Area Operations Plan; a modification for coastal wellfield operations in the Lower East Coast ; Lower East Coast utility water conservation; and operational modifications to the southern portion of L-31N and C-111. These features will result in significant environmental benefits to the CERP project area.

6.24 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Construction of the proposed project will include features considered permanent, which may be deemed irreversible. This would include construction of the reservoir, embankment, and perimeter canal. Resources committed would include state and Federal funding to purchase lands (project lands have already been acquired with state and Federal funds) and labor, energy and project materials to build, operate, and maintain the project. Limited fish and wildlife habitat on project lands will be converted to open water habitat.

6.25 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

6.25.1 Land Use

Existing citrus groves would be permanently altered to construct the reservoir and associated features.

6.25.2 Wetlands

Although the project site is a producing citrus grove, it contains 125 acres of remaining wetlands. These wetlands are of low to moderate quality with limited function and value due to their reduced hydroperiod, infestation by exotic plant species, and location in the landscape i.e., separation from other habitats and corridors). Implementation of the project would permanently alter wetlands within the footprint of the project features.

6.25.3 Water Quality

Temporary increases in turbidity of local waters within allowable limits are expected during construction. Precautions to limit turbidity will be employed.

6.25.4 Air Quality

Fugitive dust from vehicular traffic and earth moving during construction will be unavoidable but insignificant overall.

6.25.5 Soils

The disruption of soils is expected to result from construction activities. The conversion of prime farmland to an open water habitat is anticipated to be significant and irretrievable.

6.25.6 Wildlife

Localized short-term disturbance to fish and wildlife are expected from construction activities of the plan components.

6.25.7 Threatened and Endangered Species

Short-term disturbance to fish and wildlife are expected from construction activities of the plan components. Precaution measures and construction conditions to limit impacts to threatened and endangered species will be implemented.

6.26 RELATIONSHIP BETWEEN SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

While regional conditions will improve, short-term or localized problems will undoubtedly occur. Although overall restoration of the Everglades ecosystem is expected to improve habitat for nesting wading birds regionally over time, the transition period might adversely affect regional wading bird populations. Proper sequencing of project features should mitigate impacts to existing wildlife resources expected to be impacted by restoration activities within their vicinity. Further assessment and monitoring will be critical to recovery of ecosystem attributes and maintaining a viable fish and wildlife population during the implementation of CERP.

6.27 COMPATIBILITY WITH FEDERAL, STATE, AND LOCAL OBJECTIVES

The proposed action is consistent with the overall goals and objectives of the CERP. It is expected that the proposed action will be consistent with Federal, State, and local plans and objectives.

6.28 SIGNIFICANCE OF HABITAT

The significance of the habitat for this project is clearly identified below using the categories and criteria defined in Section 3.4.3 of Principles and Guidelines and in paragraph 16.b of Engineering Pamphlet (EP) 1165-2-502. Significance of the benefited area (Caloosahatchee Estuary, San Carlos Bay, Pine Island Sound, and Matlacha Pass) is identified by the following:

- Plans and constitutions, laws, directives, resolutions, gubernatorial directives, and other policy statements of States with jurisdiction in the planning area.
  - Matlacha Pass and Pine Island Sound are designated as aquatic preserves by the Florida Department of Environmental Protection
  - Caloosahatchee Water Management Plan (April 2000)
  - Lower West Coast Water Supply Plan 2005-2006 Update
  - Minimum Flows for Caloosahatchee River (Chapter 40E-8, Florida Administrative Code)
- Endangered Species Act of 1973, as amended, Pub. L. 93-205; 16 U.S.C. 1531, et seq.
  - Threatened and endangered species found in the Caloosahatchee Estuary and other benefited areas include the West Indian manatee, smalltooth sawfish and five species of sea turtles
- Estuary Protection Act, Pub. L. 90-454; 16 U.S.C. 1221, et seq.
- Marine Mammal Protection Act of 1972, Pub. L. 92-522; 16 U.S.C. 1361, et seq
  - The West Indian Manatee could benefit immensely from increased aquatic vegetation which is its main source of food
  - Benefits area includes San Carlos Bay Federal Manatee refuge
- Migratory Bird Treaties and other international agreements listed in the Endangered Species Act of 1973, as amended, Section 2(a)(4).
  - The South Florida ecosystem is located along one of the primary migratory routes for bird species that breed in temperate North America and winter in the tropics of the Caribbean and South America.
- Significance based on public recognition means that some segment of the general public recognizes the importance of an EQ resource or attribute. Public recognition may take the form of controversy, support, conflict, or opposition and may be expressed formally (as in official letters) or informally.

  - This project has received intense public and local government support. There has been long-term and intense interest in the degraded state of the Caloosahatchee estuary and interest in improving its condition. Please see the inventory of public concerns and dPIR comment matrix in Annex B for further information.
  - American Rivers listed the Caloosahatchee River in the top 10 endangered rivers in US
- Effects on the resources in terms of differences between estimated future without- and with plan conditions
  - The selected alternative plan improves flows to the estuary during both the wet and dry season, but is especially good at meeting the dry season demands of the estuary. This results in a forecasted significant improvement of many ecosystem indicators such as oysters, crab, submerged aquatic vegetation, and fisheries.
- Other relevant information concerning duration, frequency, location, magnitude, and other characteristics, such as reversibility, retrievability, and the relationships to long-term productivity (P&G).
  - Please see Sections 6.23 – 6.28 for a discussion of these factors

In summation, the significance of the project is demonstrated by a combination of applicable policy, technical attributes and public interest as outlined above.

6.29 UNCERTAIN, UNIQUE OR UNKNOWN RISKS

The risk and uncertainty associated with the construction and operation of these features of the proposed project should be minimal. All features have been designed and constructed through established and applied technology. No experimental design was necessary for any component of the proposed impoundment. Additionally, both the USACE and the SFWMD have extensive and reputable credibility in the design, construction and O&M of the proposed features from previous water resources planning efforts.

A cutoff wall along the perimeter of the dam embankment is being considered and will be further investigated as the project proceeds to design. For estimating purposes, a 42-47 foot cutoff wall was included. These use standard technology and should pose minimal risk.

Soil cement protection was included for armoring. This will be further investigated as the team proceeds with the design. Armoring generally uses standard technology and should pose minimal risk.

A freeboard of approximately 17 feet was used in preparing the ROM cost estimates. The freeboard design will be further refined in accordance with applicable CERP DCM. These DCMs were developed to provide consistent working level guidance for impoundment design by the Acceler8 teams. The

DCMs consolidate and incorporate design criteria from various agency regulations and guidelines including USACE, U.S. Bureau of Reclamation, Federal Energy Regulatory Commission, Florida Building Code, and the American Society of Civil Engineers. The DCMs do not supersede USACE. Freeboard designed in compliance with the DCMs, and thusly USACE regulations, should result in minimal risk of embankment failure due to overtopping (refer to DCM-2 for additional detail).

AM consists of an active strategy for dealing with the considerable uncertainties that characterize management of large natural ecosystems, which are complex and difficult to predict. The overall purpose of AM is to maximize the chance of success and includes methods, such as proactive approaches to dealing with uncertainties, the use of modern ecosystem science and scientific practices, active collaboration, and the use of open, inclusive, and integrative processes.

Five key principles help implement this approach to AM:

1. Anticipate future uncertainties and contingencies
2. Employ science-based approaches to build knowledge
3. Design robust projects that can be adapted to changing conditions
4. Build a shared understanding through collaboration and conflict resolution
5. Reconcile competing objectives to benefit both nature and society

The C-43 project is a component of the CERP, which consists of sixty-eight (68) major components. The uncertainty associated with a program of this magnitude was recognized during the Restudy, which led Congress to address the necessity of AM in the WRDA 2000.

As such, a fundamental implementation principle for CERP is to utilize adaptive assessment and management in order to continually refine and improve the performance of CERP projects so that planned benefits are attained. Incremental revisions of optimal project designs and project operations throughout the planning and implementation process will lead to improved performances. The use of the adaptive assessment policy minimizes the effects of uncertainty with respect to the effects of CERP projects on the natural system and other water-related needs of the region related to the design and implementation of the CERP.

6.30 ENVIRONMENTAL JUSTICE

In accordance with E.O. 12898, USACE has made achieving environmental justice part of its mission. While the President's E.O. on Environmental Justice made this directive explicit, it is implicit in NEPA and in planning regulations that USACE and SFWMD planners must conduct an objective evaluation of all

project objectives in terms of their social and economic performance. This is accomplished by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. In public outreach efforts to date, only one potential environmental justice issue has been identified: the loss of jobs for low income and minority workers as a result of acquiring agricultural land for the construction of the reservoir. The expected loss in employment will occur to seasonal and/or temporary migrant workers, and as can be noted in the future land use section agricultural acreage in the surrounding study area and counties is expected to increase. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project PIR and EIS is an opportunity to somewhat alleviate this potential problem by providing jobs within and during construction of the project, some of which could provide seasonal and temporary employment. To address this issue the SFWMD is conducting training programs to allow local individuals to acquire the skills needed to construct the reservoirs. In addition, it is anticipated that adjacent lands will continue to support agricultural operations.

In order to keep all members of the public updated, the SFWMD will be providing regular updates to the County Commission which are open to the public. In addition, meetings with stakeholders will be held on an as needed basis.

This page intentionally left blank

SECTION 7
THE SELECTED ALTERNATIVE PLAN

This page intentionally left blank

7.0 THE SELECTED ALTERNATIVE PLAN (SAP)

The Caloosahatchee River (C-43) West Basin Storage Reservoir project is planned and designed primarily to restore the ecosystem function in the Caloosahatchee Estuary by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuary system. The project also helps to maintain a desirable minimum flow of fresh water to the estuary during dry periods. These two primary functions help to moderate unnatural changes in salinity which is extremely detrimental to estuarine communities.

Detailed design of the Caloosahatchee River (C-43) West Basin Storage Reservoir project will be accomplished by the SFWMD as part of the State of Florida's Acceler8 program. Design information and details will be coordinated and reviewed by the USACE pursuant to the Design Agreement between USACE and SFWMD dated May 12, 2000. Activities during the construction phase will be in accordance with the Acceler8 program and will be the responsibility of the SFWMD.

The State of Florida's "Acceler8" program was developed for the purpose of accelerating design and construction of a number of critical restoration projects consistent with the Comprehensive Everglades Restoration Plan (CERP) prior to one or more of the following: administration approval, Congressional committee resolution, Congressional authorization, or Federal construction funding. The SFWMD proposes to initiate construction of the C-43 West Reservoir/Acceler8 Project prior to implementation of the Federal Caloosahatchee River (C-43) West Basin Storage Reservoir project.

7.1 DESCRIPTION OF PLAN COMPONENTS

Through the formulation of alternative plans described in Section 5.0, Alternative 3B was identified as the Selected Alternative Plan (SAP) for the Caloosahatchee River (C-43) West Basin Storage Reservoir project. The SAP was further refined based on additional engineering and design and described in this section of the report. The SAP provides approximately 170,000 ac-ft of above-ground storage volume in a two-cell reservoir with normal pool depths when the reservoir is full varying from 15 feet at the southeast corner to 25 feet at the northwest corner. Major features of the project include external and internal embankments, canals, two pump stations, internal control and outflow water control structures, and environmentally responsible design features to provide fish and wildlife habitat such as littoral areas in the perimeter canal and deep water refugia within the reservoir.

Once the SAP was identified more detailed design (i.e. surveys and real estate) was completed. The final design details necessary for the plan to be authorized

are described in this section with additional detail provided in ***Appendix A***. The additional engineering and design analysis that was completed does not effect the plan formulation as the cost changes and project refinements would be applied proportionally to all projects. The total benefits derived by the plan does not change based on these additional refinements.

The following is a general description of the location and design of SAP features. For a detailed description of project features refer to ***Appendix A***.

7.1.1 General Plan Description

The SAP, as shown in ***Figure 7-1,*** consists of a two-cell reservoir with a "normal pool" storage capacity of 170,000 ac-ft. This SAP comes closest to approximating the Restudy Caloosahatchee River (C-43) West Basin Storage Reservoir recommended volume of approximately 160,000 ac-ft of storage and is the size evaluated and currently being designed by the SFWMD under their Acceler8 program. The project footprint for the SAP encompasses approximately 10,700 acres, of which approximately 10,480 acres are required in fee, approximately 20 acres will be perpetual easements, and approximately 200 acres will be used on a temporary basis for staging area. The project consists of major features and components to include a two-cell reservoir with armoring, cutoff walls, and embankments. Other features are pump stations, spillways with emergency overflow and vertical lifts, drawdown structures, culverts, canals, earthwork artificial habitat creation, and recreational features. The reservoir design includes a pump station with 1,500 cfs capacity to pump water from the Townsend Canal to fill the reservoir.

The existing Townsend Canal, located along the west perimeter of the reservoir, will serve as the west perimeter canal. The existing disposal mounds along the east side of the Townsend Canal will be removed as part of the project. A drainage culvert will be located on the east perimeter canal connecting the LPDD Canal (also known as the Header Canal), which will maintain historical drainage from the Paul property east of the project. Improvements to or the relocation of the existing weir structure located at the mouth of the Townsend Canal are included. Work to that structure will be done within an existing easement.

The Selected Alternative Plan has a water surface elevation of 42 feet at "normal pool" (NAVD88), with the average depth ranging from 17-19 feet. Dam (embankment) heights for the SAP range from 32-37 feet (top of dam is at elevation 57 ft (NAVD88)). The maximum water depths and dam heights will occur in Cell 1 due to lower land surface elevations in that cell. The exterior and interior dams are to have a crest width of 14 feet. The side slopes are 3 Horizontal to 1 Vertical (3H:1V). The exterior dams are to be constructed from existing on-site material and have a low permeability core. A graded filter is to

be provided on the exterior side of the dam to direct seepage. Soil cement protection would be included on the interior side of all reservoir slope faces. A freeboard of 15 feet was used based on detailed analysis of wind and wave height run-up.

A perimeter canal (seepage canal) is provided on the south, east, and north sides of the reservoir. The existing Townsend Canal will act as a seepage canal on the west side of the reservoir. In addition to seepage collection, the perimeter canal will also convey discharges from the reservoir; convey surface runoff from the south and east of the reservoir including drainage for SR29; provide flows to the Crawford Canal, Banana Branch and Fort Simmons Branch; and maintain the surface water elevation in the expanded northeast rim ditch that provides irrigation for the A. Duda and Sons (Duda) citrus operations, located to the south of the reservoir. A cutoff wall (approximate total height of 47 feet) along the perimeter of the dam embankment has also been included in the reservoir design.

Improvements to the Townsend Canal are based on the necessary capacity to meet maximum pumping requirements to fill the reservoir. Pre-storm and post-storm event flows have been simulated to evaluate flows in the Townsend Canal and other local canals and tributaries. Storm event flows in the Townsend Canal will be decreased over existing conditions with the construction and operation of the reservoir.

Each cell is designed to discharge independently through separate discharge structures. Cell 1 will discharge via the S-1 structure into the Townsend Canal. Cell 2 will discharge via S-8 structure into the perimeter canal. These structures will be designed for incremental operation allowing required flows to be released to the Caloosahatchee River (C-43 Canal) during periods of low flow. These structures could also serve as design storm control structures for releases prior to and during a storm event. The storm releases must be balanced with the targeted maximum flow allowed over S-79, which is 4,500 cfs. An emergency spillway with a crest elevation based on retaining the 25-year, 72-hour storm event is to be provided within each cell's discharge structure. The 25-year, 72-hour storm captured in the reservoir would be a "control release" after the storm event in order to restore the water surface to the normal pool elevation while not exceeding the maximum flow of 4,500 cfs at S-79. The final design of the emergency spillway(s) will be in accordance with the requirements of Design Criteria Memorandum 3 (DCM-3).

Within the reservoir, structure S-12 will hydraulically connect the two reservoir cells and is designed to be gated so that either cell can be "isolated" for operational or maintenance (O&M) purposes. A number of other culverts, weirs, and spillways are included to operate the reservoir and maintain appropriate water levels in existing canals and the perimeter canals.

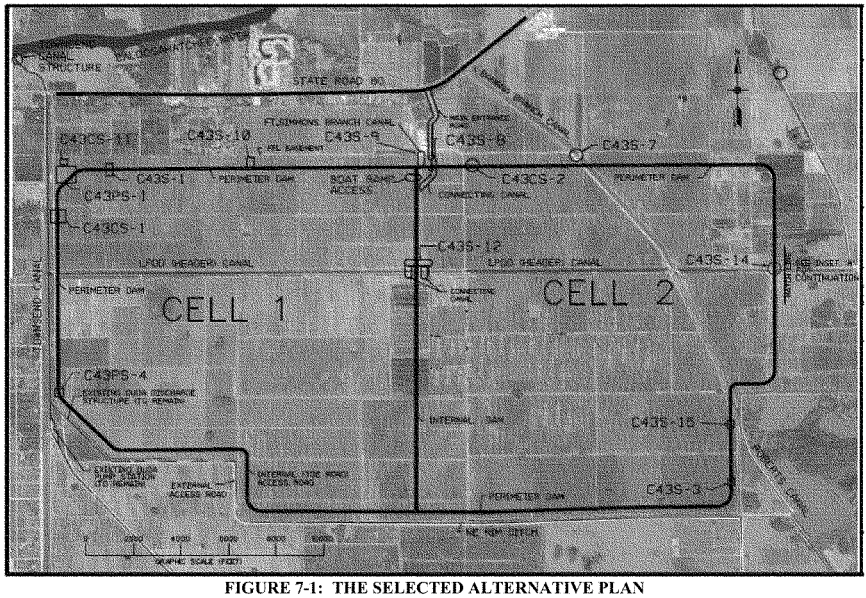


FIGURE 7-1: THE SELECTED ALTERNATIVE PLAN

7.1.2 Major Project Components

7.1.2.1 Reservoir

The reservoir is an earthen impoundment consisting of approximately 9,220 acres of interior storage that is to be constructed above the existing ground. It will consist of an approximate 170,000 ac-ft two-cell reservoir. Water will be pumped from the Caloosahatchee River (C-43 Canal) and into the reservoir by utilizing the existing Townsend Canal and a new pump station (C43PS-1) located in the northwest corner of the project.

Water will be discharged from the reservoir through gravity discharge structures in each cell that discharge into a perimeter canal. Both flows into and out of the reservoir will be controlled by monitoring flows at S-79.

7.1.2.2 Intake Canal

The existing Townsend Canal will serve as intake canal. The West Storage Reservoir (WSR) has been designed so that during storm events flows in the Townsend Canal will not exceed the "pre-existing" condition. Therefore, there will be no negative impacts to the Townsend Canal, SR 80 bridges, or the existing flap gate weir structure. However, two additional flap gates will be installed in the weir structure to provide capacity for pumping rates of 1500 cfs at C43PS-1.

The perimeter canal will serve as a seepage canal and as a means of conveying both surface storm water runoff and off site flows entering the project. The perimeter canal design includes littoral shelves along the exterior slope that are intended to promote wetland vegetation, fisheries, and recreation activities.

7.1.2.3 Embankments (Dams)

The perimeter embankment will have an external geometry that includes a 14-foot wide crest and 3 horizontal to 1 vertical sideslopes. Crest elevations have been established at +57 feet NAVD88 for both Cell 1 and Cell 2. The embankment will be constructed largely of random fill, but will also include a low permeability soil-bentonite wall, an internal drain, and upstream slope protection. The soil-bentonite wall will extend from an elevation that is five feet above the normal pool elevation to five feet below the top of a clay layer which underlies the project site at depths generally in the range of 20 to 25 feet below existing surface grades. A few structures pass through the perimeter embankment. At these locations, the above ground portion of the soil-bentonite wall will be replaced with select fill. A roughly 100-foot wide bench will be raised above the existing ground surface immediately downstream of the

perimeter embankment. A perimeter canal is to be located on the outside of the bench.

The separator dam between Cells 1 and 2 will be a homogenous embankment with a crest elevation of +50 feet NAVD88. It will not include any soil-bentonite wall or internal drain. The separator dam will be covered on both sides with soil-cement. The components of the embankments are described in more detail in the following sections.

7.1.2.4 Pumping Station C43PS-1

It will consist of a steel and reinforced concrete structure that will house the main pumps and pumping motors for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. The structure will be located adjacent to the downstream side of the dam and will have plan dimensions of approximately 200 feet (parallel with the dam) by 100 feet (measured at the intake level). It will have a base slab elevation on the intake side of the structure of -16 feet with respect to the North American Vertical Datum of 1988 (NAVD88). The structure bottom will step up to elevation +10 feet NAVD88 for a distance of about 30 feet in the area between the intake bay and the toe of the dam. The existing surrounding grades at the site of the proposed construction are approximately +16 to +17 feet NAVD88.

7.1.2.5 Pumping Station C43PS-4

C43PS4 will provide water to the perimeter canal during dry periods when water cannot be released from Cell 2 of the reservoir due to low Reservoir water levels. C43P-S4 will maintain the water level in the perimeter canal, provide water to the Paul property, and supply water to the Banana Branch and Ft. Simmons Branch.

It will consist of a steel and reinforced concrete structure that will include a "can" type intake. The structure will be located adjacent to the top of bank of the Townsend Canal and will have plan dimensions of approximately 55 feet by 45 feet. It will have a separate intake bay that will have a top of slab elevation of -12 feet with respect to the NAVD88. The intake pipes will consist of three 48-inch diameter steel pipes that connect the intake bay with the vertical cans. Invert elevations for these pipes will be approximately elevation -10 feet NAVD88. The bottom of the can structures will be elevation -20.4 feet NAVD88. Surface water levels in the Townsend Canal are expected to range between +3 and -3 feet NAVD88. The pumping station floor level will be elevation +10 feet NAVD88, and will step up to elevation +19 feet NAVD88 in the discharge bay. The existing surrounding grades at the site of the proposed construction are approximately +22 to +23 feet NAVD88.

7.1.2.6 Culvert Structure C43S-7

This culvert structure will provide a hydraulic connection between the perimeter canal and the Banana Branch Canal. It will consist of a 222-foot long double barrel concrete box culvert that rests upon a combined footing with bottom width of approximately 26 feet. The culvert will have an invert elevation of +10 feet with respect to the NAVD88. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD88. Finished grades above the culvert are expected to be about +22 to +23 feet NAVD88.

7.1.2.7 Culvert Structure C43S-9

This culvert structure will provide a hydraulic connection between the perimeter canal and the Fort Simmons Branch. It will consist of a 102-foot long double barrel concrete box culvert that rests upon a combined footing with bottom width of approximately 26 feet. The culvert will have an invert elevation of +14 feet with respect to the NAVD88. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD88. Finished grades above the culvert are expected to be about +21 to +22 feet NAVD88.

7.1.2.8 Culvert Structure C43S-14

This culvert structure will provide a hydraulic connection between the perimeter canal and the Header Canal. It will consist of a 97-foot long single barrel concrete box culvert that rests upon a footing with bottom width of approximately 15 feet. The culvert will have an invert elevation of +15 feet with respect to the NAVD88. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD88. Finished grades above the culvert are expected to be about +28 to +29 feet NAVD88.

7.1.2.9 Culvert Structure C43S-15

This culvert structure will provide a hydraulic connection between the perimeter canal and the Roberts Canal. It will consist of an 86-foot long double barrel concrete box culvert that rests upon a combined footing with bottom width of approximately 26 feet. The culvert will have an invert elevation of +14 feet with respect to the NAVD88. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD88. Finished grades above the culvert are expected to be about +26 to +27 feet NAVD88.

7.1.2.10 Gated Culvert Structure C43S-3

This structure will consist of a gated dual culvert that will be situated in the perimeter canal and will control the water levels in the canal. It will have base dimensions of 65 feet (parallel with the canal) by 25 feet (across the canal). The

structure will bottom new elevation +11.5 feet with respect to the NAVD88. A concrete tremie seal will be placed between the structure bottom level and elevation +6.5 feet NAVD88. The ground surface elevation in the project vicinity is estimated to be +26 feet NAVD88. Surface water levels across the structure will be +23 and +19 feet NAVD88 on the upstream and downstream sides of the structure, respectively. Steel sheet piling will be used to construct wingwalls as needed. A seepage cutoff wall will be set below the upstream edge of the structure. The bottom of the cutoff wall is currently designed at elevation -1.5 feet NAVD88.

7.1.2.11 Gated Spillway Structure C43S-10

This structure will consist of a gated spillway that will be situated in the perimeter canal and will control the water levels in the canal. It will have a base slab that has plan dimensions of 64 feet (parallel with the canal) by 55 feet (across the canal). The structure will bottom near elevation +2 feet with respect to the NAVD88. A concrete tremie seal will be placed between the structure bottom level and elevation -3 feet NAVD88. The ground surface elevation in the project vicinity is estimated to be +20 feet NAVD88. Surface water levels across the structure will be +19 and +15 feet NAVD88 on the upstream and downstream sides of the structure, respectively. Steel sheet piling will be used to construct wingwalls and seepage cutoff walls. A seepage cutoff wall will be set below the upstream edge of the structure. The bottom of the cutoff wall is designed to be approximately elevation -8 feet NAVD88.

7.1.2.12 Gated Spillway Structure C43S-11

This structure will consist of a gated spillway that will be situated in the perimeter canal and will control the water levels in the canal. It will have a base slab that has plan dimensions of 75 feet (parallel with the canal) by 62 feet (across the canal). The structure will bottom near elevation -8 feet with respect to the NAVD88. A concrete tremie seal will be placed between the structure bottom level and elevation -13 feet NAVD88. The ground surface elevation in the project vicinity is estimated to be +17 feet NAVD88. Surface water levels across the structure will be +15 and +3 feet NAVD88 on the upstream and downstream sides of the structure, respectively. Steel sheet piling will be used to construct wingwalls and seepage cutoff walls. A seepage cutoff wall will be set below the upstream edge of the structure. The bottom of the cutoff wall is designed to be approximately elevation -18 feet NAVD88.

7.1.2.13 Cell 1 Main Outlet Structure C43S-1

Structure C43S-1 refers to the main operational outlet from Cell 1 to the perimeter canal. It will consist of twin concrete conduits, which will be constructed essentially at existing grade, and will be buried beneath the

perimeter dam and oriented perpendicular to the dam. The conduits will each be ten feet wide and six feet high. The outlet will include an intake structure located on the upstream side of the dam, consisting of a concrete box supported on a reinforced concrete mat foundation. The top of the box has been established at elevation +44 feet with respect to the NAVD88. The existing ground elevation in the vicinity of the intake box is estimated to be +17 feet NAVD88. The crest of the dam will have an elevation of +57 feet: NAVD88. Operational and emergency gates will be located within a control building near the center of the dam. The control works will also be supported on a reinforced concrete mat foundation. The outlet works will discharge to an impact stilling basin located on the downstream side of the dam. The stilling basin will be approximately 26 feet wide and have an invert elevation of +5 feet NAVD88. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +15 feet NAVD88.

7.1.2.14 Cell 2 Main Outlet Structure C43S-8

Structure C43S-8 refers to the main operational outlet from Cell 2 to the perimeter canal. It will consist of twin concrete conduits, which will be constructed essentially at existing grade, and will be buried beneath the perimeter dam and oriented perpendicular to the dam. The box culverts will each be ten feet wide and six feet high. The outlet will include an intake structure located on the upstream side of the dam, consisting of a concrete box supported on a reinforced concrete mat foundation. The top of the box has been established at elevation +29 feet with respect to the NAVD88. The existing ground elevation in the vicinity of the intake box is estimated to be +20 feet NAVD88. The crest of the dam will have an elevation of +57 feet NAVD88. Operational and emergency gates will be located within a control building near the center of the dam. The control works will also be supported on a reinforced concrete mat foundation. The outlet works will discharge to an impact stilling basin located on the downstream side of the dam. The stilling basin will be approximately 26 feet wide and have an invert elevation of +9 feet NAVD88. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +19 feet NAVD88.

7.1.2.15 Balancing Outlet Structure C43S-12

Structure C43S-12 refers to the operational hydraulic connection between Cells 1 and 2. It will consist of triple concrete conduits, which will be constructed essentially at existing grade, and will be buried beneath the internal dam and oriented perpendicular to the dam. The box culverts will each be ten feet wide and six feet high, and will be supported on a reinforced concrete mat foundation. The existing ground elevation in the vicinity of the spillway is estimated to be

+21 feet with respect to the NAVD88. The top of the internal dam is expected to have a crest elevation of +50 feet NAVD88.

7.1.2.16 Crest Spillway Structure C43CS-1

Crest Spillway Structure C43CS-l refers to the service spillway from Cell 1 to the Townsend Canal. It will consist of a concrete conduit, which will be constructed across the perimeter dam and oriented perpendicular to the dam. The conduit will be 12 feet wide. The invert elevation for the conduit will be set at elevation +38 feet with respect to the NAVD88. A concrete weir will be set at elevation +42 feet NAVD88. The existing ground elevation in the vicinity of the spillway is estimated to be +17 feet NAVD88. The crest of the dam will have an elevation of +57 feet NAVD88. The spillway will discharge down a concrete lined channel to a stilling basin located on the downstream side of the dam. The stilling basin will be approximately 12 feet wide and have an invert elevation of -feet NAVD88. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +3 feet NAVD88.

7.1.2.17 Crest Spillway Structure C43CS-2

Crest Spillway Structure C43CS-2 refers to the service spillway from Cell 2 to the perimeter canal. It wi11 consist of a concrete conduit, which will be constructed across the perimeter dam and oriented perpendicular to the dam. The conduit will be 12 feet wide. The invert elevation for the conduit will be set at elevation +38 feet with respect to the NAVD88. A concrete weir will be set at elevation +42 feet NAVD88. The existing ground elevation in the vicinity of the spillway is estimated to be +21 feet NAVD88. The crest of the dam will have an elevation of +57 feet NAVD88. The spillway will discharge down a concrete lined channel to a stilling basin located on the downstream side of the dam. The stilling basin will be approximately 12 feet wide and have an invert elevation of +7 feet NAVD88. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +19 feet NAVD88.

7.2 RECREATION FEATURES

The study area for the recreation benefit analysis for this project includes the counties of Lee, Collier, Hendry, Glades and portions of Charlotte county; approximately the same geographical extent as Region 9 of Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP). The 2000 SCORP identifies the proposed project area as part of Region 9 comprised of Charlotte, Collier, Lee, Sarasota, Glades and Hendry counties. Recreation deficits identified by the SCORP for this region include; bicycle riding, tent camping, hiking, nature study and saltwater beach activities. Subsequent FWC and FDEP, letters included as

Addendums I and II in Recreation Appendix H demonstrate need for motor boat ramps. A statewide need assessment through 2010 identifies these deficits and the unit need for each (i.e. miles of trail and camp sites); is provided in SCORP 2000.

Some existing recreational facilities within the Caloosahatchee Basin provide opportunity to hike, boat, fish and camp. Existing recreation facilities near the project site include Ortona Lock Recreation Area, Caloosahatchee Regional Park, and WP Franklin Lock Recreational Area that are used by residents and tourists alike. The Caloosahatchee is used as a boating corridor between the east and west coasts of Florida. Boat traffic is moderately heavy with boating and fishing occurring on the river. The banks of the Caloosahatchee are too steep to be useful for bank fishing. Access for boat launch is provided at the three USACE lock structures located along the river. The FWC provides ramps at Wayside Park in Hendry County and at the intersection of SR 80 and Highland, east of Ft. Myers, in Lee County. All are well used.

The recreation activities proposed for the Caloosahatchee River (C-43) West Basin Storage Reservoir project include: nature study, multi-use trail atop the levee, equestrian use, boat and bank fishing, canoeing/kayaking, motor boating and hunting which will fit with the project purposes as managed by the SFWMD. A major recreation attraction of the Caloosahatchee River (C-43) West Basin Storage Reservoir project will be an approximately 12-mile multi-purpose trail loop atop the levee constructed as part of the project. Recreation facilities proposed include: parking and toilet facilities (clivas multrum waterless vault toilets), information kiosk, canoe/kayak launch facility, a shade structure, traffic-control fencing and a pedestrian footbridge bridge over the perimeter canal to provide public access to the reservoir.

Two handicapped accessible, double-lane public motor boat ramps would be provided; one into each of the two reservoir cells. Vehicle access will be provided via the single-lane bridge over S-10. The ramps are proposed within the reservoirs on the north levee. A paved two-lane public road will provide vehicular access to a one-lane bridge across the perimeter canal. A two-lane crushed shell road up the levee and to the ramps is proposed. Boat traffic control buoys would keep boaters clear of the reservoir structures. Signage would post warnings. The canoe/kayak launch facility would be on the perimeter canal.

Littoral areas are proposed at the corners of the seepage canal as part of the project and would provide ideal bank fishing locations outside the levee perimeter. The Florida Fish & Wildlife Conservation Commission (FWC) has endorsed the littoral shelf concept for habitat benefit and potential water quality benefits. Shades trees are proposed on the outside area of the north rim canal

adjacent to parking areas. Ample public parking will be developed outside of the north levee and perimeter canal in the general area of the construction staging location.



FIGURE 7-2: CONCEPTUAL RECREATION PLAN

7.2.1 Recreational Costs

The costs for proposed recreation features would be $2,519,000. An additional ten percent for PED, and an additional eight percent for construction supervision and administration bring the estimated total costs for recreation to $2,972,000.

The justification of incurring additional costs for recreation features is derived by utilizing a benefit to cost ratio. The tangible economic justification of the proposed project can be ascertained by comparing the equivalent average annual charges with the estimate of the equivalent average annual benefits, which would be realized over the period of analysis. These average annual recreation benefits and costs are summarized in (***Table 7-1***).

Engineering Regulation (ER) 1105-2-100 (The Planning Guidance Notebook) provides economic evaluation procedures to be used in all Federal water resources planning studies. The guidelines specified in the ER 1105-2-100 dated 22 April 2000 were observed in preparing this cost analysis. The Federally mandated project evaluation interest rate of 4 7/8 percent, an economic period of analysis of 40 years and current prices were used to evaluate economic feasibility.

TABLE 7-1: SUMMARY OF RECREATION COSTS AND BENEFITS (OCTOBER 2006 PRICE LEVEL)

Recreation Construction Costs	**$2,519,000**
PED & S/A (18%)	$453,000
Total Recreation Construction	**$2,972,000**
Construction Duration	12 months
Interest During Construction Costs	$72,000
Total Recreation Investment	**$3,044,000**
Period of Analysis	40 years
Annualized Cost	$174,000
OMRR&R	$25,000
Total Annual Costs	**$199,000**
Annual Benefits	
User Day Value	$6.79
Daily Use	145
Annual Use	52,925
Average Annual Benefit	**$359,000**

The benefit to cost ratio for the proposed recreation features is approximately 1.80, with net annual benefits equaling approximately $160,000. Therefore the Caloosahatchee River (C-43) West Basin Storage Reservoir project recreation sites are economically justified. ***Appendix H*** describes in greater detail the recreation plan and associated benefits and costs.

7.3 COST ESTIMATES

Table 7-2 includes a breakdown of the cost of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project including construction, lands and damages, ecosystem restoration elements, Pre-Construction Engineering and Design (PED) costs, recreation and interest during construction. Costs are estimated at October 2006 price levels and rounded to the nearest $10,000.

TABLE 7-2: PROJECT COSTS FOR THE SELECTED ALTERNATIVE PLAN (OCTOBER 2006 PRICE LEVEL)

(Initial cost rounded to the nearest $10,000)

Ecosystem Restoration Elements	**TOTAL**
Construction	
Demolition	$70,000
Mobilization/Demobilization	$11,240,000
Relocations	$1,050,000
Site Work	$4,040,000
Reservoir (embankments, slurry wall, drains, soil cement, perimeter canal, spillways, structures, etc.)	$250,660,000
Pumping Plants	$72,820,000
Main Outlet Structures	$8,250,000
Townsend Canal Improvements	$2,000,000
Recreation	$2,520,000
Manatee Protection Structure	$2,520,000
Sub-Total Construction Cost	**$355,170,000**
Non-Construction	
Lands and Damages	$80,420,000
Planning, Engineering, and Design	$44,650,000
Construction Management	$27,000,000
Sub-Total Non-Construction Cost	**$152,070,000**
TOTAL INITIAL COST	**$507,240,000**

*The costs shown above are updated, detailed costs and are not exactly equivalent to the costs that were utilized in the Economic Appendix.

Table 7-3 includes a comparison of Yellow Book, project first cost and fully funded estimate in October 2006 price levels.

TABLE 7-3: COMPARISON OF YELLOW BOOK AND SELECTED ALTERNATIVE PLAN FIRST COST FOR CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT (OCT 2006 PRICE LEVEL)

Component	Yellow Book	Project First Cost	Fully Funded Cost
Caloosahatchee River (C-43) West Basin Storage Reservoir	$400,000,000	$507,240,000	$565,700,000

Based on the engineering and design of the SAP for this study, the average annual cost for the SAP (Alternative 3B), is $35,100,000 that result in total average annual habitat units (HUs) of 12,809 and average annual net benefits for recreation of $160,000. The average annual cost per the combined average annual HUs generated by the project is $ 2,740.

7.4 DESIGN AND CONSTRUCTION CONSIDERATIONS

7.4.1 Engineering and Design

PED activities will be in accordance with USACE and SFWMD requirements. Preliminary design activities, which include survey and geotechnical investigations as well as cultural resources compliance, commenced in early 2004. Under the State's Acceler8 program, the SFWMD prepared a Basis of Design Report for the Caloosahatchee River (C-43) West Basin Storage Reservoir project (otherwise known in Acceler8 as the C-43 West Storage Reservoir). The Basis of Design Report includes all engineering assumptions and conceptual designs for each of the projects features. Upon reviewing the Basis of Design Report, the SFWMD will prepare initial, intermediate and final plans and specifications for construction contract award. All design work will be coordinated and reviewed with the USACE to meet USACE standards and regulations.

7.4.2 Construction and Implementation of the Plan

The non-Federal sponsor is exploring alternative project delivery methods to expedite implementation of the through the Acceler8 program. Such delivery methods may include the formation of a public-private partnership in which the non-Federal sponsor enters into an agreement or agreements with a private or not-for-profit entity for the provision of services that may include designing, building, operating or financing these components. It may also involve the non-Federal sponsor initiating construction activities prior to executing a Project Cooperation Agreement (PAC). Expedited implementation of the

Caloosahatchee River (C-43) West Basin Storage Reservoir project is in the best interest of the Federal government because it will provide early restoration benefits, potential cost savings, and reduced cash flow demands. Credit for such work is subject to the Secretary of the Army determining that the work performed was for a reasonable cost, necessary and integral to the authorized CERP project, and that the construction is consistent with applicable USACE construction standards and applicable Federal law. The non-Federal sponsor is aware that it will not receive credit for those costs unless the Congress approves the granting of the credit in law by the authorization of the Caloosahatchee River (C-43) West Basin Storage Reservoir project and the Secretary of the Army later determines the work is necessary and integral to the authorized Caloosahatchee River (C-43) West Basin Storage Reservoir project.

7.5 LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, AND DISPOSALS (LERRD) CONSIDERATIONS

Section 601 of the WRDA of 2000 and USACE policy requires that the non-Federal sponsor will obtain and provide certification of all LERRDs necessary for project implementation.

7.5.1 Real Estate Requirements

The lands required for the recommended plan are based on an analysis of the lands needed for construction, and operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project. The real estate component of the recommended plan is tentative in nature for planning purposes only. Both the final real property acquisition lines and the real estate cost estimates provided herein and in ***Appendix D*** are subject to change. More detail on the real estate requirements for the recommended plan is discussed in ***Appendix D***.

7.5.2 Land Acquisition

Within the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, comprised of approximately 10,700 acres, which consists of approximately 10,480 acres are required in fee, approximately 20 acres will be perpetual easements and approximately 200 acres will be used on a temporary basis for staging areas. Approximately 7,080 acres of the 10,700 acres within the project footprint were acquired under a Federal grant using a combination of State and Federal funds.

7.5.2.1 Department of Interior Grant Number LWCF-1, Addendum 3, Land and Water Conservation Act Funds

In June 1999, the DOI and SFWMD executed a grant agreement entitled Everglades Watershed Restoration-Grant Number LWCF-1, in which DOI provided $38,900,000 in Federal funds to the SFWMD for the acquisition of land

in the East Coast Buffer/Water Preserve Areas and Southern Corkscrew Regional Ecosystem Watershed Project. SFWMD matched the Federal share with a State share of $38,900,000, making the total expenditures on land acquisition at $77,800,000. This grant contained language to allow SFWMD to manage these acquired lands during an interim period defined as "...the period of time: 1) commencing a) with respect to Grant Lands, the date of purchase or date of possession under condemnation, as appropriate, and b) with respect to Match Lands, the effective date of the Grant Agreement as defined below, and 2) ending a) sixty (60) days prior to the issuance of a notice to proceed with construction phase of the District/Corps Caloosahatchee River (C-43) West Basin Storage Reservoir PIR project, at which time the Grant Land or Match Land is deemed to be 'Incorporated into a District/Corps project', or b) on the date of receipt by Interior of written notice from the Corps or the District that the particular Grant Land or Match Land is not to be included within a District/Corps project, or c) such other date agreed to by Interior and the District." .... "Upon incorporation of each Grant Land or Match Land into a District/Corps Project, such Grant Land or Match Land shall be managed in accordance with Corps approved water management and control plans and operation and maintenance manuals for the project so long as the project remains authorized."

This grant was amended in December 1999 to add an additional $13,900,000 from each of the parties bringing the total to $105,600,000. The grant was amended again in April 2000 to add an additional $18,900,000 from each of the parties bringing the total to $143,000,000. This additional $38,900,000 was to be used to purchase the Berry Groves property (C-43) West Basin Storage Reservoir Project). The DOI's additional $18,900,000 in funding came from Land and Water Conservation Funds provided to the DOI by Congress. The last amendment to this grant was executed in June 2001 with each party contributing an additional $5,974,000 bringing the total State and Federal funding under the grant to $155,348,000. Not all the lands covered in this grant agreement are within the footprint of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project.

A total of $$27,567,669 in Federal funds was utilized to acquire approximately 7,080 acres, within the 10,700 acres within the project footprint, which will be credited to the Federal government.- These costs include both the land acquisition cost as well as the cost of any improvements and a major portion of SFWMD's administrative costs for the acquisition of the lands. This amount may be increased or decreased based on a more detailed analysis during the crediting review process after approval of the project, execution of a PCA and certification of the land.

A thorough discussion of this act, the Federal Grant, and its effects on this project are located in ***Appendix D***.

7.5.3 Hazardous, Toxic and Radioactive Waste

The existing conditions section of this document (**Section 2**) includes a summary of the Phase I/II Environmental Site Assessment (ESA) studies done on the five properties acquired (totaling approximately 12,372 acres) or being acquired (totaling approximately 600 acres) for the reservoir project. These are the Berry Groves tract composed of approximately 9,000 acres, the Bryan Paul Grove tract composed of approximately 600 acres, which has not been acquired, the MG Enterprises LLC property composed of approximately 2,399 acres, and the Griffin property, composed of approximately 954 acres. In the course of these studies, over 50 point source sites with potential HTRW contamination were identified. At this time, most if not all of these potential contamination sites have been either remediated or further investigated to characterize the sites and prepare remediation plans. The project sponsor, the SFWMD, has made a commitment to the USACE and USFWS that after it takes control of the properties from the present lessees and begins construction of the reservoir, all of the outstanding point source remediation efforts will be completed. In addition to the point source contamination sites, the SFWMD also identified distributed soil contamination in portions of the cultivated areas on all of the acquired properties. The remediation of the cultivated soil sites involves the placement of these soils into the core of the reservoir dam. This will isolate the contaminated soils from benthic organisms that serve as food for higher level organisms and thus reduce the potential for bioaccumulation of contaminants by fish and wildlife. In accordance with USACE policy, costs incurred by the non-Federal partner to characterize and remediate environmental contamination will not be cost-shared.

The USFWS has reviewed all of the SFWMD's remediation plans and indicated that they believe that the efforts will sufficiently reduce the risk of harm to fish and wildlife in those areas where the remediation will be performed. The USFWS has also stated that moderate levels of copper and other contamination of the cultivated areas are believed to not pose a direct threat to species of concern; however, they believe that an indirect effect may occur since widespread low-level soil contamination may reduce the population of benthic organisms upon which the species of concern normally feed.

Despite the diligent work performed by the SFWMD and USFWS to reduce the risk to environmental resources, it is possible that once the reservoir is built bioaccumulation of soil contaminants will result in harm to one or more species of interest. If this does happen, additional remediation efforts, such as more extensive removal of the reservoir bottom sediments could be performed to further reduce the exposure of benthic organisms to near surface soil

contamination. The cost of additional remediation, if necessary, would be the responsibility of the non-Federal sponsor. If such remediation is necessary, it may be schedule in one cell at a time, possibly during the late dry season, thereby keeping the reservoir somewhat operational. In accordance with Corps policy, costs incurred by the non-Federal sponsor to characterize and remediate environmental contamination will not be cost-shared.

A summary of the proposed SFWMD remediation efforts and USFWS opinions for each property are included below.

7.5.3.1 Berry Groves Property

The most environmentally significant soil contamination was found on the Berry Groves property which had elevated levels of copper contamination distributed over a large fraction of the approximately 9,000 acres. As part of an Environmental Risk Assessment (ERA) study, the SFWMD estimated an interim screening concentration for risk to the snail kite to be 85 mg/kg. After extensive grid based testing, the SFWMD identified approximately 300 acres of groves located within the footprint of the planned reservoir that exceed the interim screening concentration of 85 mg/kg. The copper contaminated grids cells (50 acres in size) are identified as the entirety of numbers 124, 125, 134, 135, 143, and the southern half of 56 and 58. In addition to these heavily copper contaminated grid cells, the geometric mean copper concentration in the Berry Groves property was calculated to be 51.9 mg/kg. This exceeds the threshold effects concentration (TEC) 32 mg/kg for benthic organisms.

To remediate the 300 acres of the Berry Groves property that exceed the interim screening criteria, the SFWMD proposed that one foot of topsoil be scraped and placed within the core of the reservoir levee as construction progresses. The intent is to isolate these soils from benthic organisms that typically live in sediments within one to two feet of the sediment/water interface. Since benthic organisms would not typically be present in the core of the levee, the potential for bioaccumulation of copper by these organisms and the later biomagnification of these contaminants by higher tropic levels will be much less than if the soils are left in place.

The USFWS reviewed the SFWMD's plan to place the contaminated soils from the 300 acres into the core of the levee and they agreed that this will reduce the copper concentrations in the affected grids to below the interim screening value for risk to the snail kite. However, the USFWS also believes that while remediating the 300 acres with the highest levels of copper concentration will likely protect the snail kite, the property-wide average copper concentration of 45 mg/kg will still exceed the TEC of 35 mg/kg for benthic organisms. The USFWS concludes that direct impacts to the snail kite are not likely, but indirect

impacts are likely since the food base for the snail kite will be reduced as a result of the elevated property-wide copper concentration.

7.5.3.2 Griffin Property

Five areas of potential concern including the cultivated areas, canal sediments, maintenance area/chemical barn, fertilizer mix/load area, and burn area were identified in the Phase I/II ESA studies. The investigation of the cultivated areas indicated that though there is evidence of residual pesticide contamination, the detected concentrations of persistent pesticides were not above the levels of concern. Aldicarb was detected at a concentration above the site-specific Florida Sediment Quality Assessment Guidelines (SQAG); however, this was not of great concern because discontinuing its use would likely result in much lower residual concentrations since this pesticide readily degrades.

The Phase II audit recommended that remediation be performed at the maintenance/chemical barn area and the burn area. The remediation plan for the maintenance area/chemical barn area requires the excavation and proper disposal of 140 tons of soil that is contaminated with petroleum products. Two groundwater monitoring wells will be installed at this site. Samples from the monitoring wells will be analyzed for petroleum products, organophosphorous pesticides, lead, arsenic, copper, and zinc. The remediation plan for the burn area requires the excavation and proper disposal of 50 tons of soil. One groundwater monitoring well will be installed at this site. Samples from this well will be analyzed for copper.

Based on a review of the Phase I/II ESAs and proposed remediation efforts, the USFWS indicated in a letter to the SFWMD (dated October 12, 2004) that incorporation of the Griffin property into the reservoir project would not pose a threat to listed species.

7.5.3.3 MG Enterprises LLC, also known as the Winthrop Property

Five areas of potential concern including the cultivated areas, canal sediments, two agricultural maintenance areas and the exploratory oil/gas well were identified in the Phase I/II ESA studies. The investigation of the cultivated areas indicated that though there is evidence of residual aldrin contamination in one sample, the risk to avian species was not significant. Aldicarb was also detected above levels of concern; however, the cessation of its use was considered by the SFWMD to be an adequate remediation method since this compound readily degrades.

Of the point source contamination sites, the two maintenance areas were identified as requiring remediation. The remediation plan for Maintenance Area A requires the excavation of approximately 300 tons of topsoil that is

contaminated with pesticide residue and petroleum products. Contaminated soils will be disposed of offsite. Clean fill will be placed and at least two monitoring wells will be installed to monitor for contamination of the surficial aquifer by petroleum products, pesticides, copper, lead, and zinc. The remediation plan for Maintenance Area B requires the excavation and proper disposal of 300 tons of contaminated soil. Clean fill will be placed and two monitoring wells will be installed to monitor for contamination of the surficial aquifer by petroleum products, and lead.

The USFWS, in a July 14, 2003 letter, indicated that the proposed remediation methods for the aldicarb and paraquat on the cultivated areas and the soil removal at the maintenance area should reduce the risk to benthic organisms from exposure to the detected contaminants. After review of the ESA studies the USFWS agreed (letter to Robert Kukleski, SFWMD, dated July 1, 2004) that the risk presented by aldrin contamination was not significant.

7.5.3.4 Bryan Paul Property

In a summary of the Phase I/II ESA studies, the SFWMD (internal memo dated August 24, 2004, from Robert Taylor to Ruth Clements) identified ten remediation actions that would have to occur to make the Bryan Paul property suitable for use in the reservoir project. The identified actions are cleanups at the nursery barn, C-1 mix station, graded area, auxiliary tank area, cultivated citrus area, burn area, and canal sediment sampling site. Tasks included removing the well/septic tank and the above ground storage tanks (ASTs). The total projected cost of these actions was $565,000. Of this amount approximately $90,000 could be attributed to actions required if the future land use of the property was agricultural or residential. The remaining expense is necessary only if the future land use would be water storage or natural use.

The most expensive remediation action required on this property is the removal and disposal of two feet of top soil from approximately 20 acres of cultivated land. This soil is contaminated with chlordane. The SFWMD has proposed that this soil be excavated and placed within the core of the reservoir's dam. In a letter to the SFWMD dated August 9, 2006, the USFWS states that it agrees with the SFWMD's proposed cleanup target level of 18 ug/kg. The USFWS also concurs that placing the contaminated soils within the reservoir dam is an appropriate remediation technique.

7.5.4 Relocation Assistance

In accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended (Public Law [PL] 91-646), relocation assistance is required to be provided to affected residents and business. Information provided by SFWMD indicates that there is no relocation or

displaces. Upon certification of the LERRD, SFWMD will be required to demonstrate compliance with the requirements of PL 91-646 including that landowners have been properly advised of their rights under the program and that which evidence appropriate benefit determinations. To include:

- Number of persons, farms, and businesses displaced.
- Estimate of all PL 91-646, Title II costs and contingencies.
- Discuss/describe availability of replacement housing and any need for last resort housing benefits.

Based on current information, it appears that there were no relocation assistance payments made or required.

7.6 OPERATIONS AND MAINTENANCE CONSIDERATIONS

The SAP will be operated in a manner consistent with the original design intent for the Caloosahatchee River (C-43) West Basin Storage Reservoir project components included in the 1999 Comprehensive Review Study Report. In very brief summary, the Caloosahatchee River (C-43) West Basin Storage Reservoir project will be operated to capture regulatory releases from Lake Okeechobee (via pumping station) and to collect and store basin runoff from the lower southwestern Caloosahatchee River Basin currently discharged to the Caloosahatchee River (C-43 Canal) through existing canal systems and natural drainage ways. The reservoir will be operated to collect and store water during the wet season, then release the water when needed during the dry season to meet estuarine demands by helping to maintain a minimum flow of 450 cfs at S-79. Since the reservoir's perimeter canal serves as a means of conveying both surface storm water runoff and off site flows entering the project several canals discharge to and from the reservoir's perimeter. Additional details about project operations are included in ***Annex D*** (Draft Operating Manual).

7.6.1 Operations and Maintenance Costs

Annual operations and maintenance (O&M) costs were estimated for the construction features of the recommended plan for Caloosahatchee River (C-43) West Basin Storage Reservoir Project. The O&M costs were determined by extrapolation from operational costs histories supplied by the SFWMD using industry standard cost data and data from past and projected cost trends. O&M activities include such items as mowing, erosion control, pump maintenance, levee road maintenance, and building maintenance. The annual (OMRR&R) costs are estimated to be $3,000,000 (rounded to the nearest $10,000), which includes ecologic and water quality monitoring associated with the project level Adaptive Program described in ***Annex D***. Recreation OMRR&R costs have been estimated at approximately $25,000. The non-Federal sponsor is responsible for 100 percent of the OMRR&R recreation costs.

7.6.2 Monitoring and Adaptive Management Costs

The estimated cost for water quality during the initial year is $610,000, which would be construction funded. The estimated cost for water quality monitoring during operations of the project is $604,000 per year, which would be OMRR&R funded. The water quality monitoring plan is included in Annex D. The Ecological monitoring plan (also in Annex D) includes recommendations for salinity, oysters, SAV, fish, and estuarine water quality. This ecological monitoring plan is not recommended for funding by this project. It has been recommended to RECOVER for funding as part of the Monitoring and Assessment Plan (MAP). Most of the ecological monitoring recommended for the Caloosahatchee Estuary is already currently recommended by the MAP. A hydrologic monitoring plan is also included in Annex D which includes recommendations for monitoring of reservoir water level, flow, groundwater, weather, and structures. This cost is included in the OMRR&R estimate cited above in 7.6.1.

7.7 PLAN ACCOMPLISHMENTS

The SAP affirmed that an above-ground storage reservoir (including pump stations and water control structures) and associated conveyance can meet the needs of the Caloosahatchee Estuary at the right time, and is a cost-effective solution to achieving system-wide benefits in Caloosahatchee River, estuary and the south Florida ecosystem. In addition, the plan helps achieves the benefits of the project as previously developed for CERP.

The SAP includes a key component that was identified in the Restudy and helps to promote a salinity balance in the Caloosahatchee Estuary that will provide for vegetation, fish and wildlife habitat restoration functions that are critical to the continual health and development of the estuary. The additional water injected into the estuary's natural system areas are key aspects of restoration planning for the Caloosahatchee Estuary. The Caloosahatchee Estuary is part of south Florida's fragile ecosystem and has long been recommended as a management measure to achieve restoration objectives. Based on a salinity model, the area within the Caloosahatchee Estuary system beneficially affected by the project conservatively encompasses at least 71,000 acres in the Caloosahatchee River, San Carlos Bay, and a portion of Pine Island Sound, although in all likelihood the area beneficially affected by project implementation will be much larger, including portions of Pine Island Sound, Estero Bay, and the Gulf of Mexico. These acres are within the navigable waters of the United States and within the navigational servitude of the United States.

Two planning goals and seven planning objectives have been established for CERP projects through the Restudy. The two planning goals are: (1) enhance ecological values and (2) enhance economic values and social well-being. The

SAP for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project positively contributes to both of these goals and all seven of the objectives originally established for these two underlying planning goals.

7.7.1 Relationship of Other Projects in CERP to Caloosahatchee River (C-43) West Basin Storage Reservoir Project

The intent of Caloosahatchee River (C-43) West Basin Storage Reservoir Project is to meet the immediate needs of the Caloosahatchee Estuary and thereby show ecosystem restoration benefits in the estuary. Construction and implementation of the reservoir and the subsequent achievement of estuarine benefits are not dependent on CERP being in place. The implementation or non-implementation of CERP will not diminish benefits achieved by the Caloosahatchee River (C-43) West Basin Storage Reservoir. The need for additional storage to prevent harmful discharges to the natural system and improve the timing and quality of water delivered to the natural system is well-established as a basic premise of the CERP.

7.7.2 Project Justification: Next-Added Increment

7.7.2.1 Next–Added increment Analysis

Section 385.26 of the CERP Programmatic Regulations requires the development of a series of programmatic guidance memoranda (GM) that includes guidance for performing plan formulation and evaluation process and next-added incremental (NAI) justification. The CERP Programmatic Regulations requires a NAI evaluation of the Tentatively Selected Plan (TSP) as is defined in the CERP Programmatic regulations as "the next project to be added to a system of projects that includes only those projects that have been approved according to general provision of law or specific authorization of Congress and likely to be implemented by the time the project being evaluated is completed." The NAI analysis evaluates the effects, or outputs, of the TSP as the next project to be added to the group of already approved CERP projects. This analysis helps illuminate the amount of benefits the SAP contributes without regard to future CERP projects. It also helps to ascertain whether sufficient benefits would accrue to the SAP to justify the cost if no additional CERP projects (other than those already existing or authorized) were implemented. In the case of this analysis no other CERP projects are assumed to exist for the purposes of the NAI analysis.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project aims to 1) reduce harmful discharges to the Caloosahatchee Estuary by capturing some high flow releases from Lake Okeechobee and basin runoff from the lower West Caloosahatchee River Basin during the wet season, 2) storing the water till needed in a reservoir and 3) provide incidental water deliveries to supplement

river flows over S-79 to Caloosahatchee Estuary during the dry season, thereby reducing stress on the natural system due to low flows which allowed increased salinity levels to occur in the estuary. The SAP affirmed that a reservoir and discharging to better meet the needs of the basins at the right time, together is a cost-effective solution to achieving system-wide benefits in the south Florida ecosystem. In addition, the plan achieves the benefits of the project as previously developed for the CERP.

Alternative 3C was identified as the NER plan that provides the maximum net environmental benefits on a system-wide basis. Alternative 3B, which is a variant of Alternative 3C, is a cost effective plan that will provide environmental benefits on a system-wide basis, has a lower project cost, is a part of an incremental adaptive restoration approach and is justifiable alternative. The project is justified by its beneficial effect on seagrass habitat, an important indicator of estuarine ecosystem function. The NAI condition produces more total benefits than seen in the system-wide analysis.

The system-wide formulation was conducted to determine the input for the CE/ICA and assist in the selection of the recommended plan. An additional analysis was also conducted to use in justifying and describing the benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir as a stand-alone project without the system-wide benefits attributed to other CERP projects, otherwise known as the NAI analysis. This analysis was completed for all the alternatives that were evaluated under the system formulation. This was done to demonstrate that all alternatives would have similar benefit outputs during the NAI as they do with the system-wide formulation analysis.

An identical method was used for the NAI as was used for the system formulation. As described in the system formulation analysis, five attributes were studied to determine system response. Oysters, *Vallisneria*, seagrasses, extreme events and EST05 were all measured and compared to 2050 in order to determine the benefit lift for the TSP (***Table 7-4***). This methodology is described in the environmental benefits evaluation section.

Although the NAI and system formulation analysis are listed below, this is not a valid comparison due to different sources of data for the two analyses. Therefore, even though the HSIs are similar, the total project average annual HUs are based on different 2050 model conditions, resulting in a larger lift for the NAI analysis. The NAI analysis reflects 28 percent more benefits than the system-wide formulation. There are several variables which could explain the higher benefits with the NAI approach. The first and most influential of these results from the rest of CERP's impact on the overall water budget provided to the Caloosahatchee River (C-43) basin. The system-wide analysis has a lower water budget than the NAI analysis, leading to diminished dry season

conditions. The other variances may stem from differing models being utilized for the benefit analysis. The system-wide analysis utilized the MIKESHE model and the NAI run utilized spreadsheet flow models, which utilized flows from the SFWMM and is further described in ***Section 8*** and ***Appendix A***.

TABLE 7-4: COMPARISON OF NAI AND SYTEM FORMULATION SCORES

Alternative	Oyster	*Vallisneria*	Seagrasses	Extreme Events	EST05	Total Project Average Annual Habitat Units
3B – System-wide	.60	.33	.59	.43	.70	12,809
3B – NAI	.23	.60	.52	.24	.71	15,297

7.7.2.2 Next–Added increment Analysis Conclusions

Both the system formulation and the NAI evaluations of Alternative 3B (SAP) demonstrate significant ecological benefits due to implementation of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project.

It was determined through this analysis that there are benefits associated with the NAI analyses completed for the West Basin Storage Reservoir Project. Overall, the project design is consistent with attaining project goals and objectives. Operational flexibility will lead to increased benefits by further minimizing potential high flows to the estuary as well as by minimizing discharges (and associated sediment loads).

In comparing the NAI benefits with the system-wide analysis it can be noted that there is a perception of more benefits realized in the NAI analysis. There were approximately 12, 809 average annual HUs calculated for the system-wide analysis compared to the 15,300 average annual HUs in the NAI analysis. In reality the NAI and system-wide HSI scores are relatively close. ***Table 7-5*** presents a summary of the raw HSI scores for both the NAI and system-wide calculations.

TABLE 7-5: SUMMARY OF RAW HSI SCORES

	SYSTEM WIDE FORMULATION			NAI ANALYSIS		
	2000	2050	ALT 3B	2000	2050	ALT 3B
Vallisneria	0.16	0.20	0.33	0.03	0.08	0.60
Seagrasses	0.51	0.54	0.59	0.49	0.51	0.52
Oysters	0.48	0.52	0.60	0.52	0.52	0.23
Extreme Events	0.28	0.30	0.43	0.22	0.24	0.24
EST05	0.38	0.43	0.70	0.20	0.21	0.71

The Caloosahatchee River (C-43) West Basin Storage Reservoir project NAI analysis demonstrates that as a stand-alone project, all of the benefits achieved in the system-wide formulation process were met or exceeded. The NAI analysis yields a greater average annual HU lift than the system-wide analysis. The reason behind the additional benefits calculated during the NAI analysis is due to different water budgets afforded to the model for both the system-wide and NAI computations, stemming from demands on Lake Okeechobee. The variables in the water budget reflect additional demands from CERP features located outside the Caloosahatchee River (C-43) West Basin Storage Reservoir study area. This additional water being supplied to other CERP features in the system-wide analysis leads to a lower potential benefit to the study area. This does not imply that the West Basin Storage Reservoir is operating less efficiently as part of the CERP system, but instead illustrates difficulties in comparing model results when the boundary conditions are not consistent.

The system-wide analysis does not capture all of the benefits that are being provided to the other CERP features by limiting the water available to the Caloosahatchee River (C-43) West Basin Storage Reservoir study area, and mainly aims to capture the direct benefits to the study area. Due to the nature of the models and uncertainty in the independent CERP features included in the system-wide analysis it was not practicable to characterize all of the benefits. If all of the benefits to the other conceptual CERP features were characterized, it is fully expected that the cumulative system-wide benefit analysis would exceed the cumulative NAI benefits.

Total system-wide analysis includes each of the projects that are affected by the water budget changes reflected in the modeling. The NAI analysis does not include these other projects shifting water from the Caloosahatchee River (C-43) West Basin Storage Reservoir study area, so it is likely that the additional benefits calculated in the NAI analysis result from the difference in the water budget in the system-wide and NAI analysis, and are not directly related to the features in the NAI analysis.

The conclusion from this analysis is that as a stand-alone project the Caloosahatchee River (C-43) West Basin Storage Reservoir will be efficient and effective at meeting the goals and objectives of the project. The risk of being unable to obtain project benefits is expected to be minimal.

7.8 CONTRIBUTION TO ACHIEVEMENT OF INTERIM GOALS AND TARGETS

Section 601(h)(3)(C)(III) of the WRDA 2000 (PL 106-541) required the CERP Programmatic Regulations to include the "establishment of interim goals to provide a means by which the restoration success of the Plan may be evaluated

throughout the implementation process." Section 385.38 of the CERP Programmatic Regulations (33 CFR Part 385) further describes the intent and the underlying principles for establishing interim goals and a process for developing them. Section 385.39 of the CERP Programmatic Regulations also established the requirement to develop interim targets to measure progress toward meeting the other water-related needs of the south Florida region, and describes the intent, underlying principles, and the process for establishing interim targets.

Consistent with the processes for developing interim goals and targets required in the CERP Programmatic Regulations, RECOVER issued a final report containing recommendations for interim goals and targets on February 17, 2005. The RECOVER report was then utilized to develop the Interim Goals and Interim Targets Agreements and will be updated after the final PIR is completed and when the agreements are finalized.

For the purposes of this PIR the project delivery team (PDT) utilized the RECOVER report to evaluate the progress towards the interim goals and interim targets. Interim goals for evaluating progress toward the restoration of the south Florida ecosystem are recommended for the Northern Estuaries, Lake Okeechobee, the Everglades, and the Southern Estuaries. Interim targets for water supply and flood protection are also recommended.

7.8.1 Progress toward Interim Goals

Although the Caloosahatchee River (C-43) West Basin Storage Reservoir project will create minor hydrologic and ecosystem response effects throughout a large portion of the south Florida ecosystem due to the interconnectedness of the regional water management system, the magnitude of the project's contribution toward restoration objectives for the Northern Estuaries, Lake Okeechobee, and the Southern Estuaries is relatively insignificant when considered with other components which were specifically included in the Plan to beneficially affect those areas. However, the Caloosahatchee River (C-43) West Basin Storage Reservoir Project's effects on fish and wildlife habitat functions in the Northern Estuaries, specifically the Caloosahatchee Estuary, are quite significant. Accordingly, this applies to the project's effects on the twelve "Everglades Restoration Indicators" listed in RECOVER's Interim Goals and Interim Targets report, which in general are indicators of effects on hydrology, water quality, and biological response. The interim goal indicators for the Everglades included in RECOVER's February 17, 2005 report are listed in ***Table 7-6.***

TABLE 7-6: EVERGLADES INTERIM GOAL INDICATORS

No.	*Indicator*
1.1	American Oysters in Northern Estuaries
1.2	Submerged Aquatic Vegetation in Northern Estuaries
3.1	Water Volume
3.2	Sheet Flow in Natural Areas
3.3	Hydropattern
3.4	System-Wide Spatial Extent of Habitat

In general, the Caloosahatchee River (C-43) West Basin Storage Reservoir project will result in improvement in ecosystem function and will create a substantial incremental contribution toward the achievement of the interim goals for ecosystem restoration in the Northern Estuaries. The project's contributions toward the achievement of interim goals for the restoration of the south Florida ecosystem are assessed by evaluating the effects on the above-listed indicators. Although not all of the indicators were quantitatively assessed using hydrologic-based performance measures during plan formulation and evaluation work, a qualitative assessment was performed for all of the Everglades interim goals indicators. Due to the magnitude of hydrologic change necessary to meaningfully affect some of the indicators and the actual hydrologic effects predicted to result from implementation of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, it is not expected that the project will affect all of the indicators equally. Detailed information about the performance measures and methodologies used to evaluate and compare alternative plans can be found in ***Appendix C*** (Environmental Information). ***Table 7-7*** is a summary of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project's effects on Northern Estuaries indicators.

TABLE 7-7: PROJECT EFFECTS ON EVERGLADES INTERIM GOALS AND INDICATORS

No.	*Indicator*	*Project Effects*
1.1	American Oysters In Northern Estuaries	The reduction in number and duration of high flow events reduces low salinities and creates favorable conditions for oyster recruitment that will lead to increased diversity and abundance of estuarine fauna. The reduction in low flow events reduces high salinities and will benefit oyster populations by killing predators, reducing disease and diminishing predation pressure on oyster spat allowing greater recruitment.
1.2	Submerged Aquatic Vegetation in Northern Estuaries	The reduction in the number and duration of high flow events reduces low salinities and creates favorable conditions for more extensive seagrass beds including shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*) that are an important habitat for a variety of estuarine invertebrate and vertebrate species, including some commercially and recreationally important fishes. The reduction in low flow events reduces high salinities and will lead to more extensive tape grass (*Vallisneria americana*) beds and greater ecological function.
3.1	Water Volume	170,000 ac-ft of storage capacity.
3.2	Sheet Flow in Natural Areas	No change; project does not include removal of barriers to sheet flow.
3.3	Hydropattern	The reduction in the number and duration of extreme high and low flow events will improve quantity, timing and distribution of freshwater flows to Caloosahatchee Estuary which will lead to increased diversity and abundance of estuarine flora and fauna.
3.4	System-Wide Spatial Extent of Habitat	The reduction in extreme high and low flow events will significantly benefit the valued ecosystem components such as tape grass (*Vallisneria americana*), shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*) manatee grass (*Syringodium filiforme*) and the American oyster (*Crassostrea virginica*) which are crucial to maintaining the ecological structure and function of the estuary by providing food, living space and foraging sites for other naturally occurring estuarine species.

7.8.2 Progress toward Interim Targets

To evaluate project effects on progress toward meeting CERP objectives for other water-related needs of south Florida, eight interim target indicators were recommended by RECOVER in the February 17, 2005 report. The interim targets were developed using the Yellow Book version of the 2x2 model run which limited some of the information to certain geographic areas. The only performance measures available for flood control were for the southern Dade area so there is not an interim target to compare to in the Caloosahatchee River (C-43) West Basin Storage Reservoir project area. The severity and duration of water restrictions when drought levels exceed a one-in-ten condition need to be reviewed to determine the full extent of predicted water supply impacts in the

Caloosahatchee River (C-43) basin. To perform a review based on supply-side management, raw or post-processed data that will allow the determination of monthly demand volume, number of days per month with cutbacks (demands not met), and volume of cutbacks (demand not met) per each month is required. Since this data is not readily available from MIKESHE output, annual average volumes were evaluated. The average annual volumes will not allow for a determination of differences in alternative performance regarding water supply deliveries. However, of the eight indicators, the Caloosahatchee River (C-43) West Basin Storage Reservoir project is expected to improve surface water annual average volumes deliveries to agricultural users in the Caloosahatchee East and Caloosahatchee West basins. The project is expected to slightly increase groundwater average annual volumes agricultural demand over the 2050WO in the Caloosahatchee East Basin without significantly affecting performance. Detailed information about the project's effects on sources of water for supply, aquifer protection and flood damage reduction can be found in ***Annex C***. ***Table 7-8*** is a summary of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project's effects on applicable interim targets indicators.

TABLE 7-8: PROJECT EFFECTS ON INTERIM TARGETS INDICATORS

No.	*Indicator*	*Project Effects*
5.1	Water Volume	Effects unknown due to absence of adequate evaluation tools.
5.2	Water Supply for Lower East Coast Service Area	Not applicable to this geographic area
5.3	Water Supply for Lake Okeechobee Service Area	Effects unknown due to absence of adequate evaluation tools.
5.4	Protect Biscayne Aquifer from Saltwater Intrusion	Not applicable to this geographic area.
5.5	Protect Southern Portion of Biscayne Aquifer from Saltwater Intrusion	Not applicable to this geographic area
5.6	Flood Control: Root Zone Groundwater Levels in South Miami-Dade Agricultural Area East of L-1N	Not applicable to this geographic area
5.7	Flood Control: Groundwater Stages for Miami-Dade, Broward, Palm Beach, and Seminole Tribe Surface Water Management Basins	Not applicable to this geographic area
5.8	Flood Control: Flood Water Removal Rate for Everglades Agricultural Area (EAA)	Not applicable to this geographic area

7.9 SUMMARY OF ECONOMIC, ENVIRONMENTAL, AND OTHER SOCIAL EFFECTS

7.9.1 Other Social Effects

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project alternative restoration plans could result in beneficial and adverse Other Social Effects (OSE) within the study area. As is evident throughout this appendix, a variety of positive and adverse NED impacts on water supply, flood damage reduction and recreation are expected to result from the reservoir construction. Similarly, the alternative restoration plans could have positive or adverse OSE impacts on the study area associated with (1) plan implementation, including land acquisition, project construction, and O&M activities, and (2) operation of the modified C&SF system. As in the case of the NED effects, the OSE account is concerned with the net effects of the alternative plans (i.e., the differences between the with- and without-project future conditions).

Some of the potential OSE impacts would occur primarily at the regional scale, and others would have more localized effects. At both scales, there may be some individuals and communities that are positively affected by project implementation, some that are adversely affected, and many that are not affected at all. Relative to the size of the regional or local economies, the OSE effects may be minimal. However, if these effects occur predominantly within a limited geographic area, or affect a relatively small or vulnerable population, then the impacts can be disproportionately large. Therefore, the purposes of

OSE analysis include not only determining the total magnitude of potential impacts, but also identifying the population (and its characteristics) that would be affected by any proposed action.

Some of the categories of effects typically included in the OSE account do not pertain to the alternative restoration plans. For example, the alternative plans are not expected to affect energy use or energy conservation in the study area. As will be noted, other categories of potential OSE impacts have been addressed and can be found in ***Appendix G***.

7.9.2 Environmental Justice

Executive Order (E.O.) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires the Federal government to achieve environmental justice by identifying and addressing high, adverse and disproportionate effects of its activities on minority and low-income populations. E.O. 12898, Environmental Justice, states that the proposed action would not result in adverse human health or environmental effects. Any impacts of the action would not be disproportionate towards any minority or low-income population. The activity does not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin. The activity would not impact "subsistence consumption of fish and wildlife." It requires the analysis of information such as the race, national origin, and income level for areas expected to be impacted by environmental actions. It also requires Federal agencies to identify the need to ensure the protection of populations relying on subsistence consumption of fish and wildlife, through analysis of information on such consumption patterns, and the communication of associated risks to the public.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project will provide benefits to quality of life by improving the natural environment in which we live. The project improves flows to the estuary. This is achieved through a reservoir which is located in a rural area so that negative impacts are minimized for all communities. The project is a Congressionally approved project funded with Federal and State dollars to make improvements to hydrology for people and the environment.

In public outreach efforts to date, only one potential environmental justice issue has been identified: the loss of jobs for low income and minority workers as a result of acquiring agricultural land for the construction of the reservoir. The expected loss in employment will occur to seasonal and/or temporary migrant workers, and as can be noted in the future land use section agricultural acreage in the surrounding study area and counties is expected to increase. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project PIR and EIS is an opportunity to somewhat alleviate this potential problem by providing jobs

within and during construction of the project, some of which could provide seasonal and temporary employment. To address this issue the SFWMD is conducting training programs to allow local individuals to acquire the skills needed to construct the reservoirs. In addition, it is anticipated that adjacent lands will continue to support agricultural operations.

The reservoir does not present any environmental impacts that are high, adverse and disproportionate to low income, minority or Tribal populations. Through the public participation process of the outreach and NEPA scoping no high and adverse impacts became known. There was sufficient public input to feel confident that scoping was successful and that the breadth of the potential impacts were communicated and understood by the public. Thus this NEPA process has found no evidence of high, adverse and disproportionate impacts.

The reservoir site is located based upon hydrologic characteristics, land availability and interconnection to existing canals and structures to optimize operations. Furthermore, in the consideration of the project site, urban areas are avoided to eliminate the negative impacts typically associated with site location of large projects. Through "willing seller agreements" a variety of land rights have been or will be acquired that allow the use of land for the resulting improvements to the human quality of life and the intended environmental benefits intended by the impoundment.

These environmental benefits provide quality of life improvements to all people and primarily to people in the communities within the study area. By the nature of design, this operating procedure will maintain if not improve flood damage reduction. This will improve the quality of human life by providing increased wildlife activity; a special bonus for those who appreciate seeing increases in fish and bird populations. This logically translates to the increased benefits in enjoyment, aesthetics, and economics for recreational activities.

7.10 SIGNIFICANCE OF HABITAT

The Selected Alternative Plan is consistent with each of the USACE "Environmental Operating Principles" particularly with respect to the south Florida ecosystem-wide approach for plan formulation, evaluation, and selection, and a holistic consideration of water resources needs and solutions to water resources problems in the study area.

Principle One: **Strive to achieve environmental sustainability**. An environment maintained in a healthy, diverse condition is necessary to support life.

Natural resource specialists agree that the remaining ecosystems in south Florida no longer maintain the functions and richness that defined the pre-

drainage system. These measures of ecological health will continue to decline without preventative actions. Not only is it certain that these natural systems will not recover their defining attributes under current conditions, it is unlikely that the current, degraded ecological conditions can be sustained in the future.

The SAP contributes to the restoration of the Caloosahatchee Estuary by capturing high-volume flows released from Lake Okeechobee and basin run-off and storing this excess water to provide flows during the dry season to provide supplemental flows over S-79 to maintain correct salinity balance in the estuary.

Principle Two: **Recognize the interdependence of life and the physical environment.** Proactively consider environmental consequences of USACE programs and act accordingly in all appropriate circumstances.

Life within the Caloosahatchee Basin is dependent on the river as a source to meet drinking water and irrigation needs. The USACE currently manages Lake Okeechobee as well as the Caloosahatchee River (C-43). As a result of conditions within the lake and the lake infrastructure, large regulatory releases are required to maintain lake levels within acceptable safety parameters.

The Caloosahatchee River (C-43) West Basin Storage Reservoir will provide immediate benefits to the Caloosahatchee Estuary, a part of the South Florida Everglades Ecosystem. The damaging estuarine effects of basin run-off and water releases from Lake Okeechobee will be reduced. Untimely discharges of fresh water to the estuaries would be partially equalized, leading to more natural salinity levels and the recovery of the estuarine ecosystem in the project area. By maintaining salinity balance and preventing salinity intrusion, the SAP will reduce the need for desalinization technologies. Any additional water made available through this project could be used for incidental benefits for water supply.

The SAP footprint is located on an active orange grove which provides employment in the local community. This loss in jobs will be offset by the construction opportunities in relation to implementing the project as well as related recreation.

Principle Three: **Seek balance and synergy** among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another.

Caloosahatchee River (C-43) West Basin Storage Reservoir was designed to meet the needs of competing municipal, agricultural, and environmental water supply in the basin. Every effort was made to provide for a beneficial effect in the adjacent natural system and also to ensure that the proposed project would not

impact the current water supply needs. The proposed Reservoir would provide additional resources for the human environment through improved recreation within the Reservoir itself. The Caloosahatchee River (C-43) West Basin Storage Reservoir will have no negative effect on water resources for urban utilities, agricultural or flood damage reduction.

Principle Four: Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.

The Caloosahatchee River (C-43) West Basin Storage Reservoir PIR complies with all applicable laws such as the NEPA, Clean Water Act, Endangered Species Act, and all other applicable legislation. The proposed Reservoir will enhance both ecologic values and also economic values and social well-being.

Public safety concerns were raised in regards to possible flooding and damage to the SR 80 Bridge (main evacuation route for Lee County) and surrounding area homes and businesses. These concerns were addressed by designing the reservoir embankments to USACE dam safety standards.

Principle Five: Seek ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.

The Caloosahatchee River (C-43) West Basin Storage Reservoir is one of 68 different projects as part of the CERP. Congress approved the CERP as the "framework for modifications and operational changes to the C&SF Project that are needed to restore, preserve, and protect the south Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection (WRDA 2000). As such, the primary purpose of the CERP is the restoration of the Everglades ecosystem, including specific safeguards to ensure that the benefits to the natural system are achieved and maintained, while providing for other water-related needs of the south Florida region. By doing this, the USACE is able to avoid and minimize any potential project impacts that may occur as a result of the implementation of any project.

Potential impacts to the natural system have been assessed as part of the PIR process and considered in the plan selection. Specifically, NEPA consultation was performed for the Eastern Indigo Snake, Audubon's Crested Cara Cara and the East Indian Manatee. Guidelines for fill rates, operations and control structures have been established to minimize impacts to these species. In addition, a system wide monitoring plan of the natural environment will be in place to continue to assess all impacts, and used along with adaptive

management of the project and other CERP components, in order to maximize benefits to the system while identifying and limiting any negative effects.

Principle Six: Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.

As part of the Adaptive Management strategy for the CERP, three sub-teams from RECOVER meet monthly to discuss ways to improve the overall effects of the CERP program. The three RECOVER teams are the Planning, Evaluation, and Assessment teams. These three teams collectively are composed of many individuals with separate disciplines in order to integrate their specific knowledge of science, economics, and sociology. The teams evaluate the different environmental effects that are expected to occur as a result of CERP implementation, and also assess possible impacts to any areas that can be beneficially adjusted through Adaptive Management. RECOVER reviewed the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir PIR as it was being developed and provided input as to how the project could best be implemented and operated.

Additionally, extensive modeling was performed to mimic the natural system in the project area, both hydrologically and ecologically, in order to better understand how the system will function with the SAP in place.

Principle Seven: Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems that also protect and enhance the environment.

The USACE fully addressed and considered all public comments concerning the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir. Comments were received from state and federal agencies as well as non-governmental agencies, tribal interests, and the general public. As part of the NEPA process, the USACE sent out a scoping notice to provide information to the public and/or other agencies in order to encourage participation and receive comments about the proposed project. Further public input was encouraged through public meetings, stakeholder meetings, and Regional Project Delivery Team meetings. Changes to the report were made where applicable; as an example, changes were made to the final in response to comments provided by Lee County during the public review period for the draft PIR. These changes included adding information about the Northern Everglades and Estuary Protection Act to the final PIR, this information can be found on page 1-17 of this report.

The Selected Alternative Plan is consistent with the USACE's 12 Actions for Change. The "12 Actions for Change" can be grouped into three overarching themes: Effectively implement a comprehensive systems approach; communication; and reliable public service professionalism. Below is a summary of the grouped actions for change, and how the Caloosahatchee River (C-43) West Basin Storage Reservoir is consistent with those actions.

Effectively Implement a Comprehensive Systems Approach: Comprehensively design, construct, maintain and update engineered systems to be more robust, with full stakeholder participation.

1. Employ integrated, comprehensive and systems-based approach
2. Employ risk-based concepts in planning, design, construction, operations, and major maintenance
3. Continuously reassess and update policy for program development, planning guidance, design and construction standards
4. Employ dynamic independent review
5. Employ adaptive planning and engineering systems
6. Focus on sustainability
7. Review and inspect completed works
8. Assess and modify organizational behavior

In order to effectively implement a comprehensive systems approach the Selected Alternative Plan was formulated to optimize system-wide benefits to further CERP goals and objectives. The Selected Alternative Plan minimized risk in several ways. First, reservoir design complies with the Design Criteria Memoranda, developed jointly by USACE and the South Florida Water Management District, and USACE dam safety criteria. Test cells were constructed by the project's non-Federal sponsor at the project site in order to assess reservoir site characteristics, embankment design, reservoir cell operation, and overwash scenarios. The information gathered from test cell construction and operation has minimized risk of proposed construction methods, as well as reservoir operation. The project delivery team reviewed CERP program guidance and applied lessons learned from other projects to this project. Independent review was conducted at the programmatic level by the National Academy of Sciences/National Research Council. Lessons learned from those programmatic reviews were applied in the planning and design of the Selected Alternative Plan. In addition, external ITR was conducted at key milestone points throughout the planning and decision document preparation process. The SAP includes program-level adaptive assessment and ecological monitoring that will study the long-term system-wide contributions of the SAP. It also includes project-specific water quality monitoring, as well as operational monitoring to ensure the reservoir functions as planned and does not cause or contribute to water quality degradation.

Communication: Effective and transparent communication with the public, and within the USACE, about risk and reliability.

9. Effectively communicate risk
10. Establish public involvement risk reduction strategies

Information has been provided regularly via public notices PDT meeting and summaries, newsletters, internet, and other methods. Risk reduction strategies have been communicated through utilizing the above methods as well as by gathering the input of the public through public meetings and by public review of the draft PIR.

Risk and uncertainty analyses have been documented throughout the PIR. Risk and uncertainty were also discussed at public meetings as well as at PDT meetings.

Reliable Public Service Professionalism: Improve the state of the art and the USACE' dedication to a competent, capable workforce on a continuing basis. Make the commitment to being a "learning organization" a reality.

11. Manage and enhance technical expertise and professionalism
12. Invest in research

SAJ, SFWMD and SFWMD consultants have extensive expertise in dam and reservoir construction in South Florida, pump station construction and operation, and other technologies used in this project.

Project level investments were made in creating the habitat suitability index model which provided a new methodology for evaluating and ranking ecosystem benefits resulting from the different project alternatives. Additionally, the construction and operations of the test cells have provided important lessons learned which have been implemented in the reservoir design.

This page intentionally left blank

SECTION 8
PLAN IMPLEMENTATION

This page intentionally left blank

8.0 PLAN IMPLEMENTATION

8.1 DIVISION OF IMPLEMENTATION RESPONSIBILITIES

The SFWMD proposes to initiate construction on the Caloosahatchee River (C-43) West Basin Storage Reservoir project (also referred to as the "C-43 West Storage Reservoir" under Acceler8) project as part of the State's Acceler8 plan prior to implementation of the Federal project. The USACE is proceeding with two separate and independent but related actions: the planning evaluation of the Federal project and the regulatory evaluation of the SFWMD's application for a Section 404 (Clean Water Act) permit for the proposed project, both of which are described in this Final PIR/EIS. The Caloosahatchee River (C-43) West Reservoir (Acceler8 project) is consistent with the plan recommend in this document. The purposes of the Federal recommended plan identified in this Final PIR and the Acceler8 project are consistent. Therefore, it is anticipated that the Final PIR/EIS will also serve as the basis for the Regulatory Division's NEPA evaluation of the SFWMD's proposed Acceler8 project.

8.1.1 Schedule

Availability of a Final PIR/EIS is scheduled for July 2007. Once the public review period of the Final PIR/EIS is complete and comments are addressed the Record of Decision (ROD) will be signed in and a fully executed Project Cooperation Agreement (PCA) will follow (A separate ROD on the Section 404 permit application will be signed by the Jacksonville District Commander for SFWMD's proposed action.). SFWMD commenced engineering design in late 2003 under the Acceler8 program with survey and subsurface geotechnical investigations. It is anticipated that full scale construction on the Caloosahatchee River (C-43) West Storage Reservoir by the SFWMD will begin in 2008, pending issuance of all permits and authorizations. The Assistant Secretary of the Army for Civil Works (ASA[CW]) cannot consider awarding credit for the SFWMD design and construction work until the recommended project is authorized and funds are appropriated by Congress

8.1.2 Preconstruction Engineering and Design

Detailed design of the C-43 West Reservoir is currently being conducted by the SFWMD with coordination and review by the USACE under the Acceler8 program. All detailed design and construction will be coordinated with the USACE. Crediting for work performed by the SFWMD will be subject to project authorization and adherence to USACE design standards and regulations. Lands, Easements, Right-of-ways, Relocations and Disposal (LERRDs) will be the responsibility of the SFWMD.

8.1.3 Implementation of Project Operations

A Project Operating Manual has been prepared and is included in ***Annex D*** of this PIR. Modifications of the Project Operating Manual may occur as operational experience and knowledge is gained. An Interim Operating Manual will be completed during the Detailed Design phase of the project to allow for use during the construction phase. The Interim Operating Manual will incorporate any modifications to the Operating Manual resulting from the Detailed Design phase. The USACE and SFWMD will share in the responsibilities for conducting water management operations during the Operational Testing and Monitoring phase. Following completion of the Operational Testing and Monitoring phase, a Final Project Operating Manual will be prepared for the Operations and Maintenance (O&M) phase of the project.

8.2 COST SHARING

The total first cost of the project, including the value of LERRDs and pre-construction engineering and design costs will be shared equally between the Federal government and the non-Federal sponsor and is described in ***Table 8-1***. The non-Federal sponsor will provide cash or manage a portion of construction as necessary to meet its 50 percent share of the total first cost of the project to be balanced according to Section 601 of WRDA 2000 to maintain a 50/50 cost share as measured cumulatively for the entire CERP Program. Section 601 of the WRDA of 2000 and USACE policy requires that the non-Federal sponsor must obtain and provide certification of LERRDs necessary for project implementation.

TABLE 8-1: COST APPORTIONMENT TABLE FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR (OCTOBER 2006 PRICE LEVEL ROUNDED TO THE NEAREST $10,000)

Item	Non-Federal Cost	Federal Cost	Total Cost
PED	$ 22,330,000	$ 22,330,000	$ 44,650,000
Lands & Damages*	$ 52,490,000	$ 27,930,000	$ 80,420,000
Construction Management**	$ 13,500,000	$ 13,500,000	$ 27,000,000
Construction Total	$165,300,000	$189,860,000	$355,170,000
Total	**$253,620,000**	**$ 253,620,000**	**$507,240,000**

Note: Total costs shown are consistent with costs shown through out the report. Due to rounding to the nearest $10,000, numbers may not total correctly.

*Federal costs include Federal funds provided via Grant Agreement entitled Everglades Watershed Restoration-Grant Number LWCF-1 and future estimated administrative expenses of the Federal Government associated with crediting and project implementation.

**Non-Federal Cost for construction total is less than Federal Cost since consideration is given for cost already provided by the Non-Federal Sponsor.

8.2.1 Cost Sharing of Construction and Land Costs for Restoration Features

Section 601 of the WRDA of 2000 and USACE policy requires that the non-Federal sponsor will provide LERRD.

The total first cost of the restoration features of the project, including the value of LERRD and pre-construction engineering and design costs, will be shared equally between the Federal government and the non-Federal sponsor. The non-Federal sponsor will provide cash or manage a portion of construction as necessary to meet its 50 percent share of the total first cost of the project to be balanced according to Section 601 of WRDA 2000.

8.2.2 Cost Sharing of Monitoring

A project monitoring plan, including water quality, hydrometeorological, and ecosystem monitoring has been prepared and is included in ***Annex D*** of this PIR. Water quality and hydrometeorological monitoring will be cost-shared during the construction and O&M phases of the project in accordance with Section 601(b)(2) of WRDA 2000 and USACE policy for cost-sharing of operational monitoring. Ecosystem monitoring will be performed as part of the CERP Adaptive Assessment and Management program implemented by RECOVER. Regional data collected as part of the monitoring program is critical to the refinement of the features and operation of the selected alternative plan by providing the basis for modifications to design and operational criteria as needed.

8.2.3 Cost Sharing of Operations and Maintenance

Section 601(e)(4) of the WRDA 2000 specifies that the O&M of authorized projects of the CERP would be cost shared equally by the Federal government and the non-Federal sponsor. Consistent with the provisions of section 601(e)(4) of the WRDA of 2000 and given the multi-objective nature of the features in this plan, it is appropriate for the Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) associated with this plan to be shared equally between the Federal government and the non-Federal local sponsor. OMRR&R costs associated with recreation features of the plan will be funded 100 percent by the non-Federal local sponsor. Note that the proposed one-lane bridge and boat ramps will be used by operations staff to access the reservoir and are necessary with or without recreation features.

8.3 PROJECT DESIGN

8.3.1 Application of the Design Criteria Memorandums for Hazard Potential Classifications of Impoundments

USACE Engineering Regulation typically provides rules and policies that engineers must follow to correlate their design parameters and decisions to for approval. USACE Engineering Manuals typically provide general guidance in formulations and procedures that can be followed to complete design efforts for typical projects. Therefore, these general based publications allow unique project factors to be considered to optimize designs on a case-by-case basis. The design of impoundments in south Florida is thought to be unique in that the impoundments are not classic cross-stream dams, but include 360° perimeter embankments where each foot of increase in embankment height adds significantly to the cost of the project, especially as normal pool depths for these impoundments are relatively deep (for C-43 West Basin Reservoir, between 17 and 19 feet). Another unique factor for south Florida reservoirs is the high design wind speed that is considered "reasonable" to be applied on the Probable Maximum Flood surcharged pool for High Hazard Potential Classification (HPC) impoundments. These factors led to a series of discussions between the USACE, Jacksonville District and the SFWMD that resulted in the Design Criteria Memorandums (DCMs) that provide selected and USACE approved design formulations and procedures for impoundments in south Florida that adhere to USACE and State of Florida engineering regulations. The following final DCMs were followed in the design of the Caloosahatchee (C-43) West Basin Storage Reservoir:

- DCM-1 Hazard Potential Classification
- DCM-2 Wind and Precipitation Design Criteria for Freeboard
- DCM-3 Spillway Capacity and Reservoir Drawdown Criteria
- DCM-4 Minimum Dimensions of Dams and Embankments

Other draft DCMs were used in the design of other features of the project, some associated with the impoundments, others not. Each DCM lists USACE, State of Florida, or literature references for all supporting data, procedures, and guidance that were used to complete the documentation(s).

DCM-2 produced as a non-binding guidance agreement for the project team's design use, four cases for completing a sensitivity analysis in selection of the embankment design. As a default for all reservoirs with a HPC, Case 1 (scenario that includes the Probable Maximum Flood (resulting from routing the Inflow Design Flood using the Probable Maximum Precipitation event) in combination with the 100-year return frequency wind speed) was the selected condition for design as it claims the more conservative design.

8.4 PROJECT OPERATIONS

8.4.1 Existing Operations

In the Caloosahatchee Drainage Basin, excess water in the eastern basin resulting from Lake Okeechobee releases (at S-77) and basin runoff drains to the west by way of the Caloosahatchee River (C-43 Canal). Releases from the eastern Caloosahatchee basin are then made at S-78 (which serves as the basin divide between the East and West Caloosahatchee River basins) where inflow along the river is passed into the West Caloosahatchee River Basin. Excess stormwater in the western basin also drains to the Caloosahatchee River (C-43 Canal) and along with the inflow from the East Caloosahatchee River (upper) basin is then discharged to the Caloosahatchee Estuary from S-79.

S-77, S-78, and S-79 are operated based on the Water Control Plan for Lake Okeechobee and Everglades Agricultural Area (EAA) (USACE, July 2000). Within the current approved Lake Okeechobee Regulation Schedule (WSE) is an "Operational Guidelines Decision Tree" used for deciding when and how much water can be discharged from Lake Okeechobee to the Caloosahatchee River. The range of water released to the Caloosahatchee River in the decision tree is from "up to maximum discharge" in the case where the lake is in Zone A of the regulation schedule, and "no discharge to tidewater" when the lake is in Zone D and the tributary conditions are dry. The operational flexibility of the WSE schedule allows for adjustments to be made in the timing and magnitude of Lake Okeechobee regulatory discharges based on conditions in the lake and in tributary basins, and on extended meteorological and climate outlooks.

8.4.2 Initial Operating Regime

The Initial Operating Regime is a depiction of the operational conditions that would exist when project operations would commence. For this PIR, initial operating regime baseline assumptions include a consideration of land use and water supply demands in the study area assumed for 2010, operations of the C&SF Project at the time that the selected alternative plan (SAP) is identified, the effect of non-CERP activities with approved operating manuals (if any), and authorized CERP projects with approved operating manuals (none at this point in time). The selected plan features and operations are incorporated into the initial operating regime baseline to prepare the Draft Project Operating Manual consistent with project objectives.

The conceptual intent of the project is that the excess runoff and discharges from Lake Okeechobee in the Caloosahatchee River (C-43 Canal) will be diverted to the reservoir. Water will be released from the reservoir back to the Caloosahatchee River (C-43 Canal) to maintain desirable salinity levels in the Caloosahatchee Estuary as measured by flow at the S-79 (W.P. Franklin Lock

and Dam) structure. Project operations will be dependent upon the stage in the Caloosahatchee River, Lake Okeechobee, the conditions at S-77, S-78, S-79, and the estuary. All of these locations are affected primarily by seasonal and short-term hydrologic and climatic conditions.

After the initial filling of the reservoir and operational testing and verification is complete, initial operating regime project operations will be a function of conditions of flows measured at the S-79 structure. When flows at the S-79 structure are less than 450 cfs, the C43S-1 structure (the main reservoir outflow structure located in Cell 1) will be opened to allow releases from the reservoir. When the flows at S-79 are greater than 450 cfs, releases from the reservoir will end. When excess flows are present in the basin and there is capacity in the reservoir, the C43PS-1 (1,500 cfs pump station) will begin pumping into the reservoir.

Annex D ("Draft Project Operating Manual and Monitoring Plan") contains additional detailed information on operations of all of the project structures.

8.4.3 Initial Operating Regime Local Water Supply Operations

The project is within the LaBelle Private Drainage District (LPDD) service area. The LPDD has historically served both the Berry Groves property (project site) and the Bob Paul property by pumping water from the Townsend Canal to the Header Canal. Irrigation water will continue to be supplied to the Bob Paul property. The existing Berry Groves No. 1 and No. 2 pump stations will remain in operation until project features including C43PS-4, a 150 cfs water supply pump station) and the perimeter canal are constructed and operational testing and verification is complete. The Crawford Canal will still be available to the Bob Paul property for drainage and is not affected by the project.

8.4.4 Future Operations

To depict conditions that are likely to exist in the future for analytical purposes and for purposes of describing future project operations, a next-added increment (NAI) baseline condition is prepared, including projected future (2050) land use and water supply demands and the effects of non-CERP activities. The selected plan features and operations are incorporated into the NAI baseline for inclusion in the Project Operating Manual to ensure that future operations will be consistent with the benefits that justify the project.

For project operations purposes, the conceptual intent of the project applies to both the initial operating regime and NAI operations. For this project, the only significant assumed difference between the initial operating regime and NAI conditions is water supply deliveries to the Caloosahatchee River (C-43 Canal) basin from Lake Okeechobee. As demand for water supply in the basin increases

in the future, additional water could be released from Lake Okeechobee (if available, and based on other C&SF project operations requirements) to meet those demands. However, such water supply releases from Lake Okeechobee would not effect reservoir operations, since filling of the reservoir is based on excess basin flows, and releases from the reservoir are based on maintaining desirable flows at the S-79 structure.

Similar to the initial operating regime, future project operations will be based on flow at the S-79 structure. When flows at S-79 are less than 450 cfs, the C43S-1 structure (the main reservoir outflow structure located in Cell 1) will be opened to allow releases from the reservoir. When the flows at S-79 are greater than 450 cfs, releases from the reservoir will end. When excess flows are present in the basin and there is capacity in the reservoir, the C43PS-1 (1,500 cfs pump station) will begin pumping into the reservoir.

8.4.5 Future Local Water Supply Operations

To maintain water supply to the Bob Paul properties, deliveries will be made via the C43PS-4 structure into the perimeter canal surrounding the reservoir.

8.5 PROJECT ASSURANCES

8.5.1 Level of Service for Flood Protection

Each PIR is required to include an analysis of the project's impacts on levels of service for flood protection that existed on the date of enactment of WRDA 2000, December 2000, and in accordance with applicable law. If a project is expected to result in an impact on the existing levels of service for flood protection, the PIR will modify operations or re-design the project, consider further acquisitions and or formulate other alternatives to address the potential impact. The analysis to determine if there was an impact on existing levels of service for flood protection was conducted on both the system-wide and project level scales.

8.5.1.1 System-wide

The operations of this project will not change the operations of the Caloosahatchee River (C-43 Canal) based on the key assumptions outlined in ***Annex C***. Therefore, there will be no system-wide effects on flood protection as a result of the project.

8.5.1.2 Project Level

Based on an analysis of effects on local groundwater using the local reservoir MIKESHE model as outlined in ***Annex C***, there will be no significant and adverse reduction to existing levels of service for flood protection in the vicinity

of the reservoir. In addition, results of the C-43 Test Cell Pilot Project described in ***Annex C*** support this conclusion. Furthermore, the canal stages and groundwater levels adjacent to the reservoir would be maintained by adjusting the operations of the perimeter canal water levels and its structures as explained in the project operating manual.

8.5.2 Effects on Existing Legal Sources for Water Supply

Each PIR is required to determine if existing legal sources of water are to be eliminated or transferred as a result of project implementation. If a project is expected to result in an elimination or transfer of an existing legal source of water, the PIR shall include an implementation plan that ensures a new source of water of comparable quantity and quality is available to replace the source that is being transferred or eliminated. The analysis to determine if there is an elimination or transfer of existing legal sources was conducted on both the system-wide and project level scales.

8.5.2.1 System-wide

The only system-wide basin affected by the project will be the Western Caloosahatchee Basin and Estuary. The operations of this project, as described in ***Annex C***, will result in no changes in the operations of the Caloosahatchee River (C-43 Canal) or to the source of water to meet agricultural and urban water supply. Therefore, there will be no system-wide effects that eliminate or transfer of existing legal sources of water as a result of this project.

8.5.2.2 Project Level

The project will transfer an existing legal source of water for agricultural water supply on lands adjacent to the project site from a portion of the existing Header Canal within the project's footprint to the perimeter canal surrounding the reservoir. However, the new source (water in the perimeter canal) will be comparable in volume of water available and water quality to the existing conditions. Upon completion of construction, operational testing and monitoring will occur to ensure that the reservoir and structures designed to deliver water from the reservoir to existing agricultural uses will function as intended. The Project Operating Manual includes project operations to ensure that agricultural water supply deliveries will be provided.

8.5.3 Identification of Water Made Available for the Natural System and Water for Other Water-Related Needs

Each project implementation report is required to identify the quantity, timing, and distribution of water to be dedicated and managed for the natural system, the amount of water to be reserved or allocated for the natural system by the

State of Florida, and water made available for other water-related needs of the region.

8.5.3.1 Identification of Water Made Available and Water for Other Water-Related Needs

The Caloosahatchee River (C-43) West Basin Storage Reservoir project was designed to store excess, high-volume flows in the basin (as measured by flows at the S-79 control structure) and to release water to supplement periods of low flows to improve salinity levels towards estuary restoration targets. To achieve the project purpose, all water made available by the project is for the natural system to attain the benefits of the project. Therefore, there will be no water made available for other water-related needs of the region by the project. Unmet municipal, agricultural and natural system needs for water supply will be further investigated in the second PIR to be initiated upon completion of this first PIR.

8.5.3.2 Identification of Water to be Reserved or Allocated for the Natural System

The volume of water to be reserved or allocated by the State of Florida is based on the Initial Operating Regime condition. As shown in ***Annex C***, section C.3.2.3, the 10th, 50th and 90th percentile average annual volumes of additional water for the natural system simulated in the initial operating regime condition were calculated to be approximately 159,485 ac-ft/year, 105,990 ac-ft/year and 27,619 ac-ft/year, respectively. These volumes will be reserved or allocated for the natural system to achieve the benefits of the project.

8.5.4 State and Federal Assurances

The overarching objective of the Comprehensive Everglades Restoration Plan ("Plan") is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Federal Government and the State of Florida are committed to the protection of the appropriate quantity, quality, timing, and distribution of water to achieve and maintain the benefits to the natural system described in the Plan. As envisioned in WRDA 2000 and the Programmatic Regulations, each PIR will identify this appropriate quantity, quality, timing, and distribution of water for the natural system.

The following language sets forth these commitments:

> "The overarching objective of the Plan is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Federal Government and the non-Federal sponsor are committed to the

protection of the appropriate quantity, quality, timing, and distribution of water to ensure the restoration, preservation, and protection of the natural system as defined in WRDA 2000, for so long as the project remains authorized. This quantity, quality, timing, and distribution of water shall meet applicable water quality standards and be consistent with the natural system restoration goals and purposes of CERP, as the Plan is defined in the programmatic regulations. The non-Federal sponsor will protect the water for the natural system by taking the following actions to achieve the overarching natural system objectives of the Plan:

1. Ensure, through appropriate and legally enforceable means under Federal law, that the quantity, quality, timing, and distribution of existing water that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report is available to the natural system, will be available at the time the Project Cooperation Agreement for the project is executed and will remain available for so long as the Project remains authorized.

2a. Prior to the execution of the Project Cooperation Agreement, reserve or allocate for the natural system the necessary amount of water that will be made available by the project that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report.

2b. After the Project Cooperation Agreement is signed and the project becomes operational, make such revisions under Florida law to this reservation or allocation of water that the Federal Government and the non-Federal sponsor determines, as a result of changed circumstances or new information, is beneficial for the natural system.

3. For so long as the Project remains authorized, notify and consult with the Secretary of the Army should any revision in the reservation of water or other legally enforceable means of protecting water be proposed by the non-Federal sponsor, so that the Federal Government can assure itself that the changed reservation or legally enforceable means of protecting water conform with the non-Federal sponsor's commitments under paragraphs 1 and 2. Any change to a reservation or allocation of water made available by the project shall require an amendment to the Project Cooperation Agreement.

8.6 PROJECT MONITORING PLAN

The SAP includes water quality, hydrologic, and environmental monitoring activities to ensure that the intended purposes of the project will be achieved through long-term operations.

Water quality and hydrologic monitoring activities are described in detail in ***Annex D*** ("Draft Project Operating Manual and Monitoring Plans"). Water quality monitoring involves sample collection and analysis for baseline, startup, and operational phases of the project. Water quality parameters to be monitored include physical parameters (i.e., temperature and dissolved oxygen concentration), turbidity, nutrients, and organochlorine compounds. Hydrologic monitoring includes measurements of stage and elevation (groundwater) and flow at water control structures. Project environmental monitoring includes monitoring of nuisance exotic vegetation within the reservoir and the perimeter canal around the reservoir.

A project-specific ecological monitoring plan was also prepared, focusing on estuarine performance measures. Ecological monitoring is recommended to be implemented as part of RECOVER's system-wide Monitoring and Assessment Plan (MAP) efforts and incorporated into the adaptive management (AM) strategy for south Florida ecosystem restoration.

8.7 COMPLIANCE WITH ENVIRONMENTAL LAWS, STATUTES, AND EXECUTIVE ORDERS

For more complete information on all coordination please see Section 9 Summary of Coordination.

TABLE 8-2: COMPLIANCE WITH ENVIRONMENTAL LAWS, STATUTES, AND EXECUTIVE ORDERS

Law, Regulation, or Policy	Status C, P, NC	Status	Compliance
Clean Air Act	C	PIR/EIS will be coordinated with USEPA. Air emissions permit may be required for large diesel pumps; normally applied for during PED phase	Compliance with Section 309 of the CAA will occur with the coordination and review of the PIR/EIS by EPA.
Clean Water Act	P	WQC will be required; NPDES permit will be required ; WQ evaluation completed and included in this PIR/EIS; 404b evaluation included in Annex F	Full compliance upon issuance of the WQC and NPDES permits by the state – before operation of reservoir; as well as review of the Final PIR by State agencies

Law, Regulation, or Policy	Status C, P, NC	Status	Compliance
Coastal Zone Management Act	C	Based on a review of the March 2003 scoping notice and comments provided by the state reviewing agencies, as well as the dPIR, the state has determined that, at this stage, the project is consistent with the Florida Coastal Management Program. CZM consistency review included in Annex F.	Additional consistency review by the state will occur during coordination of the final PIR/EIS.
National Environmental Policy Act (NEPA)	P	NOI published; scoping meetings held; draft PIR/EIS NOA in Federal Register April 27, 2007	Full compliance upon coordination of the final PIR/EIS, public outreach activities completed and signing of the ROD.
Fish and Wildlife Coordination Act	C	Funds transferred annually to FWS; PALs received; Draft CAR received in March 2007; Final CAR received July 2007 and included in Annex A. FWS active team participant; has provided info on fish and wildlife elements on project and been lead on field documentation.	Coordination complete.
Farmland Protection Policy Act	C	Form AD-1006 to NRCS in November 2006, returned to the USACE in January 2007 and re-submitted in March 2007.	Coordination complete.
Endangered Species Act	C	USACE submitted a BA and letter dated 10 January 2007 to USFWS requesting formal consultation on Eastern Indigo Snake, Florida panther, and Audubon's Crested Caracara. Formal consultation is complete. NMFS concurred with Corps' determination for sea turtles and smalltooth sawfish.	Coordination complete.
Magnuson-Stevens Fishery Conservation and Management Act	C	EFH present in Caloosahatchee River. NMFS concurred with Corps EFH evaluation.	Coordination complete.
National Historic Preservation Act	C	Coordination with SHPO has occurred and the Section 106 Process is complete. A determination of no historic properties affected has been made.	Coordination is complete.

Law, Regulation, or Policy	Status C, P, NC	Status	Compliance
RECRA, CERCLA, other HTRW laws	P	Caloosahatchee River (C-43) West Basin Storage Reservoir surveys completed – received recommendation letter from FWS Spring 2006.	Full compliance before construction. WMD responsible for ensuring present lessee provides final assurances.
Coastal Barrier Resources Act and Coastal Barrier Improvement Act	C	The Coastal Barrier Resources on Sanibel Island are being coordinated with USFWS. The project is expected to benefit these resources and is therefore consistent with the Act.	Coordination complete.
Marine Mammal Protection Act	C	The West Indian Manatee does occur in the Caloosahatchee River and associated canals. Incorporation of the safeguards used to protect T&E species during construction and operation would protect any marine mammals in the area. No take of Marine Mammals is expected.	The project is in compliance with the intent of this act.
Marine Protection, Research, and Sanctuaries Act	C	The Caloosahatchee River (C-43) West Basin Storage Reservoir does not involve any ocean dumping nor does it establish a marine sanctuary. The project is in compliance with this act.	The project is in compliance with the intent of this Act.
Estuary Protection Act of 1968	C	The main purpose of this project is to improve flows and salinity to the estuary. The project is in compliance with this act.	The project is in compliance with the intent of this Act.
Anadromous Fish Conservation Act	P	Anadromous fish species are not expected to be adversely affected by this project. The NMFS concurred with the Corps evaluation in the dPIR.	Coordination complete.

Law, Regulation, or Policy	Status C, P, NC	Status	Compliance
Migratory Bird Treaty Act and Migratory Bird Conservation Act	C	Few adverse impacts are expected to migratory birds. The restoration of the estuary should also increase available forage species such as amphibians, fish, and aquatic invertebrates for wading birds. Littoral zones created in the seepage canals may also benefit migratory birds.	Coordination complete.
Wild and Scenic River Act of 1968	C	No designated Wild and Scenic River reaches would be affected by project related activities	The project is in compliance with this Act.
Federal Water Project Recreation Act	C	The recreation plan for the project is included in Appendix H. The project is in compliance with this act.	The project is in compliance with the intent of this Act.
Submerged Lands Act of 1953	C	This project does not occur on submerged lands of the state of Florida.	The project is in compliance with the intent of this Act.
Rivers and Harbors Act of 1899	C	The proposed work would not obstruct navigable waters of the United States.	The project is in compliance with this Act.
E.O. 11988 Floodplain Management	C	The purpose of the EO is to discourage Federally induced development in floodplains. Commitment of lands to reservoirs will preclude such development. In addition, existing flood levels will not be significantly or adversely impacted.	The project is in compliance with this E.O.
EO 11990 Protection of Wetlands	C	The area proposed for the C-43 BSRP is mostly farmland with a few disturbed wetlands. The reservoir design will include areas of littoral shelf along the seepage canal. Construction of the Caloosahatchee River (C-43) West Storage Reservoir will result in the loss of 125 acres of wetlands through discharge of dredge or fill material, excavation, and/or flooding. However, CERP projects are expected to have a net positive lift of wetland function.	This project is in compliance with this EO.

Law, Regulation, or Policy	Status C, P, NC	Status	Compliance
EO 12898 Environmental Justice	C	This E.O. requires consideration of, and avoidance of disproportionately adverse effects on, minority and low-income populations. No such impacts were identified during project scoping. Minimal adverse impacts are expected.	This project is in compliance with this EO.
EO 13089 Coral Reef Protection	C	This project will not adversely impact coral reefs or coral reef resources.	This project is in compliance with this EO.
EO 13112 Invasive Species	C	The project will follow all feasible and prudent measures to minimize the risk of introducing new invasive species. An analysis of invasive species potential impacts is included in Sections 3 and 6.	This project is in compliance with this EO.

C= compliance; P=pending; NC=non compliance

8.8 COMPLIANCE WITH FLORIDA STATUTES

The State of Florida has enacted several laws pertaining to implementation of CERP projects. These include amendments to section 373.026 (8), F.S., which establishes a requirement for the SFWMD to submit a report for review and approval by the FDEP prior to formal submission of a request for authorization from Congress and prior to receiving an appropriation of state funds for construction and other implementation activities (except the purchase of lands from willing sellers); enactment of Section 373.1501, Florida Statue (F.S.), which establishes the intent of the Florida Legislature with respect to the CERP and the criteria for FDEP approval and the procedures to be followed by the SFWMD and FDEP for submitting and reviewing requests for approval; the enactment of Section 373.1502, which establishes permitting requirements and a process for the submittal, review, and issuance of certain regulatory permits for CERP projects; and the enactment of Sections 373.470, and 373.472 F.S. establishing the "Save Our Everglades Trust Fund," funding and reporting requirements, and procedures for distributions from the trust fund. The SFWMD's report addressing the criteria for approval listed in Section 373.1501, F.S. is included in ***Annex C***.

In addition to the above-described statutory requirements, other sections of Chapters 373 (Water Resources) and 403 (Environmental Control) of the F.S. include requirements that may apply to various aspects of CERP project

planning and implementation. In particular, Chapter 403 and the administrative laws adopted in accordance with Chapters 373 and 403 contain the requirements for facilities that involve the discharge or potential discharge of pollutants to surface and ground waters and the discharge of air pollutants, including facilities regulated under the Federal Clean Water and Safe Drinking Water Acts and the Federal Clean Air Act. Based on the information contained in the PIR, the selected plan complies with the applicable provisions of F.S. A detailed explanation of how the project complies with the applicable requirements for CERP projects contained in the F.S. can be found in ***Annex C***.

8.8.1 Permits, Entitlements and Certifications

In as much as construction activities on the Caloosahatchee River (C-43) West Reservoir are scheduled to begin in 2008 in accordance with the schedule for the State of Florida's Accler8 program, the SFWMD will be responsible for obtaining permits issued by the Regulatory Division of the USACE under the authority of Section 404 (discharge of dredged or fill material into waters) of the Clean Water Act (CWA) and any corresponding permits required by the State of Florida in accordance with Chapters 373 and 403 of the F.S.

SFWMD will also be responsible for obtaining the Section 401 (CWA) water quality certification or waiver of water quality certification, as appropriate, from the State of Florida. Typically, water quality certification is obtained through the State of Florida's regulatory program established under the authority of Chapter 373, F.S.

Section 402 National Pollutant Discharge Elimination System (NPDES) permits required under the CWA may be required for the construction (non-point source runoff) of project features. This program has been delegated by the U.S. Environmental Protection Agency (USEPA) for implementation to the State of Florida (FDEP). NPDES permits for construction of project features under the Acceler8 program prior to Federal approval and authorization of the Calooshatchee (C-43) West Basin Storage Reservoir project will be the responsibility of SFWMD. At this time, a NPDES permit will not be required for the operation of Caloosahatchee River (C-43) West Basin Storage Reservoir Project features, as the project does not involve treatment or the discharge of pollutant.

Depending upon the schedule for obtaining Federal review and approval of the project, the USACE will obtain the necessary permits to construct and perform initial operational testing and verification of remaining project features. The cost and schedule for obtaining the necessary permits are included in the project management plan.

8.8.2 Compliance with Applicable Water Quality Standards and Permitting Requirements

The Caloosahatchee River (C-43) West Basin Storage Reservoir project selected plan complies with water quality standards applicable to the project and adjacent waters. The selected plan's features are located in and adjacent to waters designated as Class III by the State of Florida. In accordance with Florida Administrative Code (F.A.C.) Rule 62-302 ("Surface Water Quality Standards"), the use classification of Class III waters is "Recreation, Propagation, and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife." In addition to the minimum and general criteria for surface waters found in Section 62-302.500(1), there are numerous water quality criteria for specific parameters for Class III waters listed in Section 62-302.530, F.A.C. Although the selected plan for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is not expected to affect most of the parameters listed in this rule, certain parameters (e.g., turbidity, certain metals, dissolved oxygen and nutrients) listed in the criteria may be affected by construction and operations activities.

In general, any short-term impacts to water quality associated with construction of the selected plan will be ameliorated by construction sequencing, best management practices (BMPs) for erosion and sedimentation control and monitoring during construction. Longer-term impacts to water quality associated with the operation of project features will be addressed through operational monitoring and AM actions, if potentially adverse affects are observed or predicted.

The selected plan is expected to significantly improve water quality in the study area, especially in the Townsend, Banana Branch and Ft. Simmons canals, by diverting nutrient-laden discharges from the existing canals and drainage basin and routing it through the reservoir. The diversion and storage of canal water in the reservoir and the sequestration and settling of pollutants associated with storage should also improve water quality in canals conveying source water from the reservoir. To the extent that releasing water out of the reservoir may result in the mobilization of water-borne pollutants or pollutants bound in impoundment sediments, operational protocols are included in the operations plan (see ***Annex D***, "Draft Operating Manual") to prevent the release of water not meeting Class III criteria to adjacent surface waters. Water quality in the reservoir is expected to meet Class III criteria, primarily as a result of the water quality improvement functions attributable to the reservoir; however, the Caloosahatchee River (C-43) West Basin Storage Reservoir project is not designed nor will it be operated specifically for the improvement of water quality. Upon completion of construction and initiation of operations, water quality and hydrology will be monitored to determine whether project design and operational objectives are being achieved.

8.9 ENVIRONMENTAL COMMITMENTS

The USACE, the non-Federal sponsor (SFWMD), and contractors commit to avoiding, minimizing, or mitigating for adverse effects during construction activities by taking the following actions:

1. Employ BMPs with regard to erosion and turbidity control. Prior to construction, the construction team should examine all areas of proposed erosion/turbidity control in the field, and make adjustments to the plan specified in the plan control device as warranted by actual field conditions at the time of construction.

2. The contract specifications will prohibit the contractor from dumping oil, fuel, or hazardous wastes in the work area and will require that the contractor adopt safe and sanitary measures for the disposal of solid wastes. The contractor will be required to prepare a spill prevention plan.

3. Demolition debris would be transported to a landfill or otherwise disposed of in accordance with Federal, State, and local requirements. Concrete or paving materials would be disposed of in accordance with Federal, State, and local requirements.

4. Inform contractor personnel of the potential presence of threatened and endangered species in the project area, the need for precautionary measures and the Endangered Species Act prohibition on taking listed species.

5. Any measures or restrictions resulting from Section 7 consultation shall be implemented.

6. The USACE and the SFWMD agree to maintain an open and cooperative informal consultation process with the USFWS and FWC throughout the design, construction, and operation of this restoration project.

7. To protect cultural resources, conditions stipulated by the State Historic Preservation Office (SHPO) will be followed. Language will be included in construction contract specifications outlining the steps to be taken in the event that undiscovered historical properties or unmarked human burials are encountered. An informational training session, developed by a professional archaeologist, will be conducted for the contractor's personnel to explain what kinds of archaeological/cultural materials might be encountered during construction of the impoundment, and the steps to be taken in the event these materials are encountered. A professional archaeologist will conduct periodic monitoring of the project area during ground disturbing activities to determine if activities are impacting unanticipated cultural resources.

8. As required under WRDA 2000, the PDT has identified water to be reserved for ecosystem restoration. This is addressed in ***Annex C*** of this report.

9. As likewise required under WRDA 2000, the SAP has been evaluated in the light of its potential effects on existing legal sources of water and the level of service for flood protection. This is addressed in ***Annex C*** of this report.

10. Compliance with the State of Florida's requirements for approval of CERP projects is also addressed in ***Annex C***.

8.10 VIEWS OF NON-FEDERAL SPONSOR

The non-Federal sponsor (SFWMD) supports the Caloosahatchee River (C-43) West Basin Storage Reservoir project, and has initiated design and construction efforts through the State of Florida's Acceler8 program.

This page intentionally left blank

SECTION 9
SUMMARY OF COOPERATING AGENCIES, COORDINATION, PUBLIC VIEWS, AND COMMENTS

This page intentionally left blank

9.0 PROJECT COORDINATION

9.1 COOPERATING AGENCIES

An official letter inviting USFWS, USEPA, ENP, FFWCC and FDEP to be cooperating agencies (as defined by NEPA) was sent in September 2006. These agencies were chosen because of their special expertise in the area. The selection of these agencies to be invited as cooperating agencies does not exclude any other agencies from full participation in the project.

None of these agencies agreed to be a cooperating agency. The USFWS sent a letter dated October 6, 2006 declining the offer. The reason given for declining the offer was "The Service must balance its role as a study team member with its statutory responsibilities to independently review this proposed action under the Fish and Wildlife Coordination Act and Endangered Species Act."

None of the other agencies replied.

9.2 SUMMARY OF COORDINATION, PUBLIC VIEWS, AND COMMENTS

This NEPA document is an integrated PIR and EIS (PIR/EIS). Early in project planning, a letter notifying interested parties, tribes, and Federal and state agencies was mailed to scope for potential issues or project suggestions. Comments received were evaluated and incorporated into the project planning as appropriate. Please see the NEPA ***Annex B*** for additional information on scoping and comments received. In addition, an interagency team was assembled to prepare and evaluate plans that could be implemented for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. The interagency team includes local (Lee County, Hendry County), state (FFWCC, FDEP, SFWMD), and Federal (USACE, USFWS, USEPA, USGS) representatives.

9.3 SCOPING FOR THE CALOOSAHATCHEE RIVER (C-43) BASIN STORAGE RESERVOIR

In compliance with the NEPA, the Caloosahatchee River (C-43) West Basin Storage Reservoir project initiated a scoping process in early 2002. An initial scoping meeting was held in February/March of 2002, with a follow-up scoping meeting held on May 1, 2003. Following this meeting, a letter was sent to Federal, State, and local stakeholders requesting their assistance in identifying the extent of significant issues to be addressed in this study. A public meeting was held on February 28, 2002 to specifically identify critical fish and wildlife habitat and any threatened or endangered species that may be within the project area or affected by the activities of the project.

Once it was determined that an EIS would be necessary for this project, a Notice of Intent (NOI) to prepare a draft EIS was published in the Federal Register on 28 March 2003. A NEPA scoping letter was sent to Federal, State, and local stakeholders, including those who had earlier expressed an interest in this project. A public meeting, identified in the scoping letter, was held on May 1, 2003 to ensure continued public involvement. This meeting was recorded and all issues identified were noted and reviewed.

9.4 SCHEDULING COORDINATION WITH OTHER AGENCIES

Other agencies were integrally involved in scheduling efforts for both the PIR and PED stages. This is especially true of the SFWMD, through the Acceler8 program and continued scheduling coordination for that effort. USFWS has also been closely involved in order to ensure that all of their statutory requirements for review of the project can be completed. In addition, permitting agencies such as the Florida Department of Environmental Protection have been contacted to ensure that all permits can be coordinated in a timely and consistent manner. Other agencies and organizations were updated on schedules at periodic PDT meetings which were open to agencies and the public.

9.5 OTHER REQUIRED COORDINATION

Compliance with environmental laws is summarized below. The project is currently in compliance with all applicable laws. None of the coordination to date has indicated that the project will have compliance issues in implementing any of the proposed alternatives.

9.6 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

A NOI to prepare a draft EIS for the Caloosahatchee River (C-43) West Basin Storage Reservoir project was published in the Federal Register on March 28, 2003. A scoping letter describing the project objectives and array of alternatives was mailed on 18 March 2003, to Federal, State, and local agencies, Native American Tribes, private organizations, and other interested parties to solicit their views, comments, and information about resources, study objectives, alternatives, and important features within the study area. Comments received were reviewed and incorporated in project planning. This draft PIR/EIS served as the environmental coordination with many agencies. A Notice of Availability was published in the Federal Register on 27 April 2007 when this document was released for public and agency review. Comments received were addressed and are included in ***Annex B***.

9.7 ENDANGERED SPECIES ACT OF 1973

The USACE sent a letter to the USFWS dated January 10, 2007 requesting formal coordination for this project due to potentially adverse impacts to the Florida panther, Eastern indigo snake, and Audubon's crested caracara. A biological assessment (BA) was drafted by the SFWMD contractor, reviewed and edited by the USACE, and submitted by the USACE to the USFWS and NMFS. NMFS concurred with the USACE's determination of "may affect but is not likely to adversely affect" sea turtles or smalltooth sawfish by letter dated March 28, 2007. The USFWS concurred with the Corps' determinations in a biological opinion dated July 20, 2007 (***Annex A***). The USFWS has been an active participant throughout the planning process and continues to coordinate closely with the USACE. The following letters have been provided by the USFWS and are included in ***Annex A***:

- Planning Aid Letters dated August 13, 2003 and March 29, 2005
- Scoping comments dated June 10, 2003
- List of threatened and endangered species in the study area dated April 11, 2002

9.8 FISH AND WILDLIFE COORDINATION ACT OF 1958

The central objective of the Fish and Wildlife Coordination Act (FWCA) is to allow for equal consideration of wildlife resources. Transfer funds have been made available to the USFWS in order to participate in team meetings and workshops scheduled in conjunction with the USACE's planning, implementation, and evaluation process. Funding has also been provided for the USFWS to conduct surveys and investigations necessary to determine impacts of the C-43 project on wildlife resources and to make recommendations to the USACE on measures to prevent loss of or damage to wildlife resources. Recommendations for optimizing opportunities related to the conservation and enhancement of fish and wildlife resources have been provided through the submittal of PALs listed above. A final CAR has been prepared and is included in this PIR in ***Annex A***. Additionally, the FWC has been an active participant on this project and have provided a scoping letter dated June 10, 2003 and comments on the draft PIR dated June 8, 2007.

9.9 NATIONAL HISTORIC PRESERVATION ACT OF 1966 (INTER ALIA) (PL 89-665, THE ARCHEOLOGY AND HISTORIC PRESERVATION ACT (PL 93-291), AND EXECUTIVE ORDER 11593)

The USACE has reviewed information regarding historical properties that might be affected by the C-43 project, in compliance with Section 106 of the National Historic Preservation Act of 1966 (PL89-665), as amended in 2000; its implementing regulations (36 CFR Part 800) and the Archaeological and

Historic Preservation Act of 1974 (PL93-291), as amended. A Phase I survey has been completed on all sections of the C-43 West Reservoir site.

Coordination with the SHPO has occurred and the Section 106 process is complete. In consultation with the Florida SHPO (Florida SHPO numbers 2004-8676 and 2006-07757) a determination of no historic properties affected has been made. This project is in compliance with the National Historic Preservation Act.

9.10 CLEAN WATER ACT OF 1972

A Section 404(b)(1) evaluation is included in ***Annex F***. The Water Quality Certification (WQC) will be met by the Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permit. A NPDES permit will be required and water quality will be evaluated to ensure equal or improved discharge from the reservoir. Prior to constructing the project, the USACE or the local sponsor must obtain water quality certification from FDEP in order to comply with Section 401 of the CWA. The project must be shown to not cause or contribute to violations of state water quality standards. The assessment of water quality impacts prepared for this document indicates that the project will not cause or contribute to violations of state water quality standards. Presently, the local sponsor has applied for and will obtain a 404 permit and a Section 401 Water Quality Certificate from the FDEP to construct and operate the project. It is anticipated that these permits will be issued and the project will comply with these sections of the CWA.

9.11 CLEAN AIR ACT OF 1972

Section 176(c) of the Clean Air Act (CAA) requires that Federal agencies assure that their activities are in conformance with Federally-approved CAA state implementation plans for geographical areas designated as "non-attainment" and "maintenance" areas under the CAA. This project is not located within a "nonattainment" area since there are none of these within the State of Florida. If CAA permits are required for large diesel pumps, the required permits will be obtained during the PED phase. A NOI was issued March 28, 2003 and a scoping letter was sent March 18, 2003. This project will be coordinated with the USEPA for compliance with Section 309 of the Act and with local agencies as a matter of comity. The potential to adversely affect the air quality of nearby residences is expected to be low since the diesel engines that drive the intake pumps will meet the latest USEPA emissions requirements for non-road engines that burn ultra-low sulfur diesel. Additionally, the facility is located in a sparsely populated area of Hendry County where the closest private residence is slightly more than ½ mile from the pump station and where there are no more than 20 houses within 1 mile of the proposed pump station.

9.12 COASTAL ZONE MANAGEMENT ACT OF 1972

Based on a review of the March 18, 2003 scoping notice and comments provided by the state reviewing agencies, the State determined that the project was consistent with the Florida Coastal Management Program. The State later reviewed the draft PIR and stated in a letter dated June 11, 2007 that "the state has determined that, at this stage, the proposed activities are consistent with the Florida Coastal Management Program (FCMP)".

9.13 FARMLAND PROTECTION POLICY ACT OF 1981

USACE submitted form AD-1006 to the NRCS in accordance with the Act. The form was returned to USACE for evaluation and resubmitted by letter dated March 2, 2007. There will be an unavoidable loss of unique farmland which comprises approximately five percent of this type of farmland in Hendry County. Although this is a significant loss, there were several factors which contributed to the selection of this site. The SFWMD has previously purchased the land, making it cost-effective. More importantly, the team was not able to find a contiguous parcel of non-agricultural land in the appropriate location and condition for this reservoir. Therefore the alternatives were limited to agricultural areas. Consultation with NRCS is complete and the project is in compliance with the Farmland Protection Policy Act of 1981.

9.14 WILD AND SCENIC RIVER ACT OF 1968

No designated wild and scenic river reaches would be affected by project related activities.

9.15 MARINE MAMMAL PROTECTION ACT OF 1972

The West Indian manatee does occur in the Caloosahatchee River as well as the Townsend Canal. As a result of consultation between the USFWS, USACE, SFWMD, and FFWCC, a manatee barrier will be placed at the intersection of the Townsend Canal and Caloosahatchee River to protect manatees from any potential harm due to project operations. Incorporation of safeguards used to protect threatened and endangered species during construction and operation would protect the manatee and other marine mammals in the area. The MMPA prohibits, with certain exceptions, the take of marine mammals in United States waters and by United States citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. This project is not expected to result in the "take" of any West Indian manatees.

9.16 ESTUARY PROTECTION ACT OF 1968

The main purpose of this project is to improve flows and salinity to the estuary. The project is in compliance with this Act.

9.17 FEDERAL WATER PROJECT RECREATION ACT

The recreation plan for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project was developed in coordination with the CERP Master Recreation Plan. Details of this plan can be found in the Recreation Appendix. This project is in full compliance with this Act.

9.18 FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976

The intent of this project is to improve estuarine conditions and will therefore improve fisheries. NMFS reviewed the draft EIS and stated in an email dated 30 May 2007 that "NOAA's National Marine Fisheries Service, Southeast Region, Habitat Conservation Division, has reviewed the Department of the Army permit application listed below. We anticipate that any adverse effects that might occur on marine and anadromous fishery resources would be minimal and, therefore, do not object to issuance of the permit." The permit application referred to used this draft EIS as the NEPA document, and therefore NMFS has found the project to be in compliance with this Act.

9.19 SUBMERGED LANDS ACT OF 1953

The project does not occur on submerged lands of the state of Florida. The project is in compliance with this Act.

9.20 COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990

The coastal barrier resources on Sanibel Island are being coordinated with the USFWS. The project is expected to benefit these resources and is therefore consistent with the Act.

9.21 RIVERS AND HARBORS ACT OF 1899

The proposed work would not obstruct navigable waters of the United States. The project is in compliance with this Act.

9.22 ANADROMOUS FISH CONSERVATION ACT

Anadromous fish species are not expected to be adversely affected by this project. NMFS reviewed the draft EIS and stated in an email dated 30 May 2007 that "NOAA's National Marine Fisheries Service, Southeast Region, Habitat

Conservation Division, has reviewed the Department of the Army permit application listed below. We anticipate that any adverse effects that might occur on marine and anadromous fishery resources would be minimal and, therefore, do not object to issuance of the permit." The permit application referred to used this draft EIS as the NEPA document, and therefore NMFS has found the project to be in compliance with this Act.

9.23 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

The project site may be used by migratory birds that could be affected by project activities. Appropriate surveys will be conducted prior to construction. Construction will not take place during nesting seasons in the event migratory bird nest sites are discovered. Also, with the construction of the reservoir, habitat buffer, and littoral shelves, as well as its location adjacent to natural areas, it is anticipated that migratory birds, especially wading birds, would benefit from additional foraging areas provided by the project. The restoration of the estuary should also increase available forage species such as amphibians, fish and aquatic invertebrates for wading birds. The project is in compliance with these acts.

9.24 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

The Caloosahatchee River (C-43) West Basin Storage Reservoir project does not involve any ocean dumping nor does it establish a marine sanctuary. The project is in compliance with this act.

9.25 RESOURCE CONSERVATION AND RECOVERY ACT OF 1976

Phase I and II Environmental Site Assessment work was completed on the site in December of 1999. These investigations identified 40 potential contamination sites within the project boundaries (***Table 9-1***). Seventeen (17) of the 40 sites were designated as requiring no further action because further investigation determined that contamination was not present at levels requiring remedial action. Fifteen (15) of the sites have been identified as presenting a contingent HTRW risk because contamination has been identified and quantified but remediation has either not begun or been completed. An additional five sites have been identified as requiring remediation; however, these sites have not been completely characterized such that a remediation program has been initiated as of March 2006.

The 40 contaminated sites discussed above can be generally categorized as "point source" contamination sites in which the contamination is relatively contained within an area of a few acres or less. The SFWMD is currently working with the

present lessees to ensure that the remaining contaminated sites are remediated prior to the surrender of the lands to the SFWMD.

The HTRW investigations performed to date have identified a number of point source contaminated sites as well as elevated levels of copper in the cultivated soils. Most of the contamination at the point source sites has been delineated and much of it remediated. The remaining sites are expected to be remediated prior to certification of the lands and are not likely to cause a project delay. The copper contamination issue poses a greater risk to the success of the project. At this time, the SFWMD and the USFWS are working together to identify copper hotspots as well as studying potential remediation techniques. Preliminary studies indicate that it is likely that a combination of several remediation techniques will result in an acceptable level of environmental risk to benthic invertebrates, fish, and birds. Proof of the effectiveness of the proposed remediation techniques will have to be submitted to the USACE and the USFWS as part of the 404 permit application process. The FDEP and the USEPA will participate in the environmental risk assessment review through the 404 WQC, and State Environmental Resource Permitting processes.

Until the USFWS has reviewed the results of a revised Phase III audit/Environmental Risk Assessment and the USFWS is satisfied that environmental risk is acceptable, the USACE will not be able to certify the lands for the project purpose nor will the 404 permit for the accelerated project be issued. In other words, the non-Federal sponsor will not be able to build the facility until the USFWS determines that proposed remediation techniques are sufficient. Since the SFWMD has accelerated the construction of the reservoir and proposed remediation techniques appear to be affective, there is only a small risk that the resolution of the copper contamination issue will delay the certification of the project lands as part of the federal project.

TABLE 9-1: LIST OF ACTIVE AND INACTIVE HTRW SITES ON C-43 BASIN PROJECT LANDS

No.	Area of Concern	Environmental Concern	Corrective Action	Risk	Within Reservoir Footprint
TRACT NO. GX-100-001: JACK BERRY					
1	Pole Barns A&B	None identified	NFA	No	--
3	Landfill	None identified	NFA	No	--
4	Former Landfill	None identified	NFA	No	--
5	Former Airstrip	None identified	NFA	No	--
6	Shooting Range	None identified	NFA	No	--
7	Former Spray Field	None identified	NFA	No	--
8	Bone Yard	None identified	NFA	No	--
9	Irrigation Pump Stations	None identified	NFA	No	--
10	Building C, Machine Shop	None Identified, impacted soil	Excavation and off-site disposal	Yes	No
11	Former Nursery	None identified	NFA	No	--
12	Current Airstrip	None identified	NFA	No	--
13	Former UST	Petroleum	Enter in Abandoned Tank Program	Contingent, no impact once clean up is completed	No
14	Building G, Chemical Barn	None identified	NFA	No	-
15	Building E, Maintenance Shop/Fuel Island	Petroleum	Impacted Soil, excavation and off-site disposal	Yes	No
16	Building F vehicle repair	Haz-Solvent based impacted solid-excavation and offsite disposal	Yes		No
17	Equipment Washing Area	Haz-Solvent based	Impacted soil-excavate and off site disposal	Yes	No
18	Wastewater treatment ponds	Hazardous	Impacted soil-excavate and off-site disposal	NO. Clean up completed	--
TRACT NO. GX-100-001: GRIFFIN BROTHERS PROPERTY					
19	Agricultural lands	Metals and Pesticides	Paraquat cease immediately, aldicarb cease one year prior to flooding	Contingent-no impacts if paraquat and aldicarb cease	Yes
20	Canal sediments	Low levels Copper and Penata-chlorophenol	NFA	No	--
21	Maintenance area / chemical barn	Soil impacted-agrochemicals and petroleum	133 tons of impacted soil-excavation and off-site disposal	Contingent, no impact once cleanup is completed	Yes

No.	Area of Concern	Environmental Concern	Corrective Action	Risk	Within Reservoir Footprint
22	Burn area	Soil impacts-copper	121 tons of impacted soils-excavation and off-site disposal	Contingent, no impact once cleanup is completed	Yes
23	Fertilizer mix/load area	Soil impacts-zinc	38 tons of impacted soils-excavation and off-site disposal	Contingent, no impact once cleanup is completed	Yes
24	pump stations	None identified	NFA	No	--
25	Solid waste	None identified	Remove piles of solid waste	Mp	--
TRACT NO. GX-100-005: WINTHROP CITRUS GROVES					
26	Citrus Grove crop area	Metal and pesticides	Paraquat cease immediately, aldicarb cease one year prior to flooding	Contingent, no impact once cleanup is completed	Yes
27	Canal sediments	Low levels of copper	NFA	no	--
28	Agriculture maintenance area	Metals and pesticides	Paraquat cease immediately, aldicarb cease 1 year prior	Contingent, no impacts if paraquat and aldicarb cease	Yes
29	Exploratory oil and Gas well	None identified	NFA	No	--
30	solid waste	None identified	NFA	No	--
31	Maintenance Area A	Petroleum and pesticides	653 tons of impacted soil-excavate and off-site disposal	Contingent, no impacts once cleanup is complete	Yes
32	Maintenance Area B	Petroleum	694 tons of impacted soil, excavate and off-site disposal	Contingent, no impact once clean up is completed	Yes
TRACT NO. GX-100-009: BRYAN PAUL CITRUS INC.					
33	Pump Station	Visible presence of contamination	Soils excavation adjacent to the main pump station and former pump station	Contingent, no impact once clean up is completed	Probable
34	Former Nursery Barn	Arsenic, cadmium, chloropyrifos and malathion	Soil to be excavated and off-site disposal	Contingent, no impact once clean up is completed	Probable
35	Mix station	Metals and petroleum	Impacts to soils - excavate and dispose of soils near structure, groundwater contamination - perform groundwater treatment	Contingent - no impacts once soil excavation and groundwater treatment is completed and 1 year of GW monitoring is done	Probable

No.	Area of Concern	Environmental Concern	Corrective Action	Risk	Within Reservoir Footprint
36	Auxiliary tank area	Metals	Impacted soils-excavation and disposal	Contingent no impact once cleanup is complete	Probable
37	Graded area solid waste	None identified	Solid waste present, scrape and remove waste	no	Probable
38	Burn area	Metals	Removal ash material and excavate and dispose	Contingent no impact once cleanup is complete	Probable
39	Cultivated area	Chlordane	13 acres high level contamination Options: excavate, cover with clean fill, soil inversion	yes	Probable
40	Canal Sediments	Metals	Excavate ash from bank of canal and sediments within the canal adjacent to burn area	Contingent no impact once clean up is complete	Probable

NFA-No further Action
-- Designation not made as no further action required

9.26 TOXIC SUBSTANCES CONTROL ACT OF 1976

The most prevalent chemicals known to have been applied to project area soil are fertilizers, pesticides and herbicides. However, the Toxic Substances Control Act exempts pesticides from its regulations. Extensive HTRW efforts have been undertaken on the site to identify, delineate and remediate contaminated areas. However, until the USFWS has reviewed the results of a revised Phase III audit and ERA to be performed after remediation and the USFWS is satisfied that environmental risk is acceptable, the USACE will not be able to certify the lands for the project purpose.

9.27 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

EFH is present in the Caloosahatchee Estuary. This habitat is discussed in this section under Existing Conditions as well as Effects of the Selected Plan. National Oceanic and Atmospheric Administration (NOAA) agreed to accept the Draft EIS as the EFH assessment. NMFS reviewed the draft EIS and stated in an email dated 30 May 2007 that "NOAA's National Marine Fisheries Service, Southeast Region, Habitat Conservation Division, has reviewed the Department of the Army permit application listed below. We anticipate that any adverse effects that might occur on marine and anadromous fishery resources would be minimal and, therefore, do not object to issuance of the permit." The permit

application referred to used this draft EIS as the NEPA document, therefore NMFS has found the project to be in compliance with this Act.

9.28 EO 11990, PROTECTION OF WETLANDS

The area proposed for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is mostly farmland with a few disturbed wetlands. The reservoir design will include areas of littoral shelf along the seepage canal. These littoral shelves will help to offset the loss of wetlands due to project construction. There will be no wetland mitigation for the federal project. Overall, CERP projects are expected to have a net positive lift of wetland function. However, the state Acceler8 program may have wetland mitigation requirements as a result of the permitting process. A WRAP was performed in 2004 to determine impacts of wetland function related to the proposed project. Details of the WRAP can be found in the final CAR in ***Annex A.*** This project is in compliance with this EO.

9.29 EO 13186 RESPONSIBILITIES OF FEDERAL AGENCIES TO PROTECT MIGRATORY BIRDS

The project has been coordinated with the USFWS concerning migratory birds. The project is expected to benefit migratory birds by improved habitat and increased availability of forage species (amphibians, fish, and aquatic invertebrates) for wading birds. The project is in compliance with this EO.

9.30 EO 11988, FLOOD PLAIN MANAGEMENT

The purpose of the EO is to discourage Federally induced development in floodplains. Commitment of lands to reservoirs will preclude such development. In addition, existing flood levels will not be significantly or adversely impacted. This project is in compliance with this EO.

9.31 EO 12898, ENVIRONMENTAL JUSTICE

This EO requires consideration and avoidance of disproportionately adverse effects on minority and low-income populations. No such area was identified during project scoping. In order to better communicate with minority populations in the area, a Spanish translator has been provided at public meetings. There will be no displacement of homes by this reservoir. Subsistence fishing is expected to improve due to an overall lift in habitat quality resulting in more abundant fisheries. In public outreach efforts to date, only one potential environmental justice issue has been identified. The loss of jobs for low income and minority workers as a result of acquiring agricultural land for the construction of the reservoir would be a potential issue. However, to offset this issue, the SFWMD is conducting training programs to allow local individuals to

acquire the skills needed to construct the reservoirs. Adverse impacts have been considered and minimized to the extent practicable. The project is in compliance with the EO.

9.32 EO 13089, CORAL REEF PROTECTION

This project will not adversely impact coral reefs or coral reef resources; therefore, the project is in compliance with this EO.

9.33 EO 13112, INVASIVE SPECIES

The existing and future problem of invasive species growing within the C-43 West Reservoir site has been considered during the planning process. An evaluation of exotic species was included in Existing Conditions, Future Without Project Conditions, and Effected Environment. All feasible and prudent measures to minimize risk of introducing new invasive species will be followed. The CERP also includes further studies of means and methods to reduce the influence of exotic invasive plant species. The project is in compliance with this EO.

9.34 STATUS OF COORDINATION AND COOPERATION WITH OTHER AGENCIES

This project has been developed with strong cooperation from the USFWS, USDA, NRCS, USEPA, NOAA, USGS, FFWCC and FDEP. The SFWMD is a cost-sharing partner in the study and had been a fully active participant in the formulation of this project and creation of the project report. USEPA, USFWS, and USGS have staffers located in the Planning sections of USACE, Jacksonville Division; these staffers aid in interagency coordination for CERP projects. There has also been local participation in the project from Lee and Hendry counties.

An official letter inviting USFWS, USEPA, ENP, FWC and FDEP to be cooperating agencies (as defined by NEPA) was sent in September 2006. These agencies were chosen because of their special expertise in the area. The selection of these agencies to be invited as cooperating agencies does not exclude any other agencies from full participation in the project. Although none of these agencies decided to become a participating agency, their input will continue to be valued and solicited for the project.

9.34.1 CERP Partnerships and Cooperating Agencies

For the purposes of the Caloosahatchee River (C-43) West Basin Storage Reservoir project and the preparation of this report, the lead agency is the USACE Jacksonville District, and the SFWMD is the non-Federal cost-sharing

partner. As part of the CERP partnership, the SFWMD has several roles as defined in the following Florida Statutes (F.S):

- F.S. 373.470 (3)(c) requires the completion of a PIR prior to the SFWMD entering into a PCA with the USACE;
- F.S. 373.026 (8)(b) requires the SFWMD to submit a PIR to the FDEP for approval prior to the allocation of funds for the construction of CERP projects; and
- F.S. 373.1501(5) requires the SFWMD to analyze and evaluate water supply, water quality, flood protection, threatened and endangered species, and other natural system and habitat needs and to determine that components of the Plan are feasible, efficient, cost-effective, and consistent with the purposes of the CERP.

USEPA, USFWS, and USGS have staffers located in the USACE, Jacksonville District; these staffers aid in interagency coordination for CERP projects. There has also been local participation in the project from Lee and Hendry counties.

9.35 REVIEW OF THE DRAFT CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT

A Notice of Availability of the Draft PIR/EIS was published in the Federal Register on April 27, 2007. The Draft PIR/EIS was sent to local, state, and Federal agencies, private interest groups, and interested public for review and comment in accordance with the Council on Environmental Quality's NEPA regulations and related USACE guidance. Public libraries in the project area were provided copies to maintain in the reference section of the libraries for public review. The Draft PIR/EIS was also posted on www.evergladesplan.org for web viewing. The comment period ended on June 11, 2007. Comments received during the review were considered in preparing the final study documents.

9.35.1 Comments Received and Responses

Many comments were received in response to the Draft PIR/EIS. A matrix of the comments and responses, as well as copies of the correspondence, is provided in ***Annex B***.

9.35.2 List of Agencies, Organizations and Persons to Whom Copies of the Draft PIR/EIS were Sent

The following agencies, groups, and individuals were sent copies of the Draft PIR/EIS:

Native American Tribes
Miccosukee Tribe of Indians of Florida
Seminole Tribe of Florida
Muscogee (Creek) Nation of Oklahoma
Seminole Nation of Oklahoma
Poarch Creek Indian Nation

Federal Agencies
Advisory Council on Historic Preservation
Federal Emergency Management Agency
Council on Environmental Quality
U.S. Environmental Protection Agency
U.S. Department of Agriculture
  Forestry Service
  Natural Resources Conservation Service
U.S. Department of Commerce
  National Oceanic and Atmospheric Administration
    Florida Keys National Marine Sanctuary
    National Marine Fisheries Service
U.S. Department of Energy
U.S. Department of Housing and Urban Development
U.S. Department of the Interior
  Bureau of Indian Affairs
  U.S. Fish and Wildlife Service
  U.S. Geological Survey
  National Park Service
  Office of Environmental Policy and Compliance
U.S. Department of Justice
U.S. Coast Guard
U.S. Department of Transportation
  Federal Highway Administration
U.S. Public Health Service

State Agencies
Office of the Governor
Florida House of Representatives, Environmental Protection Committee
Florida Coastal Management Program
Florida Department of Agriculture and Consumer Services
Florida Department of Community Affairs
Florida Department of Environmental Protection
Florida State Clearinghouse
Florida Fish and Wildlife Conservation Commission
Florida Department of Transportation
Florida Division of Forestry
Florida Division of Historical Resources–SHPO

Florida Division of State Lands
South Florida Water Management District
Florida Geological Survey

Regional Governments
Central Florida Regional Planning Council
South Florida Regional Planning Council

County Governments
Lee County
Hendry County
Glades County
Charlotte County

Municipalities
City of LaBelle
City of Fort. Myers
City of Clewiston
City of Moore Haven
City of Cape Coral
City of Bonita Springs

Groups
Arthur R. Marshall Foundation
Audubon Society
Caribbean Conservation Corporation
Defenders of Wildlife
Dredging Contractors of America
Environmental Defense Fund
Everglades Coordinating Council
Everglades Foundation
Florida Audubon Society
Florida Defenders of the Environment
Florida Wildlife Federation
Friends of Florida
Friends of the Everglades
Izaak Walton League of America, Inc.
League of Women Voters
National Audubon Society
National Parks and Conservation Association
National Resources Defense Council
National Sierra Club
National Wildlife Federation
Reefkeeper International
Save the Manatee Club

Sierra Club
The Nature Conservancy
The Wilderness Society
World Wildlife Fund

Individuals
A list of individuals who received the Draft PIR/EIS is on file in the Jacksonville District of the USACE at the address shown on the cover page of this document.

This page intentionally left blank

SECTION 10
RECOMMENDATIONS

This page intentionally left blank

10.0 DISTRICT ENGINEER'S RECOMMENDATION

The Caloosahatchee River (C-43) West Basin Storage Reservoir project will provide an above-ground storage reservoir (including pump stations and water control structures) and associated conveyance canals as a cost-effective solution to achieving estuarine restoration benefits in the Caloosahatchee Estuary, which is integral to achieving system-wide benefits in the south Florida ecosystem. The Project will help reduce wet season high volume flows from Lake Okeechobee and contributing basin runoff from the lower West Caloosahatchee River Basin by capturing and storing a portion of these flows in the reservoir. Then during the dry season when water levels are at their lowest, water will be released from the reservoir to the Caloosahatchee River (C-43 Canal) to promote a healthy salinity balance in the estuary, thereby reducing saltwater migration into the freshwater portion of the estuary. In addition, the plan achieves the benefits of the Project as previously developed for the CERP.

This Project is integral to achieving restoration in the Caloosahatchee Estuary and plays an important role in meeting the CERP system-wide ecosystem restoration goals and objectives and other water-related needs of the region. Fish and wildlife habitat benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir project includes improving the timing of water deliveries to the estuary thereby providing a salinity range suitable for a healthy ecosystem and reestablishment of natural hydropatterns within existing natural areas, improvement in seagrass beds in the estuary, and increase habitat for the eastern oyster, blue crab, and other fish and marine organisms. The Project is expected to produce a total of 12,809 average annual habitat units (HUs). Further, this Project is a critical building block upon which a subsequent study will be able to evaluate and achieve broader ecosystem restoration objectives in the Caloosahatchee River Watershed (includes the East Caloosahatchee River (upper) and West Caloosahatchee River (lower) fresh water river basin and the tidal basin).

I find that the Caloosahatchee River (C-43) West Basin Storage Reservoir project, located in western Hendry County, is an integral part of CERP. The Caloosahatchee River (C-43) West Basin Storage Reservoir project Recommended Plan features a reservoir with a storage capability of 170,000 ac-ft, a normal pool storage depth between 15 and 25 feet with a footprint of approximately 10,700 acres (of which approximately 10,480 acres are required in fee, approximately 20 acres will be perpetual easements, and approximately 200 acres will be used on a temporary basis for staging area).. The reservoir includes an individual inflow pump station of 1500 cfs capacity, discharge structures, emergency overflow spillways, and seepage control canals with associated structures. The reservoir may also provide opportunities to increase flood damage reduction capabilities through operational changes to the C&SF Project and local drainage systems. However, these opportunities are considered incidental and are not claimed as benefits. Additionally, the reservoir may provide some water quality improvements in the Townsend, Banana Branch and Ft. Simmons Branch canals and other areas. Again, these opportunities are considered incidental and are not claimed as benefits.

Therefore, I recommend that the Caloosahatchee River (C-43) West Basin Storage Reservoir project as described in the section of the report entitled "The Selected Plan", with such modifications that may be deemed advisable at the discretion of the Chief of Engineers, be

authorized for construction. The total estimated first cost for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is $570,480,000 (October 2009 price level).The total first cost for the Caloosahatchee River (C-43) West Basin Storage Reservoir project includes recreation features totaling $2,930,000. The estimated total annual cost of OMRR&R of the ecosystem restoration elements is $3,100,000 with an estimated Federal annual OMRR&R cost of $1,550,000 and an estimated non-Federal OMRR&R cost of $1,550,000. The estimated cost for OMRR&R of the recreation elements is $25,000 which is 100 percent non-Federal.

The above recommendations are made with the provision that the non-Federal sponsor and the Secretary of the Army shall enter into a binding agreement defining the terms and conditions of cooperation for implementing the Project, and that the non-Federal sponsor agrees to perform the following items of local cooperation:

a. Provide 50 percent of total project costs consistent with the provisions of Section 601(e) of the Water Resources Development Act of 2000 as amended including authority to perform design and construction of project features consistent with Federal law and regulation.

b. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations that the Government and the Non-Federal Sponsor jointly determine to be necessary for the construction, operation, maintenance, repair, replacement and rehabilitation of the Project and valuation will be in accordance with the Master Agreement.

c. Shall not use the ecosystem restoration features or lands, easements, and rights-of-way required for such features as a wetlands bank or mitigation credit for any other projects.

d. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land that the non-Federal sponsor owns or controls for access to the Project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project;

e. Assume responsibility for operating, maintaining, repairing, replacing, and rehabilitating (OMRR&R) the Project or completed functional portions of the Project, including mitigation features, in a manner compatible with the Project's authorized purposes and in accordance with applicable Federal and State laws and specific directions prescribed in the OMRR&R manuals and any subsequent amendments thereto. Cost sharing for OMRR&R will be in accordance with Section 601 of WRDA 2000 as amended;

f. The non-Federal Sponsor shall operate, maintain, repair, replace and rehabilitate the recreation features of the Project with responsibility for 100 percent of the cost;

g. Keep the recreation features, and access roads, parking areas, and other associated public use facilities, open and available to all on equal terms;

h. Unless otherwise provided for in the statutory authorization for this Project, comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the WRDA of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the Project or separable element;

i. Hold and save the Government free from all damages arising from construction, operation, maintenance, repair, replacement and rehabilitation of the Project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors;

j. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project to the extent and in such detail as will properly reflect total project costs and comply with the provisions of the Master Agreement;

k. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the Project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government;

l. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-ways that the Government determines necessary for construction, operation, maintenance, repair, replacement and rehabilitation;

m. As between the Government and the non-Federal Sponsor, the non-Federal Sponsor shall be considered the operator of the Project for purposes of CERCLA liability. To the maximum extent practicable, the non-Federal Sponsor shall operate, maintain, repair, replace, and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA;

n. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration

features, hinder operation and maintenance of the project, or interfere with the project's proper function;

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

p. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army;" and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708[revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c)];

q. Comply with Section 106 of the National Historic Preservation Act in completion of all consultation with the Florida State Historic Preservation Officer, and as necessary, the Advisory Council on Historic Preservation, prior to construction as part of the preconstruction engineering and design phase of the project;

r. Provide 50 percent of that portion of total cultural resource preservation mitigation and data recovery costs attributable to the Project that are in excess of one percent of the total amount authorized to be appropriated for the Project;

s. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized and in accordance with Section 601 (e)(3) of the WRDA of 2000, as amended, and in accordance with the Master Agreement;

t. The Non-Federal Sponsor agrees to participate in and comply with applicable Federal floodplain management and flood insurance programs consistent with its statutory authority.

    1. Not less than once each year the Non-Federal Sponsor shall inform affected interests of the extent of protection afforded by the Project.

    2. The Non-Federal Sponsor shall publicize flood plain information in the area concerned and shall provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood

plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the Project.

3. The Non-Federal Sponsor shall comply with Section 402 of WRDA 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to have prepared, within one year after the date of signing a PPA for the Project, a floodplain management plan. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by non-Federal interests to preserve the level of flood protection provided by the Project. As required by Section 402, as amended, the non-Federal interest shall implement such plan not later than one year after completion of construction of the Project. The Non-Federal Sponsor shall provide an information copy of the plan to the Government upon its preparation.

4. The Non-Federal Sponsor shall prescribe and enforce regulations to prevent obstruction of or encroachment on the Project or on the lands, easements, and rights-of-way determined by the Government to be required for the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project, that could reduce the level of protection the Project affords, hinder operation or maintenance of the Project, or interfere with the Project's proper function.

u. The overarching objective of the Plan is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Federal Government and the non-Federal sponsor are committed to the protection of the appropriate quantity, quality, timing, and distribution of water to ensure the restoration, preservation, and protection of the natural system as defined in Section 601 of WRDA 2000, for so long as the project remains authorized. This quantity, quality, timing, and distribution of water shall meet applicable water quality standards and be consistent with the natural system restoration goals and objectives of the CERP, as the Plan is defined in the Programmatic Regulations. The non-Federal sponsor will protect the water for the natural system by taking the following actions to achieve the overarching natural system objectives of the Plan:

1. Ensure, through appropriate and legally enforceable means under Florida law, that the quantity, quality, timing, and distribution of existing water that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report is available and beneficial to the natural system, will be available at the time the Project Partnership Agreement for the project is executed and will remain available for so long as the Project remains authorized.

2. (a) Prior to the execution of the Project Partnership Agreement, reserve or allocate for the natural system the necessary amount of water that will be made available by the project that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report.

   (b) After the Project Partnership Agreement is signed and the project becomes operational, make such revisions under Florida law to this reservation or allocation of water that the non-Federal sponsor determines, as a result of changed circumstances or new information, is necessary for the natural system.

3. For so long as the Project remains authorized, notify and consult with the Secretary of the Army should any revision in the reservation of water or other legally enforceable means of protecting water be proposed by the non-Federal sponsor, so that the Federal Government can assure itself that the changed reservation or legally enforceable means of protecting water conform with the non-Federal sponsor's commitments under paragraphs 1 and 2. Any change to a reservation of water made available by the project shall require an amendment to the Project Partnership Agreement.

Section 601(e)(5)(B) of the WRDA 2000 authorizes the Secretary of the Army to provide credit to the non-Federal sponsor for work completed by it during the period of construction pursuant to a PCA and a determination by the Secretary that the work is integral to the CERP. As part of its initiative for early implementation of certain expedited CERP projects, formerly known as the "Acceler8 Program", the non-Federal sponsor has stated that it may construct portions of the Caloosahatchee River (C-43) West Basin Storage Reservoir project consistent with this report, in advance of Congressional authorization and the signing of a PCA. The non-Federal sponsor is exploring alternative project delivery methods to expedite implementation of the Project. Such delivery methods may include public-private partnerships in which the non-Federal sponsor contracts with a private or not-for-profit entity for services that may include designing, building, operating or financing these components. I believe that it would be in the public interest for this Project to be implemented expeditiously due to the early benefits to the surrounding habitat, as well as hydrologic benefits to Federal lands and estuaries in other portions of the south Florida ecosystem. Therefore, I recommend that should the non-Federal sponsor construct portions of the Caloosahatchee River (C-43) West Basin Storage Reservoir project prior to the execution of a PAC for this Project, the non-Federal sponsor be credited for such construction costs at the time the PAC for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is executed. Such credit would be applied toward the non-Federal sponsor's share of the costs associated with the implementation of the CERP as authorized by Section 601(e)(5)(C) of WRDA 2000, shall not include cash reimbursements, and shall be subject to: a) the authorization of the Caloosahatchee River (C-43) West Basin Storage Reservoir project by law; b) a determination by the Secretary of the Army that the activities are integral to the CERP restoration project; c) a certification by the District Engineer that the costs are reasonable, allowable, necessary, auditable, and allocable; and d) a certification by the District Engineer

that the activities have been implemented in accordance with USACE design and construction standards and applicable Federal and State laws.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding.

However, prior to transmittal to the Congress, the Sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Alfred A. Pantano
Colonel, Corps of Engineers
District Engineer

This page intentionally left blank

SECTION 11
LIST OF REPORT PREPARERS

This page intentionally left blank

11.0 PREPARERS OF THE PIR

Preparer	Agency	Email Address	Phone Number
Ali, Alison	USACE	Alison.Ali@usace.army.mil	904-232-3135
Allen, Nancy	USACE	Nancy.Allen@usace.army.mil	904-232-3206
Apple, David	USACE	David.Apple@usace.army.mil	904-232-1757
Ayuso, Antonio	USACE	Antonio.Ayuso@usace.army.mil	904-232-2118
Barnes, Tomma	PBS&J	TKBarnes@pbsj.com	504-841-2226
Bond, Carrie	USACE	Carrie.Bond@usace.army.mil	904-232-1061
Bush, Eric	USACE	Eric.L.Bush@usace.army.mil	904-232-1517
Bushnell, Wesley	USACE	Wesley.Bushnell@usace.army.mil	256-895-1313
Byrd, Sue	EPJV	Sue.K.Byrd@usace.army.mil	904-232-1735
Caulk, Grady	USACE	Grady.Chaulk@usace.army.mil	904-232-1786
Chamberlain, Robert	SFWMD	Rchambe@sfwmd.gov	561-338-1668
Conner, Susan	USACE	Susan.Conner@usace.army.mil	904-232-1782
Cornwell, Brian R.	USACE	Brian.R.Cornwell@usace.army.mil	904-232-2915
Dabbs Jr, Clyde	SFWMD	Cldabbs@sfwmd.gov	239-338-2929
Doering, Peter	SFWMD	pdoering@sfwmd.gov	561-682-2772
Duever, Michael	SFWMD	Mduever@sfwmd.gov	239-338-2929
Dunne, Robert M.	USACE	Robert.M.Dunne@usace.army.mil	904-232-1539
Goral, Cem S.	USACE	Cem.S.Goral@usace.army.mil	904-232-2212
Henderson, Robert	USACE	Robert.E.Henderson@usace.army.mil	904-232-2437
Hightower, Ginevra	USACE	Ginevra.A.Hightower@usace.army.mil	904-232-1075
Hitchmon, Kamili T.	USACE	Kamili.T.Hitchmon@usace.army.mil	904-232-2773
Ho, Tien	EPJV	Tien.Ho@saj02usace.army.mil	904-232-1978
Itani, Samir Y	USACE	Samir.Y.Itani@army.mil	904-232-2933
Kelly, Aaron	USACE	Aaron.Kelly@usace.army.mil	904-232-2531
Kremer, John G.	USACE	John.G.Kremer@usace.army.mil	904-232-3551
Marlowe, Beth	USACE	Beth.A.Marlowe@usace.army.mil	904-232-1167
Martin, Patrick	SFWMD	pmartin@sfwmd.gov	561-753-2400
Mazourek, Joyce	USFWS	Joyce_Mazourek@fws.gov	239-472-1100
McAuley, Fred M.	USACE	Fred.M.McAuley@usace.army.mil	904-232-1903
McCaffrey, Jessica C.	USACE	Jessica.C.McCaffrey@usace.army.mil	904-232-2081
McCallion, Kathleen	EPJV	Katie.A.McCallion@usace.army.mil	904-232-1580
McVicker, LuAnn	SFWMD	lmcvicke@sfwmd.gov	561-242-5520
Metzler, Frank T.	EPJV	Frank.T.Metzler@saj0.usace.army.mil	904-232-1737
Meyer, Miles A.	USFWS	Miles_Meyers@fws.gov	904-232-1826
Mills, Brenda	SFWMD	bmills@sfwmd.gov	561-682-6311
Morgan, Jr., John	SFWMD	jmorganj@sfwmd.gov	561-681-2563
Nelson, Don	USACE	Don.Nelson@usace.army.mil	904-232-3874
Nelson, Jennifer	FDEP	Jennifer.Nelson@dep.state.fl.us	239-332-6975
Goines, Sonya B	USACE	Sonya.B.Goines@usace.army.mil	904-232-1004
Owosina, Akintunde	SFWMD	aowosin@sfwmd.gov	561-682 2924

Perez, Manual	USACE	Manual.Perez@usace.army.mil	904-232-1967
Pilinski, Stanley J.	USACE	Stanley.J.Pilinski@usace.army.mil	904-232-2761
Policastro, Marcy	EPJV	Marcy.Policastro@usace.army.mil	904-232-3332
Raulerson, Stephanie	USACE	Stephanie.L.Raulerson@usace.army.mil	904-232-1612
Redican, Joseph	USACE	Joseph.H.Redican@usace.army.mil	904-232-2479
Robbins, Erica	USACE	Erica.A.Robbins@usace.army.mil	561-683-1577
Roth, Stacey L.	USACE	Stacey.L.Roth@usace.army.mil	904-232-1055
Rousso, Stephanie J	FWC		941-575-5784
Shafer, Mark D.	USACE	Mark.D.Shafer@usace.army.mil	904-232-3594
Shuff, Sheldon	USACE	Sheldon.Shuff@usace.army.mil	904-232-1635
Sofia, Suzanne C.	USACE	Suzanne.C.Sofia@usace.army.mil	904-232-2785
Starnes, Janet	SFWMD	jstarne@sfwmd.gov	239-338-2929
Story, Graham N	USACE	Graham.N.Story@usace.army.mil	904-232-1158
Switanek, Milton P.	USACE	Milton.P.Switanek@usace.army.mil	904-232-1746
Taylor, Larry E	USACE	Larry.E.Taylor@usace.army.mil	904-232-1911
Teets, Tom	SFWMD	tteets@sfwmd.gov	561-682-6780
Walker, Al	USACE	Alfred.e.walker@usace.army.mil	904-2321818
White, Tori K.	USACE	Tori.White@usace.army.mil	561-472-8888
Wittman, Kevin M	USACE	Kevin.M.Wittmann@usace.army.mil	904-232-1058

SECTION 12
INDEX

This page intentionally left blank

INDEX

A

Abstract, i, 2-58, 13-18, 14-3
Acceler8, iii, iv, xx, xxiii, xxiv, xxviii, 1-20, 1-21, 1-22, 2-19, 5-3, 5-19, 5-24, 5-51, 6-29, 6-50, 7-1, 7-2, 7-17, 8-1, 8-18, 8-21, 9-2, 9-13, 10-5
Acronyms, xxxvi, 12-2, 13-1
Adaptive Assessment, 8-3, 13-1
Aesthetics, xxix, 2-62, 6-8
Agricultural Areas, iii, xxix, xxx, xxxviii, xxxix, 1-15, 1-18, 2-8, 2-13, 2-14, 2-55, 2-56, 2-61, 2-1, 2-2, 3-8, 3-21, 3-22, 3-23, 3-25, 3-26, 4-4, 4-17, 4-18, 5-4, 5-51, 6-12, 6-16, 6-17, 7-35, 8-5, 9-10, 9-11, 9-16, 9-17, 13-15, 13-17, 13-18, 13-21
Air Quality, xxix, xxx, xxxii, xxxiii, 2-50, 2-1, 3-14, 5-1, 5-2, 6-6, 6-34, 6-35, 6-47, 13-1
Alternative 1, xxxi, 4-1, 5-15, 5-24
Alternative 2, xi, xxxi, xxxii, xxxix, 4-1, 4-2, 5-15, 5-16, 5-18, 5-20, 5-24, 5-28, 5-35, 5-37, 5-39, 5-41, 5-42, 5-45, 5-1, 6-10, 6-11, 6-12, 6-15, 6-18, 6-19, 6-42
Alternative 3A, xxxix, 4-2, 5-19, 5-20, 5-24, 5-28
Alternative 3B, xi, xii, xiii, xxxii, 5-19, 5-20, 5-24, 5-28, 5-35, 5-37, 5-39, 5-41, 5-43, 5-45, 5-47, 5-50, 5-60, 5-1, 6-12, 6-13, 6-15, 6-16, 6-18, 6-42, 6-1, 7-1, 7-17, 7-27, 7-29
Alternative 3C, xi, xii, xxxi, xxxix, 4-1, 4-2, 5-20, 5-21, 5-22, 5-24, 5-29, 5-35, 5-37, 5-39, 5-41, 5-42, 5-43, 5-45, 5-46, 5-47, 5-49, 5-50, 6-15, 6-33, 6-42, 7-27
Alternative 4, xi, xxxi, xxxviii, xxxix, 4-1, 4-2, 5-21, 5-22, 5-23, 5-24, 5-29, 5-36, 5-37, 5-39, 5-41, 5-43, 5-49, 6-10, 6-11, 6-13, 6-15, 6-19, 6-42
Alternative 4A, xi, xxxi, xxxix, 4-1, 4-2, 5-21, 5-22, 5-24, 5-29, 5-35, 5-37, 5-39, 5-41, 5-43, 5-49, 6-10, 6-11, 6-13, 6-15, 6-19, 6-42
Alternative 4B, xxxi, xxxviii, xxxix, 4-1, 4-2, 5-22, 5-23, 5-24
Alternatives
  Final Array, xxxi, xxxix, 4-1, 4-2, 5-15, 5-24, 5-25, 5-31, 5-36, 5-37, 5-38
Anadromous Fish Conservation Act, xxxv, 8-15, 8-1, 9-7
Annual Costs, 7-14
Aquifer Storage and Recovery, xxviii, 13, 5-8, 5-12, 13-1, 13-17
ASR, x, xxvii, 1-2, 1-11, 1-13, 4-3, 5-9, 5-8, 5-9, 13-1, 13-17
Authorization, 13-1

B

Background, 5-34
Benefit, 6-32
Berry Groves, xxix, xxxiv, xxxviii, 1-20, 1-22, 2-50, 2-51, 2-52, 2-53, 2-54, 3-14, 4-1, 5-13, 5-14, 5-21, 5-24, 5-27, 6-28, 6-34, 6-36, 6-1, 7-19, 7-20, 7-21, 8-6
Best Management Practices, 1-18, 3-8, 5-10, 5-11, 13-2, 13-17
Biological Assessment, 2-25, 6-26, 6-29, 13-17

C

C&SF Project Modifications, xxx, 2-1, 3-5
C-43 Basin, xxvii, xxviii, xl, 1-6, 1-10, 1-11, 1-12, 1-13, 1-16, 1-19, 1-22, 6-20, 8-2, 9-10, 13-11, 14-2
C-43 Basin Storage Reservoir, xxvii, 1-16, 1-19, 6-20
C-43 Canal, v, viii, ix, x, xv, 1-2, 1-6, 1-9, 2-7, 2-8, 2-10, 2-15, 3-4, 4-1, 4-12, 4-19, 5-4, 5-16, 5-18, 5-26, 6-14, 7-3, 7-6, 7-24, 8-5, 8-6, 8-7, 8-8, 10-1
C-43 West Reservoir, 7-1, 8-1, 9-4, 9-14
Caloosahatchee Basin, x, xi, xii, xxvii, xxxvii, 1-3, 1-6, 1-7, 1-8, 1-10, 1-11, 1-13, 1-18, 1-19, 1-20, 1-21, 1-22, 2-2, 2-7, 2-8, 2-9, 2-15, 2-16, 2-20, 2-22, 2-26, 2-31, 2-32, 2-34, 3-4, 3-8, 3-9, 3-10, 3-13, 3-16, 3-17, 3-25, 3-26, 4-5, 4-6, 4-8, 4-11, 4-12, 4-19, 4-20, 4-21, 4-22, 5-4, 5-9, 5-13, 5-27, 5-49, 5-50, 6-16, 6-17, 6-19, 6-20, 7-12, 7-38, 8-8
Caloosahatchee Estuary, i, v, vii, viii, ix, x, xii, xiv, xv, xvi, xvii, xviii, xix, xxiv, xxv, xxx, xxxvii, 1-2, 1-3, 1-8, 1-9, 1-10, 1-15, 1-19, 2-1, 2-14, 2-15, 2-16, 2-17, 2-22, 2-24, 2-33, 2-34, 2-35, 2-37, 2-38, 2-39, 2-40, 2-41, 2-42, 2-44, 2-46, 2-50, 2-58, 2-59, 2-1, 3-1, 3-5, 3-7, 3-8, 3-10, 3-12, 3-13, 3-28, 3-1, 4-5, 4-6, 4-7, 4-8, 4-9, 4-11, 4-12, 4-13, 4-14, 4-15, 4-16, 4-17, 4-18, 4-19, 4-20, 4-21, 4-23, 4-24, 4-29, 4-32, 5-1, 5-4, 5-8, 5-15, 5-21, 5-26, 5-27, 5-32, 5-33, 5-46, 5-53, 5-60, 6-5, 6-10, 6-12, 6-15, 6-16, 6-32, 6-33, 6-48, 7-1, 7-25, 7-26, 7-27, 7-31, 7-33, 7-38, 8-5, 8-6, 9-12, 10-1, 14-1, 14-2, 14-3
Caloosahatchee River, i, iii, iv, v, vi, vii, viii, ix, x, xi, xii, xiii, xiv, xv, xvii, xviii, xix, xx, xxii, xxiii, xxv, xxvi, xxvii, xxviii, xxxiv, xxxv, xxxvii, xxxviii, xxxix, xl, 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, 1-10, 1-11, 1-12, 1-13, 1-14, 1-15, 1-16, 1-18, 1-19, 1-20, 1-21, 1-22, 2-1, 2-2, 2-4, 2-6, 2-7, 2-8, 2-9, 2-11, 2-13, 2-14, 2-15, 2-18, 2-19, 2-20, 2-22, 2-23, 2-24, 2-25, 2-28, 2-29, 2-31, 2-33, 2-34, 2-35, 2-36, 2-37, 2-40, 2-51, 2-52, 2-54, 2-59, 2-61, 3-2, 3-4, 3-5, 3-8, 3-9, 3-14, 3-22, 3-1, 4-1, 4-5, 4-7, 4-8, 4-9, 4-10, 4-11, 4-12, 4-14, 4-17, 4-18, 4-19, 4-20, 4-22, 4-28, 4-30, 4-33, 5-1, 5-2, 5-4, 5-5, 5-8, 5-9, 5-12, 5-13, 5-15, 5-18, 5-21, 5-24, 5-25, 5-26, 5-31, 5-32, 5-33, 5-34, 5-41, 5-42, 5-43, 5-46, 5-47, 5-48, 5-54, 5-59, 5-60, 6-3, 6-6, 6-8, 6-10, 6-11, 6-14, 6-15, 6-16, 6-18, 6-23, 6-24, 6-26, 6-27, 6-28, 6-29, 6-30, 6-32, 6-34, 6-38, 6-42, 6-43, 6-44, 6-45, 6-48, 6-49, 6-51, 6-1, 7-1, 7-2, 7-3, 7-6, 7-7, 7-12, 7-14, 7-15, 7-17, 7-18, 7-19, 7-24, 7-25, 7-26, 7-27, 7-28, 7-29, 7-30, 7-31, 7-32, 7-34, 7-35, 7-36, 7-37, 7-38, 7-39, 7-40, 7-41, 7-1, 8-1, 8-2, 8-5, 8-6, 8-7, 8-8, 8-9, 8-13, 8-14, 8-16, 8-17, 8-18, 8-19, 8-21, 8-1, 9-1, 9-2, 9-6, 9-8, 9-13, 9-15, 10-1, 10-2, 10-5, 13-2, 13-18, 14-1, 14-2, 14-3, 14-4
Caloosahatchee Water Management Plan, ix, 1-10, 1-18, 4-25, 5-2, 6-48, 13-17
CERP, iii, iv, v, vi, ix, xi, xii, xvi, xvii, xx, xxi, xxiii, xxiv, xxvi, xxvii, xxviii, xxxiv, xxxvi, xxxix, 1-1, 1-2, 1-3, 1-5, 1-9, 1-10, 1-11, 1-12, 1-13, 1-16, 1-17, 1-18, 1-20, 1-21, 1-22, 2-38, 2-40, 3-8, 3-9, 3-11, 3-22, 3-1, 4-1, 4-4, 4-8, 4-11, 4-16, 4-17, 4-21, 4-22, 4-24, 4-28, 4-33, 5-1, 5-2, 5-3, 5-4, 5-5, 5-13, 5-15, 5-25, 5-26, 5-32, 5-36, 5-41, 5-42, 5-46, 5-48, 5-51, 5-52, 5-54, 5-56, 5-57, 5-58, 5-59, 5-60, 6-4, 6-18, 6-20, 6-

24, 6-29, 6-43, 6-44, 6-45, 6-46, 6-47, 6-48, 6-50, 6-1, 7-1, 7-18, 7-25, 7-26, 7-27, 7-28, 7-29, 7-30, 7-31, 7-33, 7-39, 7-40, 7-42, 8-2, 8-3, 8-5, 8-7, 8-10, 8-16, 8-17, 8-20, 8-1, 9-6, 9-13, 9-14, 9-15, 10-1, 10-5, 13-3, 13-10, 13-17, 13-18, 14-4
Clean Air Act of 1972, xxxv, 6-35, 8-12, 8-17, 8-1, 9-4
Clean Water Act of 1972, iii, xxiv, xxxv, 1-21, 2-14, 3-1, 7-39, 8-1, 8-12, 8-17, 8-1, 9-4, 13-17
Climate, xxviii, 2-5
Coastal Barrier Improvement Act of 1990, 8-14
Coastal Barrier Resources Act, xxxv, 8-14, 8-1, 9-7
Coastal Zone Management Act of 1972, xxxv, 8-12, 8-1, 9-5, 13-17
Comprehensive Everglades Restoration Plan, iii, v, 1-1, 1-5, 1-15, 1-20, 2-38, 5-1, 7-1, 8-10, 9-4, 13-3, 13-8, 13-13, 13-17
Conclusions, xxxiv, 6-1, 7-29
Construction, xxii, xxxiv, 4-6, 5-37, 5-40, 6-4, 6-6, 6-23, 6-25, 6-27, 6-28, 6-33, 6-34, 6-46, 6-1, 7-14, 7-15, 7-16, 7-17, 7-26, 7-1, 8-2, 8-3, 8-16, 9-7
Cost Effectiveness, xxxi, xxxix, 4-1, 4-2, 5-38, 5-41, 5-42, 13-3, 13-17
Cost Estimate, xxxi, 4-1, 5-36
Cost Sharing, xxxiv, 7-1, 8-3
Costs
  Initial, xxxviii
Cultural Resources, xxix, xxx, xxxii, 2-54, 2-1, 3-15, 5-2, 6-7, 6-37
CWMP, 1-10, 1-18, 1-19, 1-20, 1-22, 2-13, 2-40, 3-8, 3-25, 3-26, 5-2, 5-13, 5-21, 5-27, 13-17

E

Economics, iii, vii, x, xxi, xxiii, xxv, 1-8, 1-21, 2-19, 3-15, 3-28, 4-6, 4-18, 4-20, 4-22, 5-36, 5-44, 6-8, 6-38, 6-39, 6-40, 6-41, 6-42, 6-43, 6-45, 6-51, 7-13, 7-14, 7-26, 7-39, 7-40, 13-1, 13-8
Economy, xxv, 2-55, 2-56, 3-15, 4-6, 4-17, 4-18, 4-22, 6-8, 6-38, 6-39, 6-41, 6-43, 6-45
Employment, xx, xxxviii, 2-58, 2-59, 3-23, 6-39, 6-41, 6-51, 7-37, 7-39
Endangered, xix, xxx, xxxiii, xxxv, xxxviii, 2-26, 2-32, 2-1, 3-2, 3-13, 5-2, 6-29, 6-47, 6-48, 7-39, 8-13, 8-20, 8-1, 9-1, 9-3, 13-4, 13-5, 13-18, 13-20
Endangered Species Act of 1973, xix, xxxv, 3-2, 3-13, 6-48, 7-39, 8-13, 8-20, 8-1, 9-1, 9-3, 13-18
Enhance Economic Values and Social Well Being, 4-21
Environment, xii, xxviii, 2-1, 5-47, 9-14, 9-18, 13-1, 13-5
Environmental Justice, xxxiii, xxxiv, xxxvi, 5-2, 6-51, 6-1, 7-36, 8-16, 8-1, 9-13, 13-4
Environmental Protection Agency, i, 1-11, 2-50, 8-18, 9-16, 13-21
Essential Fish Habitat, xxix, xxx, xxxii, 2-34, 2-1, 3-13, 5-1, 6-5, 6-32, 13-17
Estuary Protection Act of 1968, xxxv, 6-48, 7-41, 8-14, 8-1, 9-6
Executive Orders
  E.O. 11988, Flood Plain Management, 8-16
  E.O. 11990, Protection of Wetlands, 6-23
  E.O. 12898, Environmental Justice, 6-51, 7-36

F

Farmland Protection Policy Act of 1981, xxxv, 8-13, 8-1, 9-5
Federal Water Project Recreation Act, xxxv, 8-15, 8-1, 9-6
Fish and Wildlife Coordination Act of 1958, xxxv, 8-12, 8-1, 9-1, 9-3, 13-18
Flood Protection, xxxii, xxxiv, 5-1, 6-3, 6-17, 7-1, 8-7
Florida Department of Transportation, 9-17
Florida Statutes
  373.026, 8-17, 9-15
  373.1501, 8-17, 9-15

G

Geology, xxviii, 2-5, 14-3
Glossary, xxxvi, 12-2, 13-1

H

Habitat
  Fish, xxix, xxx, xxxii, 2-34, 2-1, 3-13
  Units, 5-39, 5-41, 5-43, 5-44, 7-28
Habitat Suitability Indices, 5-31, 5-34, 13-18
Hazardous, Toxic and Radioactive Waste, xxx, xxxii, xxxiv, xl, 2-50, 2-51, 2-1, 3-14, 3-15, 5-2, 6-7, 6-36, 6-1, 7-20, 8-14, 8-2, 9-8, 9-10, 9-12, 13-18
HSI, xi, xvi, 4-31, 4-32, 5-31, 5-33, 5-34, 5-48, 6-6, 7-29, 13-18

I

Implementation Schedule, 1-20, 13-19
Income, xx, 2-58, 6-41, 6-51, 7-36, 7-37, 8-16, 9-13
Incremental Cost Analyses, xxxi, xxxix, 4-1, 4-2, 5-38, 5-41

L

Lake Okeechobee, i, viii, ix, x, xi, xv, xvii, xviii, xix, xxiv, xxv, xxviii, xxx, 1-2, 1-3, 1-6, 1-7, 1-9, 1-10, 1-14, 1-15, 1-16, 1-17, 1-18, 1-19, 1-20, 2-1, 2-7, 2-8, 2-9, 2-16, 2-26, 2-32, 2-33, 2-35, 2-36, 2-38, 2-41, 2-42, 2-43, 2-46, 2-59, 2-1, 3-1, 3-5, 3-6, 3-7, 3-8, 3-9, 3-12, 3-17, 3-26, 3-28, 4-5, 4-6, 4-7, 4-8, 4-9, 4-11, 4-15, 4-18, 4-19, 4-21, 4-22, 4-32, 5-1, 5-2, 5-8, 5-24, 5-25, 5-27, 5-28, 5-36, 5-48, 5-49, 5-54, 5-60, 6-4, 6-10, 6-13, 6-14, 6-16, 6-17, 6-19, 6-20, 6-28, 6-44, 6-45, 7-1, 7-24, 7-27, 7-29, 7-31, 7-35, 7-38, 8-5, 8-6, 8-7, 10-1, 13-7, 13-19, 14-2, 14-3
Land Acquisition, xxxiv, 6-1, 7-18
Land Use, xxix, xxx, xxxii, xxxiii, xxxvii, xxxviii, xxxix, 2-13, 2-18, 2-59, 2-60, 2-61, 2-1, 2-2, 3-1, 3-16, 3-19, 3-20, 3-25, 3-26, 5-1, 5-2, 6-6, 6-34, 6-45, 6-46, 13-18
Listed Species
    Southern Bald Eagle, xxix
    Southern Bald Eagle, 2-29
  American Alligator, 2-22

Audubon's Crested Caracara, xxix, xxxii, 2-32, 5-1, 6-31, 8-13
Bald Eagle, xxix, 2-29
Everglade Snail Kite, xxix, xxxii, 2-26, 5-1, 6-27
Florida Panther, xix, 1-14, 2-24, 2-26, 2-31, 6-5, 6-26, 6-29, 6-30, 8-13, 9-3
West Indian Manatee, xx, 1-16, 2-24, 2-26, 2-27, 2-28, 3-5, 6-26, 6-28, 6-48, 7-33, 9-6
Wood Stork, ix, 1-9, 1-14, 2-27, 6-26, 6-27

M

Magnuson-Stevens Fishery Conservation and Management Act, 8-13
Mammals, xxix, 2-24, 6-25, 8-14
Manatee, xxix, xxxii, 2-27, 5-1, 6-26, 6-28, 6-48, 8-14
Manatee Protection, xxii, xxviii, xxx, 1-16, 2-1, 3-5, 7-16
Marine Mammal Protection Act of 1972, xxxv, 2-28, 6-48, 8-14, 8-1, 9-6
Migratory Bird Treaty Act and Migratory Bird Conservation Act, 8-15
Mitigation, 2-19, 13-8
Modeling, xxxi, 4-3, 4-1, 5-27, 5-52, 5-54, 6-13
Monitoring Plan, 8-6, 8-11

N

National Environmental Policy Act, ii, iv, vi, xxxv, 1-6, 1-12, 3-1, 8-12, 8-1, 9-2, 13-5, 13-9, 13-10, 13-13, 13-19
National Historic Preservation Act of 1966, xxxv, 6-38, 8-13, 8-1, 9-3, 9-4, 10-5
Natural System, xvii, xxxv, 1-19, 5-52, 7-1, 8-9
No Action Alternative, xxxi, xxxii, xxxiii, 3-1, 5-15, 5-24, 5-45, 5-1, 5-2, 6-3, 6-10, 6-11, 6-12, 6-14, 6-15, 6-16, 6-17, 6-19, 6-21, 6-22, 6-23, 6-24, 6-25, 6-32, 6-33, 6-34, 6-35, 6-36, 6-37, 6-38, 6-40, 6-42, 6-43
Noise, xxix, xxx, xxxii, 2-62, 2-1, 3-26, 5-2, 6-7, 6-35

O

OMRR&R, 7-14, 7-18, 7-25, 8-3, 10-2, 10-3, 10-4, 13-19
Outreach, 13-9, 13-11

P

Pasture, 3-21
Performance Measures, xxx, xxxix, 3-1, 4-23, 4-29, 4-32
Planning, xii, xxii, xxxi, 2-13, 2-15, 2-33, 3-17, 3-25, 4-22, 4-1, 5-36, 5-47, 5-52, 6-29, 7-14, 7-16, 7-40, 9-3, 9-14, 9-17, 13-20, 13-21, 14-4
Plant Communities, xxix, xxx, xxxii, 2-18, 2-1, 3-11, 5-1, 6-4, 6-22
Poverty, 2-58
Problems and Opportunities, xxx, 3-1, 4-4, 4-8, 4-17
Project Cooperation Agreement, 1-23, 7-18, 8-1, 8-10, 8-11, 10-2, 10-3, 13-10, 13-11, 13-20
Project Implementation, i, ii, iii, v, 1-5, 1-19, 5-2, 8-10, 8-11, 13-10, 13-11, 13-20
Public Concerns, xxx, 3-1, 4-1

R

Rainfall, 2-41
Real Estate, xxxi, xxxiv, 1-12, 2-54, 4-1, 5-50, 6-1, 7-18
Recommendations, 1-14, 9-3
Recreation, xxii, xxix, xxx, xxxiii, xxxv, xxxviii, xxxix, 2-14, 2-62, 2-1, 2-2, 3-23, 3-26, 3-28, 4-3, 4-4, 5-38, 5-2, 6-8, 6-43, 6-1, 6-2, 7-11, 7-12, 7-13, 7-14, 7-16, 7-25, 8-18, 9-6, 13-20
References, xxxvi, 13-1, 14-1
Relocation Assistance, xxxiv, 6-1, 7-24, 10-4
Resource Conservation and Recovery Act of 1976, xxxv, 8-1, 9-8
Restoration, Coordination and Verification, xxxvi, 1-17, 5-33, 5-52, 7-25, 7-31, 7-33, 7-40, 8-3, 8-11, 13-13, 13-20
Rivers and Harbors Act of 1899, xxxv, 8-15, 8-1, 9-7

S

Salinity, xxix, xxx, xxxvii, 2-37, 2-39, 2-42, 2-43, 2-44, 3-1, 4-10, 4-23, 4-24, 4-32, 13-13
Scoping, xxxv, 8-1, 9-1, 9-3, 13-13
Screening
Alternatives, 1-11, 1-12, 2-52, 2-53, 4-2, 4-3, 5-2, 5-5, 5-11, 5-13, 5-15, 7-21, 7-22
Sea level, xxviii, xxxviii, 2-5, 2-1, 3-2, 3-3, 3-4
Seepage Management Area, 1-21, 7-35
SFWMD, iii, iv, v, ix, x, xx, xxiii, xxiv, xxvi, 1-1, 1-6, 1-7, 1-10, 1-12, 1-15, 1-17, 1-18, 1-19, 1-21, 1-22, 2-2, 2-9, 2-13, 2-15, 2-17, 2-19, 2-37, 2-38, 2-39, 2-43, 2-46, 2-50, 2-51, 2-52, 2-53, 2-54, 3-7, 3-8, 3-14, 3-22, 3-25, 4-1, 4-9, 4-10, 4-12, 4-13, 4-14, 4-17, 4-19, 4-23, 4-24, 4-25, 4-26, 4-30, 4-31, 5-2, 5-10, 5-13, 5-21, 5-25, 5-27, 5-50, 5-51, 6-6, 6-15, 6-25, 6-27, 6-29, 6-34, 6-36, 6-37, 6-44, 6-49, 6-51, 7-1, 7-2, 7-12, 7-17, 7-19, 7-20, 7-21, 7-22, 7-23, 7-24, 7-25, 7-37, 7-43, 8-1, 8-2, 8-4, 8-17, 8-18, 8-19, 8-20, 8-21, 9-1, 9-2, 9-3, 9-5, 9-6, 9-8, 9-9, 9-14, 9-15, 11-1, 11-2, 13-8, 13-11, 13-17, 13-20, 14-1, 14-3
Sheet Flow, 7-32, 7-33, 13-13
Socio-Economic, xxx, 2-1, 3-15
Soils, xxviii, xxxiii, 2-6, 2-53, 5-2, 6-47, 9-11
STA, 5-7, 13-20
Stormwater Treatment Area, 5-7, 13-20
Study Area, xxxvii, xxxviii, 1-7, 2-26, 2-61, 2-2, 3-24
Submerged Lands Act of 1953, xxxv, 8-15, 8-1, 9-7
Surface Water, xxxviii, xxxix, 2-9, 2-12, 2-13, 3-1, 4-9, 7-35, 8-18
System, xvii, xxxi, xxxiv, xxxv, xxxix, xl, 1-12, 1-19, 2-6, 2-7, 2-18, 4-1, 4-2, 5-26, 5-31, 5-32, 5-34, 5-35, 5-39, 5-49, 5-52, 5-58, 7-28, 7-32, 7-33, 7-1, 8-8, 8-18, 13-18, 13-19, 13-20

T

Threatened and Endangered, xxx, xxxiii, xxxviii, 2-26, 2-1, 3-13, 5-2, 6-25, 6-47, 6-48, 13-15

Threatened and Endangered Species, ix, xix, xxix, xxxii, 1-9, 1-14, 2-24, 2-26, 2-27, 2-29, 2-31, 2-32, 2-33, 2-34, 5-1, 6-5, 6-26, 6-27, 6-28, 6-29, 6-30, 6-48, 7-40, 8-13, 8-14, 9-3
Toxic Substances Control Act of 1976, xxxv, 8-1, 9-12

U

U.S. Fish and Wildlife Service, i, 2-17, 9-16, 13-4, 13-5, 13-15, 13-21, 14-4
Unavoidable Adverse Environmental Effects, xxxiii, 5-2, 6-46

V

Vegetation, xxxvii, 3-1, 4-11, 7-31, 7-33, 13-20

W

Water
- Budget, 13-15
- Demand, xxviii, xxx, 2-13, 2-1, 3-22, 3-25
- Ground, 7-35
- Management, i, iii, v, ix, xxxi, 1-1, 1-10, 1-15, 1-18, 3-8, 4-25, 5-2, 5-25, 5-26, 5-1, 6-3, 6-14, 7-42, 9-17, 13-8, 13-14, 13-20, 14-1, 14-3, 14-4
- Quality, xxviii, xxx, xxxi, xxxii, xxxiii, xxxv, 1-16, 2-14, 2-15, 2-16, 2-1, 3-8, 3-1, 4-8, 4-32, 4-1, 5-7, 5-8, 5-8, 5-9, 5-9, 5-10, 5-10, 5-36, 5-1, 5-2, 6-3, 6-19, 6-47, 7-1, 8-18, 9-4, 13-16, 13-21
- Supply, 4-3, 4-19, 6-17
- Surface, xxxviii, xxxix, 2-9, 2-12, 2-13, 3-1, 4-9, 7-35, 8-18

Wetland Rapid Assessment Procedure, 2-19
Wild and Scenic River Act of 1968, xxxv, 8-15, 8-1, 9-5
Wildlife
- Bird, xxxv
- Bird, 2-29
- Bird, 6-48
- Bird, 8-1
- Bird, 9-7
- Amphibians, xxix, 2-22, 6-5, 6-25
- Birds, xxix, 2-24
- Fish, i, xxix, xxx, xxxii, xxxv, 2-17, 2-21, 2-23, 2-27, 2-29, 2-34, 2-1, 3-13, 4-2, 5-1, 6-5, 6-24, 7-12, 8-12, 8-18, 8-1, 9-1, 9-3, 9-16, 9-17, 10-1, 13-18, 14-2
- Invertebrates, xxix, 2-21
- Reptiles, xxix, 2-22
- Wading birds, i, 1-xv, 2-21, 3-12, 5-31, 6-25, 6-44, 6-47, 8-15, 9-7, 9-13

Without Project, 2-5, 5-15, 5-24, 5-26, 5-35, 9-14
WRAP, 2-19, 6-24, 9-13

SECTION 13
GLOSSARY OF TERMS AND ACRONYMS

This page intentionally left blank

13.0 GLOSSARY OF TERMS AND ACRONYMS

13.1 GLOSSARY OF TERMS

A

Acre — Area of land equal to 43,560 square feet. In S.I. metric system, one acre is equal to 4,046.9 square meters or 2.471 hectares.

Acre-foot — The quantity of water required to cover 1 acre to a depth of 1 foot. Equal to 43,560 cubic feet (1,233.5 cubic meters).

Activity – A specific project task that requires resources and time to complete.

Adaptive Assessment – A process for learning and incorporating new information into the planning and evaluation phases of the restoration program. This process ensures that the scientific information produced for this effort is converted into products that are continuously used in management decision-making.

Adverse Impact – The detrimental effect of an environmental change relative to desired or baseline conditions.

Affected Environment — Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action.

Air Quality — Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.

Aquatic – Consisting of, relating to or being in water; living or growing in, on or near the water; or taking place in or on the water.

Aquifer – An underground geologic formation, a bed or layer of earth, gravel or porous stone, that yields water or in which water can be stored.

Aquifer Storage and Recovery (ASR) – The practice of pumping freshwater, which has been treated to drinking water standards, approximately 1,000 feet underground where it is stored in a confined aquifer and can be recovered later. The pumped freshwater displaces, or pushes away, the brackish water of the Upper Floridan Aquifer, resulting in an underground reservoir of freshwater.

Authorization — An act by the Congress of the United States, which authorizes use of public funds to carry out a prescribed action.

B

Baseline – The initial approved plan for schedule, cost or performance management, plus or minus approved changes, to which deviations will be compared as the project proceeds.

Basin (or Caloosahatchee River Basin) - All the land drained by a river and its branches.

Best Management Practices (BMPs) – The best available land, industrial and waste management techniques or processes that reduce pollutant loading from land use or industry, or which optimize water use.

Bioaccumulation - If the input of a toxic substance to an organism is greater than the rate at which the substance is lost, the organism is said to be bioaccumulating that substance. Thus, the longer the biological half-life of the substance the greater the risk of chronic poisoning, even if environmental levels of the toxin are very low.

Bioconcentration - If the input of a toxic substance to an organism is greater than the rate at which the substance is lost, the organism is said to be bioaccumulating that substance. Thus, the longer the biological half-life of the substance the greater the risk of chronic poisoning, even if environmental levels of the toxin are very low.

Biota - The total collection of organisms of a geographic region or a time period, from local geographic scales and instantaneous temporal scales all the way up to whole-planet and whole-timescale spatiotemporal scales. The biota of the Earth lives in the biosphere.

Borrow Canal – Canal or ditches where material excavated is used for earthen construction nearby. Also, typically denotes a canal with no conveyance or water routing purpose.

C

Canal – A human-made waterway that is used for draining or irrigating land or for navigation by boat.

Central and Southern Florida Project (C&SF) – A multi-purpose project, first authorized by Congress in 1948, which provides flood control, water supply protection, water quality protection and natural resource protection.

Channel — Natural or artificial watercourse, with a definite bed and banks to confine and conduct continuously or periodically flowing water.

Comprehensive Everglades Restoration Plan (CERP) – The plan for the restoration of the greater Everglades and to meet water supply and flood protection needs in the urban and agricultural regions of south Florida.

Comprehensive Plan – See Comprehensive Everglades Restoration Plan.

Control Structure – A human-created structure that regulates the flow of waters or the level of waters.

Conveyance Capacity — The rate at which water can be transported by a canal, aqueduct, or ditch. In this document, conveyance capacity is generally measured in cubic feet per second (cfs).

Cost-Benefit Analysis – An analysis, often stated as a ratio, used to evaluate a proposed course of action.

Cost Effectiveness Analysis – An analysis, used in ecosystem restoration planning studies, in which comparison of the costs and non-monetary outputs of alternative plans to identify the least cost plan for every level of output considered. Alternative plans are compared to identify those that would produce greater levels of output at the same cost, or at a lesser cost, as other alternative plans.

Critical Habitat – A description, which may be contained in a Biological Opinion, of the specific areas with physical or biological features essential to the conservation of a listed species and which may require special management considerations or protection; these areas have been legally designated via Federal Register notices.

Cubic feet per second (cfs) — A measure of the volume rate of water movement. As a rate of streamflow, a cubic foot of water passing a reference section in 1 second of time. One cubic foot per second equals 0.0283 meter /second (7.48 gallons per minute). One cubic foot per second flowing for 24 hours produces approximately 2 acre-feet.

Culvert – A concrete, metal or plastic pipe that transports water.

D

Dam - A barrier across flowing water that obstructs, directs or slows down the flow, often creating a reservoir, lake or impoundment.

Discharge – The rate of water movement as volume per unit time, usually expressed as cubic feet per second.

Dissolved Oxygen (D.O.) – The concentration of oxygen dissolved in water, sometimes expressed as percent saturation, where saturation is the maximum amount of oxygen that theoretically can be dissolved in water at a given altitude and temperature.

Dry Season — Hydrologically, for south Florida, the months associated with a lower incident of rainfall, November through May.

Duration – The period of time over which a task occurs, in contrast to effort, which is the amount of labor hours a task requires; duration establishes the schedule for a project, and effort establishes the labor costs.

E

Ecology – The science of the relationships between organisms and their environments, also called bionomics; or the relationship between organisms and their environment.

Ecosystem — A functional group of animal and plant species that operate in a unique setting that is mostly self-contained.

Effectiveness – A measure of the quality of attainment in meeting objectives; this is distinguished from efficiency, which is measured by the volume of output achieved for the input used.

Effluent - An outflowing of water from a natural body of water, or from a man-made structure.

Embankment - An outflowing of water from a natural body of water, or from a man-made structure or to prevent or direct flooding by water.

Endangered Species — Any species or subspecies of bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion of its range. Federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Enhancement — Measures which develop or improve the quality or quantity of existing conditions or resources beyond a condition or level that would have occurred without an action; i.e., beyond compensation.

Environmental and Economic Equity (EEE) – A program-level activity, referred to in early phases of the program as Socioeconomic and Environmental Justice.

Environmental Consequences — The impacts to the Affected Environment that are expected from implementation of a given alternative.

Environmental Impact Statement (EIS) — An analysis required by the National Environmental Policy Act for all major federal actions, which evaluates the environmental risks of alternative actions.

Estuary – A semi-enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea. Estuaries are often associated with high rates of biological productivity.

Evaluate – To appraise or determine the value of information, options or resources being provided to a project.

Evapotranspiration (ET) - The sum of evaporation and plant transpiration. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and waterbodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapour through stomata in its leaves. Evapotranspiration is an important part of the water cycle.

Exotic species — Introduced species not native to the place where they are found.

F

Feasibility Study — The second phase of a project. The purpose is to describe and evaluate alternative plans and fully describe recommended project.

Federally Endangered Species — An endangered species which is officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the Federal Register.

Flood Control Storage Capacity – Reservoir capacity reserved for the purpose of regulating flood inflows to reduce flood damage downstream (compare with reservoir storage capacity).

Flow — The volume of water passing a given point per unit of time.

- **Instream flow requirements** — Amount of water flowing through a stream course needed to sustain instream values.
- **Minimum flow** — Lowest flow in a specified period of time.
- **Peak flow**—Maximum instantaneous flow in a specified period of time.

G

Geospatial Data - Information, which includes, but is not limited to surveys, maps, aerial photography, aerial imagery, and biological, ecological and hydrological modeling coverages.

Goal – Something to be achieved. Goals can be established for outcomes (results) or outputs (efforts).

Groundwater — Water stored underground in pore spaces between rocks and in other alluvial materials and in fractures of hard rock occurring in the saturated zone.

Groundwater Level — Refers to the water level in a well, and is defined as a measure of the hydraulic head in the aquifer system.

Groundwater Pumping — Quantity of water extracted from groundwater storage.

Groundwater Seepage — Groundwater flow in response to a hydraulic gradient.

Groundwater Table — The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

H

Habitat — Area where a plant or animal lives.

Hectare – A unit of measure in the metric system equal to 10,000 square meters or 2.47 acres.

Hydraulic Gradient – Denotes slope of watercourse, above or below ground water level. Typically, defines energy loss or consumption in the conveyance process.

Hydraulic Head (Lift) – Denotes relative comparison of water stages for gravity flow. Pump stations generally provide lift or increase water level elevations.

Hydrologic Condition — The state of an area pertaining to the amount and form of water present. For example, saturated ground (water table at surface), lake stage and river flow rate.

Hydrologic Response — An observed decrease or increase of water in a particular area.

Hydrology – The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hydropattern — Refers to depth as well as hydroperiod is hydropattern. Hydropatterns are best understood by a graphic depiction of water level (above as well as below the ground) through annual cycles.

Hydroperiod — For non-tidal wetlands, the average annual duration of flooding is called the hydroperiod, which is based only on the presence of surface water and not its depth.

I

Impoundment – An obstruction, such as a dam and reservoir,

Independent Technical Review Team – A group autonomous of the Project Team established to conduct reviews to ensure that design products are consistent with established criteria, guidance, procedures and policies.

Indicator Species — Organism, species, or community which indicates presence of certain environmental conditions.

In situ - A Latin phrase meaning in the original place. It is used in many different contexts

Invertebrate – A small animal that does not have a backbone, examples include crayfish, insects and mollusks, which can be indicators of ecosystem status.

L

Lag – The amount of time after one task is started or completed before the next task can be started or completed.

Lake Okeechobee Regulation Schedule (LORS)

- Manage Lake Okeechobee at optimal lake levels to allow recovery of the Lake's environment and natural resources.
- Reduce high regulatory releases to the Caloosahatchee and St. Lucie estuaries so that the health of the estuaries are not compromised.

- Continue to provide flood control, water supply, navigation and recreation water resource needs.
- Ensure public health and safety.

Land Classification — An economic classification of variations in land reflecting its ability to sustain long-term agricultural production.

Levee – A human-created embankment that controls or confines water.

Littoral Zone — The shore of land surrounding a water body that is characterized by periodic inundation or partial saturation by water level. Typically defined by species of vegetation found.

Local Sponsor – The South Florida Water Management District.

Lock and Dam - A lock is a particular type of device for raising or lowering boats between stretches of water at different levels. The distinguishing feature of a lock is a fixed chamber whose water level can be varied; whereas in a boat lift or canal inclined plane, it is the chamber itself which moves.

M

Macrophytes – Visible plants found in aquatic environments, including sawgrass, sedges and lilies.

Marl - Calcium carbonate or lime-rich muds or mudstones which contain variable amounts of clays and calcite or aragonite. The term is most often used to describe lacustrine (lake) sediments but may also be used for marine deposits.

Marsh — An area of low-lying wetland.

Master Program Management Plan (MPMP) – A document which describes the framework and processes to be used by the USACE and the SFWMD for managing and monitoring implementation of the Comprehensive Everglades Restoration Plan.

MIKESHE - An integrated surface water/ground water model, which includes a module for estimating supplemental irrigation requirements based upon land use, soil type, crop type, rainfall, and evapotranspiration.

Mitigation – To make less severe; to alleviate, diminish or lessen; one or all of the following may comprise mitigation: (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an

impact by repairing, rehabilitating or restoring the affected environment; (4) reducing or eliminating an impact over time by preservation and maintenance operations during the life of an action; and (5) compensating for an impact by replacing or providing substitute resources or environments.

Model — A tool used to mathematically represent a process which could be based upon empirical or mathematical functions. Models can be computer programs, spreadsheets, or statistical analyses.

Monitoring – The capture, analysis and reporting of project performance, usually as compared to plan.

N

National Environmental Policy Act (NEPA) - United States environmental law that was signed into law on January 1, 1970 by U.S. President Richard Nixon. (Although enacted on January 1, 1970, its "short title" is "National Environmental Policy Act of 1969.")

Nutrients - A chemical element or compound used in an organism's metabolism or physiology. Six nutrient groups exist and are broadly classified into those providing energy, and those used as components in the body or cellular structures.

O

Objective – A goal expressed in specific, directly measurable terms.

Off-peak – Less than peak design flow rate during storm runoff producing events.

Outreach - Proactive communication and productive involvement with the public to best meet the water resource needs of South Florida.
Oxbow - A bend in a river, similar to the shape of the wooden yoke of an ox.

Oxygen Demand — The biological or chemical demand of dissolved oxygen in water. Required by biological processes for respiration.

P

Performance Measure – A desired result stated in quantifiable terms to allow for an assessment of how well the desired result has been achieved.

Periphyton – The biological community of microscopic plants and animals attached to surfaces in aquatic environments, for example algae.

Phosphorus (P) — Element or nutrient required for energy production in living organisms. Distributed into the environment mostly as phosphates by agricultural runoff (fertilizer) and life cycles. Frequently the limiting factor for growth of microbes and plants.

Pollutants - Many of the compounds which are dangerous to the environment can also be harmful to humans in the long-term range and come from mineral and fossil sources or are produced by humans themselves.

Potable - Water of sufficient quality to serve as drinking water is termed potable water whether it is used as such or not.

Program – A group of related projects managed in a coordinated manner; programs usually include an element of on-going activity.

Program Management – A structure and set of strategies to be used during the implementation phase, which build upon the interagency partnership, implementation guidelines and successful strategies developed during the Restudy's feasibility planning phase.

Programmatic Environmental Impact Statement (PEIS) – An environmental impact statement prepared prior to a Federal agency's decision regarding a major program, plan or policy, which usually is broad in scope and followed by subsequently more narrowly focused National Environmental Policy Act compliance documents.

Programmatic Regulations – Section 601(h) of WRDA 2000 states that the overarching purpose of the Comprehensive Plan is the restoration, preservation and protection of the south Florida ecosystem while providing for the other water related needs of the region, including water supply and flood protection. The purpose of the regulations is to ensure that the goals and objectives of CERP are achieved. The regulations will contain: (1) processes for the development of Project Implementation Reports, Project Cooperation Agreements and operating manuals that ensure the goals and objectives of the plan are achieved; (2) processes that ensure new scientific, technical, or other information such as that developed through adaptive management is integrated into the implementation of the plan; and (3) processes to establish interim goals to provide a means by which the restoration success of the plan may be evaluated throughout the implementation process.

Project – A sequence of tasks with a beginning and an end that uses time and resources to produce specific results. Each project has a specific, desired outcome, a deadline or target completion date and a budget that limits the amount of resources that can be used to complete the project.

Project Area – The entire C-43 Basin.

Project Cooperation Agreement (PCA) – A document that describes the roles and responsibilities of the USACE and SFWMD for real estate acquisition, construction, construction management and operations and maintenance.

Project Team – An interdisciplinary group formed from the resources of the implementing agencies, which develops the products necessary to deliver the project.

Project Duration – The time it takes to complete an entire project from starting the first task to finishing the last task.

Project Implementation Report (PIR) – A decision document that will bridge the gap between the conceptual design contained in the Comprehensive Plan and the detailed design necessary to proceed to construction.

Project Management – A discipline of combining systems, techniques and people to complete a project within established goals of time, budget and quality.

Project Manager – A person who takes overall responsibility for coordinating a project to ensure the desired result comes in on time and within budget.

Project Phase – A collection of logically related project activities, usually culminating in the completion of a major deliverable.

Proposed Action — Plan that a Federal agency intends to implement or undertake and which is the subject of an environmental analysis. Usually, but not always, the proposed action is the agency's preferred alternative for a project. The proposed action and all reasonable alternatives are evaluated against the no action alternative.

Public Involvement — Process of obtaining citizen input into each stage of the development of planning documents. Required as a major input into any EIS.

Public Outreach – A program-level activity with the objectives of keeping the public informed of the status of the overall program and key issues associated with restoration implementation and providing effective mechanisms for public participation in the restoration plan development.

Pump Station – A human constructed structure that uses pumps to transfer water from one location to another.

Q

Quality Assurance (QA) – The process of evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards.

Quality Control (QC) – The process of monitoring specific project results to determine if they comply with relevant quality standards, and identifying means of eliminating causes of unsatisfactory performance.

R

Recharge — The processes of water filling the voids in an aquifer, which causes the piezometric head or water table to rise in elevation.

Reconnaissance Study — The first phase of a project. It has four phases (1) to define problem, (2) asses sponsor's level of interest and support, (3) decide to progress to feasibility phase based on Federal interest, (4) estimate time and money to complete feasibility study.

Record of Decision — Concise, public, legal document which identifies and publicly and officially discloses the responsible official's decision on the alternative selected for implementation. It is prepared following completion of an Environmental Impact Statement.

Refugia - Refers to locations of isolated or relict populations of once widespread animal or plant species.

Regional Water Supply Plan — Detailed water supply plan developed by the District under Ch. 373.0361, F.S.

Reservoir — Artificially impounded body of water.

Reservoir Storage Capacity — Reservoir capacity normally usable for storage and regulation of reservoir inflows to meet established reservoir operating requirements.

> **Flood control storage capacity** — Reservoir capacity reserved for the purpose of regulating flood inflows to reduce flood damage downstream.

Restoration – The recovery of a natural system's vitality and biological and hydrological integrity to the extent that the health and ecological functions are self-sustaining over time.

Restoration Coordination and Verification (RECOVER) – A program-level activity whose role is to organize and apply scientific and technical information in ways that are most effective in supporting the objectives of the Comprehensive Everglades Restoration Plan.

Restudy – The Central and South Florida Project Comprehensive Review Study, authorized by the Water Resources Development Act of 1992, which examined the Central and Southern Project to determine the feasibility of modifying the project to restore the south Florida ecosystem and provide for other water-related needs of the region, and which resulted in The Final Integrated Feasibility Report and Programmatic Environmental Impact Statement, which was transmitted to Congress on July 1, 1999.

Risk Analysis – An evaluation of the feasibility or probability that the outcome of a project or policy will be the desired one; usually conducted to compare alternative scenarios, action plans or policies.

Run off – Unfiltered water that reaches streams, lakes sounds, and oceans by means of flowing across impervious surfaces. These surfaces include roads, parking lots, driveways and roofs.

S

Salinity - The saltiness or dissolved salt content of a body of water

Scoping — The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Scrub – A community dominated by pinewoods with a thick understory of oaks and saw palmetto, and which occupies well-drained, nutrient-poor sandy soils.

Seepage — Water that escapes control through levees, canals or other holding or conveyance systems.

Sheet Flow – Water movement as a broad front with shallow, uniform depth.

Slough – A depression associated with swamps and marshlands as part of a bayou, inlet or backwater; contains areas of slightly deeper water and a slow current; can be thought of as the broad, shallow rivers of the Everglades.

South Florida Ecosystem – An area consisting of the lands and waters within the boundary of the South Florida Water Management District, including the Everglades, the Florida Keys and the contiguous near-shore coastal waters of South Florida.

South Florida Water Management Model (SFWMM) - An integrated surface water groundwater model that simulates the hydrology and associated water management schemes in the majority of South Florida using climatic data from January 1, 1965, through December 31, 1995. The model simulates the major components of the hydrologic cycle and the current and numerous proposed water management control structures and associated operating rules. It also simulates current and proposed water shortage policies for the different subregions in the system.

Spatial Extent – Area that is continuous without non-integrating internal barriers or land usage.

Spillway — Overflow structure of a dam.

Stakeholders – People or organizations having a personal or enterprise interest in the results of a project, who may or may not be involved in completing the actual work on that project.

Stormwater – Surface water resulting from rainfall that does not percolate into the ground or evaporate.

Subspecies - The rank immediately subordinate to a species. It is equivalent to "race" in the biological (i.e. not social) sense

Substrate - The earthy material that exists in the bottom of a marine habitat, like dirt, rocks, sand, or gravel

Success Indicator – A subset of performance measures selected as a good representation of overall performance.

Surficial Aquifer – An aquifer that is closest to the surface and is unconfined; the water level of a surficial aquifer is typically associated with the groundwater table of an area.

Sustainability – The state of having met the needs of the present without endangering the ability of future generations to be able to meet their own needs.

Swamp – A generally wet, wooded area where standing water occurs for at least part of the year.

T

Threatened Species — Legal status afforded to plant or animals species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Tiering — Procedure which allows an agency to avoid duplication of paperwork through incorporation by reference of the general discussions and relevant specific discussions from an environmental impact statement (EIS) of broader scope into a subsequent EIS of narrower scope.

Trade-Off – Allowing one aspect of a project to change, usually for the worse, in return for another aspect of the project getting better.

Tributary — A stream feeding into a larger stream, canal or waterbody.

W

Water Budget – An account of all water inflows, outflows and change in storage for a pre-specified period of time.

Water Column Turbidity – The measure of the cloudiness or opacity in the appearance of a water sample. Turbidity in natural waters is caused by the presence of suspended solids or colloidal particles. Turbidity measurement provides an indication of the clarity of water and water quality.

Water Conservation Areas (WCAs) – Marshland areas that were designed for use as storage to prevent flooding, to irrigate agriculture and recharge well fields and as input for agricultural and urban runoff; the Water Conservation Areas WCA-1, WCA-2A, WCA-2B, WCA-3A and WCA-3B comprise five surface water management basins in the Everglades; bounded by the Everglades Agricultural Area on the north and the Everglades National Park basin on the south, the WCAs are confined by levees and water control structures that regulate the inflows and outflows to each one of them.

Water Resource Development Act 2000 (WRDA 2000) – WRDA is legislation which provides for the conservation and development of water and related

resources and authorizes the Secretary of the Army to construct various projects for improvements to rivers and harbors of the United States, and for other purposes deemed appropriated by the U.S. Congress and the President of the United States.

Watershed – A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Water Quality - The physical, chemical and biological characteristics of water. The primary bases for such characterization are parameters which relate to drinking water, safety of human contact and for health of ecosystems.

Wetlands – Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction.

Wet Season – Hydrologically, for south Florida, the months associated with a higher than average incident of rainfall, June through October.

Wildlife Corridor – A relatively wide pathway used by animals to transverse from one habitat arena to another.

Wildlife Habitat – An area that provides a water supply and vegetative habitat for wildlife.

Y

Yellow Book – See "Restudy"

13.2 GLOSSARY OF ACRONYMS

>	greater than
<	less than

A

ac-ft	acre-feet
AFB	Alternative Formulation Briefing
ASA(CW)	Assistant Secretary of the Army for Civil Works
ASR	Aquifer Storage and Recovery
AST	Aboveground Storage Tanks
ASTMS	American Society for Testing and Materials Standard Price

B

BA	Biological Assessment
BCNP	Big Cypress National Park
BEBR	Florida Bureau of Economic and Business Resources
BMP	Best Management Practice
BODR	Basis of Design Report

C

C	Canal
C&SF	Central and Southern Florida
CE/ICA	Cost Effectiveness/Incremental Coat Analysis
CERP	Comprehensive Everglades Restoration Plan
CERPRA	Comprehensive Everglades Restoration Plan Regulation Act
CESAJ	U.S. Army Corps of Engineers, Jacksonville District
CFA	Core Foraging Area
CFR	Code of Federal Regulation
cfs	Cubic Feet per Second
cm	centimeter
CWA	Clean Water Act
CWMP	Caloosahatchee Water Management Plan
CZMA	Coastal Zone Management Act

D

DCM	Design Criteria Memorandum
DO	Dissolved Oxygen
DOI	Department of the Interior
DWSA	SFWMD District-Wide Water Supply Assessment

E

EAA	Everglades Agricultural Area
ECT	Environmental Consulting & Technology, Inc
EFH	Essential Fish Habitat

EIS	Environmental Impact Statement
ENP	Everglades National Park
EO	Executive Order
EPPC	Exotic Pest Plant Council
EQ	Environmental Quality
ER	Engineering Regulation
ERA	Environmental Risk Assessment
ESA	Endangered Species Act
ESA	Environmental Site Assessment

F

FAS	Floridan Aquifer System
FCRB	Freshwater Caloosahatchee River Basin
FDACS	Florida Department of Agriculture and Consumer Services
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use/Land Cover Classification System
FLUCFCS	Florida Land Use, Cover and Forms Classification System
FNAI	Florida Natural Areas Inventory
FP&L	Florida Power & Light
F.S.	Florida Statutes
FSA	Florida Statistical Abstract
FWC	Florida Fish and Wildlife Conservation Commission
FWCA	Fish and Wildlife Coordination Act
FY	Fiscal Year

G

GCTL	Groundwater Cleanup Target Levels
GIS	Geographic Information System
GM	Guidance Memorandum

H

HHD	Herbert Hoover Dike
HSI	Habitat Suitability Indices
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HTRW	Hazardous, Toxic, and Radioactive Wastes
HU	Habitat Unit

I

IAS	Intermediate Aquifer System
ICU	Initial CERP Update
ITR	Independent Technical Review
IWR	Institute for Water Resources

K

kac-ft	1000 acre feet
km	kilometer

L

L	Levee
LERRD	Lands, Easements, Right-of-Ways, Relocation, Disposal
LORSS	Lake Okeechobee Regulation Schedule Study
LOSA	Lake Okeechobee Demand Service Area
LWC	Lower West Coast
LWCWSP	Lower West Coast Water Supply Plan

M

M&I	Municipal and Industrial
MCACES	Microcomputer Aided Cost Engineering System
MERIT	Multi-species/Ecosystem Recovery Implementation Team
MFL	Minimum Flow and Levels
MGD	Million gallons per day
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
MIS-10	Master Implementation Schedule
MISP	Master Implementation Sequencing Plan
MPMP	Master Program Management Plan

N

NAI	Next-Added Increment
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NGVD	National Geodetic Vertical Datum
NLBSA	North Lake Belt Storage Area
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge

O

OMRR&R	Operation, Maintenance, Repair, Rehabilitation, Replacement
O&M	Operations and Maintenance
OSE	Other Social Effects

P

P&G	Principles and Guidelines
PAHs	Polyaromatic Hydrocarbons
PAL	Planning Aid Letter
PCA	Project Cooperation Agreement
PCP	Pentacholorophenol
PCX	Planning Center of Expertise
PDT	Project Delivery Team
PEC	Probable Effect Concentration
PED	Planning, Engineering and Design
PEIS	Programmatic Environmental Impact Statement
PEL	Probable Effects Level
PGM	Project Guidance Memorandum
PIR	Project Implementation Report
PM	Performance Measure
ppb	Parts per billion
ppt	Parts per thousand
PWS	Public Water Supply

R

RDD	Rapid Draw Down
RECOVER	Restoration Coordination and Verification
RED	Regional Economic Development
Restudy	C&SF Project Comprehensive Review Study
ROD	Record of Decision
ROW	Right of Way

S

S	Structure
SAD	South Atlantic Division
SAS	Surficial Aquifer System
SAV	Submerged Aquatic Vegetation
SCORP	Florida State Comprehensive Outdoor Recreation Plan
SCTL	Soil Cleanup Target Levels
SFRWPC	South Florida Regional Water Planning Council
SFWMD	South Florida Water Management District
SFWMM	South Florida Water Management Model
SHPO	State Historic Preservation Officer
SLERA	Screening Level Ecological Risk Assessment
SLOPES	Standard Local Operating Procedures for Endangered Species
SQAG	Sediment Quality Assessment Guidelines
SR	State Road
STA	Stormwater Treatment Area
SWFFS	Southwest Florida Feasibility Study

SWFRPC	Southwest Florida Regional Planning Council

T

TEC	Threshold Effects Concentration
TMDL	Total Maximum Daily Loads
TN	Total Nitrogen
TP	Total Phosphorus
TRPH	Total Recoverable Petroleum Hydrocarbons
TSP	Tentatively Selected Plan

U

ug/L	micrograms per liter
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey

V

VEC	Valued Ecosystem Components

W

WCA	Water Conservation Area
WQ	Water Quality
WQC	Water Quality Certification
WRDA	Water Resources Development Act
WSE	Water Supply/Environmental
WY	Water Year

This page intentionally left blank

SECTION 14
REFERENCES

This page intentionally left blank

14.0 REFERENCES

Bierman, V. 1993. Performance report for the Caloosahatchee Estuary salinity modeling. SFWMD expert assistance contract deliverable. Limno-Tech, Inc.

Bulger, A.J., B.P. Hayden, M.E. Monaco, D.M. Nelson, and M.G. McCormick-Ray. 1993. Biologically-based estuarine salinity Zones derived from multivariate analysis. Estuaries 16:311-322.

Chamberlain, R.H., D.E. Haunert, P.H. Doering, K.M. Haunert, and J.M. Otero. 1995. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary, Florida. Technical report (White Paper), South Florida Water Management District, West Palm Beach, Florida.

Chamberlain, R.H. and P.H. Doering. 1998a. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation, p. 81-90. In S.F. Treat (ed.). Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16, Punta Gorda, Florida. Charlotte Harbor National Estuary Program Technical Report No. 98-02. South Florida Water Management District, West Palm Beach, Florida.

Chamberlain, R.H. and P.H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach, p. 121-130. In S.F. Treat (ed.). Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16, Punta Gorda, Florida. Charlotte Harbor National Estuary Program Technical Report No. 98-02. South Florida Water Management District, West Palm Beach, Florida.

Doering, P.H. and R.H. Chamberlain. 1998. Water quality in the Caloosahatchee Estuary, San Carlos Bay and Pine Island Sound, Florida, p. 229-240. In S.F. Treat (ed.). Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16, Punta Gorda, Florida. Charlotte Harbor National Estuary Program Technical Report No. 98-02. South Florida Water Management District, West Palm Beach, Florida.

Doering, P.H. 1998 Preliminary Estimate of Optimum Freshwater Inflow to the Caloosahatchee Estuary: A Resource-Based Approach. Pp 121-130 in Treat, S.F. (ed) Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; n1997 March 15-16; Punta Gorda, Fla. Charlotte Harbor National Estuary Program Technical Report 98-02. West Palm Beach, FL; South Florida Water Management District 274 p.

ERD (Environmental Research and Design, Inc.) 2003. Caloosahatchee River final interpretive-report year 3. Final Report to the South Florida Water Management District, West Palm Beach, Fl.

Estevez, Ernest. 1998. The Story of the Greater Charlotte Harbor Watershed. Charlotte Harbor National Estuary Program, Fort Myers, Florida, 135 pp.

FDEP. 2003. Basin Status Report: Caloosahatchee. Division of Water Resource Management.

Gunter, G. 1961. Some relations of estuarine organisms to salinity. Limnology and Oceanography 6:182-190.

Gunter, G. and G.E. Hall. 1962. Biological investigation of the Caloosahatchee Estuary in connection with Lake Okeechobee discharges through the Caloosahatchee River. Consultant report to the U.S. Corps of Engineers, Jacksonville District, Serial No. 25, 50 pages.

Harper, H., Baker, D., 2003, Evaluation of Alternative Stormwater Regulations for Southwest Florida, Final Report Submitted to: Water and Enhancement Coalition, Inc., Prepared by Environmental Research & Design, Inc., Orlando, Florida

Harris, B.A., K.D. Haddad, K.A. Steidinger, and J.A. Huff. 1983. Assessment of Fisheries Habitat: Charlotte Harbor and Lake Worth, Florida. Florida Department of Natural Resources, Bureau of Marine Research, St. Petersburg, Florida. 211 pp.

Hunter, M.E., 1968, Molluscan guide fossils in Late Miocene sediments of southern Florida: Gulf Coast Association of Geological Societies Transactions, v. 18, p. 439-450.

Janicki, A., et al, (2003) C-43 Basin Critical Loads Report, Prepared for Florida Department of Environmental Protection, Tallahassee, FL, June, 2003.

Kinne, O. 1966. Physiological aspects of animal life in estuaries with special reference to salinity. Netherlands Journal of Sea Research 3:222-244.

Lindall, W.N. Jr. 1973. Alterations of Estuaries of South Florida: A Threat to Its Fish Resources. Marine Fisheries Review, Vol. 35, No. 10, NMFS, pp1-8.

Livingston, R.J. 1984. The relationships of physical factors and biological response in coastal seagrass meadows. Estuaries 7(4A): 377-390.

McPherson, B.F., R.T. Montgomery, and E.E. Emmons. 1990. Phytoplankton productivity and biomass in the Charlotte Harbor estuarine system, Florida. American Water resources Association, Water Resources Bulletin 26:787-800.

Missimer, T.M., 1984, The geology of South Florida: A summary: in Gleason, P.J., (ed.),

Environments of South Florida, present and past II: Miami Geological Society Memoir 2, p. 385-404.

Murray, L. M., Kemp, and D. Gurber. 1999. Comparative studies of seagrass and epiphyte communities in Florida Bay and two other south Florida estuaries in relation to freshwater inputs. Abstract. In 1999 Florida Bay and Adjacent Marine Systems Science Conference Program and Abstracts.

Pearcy, W.G. and S.W. Richards. 1962. Distribution and ecology of fishes of the Mystic River estuary, Connecticut. Ecology 43:248-259.

Phillips, R.C. and V.G. Springer. 1960. A report on the hydrography, marine plants, and fishes of the Caloosahatchee River area, Lee County, Florida. Florida Board of Conservation, Marine Laboratory. Special Science Report No. 5 , 34 pages.

Remane, A. and C. Shlieper. 1971. Biology of brackish water. Wiley-Interscience, New York.

Sackett. J.W. 1888. Survey of the Caloosahatchee River, Florida. Report to Captain of the U.S. Engineering Office, St. Augustine, Florida.

SFWMD. 2002. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary: Draft 2002 Status Update Report. South Florida Water Management District, Florida.

SFWMD 2003. Existing Legal Sources for the Caloosahatchee Estuary at the Franklin Lock and Dam (S-79). Technical Memo. Coastal Ecosystems Division. Watershed Management Department. South Florida Water Management District, West Palm Beach, FL. 30 pp.

Sproul, C.R., Boggess, D.H., and Woodard, H.J., 1972, Saline-water intrusion from deep artesian sources in the McGregor Isles area of Lee County, Florida: Florida Bureau of Geology Information Circular 75, 30 p.

SWFFS (Southwest Florida Feasibility Study). 2003. S-79, Shell Point, and San Carlos Bay freshwater inflow performance measures. Final draft of 12/04/03, prepared by R.H. Chamberlain, accepted by the SWFFS Study Team.

University of Miami, The Marine Laboratory. 1954. A Preliminary Survey Of The Effects Of Releasing Water From Lake Okeechobee Through The St.

Lucie & Caloosahatchee Estuaries. Corps of Engineers, U. S. Army, Contract No. DA-08-123-ENG-1376. Final Report, June, 1954.

U.S. Fish and Wildlife Service. 1999. South Florida Multi-species Recovery Plan. Atlanta, Georgia. 2172 pp.

Volety, A.K., S.G. Tolley, and J.T. Winstead. 2003. Effects of seasonal and water quality parameters on oysters (Crassostrea virginica) and associated fish populations in the Caloosahatchee River: Final contract report (C-12412) to the South Florida Water Management District. Florida Gulf Coast University, Ft. Myers, Florida.

Water Resources Development Act (WRDA)
1. 1992, C&SF Project
2. 1996, Everglades and South Florida Ecosystem Restoration
3. 1999, CERP
4. 2000, Everglades Provision, Title VI, 11 Dec 00

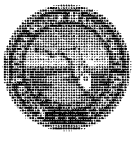
Engineering Manuals (EM), U.S. Army Corps of Engineers
1. EM 1110-2-3102, General Principles of Pumping Station Design and Layout
2. EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations

Engineering Regulations (ER), U.S. Army Corps of Engineers
1. ER 1105-2-100, Planning Guidance Notebook



US Army Corps
of Engineers®

Jacksonville District



South Florida Water
Management District

US Army Corps of Engineers ®
Jacksonville District

Central and Southern Florida Project
Comprehensive Everglades Restoration Plan

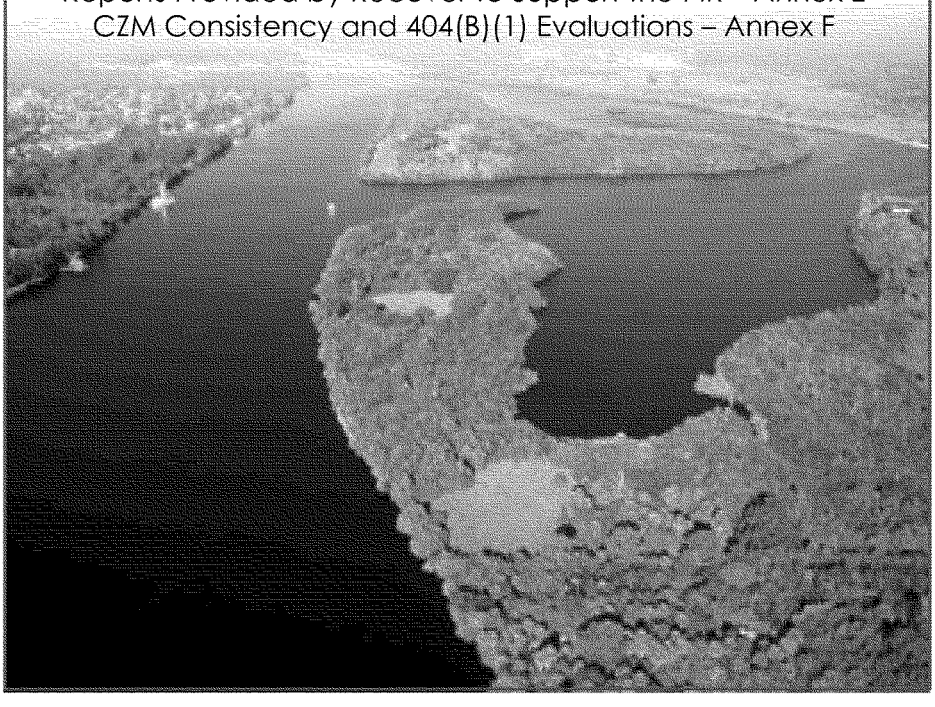
Caloosahatchee River (C-43) West Basin Storage Reservoir Project

Final Integrated Project Implementation Report

Volume 2: Final Annex FWC Report and Endangered Species Act Compliance – Annex A

and

Volume 3: NEPA Information – Annex B
Analyses Required by WRDA 2000 and State Law – Annex C
Draft Project Operating Manual and Monitoring Plan – Annex D
Reports Provided by Recover to Support the PIR – Annex E
CZM Consistency and 404(B)(1) Evaluations – Annex F



CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE EVERGLADES RESTORATION PLAN
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
FINAL PROJECT IMPLEMENTATION REPORT

FINAL ANNEX
FWCA REPORT AND ENDANGERED SPECIES ACT COMPLIANCE – ANNEX A



September 2007

This Report Contains [5] Volumes

You Are Here

Volume 1 – Main Report – November 2010
- Addendum A
- Addendum B
- Executive Summary
- Section 1 – Introduction
- Section 2 – Existing Conditions/Affected Environment
- Section 3 – Future "Without Project" Condition
- Section 4 – Identification of Problems and Opportunities
- Section 5 – Formulation of Alternative Plans
- Section 6 – Environmental Effects of the Selected Alternative Plan
- Section 7 – The Selected Alternative Plan
- Section 8 – Plan Implementation
- Section 9 – Summary of Coordination, Public Views, and Comments
- Section 10 – Recommendations
- List of Report Preparers
- Index
- Glossary of Terms
- Acronyms
- References

Volume 2- Annex – September 2007
- Annex A – FWCA and Endangered Species Act Compliance

Volume 3 – Annexes – September 2007
- Annex B – NEPA Information
- Annex C – Analyses Required by WRDA 2000 and State Law
- Annex D – Draft Project Operating Manual and Monitoring Plan
- Annex E – Reports Provided by RECOVER to Support the PIR
- Annex F – CZM Consistency and 404(b)(1) Evaluations

Volume 4 – Appendices – November 2010
- Appendix A – Engineering

Volume 5 – Appendices – November 2010
- Appendix B – Cost Estimates
- Appendix C – Environmental Information
- Appendix D – Real Estate
- Appendix E – Agency / Public Coordination
- Appendix F – Plan Formulation
- Appendix G – Economic and Social Considerations
- Appendix H – Recreation

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR

FINAL ANNEX

FWCA Report and Endangered Species Act Compliance – Annex A

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

SOUTH FLORIDA WATER
MANAGEMENT DISTRICT

September 2007

This page intentionally left blank.

ANNEX A
FISH AND WILDLIFE COORDINATION ACT AND ENDANGERED SPECIES ACT COMPLIANCE

This page intentionally left blank

TABLE OF CONTENTS

Planning Aid Letters
US Fish and Wildlife Service March 29, 2005....A-1
US Fish and Wildlife Service August 13, 2003....A-7
US Fish and Wildlife Service June 10, 2003....A-15
US Fish and Wildlife Service April 11, 2002....A-22

US Fish and Wildlife Service Correspondence
Review of Phase I/II ESA for Griffin Brothers property May 19, 2003..A-39
Review of Phase I/II ESA for Winthrop Citrus Investors Property July 14, 2003....A-43
Response to ECT on Aldrin Contamination on Winthrop Citrus Investors Property July 1, 2004....A-45
Phase I/II ESA for Bryan Paul Citrus, Inc. Property August 24, 2004..A-48
Review of Phase I/II ESA for Bryan Paul Citrus, Inc. Property September 20, 2004....A-60
Review of letter on Griffin Brothers Property October 13, 2004....A-64
Review of Phase I/II ESA for Bob Paul Citrus, Inc. Property July 1, 2005....A-66
Review of Additional Soil Assessment for Bryan Paul Citrus Property August 9, 2006....A-70
Review of Additional Soil Assessment for Berry Labelle-Congen Groves Property September 14, 2006....A-72

Endangered Species Coordination
Determination of Effects for Threatened and Endangered Species January 10, 2007....A-75
Final C-43 Biological Assessment December 2006....A-80
Final C-43 Biological Opinion July 2007....A-160

Final Fish and Wildlife Coordination Act Report A-336

This page intentionally left blank

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

March 29, 2005

Dennis Barnett
Acting Chief, Planning Division
U.S. Army Corps of Engineers
701 San Marco Boulevard, Room 372
Jacksonville, Florida 32207-8175

Attention: Deborah Wegman

Dear Mr. Barnett:

The Fish and Wildlife Service (Service) has prepared this Planning Aid Letter (PAL) in support of the C-43 Basin Storage Reservoir Project, Part 1 (C-43 Project). The C-43 Project is a component of the Comprehensive Everglades Restoration Plan (CERP), authorized under the Water Resources Development Act (WRDA) of 2000. This PAL is provided in accordance with the Fish and Wildlife Coordination Act of 1958, as amended (FWCA) (16 U.S.C. 661 *et seq.*), the Endangered Species Act of 1973, as amended (ESA) (87 Stat. 884; 16 U.S.C. 1531 *et seq.*), the Migratory Bird Treaty Act (MBTA) (40 Stat. 755, as amended; 16 U.S.C. 703 *et seq.*), and the Scope of Work agreed upon by the U.S. Army Corps of Engineers (Corps) and the Service for CERP planning studies in FY 2004.

This PAL does not constitute the report of the Secretary of Interior as required by section 2(b) of the FWCA, nor does it constitute a biological opinion under section 7 of the ESA. The purpose of this PAL is to provide guidance and recommendations on resource conservation issues related to the C-43 Project.

Introduction

The C-43 West Reservoir (previously identified as the Berry Groves Reservoir) is a component of the C-43 Project and will provide a significant portion of the overall water storage needed for restoration of the Caloosahatchee Estuary. Its funding, design, and construction have been expedited under the Acceler8 program and the design is currently under development by the South Florida Water Management District (District) and the Corps. The Service, as part of the C-43 Project Environmental Sub-team, is working with project managers to develop alternative plans that provide significant ecological benefits while supporting project goals and objectives.

Department of the Interior (DOI) funds were used to purchase lands within the C-43 West Reservoir for the purpose of ecological restoration. Fifty percent of the acquisition costs (i.e., $32,800,000) of the C-43 West Reservoir site were obtained through Federal grants, including $13,900,000 through Section 390 of the Farm Bill and $18,900,000 from the Land and Water

Conservation Fund. This letter provides Service recommendations for C-43 West Reservoir design and operation to optimize ecological benefits and minimize ecological impacts on lands purchased with DOI funding.

As per the Central and South Florida Project Comprehensive Review Study (Restudy), one of the goals and objectives of CERP projects is to enhance Everglades ecosystem ecological values by: (1) increasing the spatial extent of natural areas; (2) improving habitat and functional quality; and (3) improving native plant and animal species abundance and diversity (Corps 1999). Reservoir design and operation that achieves significant water quality improvements will help satisfy the three Restudy goals identified above.

Water Quality

Extreme variations in salinity levels and poor water quality have reduced the health and productivity of the Caloosahatchee Estuary and are linked to the volume and timing of freshwater flows at the Franklin Lock and Dam (S-79) that originate from the Caloosahatchee watershed and releases from Lake Okeechobee (McPherson and Miller 1990, Doering and Chamberlain 1998). Those releases deviate from the historical quantity, quality, and timing of freshwater flows into the river and estuary. According to the Restudy, the purpose of the C-43 Project is to capture Caloosahatchee River basin runoff and releases from Lake Okeechobee to improve water deliveries to the Caloosahatchee Estuary, and to provide some flood attenuation and water supply benefits. The Restudy included water quality benefits through the reduction of nutrient loadings to the estuary as a related consideration/assumption for the C-43 Project. Likewise, the CERP Master Program Management Plan and the C-43 Basin Storage Reservoir Project Management Plan state that the reservoir would be ". . . designed . . . to provide . . . water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary" and both documents ". . . assumed that, depending upon the location of the reservoir and pollutant loading conditions in the watershed, the reservoir could be designed to achieve significant water quality improvements, consistent with appropriate pollution load reduction targets." However, the proposed design and operation of the C-43 West Reservoir primarily focuses on salinity control by improving the timing and volume of freshwater delivery to the estuary and does not address other water quality needs within the river basin and estuary, such as high nutrient loads.

The need for water quality improvements in the Caloosahatchee Estuary has been well documented. During the 1980's, the Florida Department of Environmental Regulation conducted waste load allocation studies and, based on elevated chlorophyll *a* levels and low dissolved oxygen (DO), concluded that the Cloosahatchee had reached its nutrient loading limits (Doering and Chamberlain 1998). Subsequent water quality studies have found that nitrogen is the most likely limiting nutrient to primary production in the Caloosahatchee Estuary and nitrogen levels exceed concentrations established as upper limits for the Caloosahatchee for chlorophyll *a* (20 milligrams/Liter (mg/L), total nitrogen (1.0 mg/L) and total phophorus (0.15 mg/L) (McPherson and Miller 1990, Doering and Chamberlain 1998, Doering and Chamberlain 1999, Doering and Chamberlain 2004). Those studies also found that the highest concentrations of water quality parameters (i.e., chlorophyll *a*, total nitrogen, total phosphorus,

color) tend to occur most frequently in the upper estuary, most likely as a function of discharges at S-79. Similarly, the occurrences of low DO levels (< 2 mg/L) were also observed at the head of the Caloosahatchee Estuary.

More recently, the Florida Department of Environmental Protection (DEP) has identified impaired water bodies in the Caloosahatchee Basin as part of their Total Maximum Daily Load Program (DEP 2004). DEP lists the tidally influenced Caloosahatchee River and estuary as impaired due to high levels of nutrients (chlorophyll *a*), metals (e.g., copper), and fecal coliform, and due to low levels of DO. High nutrients were identified as the causative pollutant for DO impairment.

High nutrient loads may adversely impact the natural resources within the Caloosahatchee river estuarine system, including the J.N. "Ding" Darling National Wildlife Refuge Complex and the fish and wildlife populations that depend on those resources during various stages of their life cycles. The estuarine system consists primarily of mangrove wetlands, coastal marshes, tidal flats, and aquatic and estuarine habitats (streams, ponds, bays and submerged aquatic vegetation (SAV) beds). Those habitats provide suitable escape, feeding, breeding/spawning, brood rearing/nursery, and wintering sites for a wide variety of aquatic, estuarine, and wetland-dependent organisms for which the Service has Federal-trust conservation responsibilities (e.g., migratory waterfowl, wading birds, shorebirds, seabirds, other water birds, neotropical migratory songbirds, threatened and endangered species, and interjurisdictional fisheries).

Increased nutrient levels (i.e., nitrogen and phosphorus) stimulate phytoplankton and/or algal blooms and thus, reduce light penetration which can lead to reduced fresh and salt water SAV abundance. The loss of feeding and nursery habitat can lead to population declines in commercial and sport fishes (i.e., anchovy, redfish, black drum, and spotted seatrout) and shellfishes (i.e., oysters, pink shrimp, and blue crab), and shifts in species composition.

Threatened and Endangered Species

Additionally, the endangered West Indian manatee (*Trichechus manatus*) and its designated critical habitat occur within the Caloosahatchee River basin and estuary. Critical habitat extends downstream from the State Highway 31 bridge and includes all U.S. territorial waters adjoining the coast and islands of Lee County. Manatees migrate along the Florida coast through fresh, brackish, and marine waters, with a seasonal distribution based on water temperatures. They feed primarily on freshwater and marine grassbeds. Changes in abundance and distribution of SAV in the estuary may impact manatees by increasing travel distance between warm water refugia and suitable food sources.

The endangered wood stork (*Mycteria americana*) and other colonial nesting waterbirds regularly use mangrove islands in the estuary for nesting, roosting, and foraging. Changes in the volume, timing, and quality of Caloosahatchee flows also impact habitat and food sources on which the wood stork and other wading birds depend.

Dennis Barnett Page 4

Recommendations

Based on the above information, the Service recommends that the Corps and the District design the C-43 West Reservoir to achieve water quality benefits by reducing nutrient loads in accordance with CERP Guidance Memorandum Number-Revision 023.01 (GM 023.01) (District and Corps 2004). The C-43 Project is described in the Restudy as a Category B project. Category B projects are not required to include specific water quality improvement features, but are to be designed to achieve water quality improvement. Evaluation criteria must be developed ". . . for alternative plan evaluation, comparison, and selection purposes, as well as for maximizing the the water quality improvement efficiency during design of the selected plan." The intent of GM 023.01 was to maximize nutrient and total suspended solid reductions of proposed alternatives without significant loss of water storage potential or the addition of water quality improvement features.

Reservoirs and natural storage areas have proven to be successful at removing nutrients and total suspended solids. Their efficiency can be evaluated based on hydrologic retention time and measured using hydrologic models. We, therefore, recommend that the Corps and District conduct further modeling to develop alternatives that maximize the reduction of nutrient loads and provide the following information for the final alternatives considered: (1) describe source of water to be captured by the reservoir and its' water quality; (2) predict the quality of water retained within the reservoir; (3) predict the quality of water released from the reservoir and the relationship with water quality of flows discharged at S-79; and (4) describe the effects of the quality and volume of water released at S-79 on the estuary, including changes in hydrologic residence time. The potential of alternative plans to cause additional or contribute to existing pollutant loads should also be evaluated.

At the In Progress Review meeting on the C-43 Project held December 1 and 2, 2003, the Corps and the District discussed expanding the scope of the Reservoir project to address additional water quality benefits beyond the project objectives of reducing freshwater pulses and restoring minimum flows to the Caloosahatchee Estuary. As originally envisioned and directed, the Service supported the approach that the more comprehensive Southwest Florida Feasibility Study (SWFFS) would address these broader watershed and estuarine issues. As described in our January 9, 2004, PAL for the SWFFS, we were concerned that an expansion of the C-43 Project objectives would result in significant project implementation delays which would have serious consequences to the health of the Caloosahatchee Estuary. However, inclusion of the C-43 West Reservoir in the Acceler8 program has resolved those concerns. Thus, if modeling results provide adequate justification, the Service recommends that the C-43 Project scope be modified to include water quality improvement objectives and water quality features be included in project design.

Closing Comments

Improvements in water quality will benefit estuarine habitats, improve their functional quality, and benefit fish and wildlife populations that utilize those habitats, including threatened and

Dennis Barnett Page 5

endangered species and colonial nesting waterbirds, at a local, regional, and system-wide scale. The Service appreciates this opportunity to provide recommendations to the Corps for the benefit of fish and wildlife resources. We look forward to our continued participation as a member of the C-43 Project team. If you have questions or comments, please feel free to contact Joyce Mazourek, Fish and Wildlife Biologist, at 239-472-1100, extension 231.

Sincerely yours,

James J. Slack
Field Supervisor
South Florida Ecological Services Office

cc:
Corps, Jacksonville, Florida (Deborah Wegmann, Leigh Skaggs, David Apple)
DEP, Fort Myers, Florida (Jennifer Nelson)
District, Fort Myers, Florida (Janet Starnes)
EPA, West Palm Beach, Florida (Melanie Edwards, Eric Hughes)
FWC, Fort Myers, Florida (Jim Beever)
FWC, West Palm Beach, Florida (Chuck Collins)
Service, Vero Beach, Florida (Todd Hopkins, Sharon Fauver, Miles Meyer)
Service, Sanibel, Florida (Rob Jess)
Lee County, Fort Myers, Florida (Wayne Daltry, Ray Judah, Bob Janes)

Dennis Barnett Page 6

LITERATURE CITED

Doering, P.H. and R.H. Chamberlain. 1998. Water quality in the Caloosahatchee Estuary, San Carlos Bay and Pine Island Sound. In: Proceedings of the Charlotte Harbor Public Conference and Technical Symposium, March 15-16, 1997, Punta Gorda, Florida, pp. 229-240. Charlotte Harbor National Esturary Program Technical Report No. 98-02, West Palm Beach, Florida, South Florida Water Management District.

Doering, P.H. and R.H. Chamberlain. 1999. Water quality and source of freshwater discharge to the Caloosahatchee Estuary, Florida. Journal of the American Water Resources Association 35(4):793-806.

Doering, P.H. and R.H. Chamberlain. 2004. Total Nitrogen Loading to the Caloosahatchee Estuary at the Franklin Lock and Dam (S-79): Interim CERP water quality update. South Florida Water Management District Unpublished Report.

Florida Department of Environmental Protection (DEP). 2004. Revised Draft List of Impaired waters for the Caloosahatchee River Basin for the Group 3 Basins, Caloosahatchee River Basin. Total Maximum Daily Load Program. <http://www.dep.state.fl.us/water/tmdl/verified_gp3R.htm>.

McPherson, B.F. and R.L. Miller. 1990. Nutrient distribution and variability in the Charlotte Harbor estuarine system, Florida. Water Resources Bulletin 36:67-80.

South Florida Water Management District and U.S. Army Corps of Engineers (District and Corps). 2004. CERP Guidance Memorandum Number-Revision: 023.01, Water Quality considerations for the Project Implementation Report Phase.

U.S. Army Corps of Engineers and South Florida Water Management District (Corps and District). 1999. Central and Southern Florida Project Comprehensive Review Study. Final integrated feasibility report and programmatic environmental impact statement. Jacksonville District Office, Jacksonville, Florida.

Annex A

Fish and Wildlife

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

August 13, 2003

James C. Duck
Chief, Planning Division
U.S. Army Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Duck:

This Planning Aid Letter is submitted by the Fish and Wildlife Service (Service) in compliance with the Scope of Work for the C-43 Basin Storage Reservoir Project (C-43 Project). The purpose of this letter is to highlight potentially significant fish and wildlife issues or concerns, define fish and wildlife resource opportunities, identify information needs for plan formulation, and affirm our commitment and involvement to work on the C-43 Project in an expedited fashion. This letter is provided in accordance with the Fish and Wildlife Coordination Act (FWCA) of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq.*) but does not constitute the final report of the Secretary of the Interior as required by section 2(b) of the FWCA. These comments are also provided under the provisions of section 7 of the Endangered Species Act of 1973, as amended (87 Stat. 884; 16 U.S.C. 1531 *et seq.*).

Introduction

The U.S. Army Corps of Engineers (Corps) is beginning to gather information on issues and concerns that will be addressed in their draft Environmental Impact Statement (EIS) for this C-43 Project. On March 28, 2003, the Corps announced the start of the public scoping process under National Environmental Protection Agency for the C-43 Project. On June 10, 2003, the Service submitted scoping comments pertaining to the Draft EIS. The discussion in this Planning Aid Letter (PAL) reiterates many of the concerns we initially expressed in our scoping comments. In addition, please refer to the Service's PAL, dated April 11, 2002, for additional information on fish and wildlife concerns.

Project Description

The C-43 Project is part of the Comprehensive Everglades Restoration Plan (CERP) authorized by the Water Resources Development Act of 2000. The purpose of the C-43 Project is to capture excess storm runoff and releases from Lake Okeechobee for later release into the Caloosahatchee

James C. Duck
August 13, 2003
Page 2

River during times of need (*e.g.*, prevent saltwater intrusion or provide water supply during droughts). This C-43 Project would entail above-ground reservoir(s) with a total storage capacity of about 160,000 acre-feet within the Caloosahatchee basin. The initial design of the reservoir(s) assumed a total surface area of 20,000 acres with water levels fluctuating up to 8 feet. Anticipated benefits of the proposed C-43 Project include the attenuation of flood flows; improvement of water quality and timing of releases to the Caloosahatchee River and Estuary; protection of the Caloosahatchee Estuary from excessive fresh water deliveries, and improvement of water supply benefits for environmental, urban, and agricultural users.

Project Area

The Caloosahatchee Basin is located in Hendry, Glades, Lee and a small portion of Charlotte, Collier, and Palm Beach counties (see Figure 1). The natural systems within the Caloosahatchee Basin consist of wetlands (freshwater swamps, sloughs, marshes, and estuaries) and upland (pine flatwoods, temperate oak/palmetto hammocks, tropical hammocks, dry prairie, and xeric scrub communities) habitats which are interdependent on each other. A number of these systems are located within relatively pristine areas which are recognized as having regional importance, such as the J.N. "Ding" Darling National Wildlife Refuge Complex and the Charlotte Harbor Aquatic Preserve. These areas serve as important habitat for a wide variety of wildlife, including over 20 Federal and State listed species.

The following is a list of federally listed threatened (T) or endangered (E) animals and their critical habitat (CH), or experimental population status (E/P), known or expected to occur within the Caloosahatchee Basin and Estuary. These protected species include: Florida panther (*Puma concolor coryi*) (E), West Indian manatee (*Trichechus manatus*) (E, CH), wood stork (*Mycteria americana*) (E), everglades snail kite (*Rostrhamus sociabilis plumbeus*) (E), red-cockaded woodpecker (*Picoides borealis*) (E), Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) E, green sea turtle (*Chelonia mydas*) (E), American crocodile (*Crocodylus acutus*) (E), leatherback sea turtle (*Dermochelys coriacea*) (E), Kemp's ridley sea turtle (*Lepidochelys kempii*) (E), smalltooth sawfish (*Pristis pectinata*)(E), loggerhead sea turtle (*Caretta caretta*) (T), bald eagle (*Haliaeetus leucocephalus*)(T), Florida scrub jay (*Aphelocoma coerulescens*) (T), Audubon's crested caracara (*Caracara plancus*) (T), piping plover (*Charadrius melodus*) (T), whooping crane (*Grus americana*) T(E/P), and eastern indigo snake (*Drymarchon corais couperi*) (T). Federally listed plant species that occur or have the potential to occur in the study area include Florida bonamia (*Bonamia grandiflora*) (E), Okeechobee gourd (*Cucurbita okeechobeensis okeechobeensis* (E), and beautiful pawpaw (*Deeringothamnus pulchellus*) (E).

All of the above-mentioned species may be affected by the C-43 Project and should be considered during the planning process. As a clarification, the Service has consultation responsibilities for sea turtle nesting, and although sea turtles are known to nest on beaches in the region, the C-43

James C. Duck
August 13, 2003
Page 3

Project should have no effect on sea turtle nesting. However, the C-43 Project could have a direct effect on marine and estuarine habitats used by sea turtles, and the Corps should consult with the National Oceanic and Atmospheric Administration-National Marine Fisheries Service (NOAA-Fisheries) on these species. On April 1, 2003, the NOAA-Fisheries published a final rule listing the smalltooth sawfish (*Pristis pectinata*) as a distinct population segment. The Corps should consult with the NOAA-Fisheries regarding this species as well. In addition, the Corps should contact the Florida Fish and Wildlife Conservation Commission (FWC) to consult on the several species listed by the State of Florida.

The Berry Labelle-Congen Groves property is an intensive agricultural area that was considered capable of having high concentrations of various contaminants, including, metals, pesticides, and petroleum by-products. To address these concerns, a Phase I/II Environmental Site Assessment was conducted in the Berry Labelle-Congen Groves by the URS Corporation during 1999. In addition, URS Corporation conducted a follow-up Phase II Environmental Site Assessment, and a site-specific Ecological Risk Assessment in 2002. Results of these soil contaminant studies indicate that risks associated with detected copper concentrations appear to be isolated to the benthic macroinvertebrate community and do not appear to pose any pervasive risks to any other ecological resources. The URS Corporation concluded in this document that their findings should not preclude the conversion of Berry Labelle-Congen Groves property into a water retention area for the C-43 Project. However, a recent Phase II Environmental Site Assessment draft report for Berry LaBelle-Congen Grove indicates that copper desorption occurred in sediment samples after 3 days, and that toxicity tests showed adverse effects on growth and/or survival of flathead minnow, freshwater amphipod and midge larvae after 7 to 10-day exposures to sediment samples (URS Corporation 2003).

The Service is reviewing the results of these soil contaminant assessments at the Berry Labelle-Congen Groves properties in light of our concerns that the indicated copper concentration may have a deleterious effect on apple snails. If this is the case, then there could be an adverse impact on other species in the food web, such as the endangered snail kite and wading birds. We recommend that soil contaminant assessment data, potential impact evaluations, site remediation options, and other C-43 Project alternatives be reviewed by the Corps. We also recommend that contaminant evaluations using applicable Sediment Quality Assessment Guidelines for the protection of fish and wildlife be conducted on all proposed reservoir sites within historic or existing citrus groves in the CERP planning area.

Update of Work Completed

Since our April 11, 2002, letter, a subteam was established that developed site screening criteria for potential reservoir and restoration locations for the C-43 Project. After a series of meetings and conference calls throughout the fall and winter of 2002, the subteam and reached consensus on a screening matrix and the definitions for each criteria. The goal of this matrix is to allow the

subteam to objectively screen and rank each potential reservoir or restoration site during the alternative selection process. A preliminary site map was also generated containing potential reservoir and restoration site locations. In addition, the Service completed a series of species maps to screen T and E species, as well as other fish and wildlife trust resource concerns. These species maps were based on a 1995 land use map, digital orthophoto quads, species richness data from the FWC (Cox et al. 1994, Cox and Kautz 2000), and Florida Natural Areas elements of occurrence data. These coverages were used together with other maps provided by the Corps, South Florida Water Management District (SFWMD), FWC, and the Florida Department of Environmental Policy and applied to each criteria defined within the site selection matrix. This process refined our list of potential reservoir/restoration sites based on the occurrence of listed species habitat and cultural resources, and proximity to the river. The final draft of the matrix was accepted by the full Project Delivery Team (PDT) on March 20, 2003. We are now further refining the list of potential storage and restoration sites to develop alternatives for the Project Implementation Report.

Comments

It is important that the Corps conduct a water budget analysis for the entire Caloosahatchee Basin. This information is necessary to identify the amount of water required to restore and maintain the Estuary year around. As part of this analysis, we recommend evaluation studies to determine the quantity, quality, timing, and distribution of water necessary for riverine and estuarine recovery in the basin be conducted by the Corps, and evaluated by the Service and the subteam.

The primary C-43 Project purpose is to improve environmental conditions in the Caloosahatchee Basin. To support this purpose, the Corps, SFWMD, and Service should jointly identify specific ecological targets (*e.g.*, amounts and timing of water releases, and water quality controls) for the Caloosahatchee River and Estuary, as well as proposed changes in operational scenarios for the reservoir(s) and other adaptive management options in the event these targets are not met. Presently, minimum flows of 300 cubic feet per second (cfs) are authorized by the SFWMD. However, minimum discharges of this magnitude can cause harm to estuarine resources (SFWMD 2003). We recommend that minimum flow targets between 500 and 2000 cfs, which provide better conditions for oysters, be considered in determining minimum freshwater inflows for the Caloosahatchee Estuary. We also recommend that ecologically-meaningful measures, such as flow quantity, quality, duration and timing, be considered by the Corps for purposes of quantifying the water to be reserved for restoration of fish and wildlife habitats, pursuant to Section 601(h)(4)(A)(iii) of the Water Resources Development Act of 2000 (Published Law 106-541).

We suggest that the Corps address the construction of smaller reservoirs distributed along canals in the Caloosahatchee Basin as an alternative to one large reservoir for storing water to restore

James C. Duck
August 13, 2003
Page 5

estuarine values. Depending on their design, location and operation, these "distributed" reservoirs could provide significant onsite fish and wildlife values. Furthermore, if the Berry Labelle-Congen Groves location is chosen as the C-43 Project site (storage capacity of 64,000 acre-feet), then an additional 96,000 acre-feet of water would be required to reach the 160,000 acre-feet of water necessary to satisfy current C-43 Project objectives for the Estuary. We have discussed the restoration potentials in Lake Hicpochee and Telegraph Swamp in past meetings, and are interested in exploring additional areas with the Corps that may also be suitable for habitat restoration.

The impacts on fish and wildlife resources and habitats from the full-scale C-43 Project would include not only the direct effects within each project footprint, but also any potential impacts on fish and wildlife resources (including bioavailability of contaminants) up and downstream of the C-43 Project as a result of reservoir construction, operations, and water delivery. To be consistent with the C-43 Project objectives, the Corps should address potential project-related effects beyond the project footprint, including the restoration of the Caloosahatchee Estuary by modifying inflows to reflect a more natural hydrological regime. In addition, the Lake Okeechobee regulations and the schedule and operation protocols associated with the C-43 Canal should be included in the Corps' assessment of impacts. Currently, the Regulation Schedule and operating protocol for Lake Okeechobee calls for a minimum discharge of 300 cfs. The level of water storage in Lake Okeechobee at any given time would dictate how releases would be made, as well as how the C-43 Project would be operated. Therefore, the regulation schedule and operation protocol should be reevaluated in light of its effect on this and other CERP projects. We recommend that the Corps fully address these potential impacts in its Project Implementation Report and NEPA documents for the C-43 Project.

As discussed at the March 20, 2003, PDT meeting, we recommend that all potential reservoir locations be independently screened through the Site Selection subteam's storage and restoration criteria. This is important because no potential restoration location should be left out of the alternative selection process. In-basin restoration with storage, (*i.e.*, water storage facilities within the C-43 Project area that include habitat restoration benefits) will meet the goals of the C-43 Project, as well as benefit fish and wildlife resources within the basin by rehydrating wetlands and improving other habitats.

In the event infrastructure designs change during the planning process, the Service requests a complete description of these changes to evaluate the potential impacts to fish and wildlife resources and habitats, including listed species. An infrastructure change could include such actions as blocking a canal and rediverting water to a reservoir. The Service would need to know the quantity, design, and fate of diverted water to determine potential effects on fish and wildlife values.

James C. Duck
August 13, 2003
Page 6

This concludes our PAL which provides recommendations for planning activities related to the C-43 Project. The Service is committed to continued participation in future planning efforts with C-43 Project sponsors and other agency staff to evaluate the potential effects of the C-43 Project on fish and wildlife values. If you have any questions regarding these comments, please contact Stephanie Brady at 239-472-1100, extension 242.

Sincerely yours,

James J. Slack
Field Supervisor
South Florida Ecological Services Field Office

Enclosure

cc: w/enclosure
Corps, Jacksonville, Florida (Doris Marlin, David Apple, Susan Conner)
EPA, Jacksonville, Florida (Eric Hughes)
EPA, West Palm Beach, Florida (Richard Harley)
FWC, Punta Gorda, Florida (Jim Beever)
FWC, Vero Beach, Florida (Joe Walsh)
NOAA-Fisheries, St. Petersburg, Florida (Mark Sramek)
Service-EPA, Fort Myers, Florida (Bruce Boler)
Service, Jacksonville, Florida (Miles Meyer)
Service, J.N. "Ding" Darling NWR, Sanibel, Florida (Robert Jess)
Service, Vero Beach, Florida (Carl Couret)
SFWMD, West Palm Beach, Florida (Agnes Ramsey)
SFWMD, Fort Myers, Florida (Janet Starnes)

James C. Duck
August 13, 2003
Page 7

Literature Cited

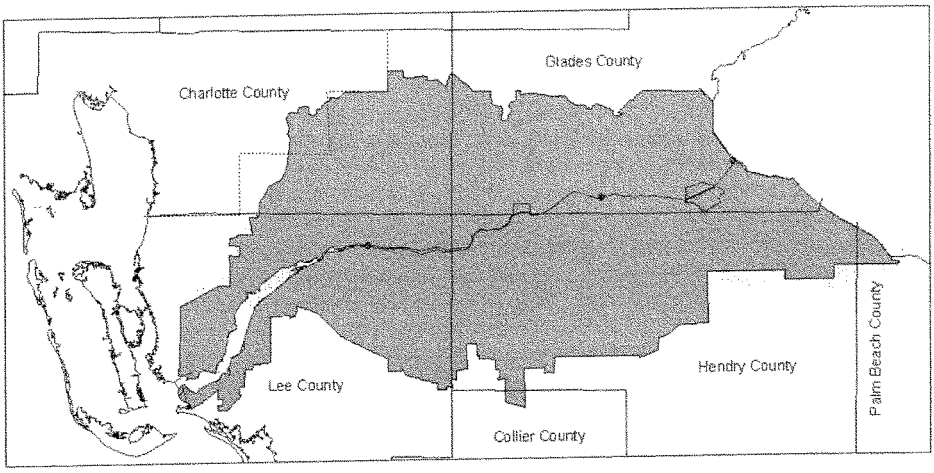
Cox, J. A., and R. Kautz. 2000. Habitat conservation needs of rare and imperiled wildlife in Florida. Office of Environmental Services, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Cox, J. R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Office of Environmental Services, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

South Florida Water Management District. 2003. Technical Document to Support Development of Minimum Flows and Levels for the Caloosahatchee River and Estuary. South Florida Water Management District, Florida Bay and Lower West Coast Division, Fort Myers, Florida.

URS Corporation. 2003. Ecological Risk Assessment – Draft Report, Berry LaBelle–Congen Grove, Hendry County, Florida. Contracted by South Florida Water Management District, Florida Bay and Lower West Coast Division, Ft. Myers, FL (Job #10582-145-024). 28 pp.

Figure 1. Caloosahatchee Basin. The red dots indicate Franklin, Ortona, and Moorehaven Locks on the Caloosahatchee River.



Caloosahatchee Basin



Annex A

Fish and Wildlife

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

June 10, 2003

James C. Duck
Chief, Planning Division
U.S. Army Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Duck:

The Fish and Wildlife Service (Service) has prepared the following scoping comments for consideration in the proposed development of a Draft Environmental Impact Statement (EIS) for the C-43 Basin Storage Reservoir Project. These comments are provided in accordance with the Fish and Wildlife Coordination Act (FWCA) of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq.*) but do not constitute the final report of the Secretary of the Interior as required by section 2(b) of the FWCA. These comments are also provided under the provisions of section 7 of the Endangered Species Act (ESA) of 1973, as amended (87 Stat. 884; 16 U.S.C. 1531 *et seq.*) and are consistent with the National Environmental Policy Act of 1969, as amended (Pub. L. 91-190, 42 U.S.C. 4321-4347 *et seq.*). Please refer to the Service's Planning Aid Letter dated April 11, 2002, for additional information on fish and wildlife concerns.

Project Description

The C-43 Basin Storage Reservoir Project (Project) is part of the Comprehensive Everglades Restoration Plan (CERP) authorized by the Water Resources Development Act (WRDA) of 2000. The purpose of this project is to capture excess storm runoff and releases from Lake Okeechobee, and then release these stored waters into the Caloosahatchee River during times of need, such as saltwater intrusion or drought. This Project would entail above-ground reservoir(s) with a total storage capacity of about 160,000 acre-feet within the Caloosahatchee Basin. The initial design of the reservoir(s) assumed a total surface area of 20,000 acres with water levels fluctuating up to eight feet. Anticipated benefits of the proposed Project include the attenuation of flood flows, improvement of water quality and timing of releases to the Caloosahatchee River and estuary, protection of the Caloosahatchee estuary from excessive fresh water deliveries, and improvement of water supply benefits for environmental, urban, and agricultural users.

The Caloosahatchee Aquifer Storage and Recovery (ASR) pilot project is related to this Project and also authorized by WRDA 2000. The purpose of the ASR is to store partially-treated

James C. Duck
June 10, 2003
Page 2

available surface or groundwaters within the Floridan Aquifer System for subsequent recovery and use. Benefits of implementing the ASR technology within the Caloosahatchee River Basin would include minimizing high-volume stormwater releases to the Caloosahatchee estuary, maintaining minimum flows in the Caloosahatchee River, preventing salt water intrusion, and supplying future urban and agricultural demands. Another project associated with the C-43 Basin Storage Reservoir Project is the Southwest Florida Feasibility Study (SWFFS) which was recommended to Congress in July 1999 as part of the Central and Southern Florida Project (Restudy), now the CERP. The purpose of the SWFFS is to better define problems and opportunities to restore ecosystems in the southwest region of Florida.

Project Area

The Caloosahatchee Basin is located in Hendry, Glades, Lee, and a small portion of Charlotte, Collier, and Palm Beach counties (Figure 1). The natural systems within the Caloosahatchee Basin consist of wetlands (freshwater swamps, sloughs, marshes, and estuaries) and upland (pine flatwoods, temperate oak/palmetto hammocks, tropical hammocks, dry prairie, and xeric scrub communities) habitats which are interdependent on each other. A number of these systems are located within relatively pristine areas which are recognized as having regional importance, such as the J. N. "Ding" Darling National Wildlife Refuge complex and the Charlotte Harbor Aquatic Preserve. These areas serve as important habitat for a wide variety of wildlife, including over 20 Federal and State listed species.

The following is a list of federally listed threatened (T) or endangered (E) animals and their critical habitat (CH) or experimental population status (E/P), known or expected to occur within the Caloosahatchee Basin and estuary. These protected species include: the Florida panther (*Puma concolor coryi*) (E), West Indian manatee (*Trichechus manatus*) (E, CH), wood stork (*Mycteria americana*) (E), everglades snail kite (*Rostrhamus sociabilis plumbeus*) (E), red-cockaded woodpecker (*Picoides borealis*) (E), Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) E, green sea turtle (*Chelonia mydas*) (E), American crocodile (*Crocodylus acutus*) (E), leatherback sea turtle (*Dermochelys coriacea*) (E), Kemp's ridley sea turtle (*Lepidochelys kempii*) (E), loggerhead sea turtle (*Caretta caretta*) (T), bald eagle (*Haliaeetus leucocephalus*)(T), Florida scrub jay (*Aphelocoma coerulescens*) (T), Audubon's crested caracara (*Caracara plancus*) (T), piping plover (*Charadrius melodus*) (T), whooping crane (*Grus americana*) T(E/P), and eastern indigo snake (*Drymarchon corais couperi*) (T). Federally listed plant species that occur or have the potential to occur in the study area include Florida bonamia (*Bonamia grandiflora*) (E), Okeechobee gourd (*Cucurbita okeechobeensis okeechobeensis* (E), and beautiful pawpaw (*Deeringothamnus pulchellus*) (E).

All of the above-mentioned species may be effected by the Project and should be considered during the planning process. As a clarification, the Service has consultation responsibilities for

James C. Duck
June 10, 2003
Page 3

sea turtle nesting, and although sea turtles are known to nest on beaches in the region, the Project should have no effect on sea turtle nesting. However, the Project could have a direct effect on marine and estuarine habitats used by sea turtles, and the U.S. Army Corps of Engineers (Corps) should consult with the National Marine Fisheries Service (NMFS) on these species. On April 1, 2003, the NMFS published a final rule listing the Smalltooth Sawfish (*Pristis pectinata*) as a distinct population segment. The Corps should consult with the NMFS regarding this species as well. In addition, there are several species listed by the State of Florida that should be addressed in this document.

The Berry Groves property is an intensive agricultural area that was considered capable of having high concentrations of various contaminants, including, metals, pesticides, and petroleum by-products. To address these concerns, a Phase I/II Environmental Site Assessment was conducted in the Berry Groves by the URS Corporation during 1999. In addition, URS Corporation conducted a follow-up Phase II Environmental Site Assessment and a site-specific Ecological Risk Assessment in 2002. Results of these soil contaminant studies indicate that risks associated with detected copper concentrations appear to be isolated to the benthic macroinvertebrate community and do not appear to pose any pervasive risks to any other ecological resources. Based on these data, URS Corporation concluded that their findings should not preclude the conversion of Berry Groves property into a water retention area for this Project.

The Service is reviewing the results of these soil contaminant assessments at the Berry Groves property in light of our concerns that the indicated copper concentration may have a deleterious effect on apple snails. If this is the case, then there could be an effect on other species in the food web, such as the endangered snail kite and wading birds. We recommend that soil contaminant assessment data, potential impact evaluations, site remediation options, and other Project alternatives be discussed in the Corps's National Environmental Policy Act (NEPA) document. We also recommend that contaminant evaluations using applicable Sediment Quality Assessment Guidelines for the protection of fish and wildlife be conducted on all proposed reservoir sites within historic or existing citrus groves in the CERP planning area.

Comments

It is important that the Draft EIS include analysis of a water budget for the entire Caloosahatchee Basin. This information is necessary to assess the amount of water that is required for restoration and maintenance of the estuary year-round. As part of this analysis, we recommend that evaluation studies determine the quantity, quality, timing and distribution of water necessary for riverine and estuarine recovery in the basin and be included in the Draft EIS.

The primary project purpose is to improve environmental conditions in the Caloosahatchee Basin. Consequently, the Draft EIS should identify specific ecological targets (*e.g.*, amounts and timing

James C. Duck
June 10, 2003
Page 4

of water releases, and water quality controls) for the Caloosahatchee River and Estuary, as well as proposed changes in operational scenarios for the reservoir(s) and ASR facilities and other adaptive management options in the event these targets are not met. Flow targets should be greater than the 300 cubic feet per second (cfs) minimum flows and levels that are currently authorized by the South Florida Water Management District because discharges of 300 cfs are too low and can cause harm to estuarine resources. Target flows from 500 to 2000 cfs, which provide better conditions for oysters, should be considered in determining minimum freshwater inflows for the Caloosahatchee estuary. We recommend that such ecologically-meaningful measures of flow, timing, and water quality be incorporated into the Draft EIS and Project Implementation Report for purposes of quantifying the water to be reserved for restoration, pursuant to Sec. 601(h)(4)(A)(iii) of the Water Resources Development Act of 2000 (Pub. Law 106-541).

We recommend that the Draft EIS address the option of smaller reservoirs distributed along canals in the Caloosahatchee Basin as an alternative to one large reservoir for storing water to restore estuarine values. Depending on their design, location and operation, these distributed reservoirs could provide significant fish and wildlife values. Furthermore, if the Berry Groves location is chosen as the Project site (storage capacity of 64,000 acre-feet), then an additional 96,000 acre-feet of water would be required because a total of 160,000 acre-feet of water would be necessary to satisfy estuary restoration objectives for this Project. For these reasons, we recommend that this option continue to be considered as a Project alternative.

We recommend that "in-basin restoration" at additional locations be identified in the Draft EIS as a possible alternative. We have discussed the restoration potentials in Lake Hicpochee and Telegraph Swamp in past meetings and are interested in exploring additional areas with the Corps that may also be suitable for habitat restoration.

It is important that the Draft EIS discuss the relationship of this Project to the Caloosahatchee ASR pilot project because all the ASR projects will be reservoir-dependent. It is also important that the Draft EIS discuss the relationship between this project and the SWFFS because if the C-43 Basin Storage Reservoir Project cannot meet the water needs of the estuary, then additional releases may be necessary from additional storage reservoirs that could be recommended through the SWFFS.

The Draft EIS should address any potential project effects outside the footprint of the C-43 Basin Storage Reservoir. These could include potential impacts on downstream receiving waters and associated aquatic communities including the beneficial effects of restoring the Caloosahatchee estuary by restoring more natural hydrological patterns. In addition, the Corps should include the Lake Okeechobee regulation schedule and operation protocols associated with the C-43 Canal. Currently, the regulation schedule and operating protocol for Lake Okeechobee calls for a minimum discharge of 300 cfs. Therefore, the level of water storage in Lake Okeechobee at any given time

James C. Duck
June 10, 2003
Page 5

would dictate how releases would be made, as well as how the C-43 would be operated. Therefore, the regulation schedule and operation protocol should be reevaluated in light of its effect on this and other CERP projects.

The NEPA defines Cumulative Impacts as those impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. For this Project, the potential impacts of the proposed ASR projects should be included in the Draft EIS among the reasonably foreseeable future actions that would affect the Caloosahatchee River and estuary.

The impacts on fish and wildlife resources and habitats from the full-scale C-43 Basin Storage Reservoir Project would include not only the direct effects within the Project footprint, but also any potential impacts on fish and wildlife resources (including bioavailability of contaminants) that could occur up and downstream of the Project as a result of reservoir operations and water deliveries to the ASR site. We recommend that the Draft EIS address the relationship between the ASR pilot and the C-43 Reservoir Project with regard to threatened and endangered species, as well as other fish and wildlife values.

The following comments are related to specific items that were discussed in various meetings associated with the C-43 Basin Storage Reservoir Project. As discussed at the March 20, 2003, Project Delivery Team meeting, we recommend all potential reservoir locations be independently screened through the sub-team's storage and restoration criteria in the Draft EIS. It is important that no potential restoration locations be left out of the alternative selection process. In-basin restoration with storage, (*i.e.*, water storage facilities within the project area that include habitat restoration benefits) will not only meet the goals of the Project, but it will also benefit fish and wildlife resources within the basin by rehydrating wetlands and improving other habitats. Future analysis may show that several smaller reservoirs throughout the basin could satisfy project goals while providing a greater gain in fish and wildlife values.

For each infrastructure change, we would need a complete project description to evaluate the potential impacts to fish and wildlife resources and habitats, including listed species. An infrastructure change could include such actions as blocking a canal and rediverting water to a reservoir. The Service would need to know how the water would be diverted to determine effects on fish and wildlife values. In addition, these changes may affect hydrological regimes that in turn may negatively impact fish and wildlife habitats and resources in the project area.

The Service appreciates this opportunity to offer input into the scoping of issues for the C-43 Basin Storage Reservoir Project Draft EIS. We are committed to our continuing participation in

James C. Duck
June 10, 2003
Page 6

the NEPA process and development of a project consistent with the CERP goals. If you have any questions regarding these comments, please contact Stephanie Brady at 239-472-1100, extension 242.

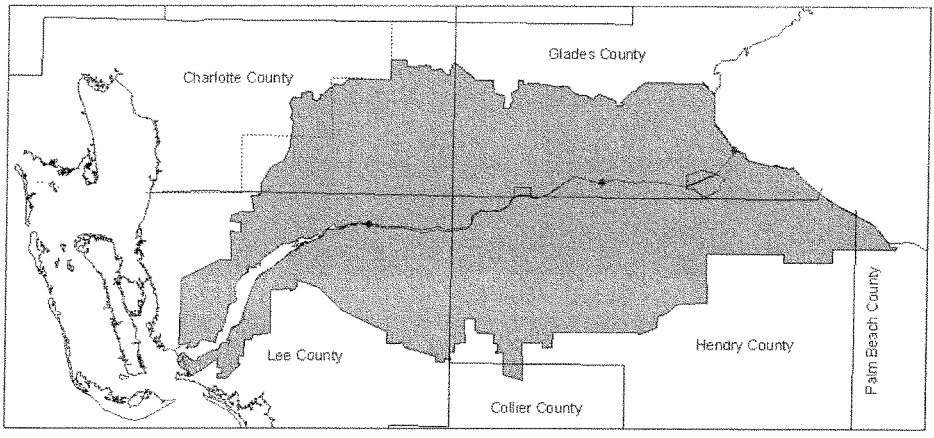
Sincerely yours,



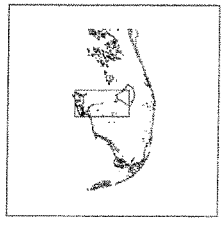
James J. Slack
Field Supervisor
South Florida Ecological Services Office

cc:
Corps, Jacksonville, Florida, (Doris Marlin)
Corps, Jacksonville, Florida, (David Apple)
Corps, Jacksonville, Florida, (Susan Conner)
Service, Jacksonville, Florida (Miles Meyer)
SFWMD, West Palm Beach, Florida, (Agnes Ramsey)
SFWMD, Ft. Myers, Florida, (Janet Starnes)
EPA, Jacksonville, Florida
EPA, West Palm Beach, Florida
EPA, Ft. Myers, Florida, (Bruce Boler)
FWC, Vero Beach, Florida
FWC, Punta Gorda, Florida, (Jim Beever)

Figure 1. Caloosahatchee Basin



Caloosahatchee Basin



Annex A

Fish and Wildlife

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

April 11, 2002

Mr. James Duck
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

RE: C-43 Basin Storage Reservoir

Dear Mr. Duck:

This is in response to your February 25, 2002, request for the U.S. Fish and Wildlife Service (Service) expertise in identifying any critical fish and wildlife habitat and any threatened or endangered species that may be within the project area or affected by the activities of the C-43 Basin Storage Reservoir. The Service has prepared this Planning Aid Letter (PAL) for the C-43 Basin Storage Reservoir Project, Hendry, Glades, and Lee counties. This PAL is provided in accordance with the Fish and Wildlife Coordination Act (FWCA) of 1958 (48 Stat. 401, as amended: 16 U.S.C. 661 *et seq.*) and section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

This PAL does not constitute the report of the Secretary of Interior as required by section 2(b) of the FWCA, nor does it constitute a biological opinion under section 7 of the ESA. This PAL provides guidance and recommendations regarding several resource conservation issues to be considered in plan formulation and evaluation.

I. Introduction

The C-43 Basin Storage Reservoir is part of the Comprehensive Everglades Restoration Plan (CERP) authorized by the Water Resources Development Act of 2000. This project entails above-ground reservoir(s) with a total storage capacity of approximately 160,000 acre-feet within the Caloosahatchee basin. The initial design of the reservoir(s) assumed a total surface area of 20,000 acres with water levels fluctuating up to eight feet above grade. The purpose of this project is to capture excess storm runoff and releases from Lake Okeechobee. The captured water could then be released into the Caloosahatchee River during times of need or drought. Anticipated benefits of the proposed project include the use of water normally lost to tide, flood attenuation, improvements of water quality and timing of releases to the Caloosahatchee basin, river, and estuary, protection of Caloosahatchee estuary from excessive fresh water deliveries, and water supply benefits for environmental, urban, and agricultural users.

James C. Duck
April 11, 2002
Page 2

The 9,000-acre Berry Groves property, located in Hendry County, is available for an approximately 8,000-acre reservoir. Assuming an 8-foot maximum depth of storage, the Berry Groves reservoir could potentially hold 64,000 acre-feet of water. The property is currently in agricultural production with citrus as the primary crop. The locations for the remaining 96,000 acre-feet of storage are to be identified within the Caloosahatchee basin in Hendry, Glades, or Lee counties.

II. Project Area Setting

The Berry Groves reservoir site is located west of La Belle, in Hendry County (Figure 1). Currently, the land is an 9,000-acre citrus grove. There are two adjacent canals that adjoin the property, the Townsend Canal to the west and the Roberts Canal to the east. Staff from the Corps of Engineers (Corps), the South Florida Water Management District (SFWMD), and the Service conducted a site visit on February 28, 2002. The purpose of the site visit was to check the area for a monitoring well site for the C-43 Aquifer Storage and Recovery Pilot Project. However, the site visit also gave a Service biologist the opportunity to see a portion of the location for the reservoir project. The area is primarily citrus groves, with strips of shrubs along irrigation/drainage ditches in the grove. The primary vegetation in the ditches was Brazilian pepper (*Schinus terebinthifolius*), with some grasses and other herbaceous plants.

Currently, the Berry Groves operation obtains water from the Townsend Canal through a pump, located about half-way along the eastern-most boundary of the property. A system of many secondary ditches provides conveyance of water to, and drainage from, the citrus grove.

Other potential reservoir sites for the remaining 96,000 acre-feet of storage are yet to be determined. Based on a conversation at the Project Delivery Team meeting, the Service understands that the Corps is looking throughout the Caloosahatchee basin, and elevation contours are being used to make initial rough determinations of site suitability. This PAL provides additional rough screening of potential reservoir sites, based primarily on landuse coverages and species richness models.

IV. Fish and Wildlife Resources of the Project Area

A. Federally Listed Species

The focus of the Corps' February 25, 2002, letter requesting the Service's planning input was federally listed threatened and endangered species, and that is an emphasis of this PAL. As shown in Table 1, 19 federally listed species are known to occur in Lee, Collier, and Glades counties, and three of these species have a portion of their designated critical habitats within or adjacent to the study area.

James C. Duck
April 11, 2002
Page 3

TABLE 1. FEDERALLY LISTED THREATENED AND ENDANGERED SPECIES IN LEE, HENDRY, AND GLADES COUNTIES

Scientific Name	Common Name	Status
Amphibians and Reptiles		
Caretta caretta	Loggerhead sea turtle	T
Chelonia mydas	Green sea turtle	E
Crocodylus acutus	American crocodile	E
Dermochelys coriacea	Leatherback sea turtle	E
Drymarchon corais couperi	Eastern indigo snake	T
Eretmochelys imbricata	Hawksbill sea turtle	E
Lepidochelys kempii	Kemp's (=Atlantic) ridley sea turtle	E
Birds		
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E
Aphelocoma coerulescens	Florida scrub jay	T
Charadrius melodus	Piping plover	T*
Haliaeetus leucocephalus	Bald eagle	T
Mycteria americana	Wood stork	E
Picoides borealis	Red-cockaded woodpecker	E
Polyborus plancus audubonii	Audubon's crested caracara	T
Rostrhamus sociabilis plumbeus	Everglade snail kite	E*
Mammals		
Felis concolor coryi	Florida panther	E
Trichechus manatus latirostris	West Indian manatee	E*
Plants		
Cucurbita okeechobeensis	Okeechobee gourd	E
Deeringothamnus pulchellus	Beautiful pawpaw	E

*Critical Habitat present

James C. Duck
April 11, 2002
Page 4

The direct and indirect effects of the project as a whole would potentially benefit or adversely impact any of the species in Table 1. To our knowledge, no comprehensive surveys have been completed for fish and wildlife species within the Berry Groves property, but due to its highly altered habitat conditions, we expect that it has limited value for listed species. .

The snail kite (*Rostrhamus sociabilis plumbeus*) inhabits the watersheds of the Everglades, lakes Okeechobee and Kissimmee, the upper St. Johns River, and the Caloosahatchee basin. Critical habitat for the snail kite (see 50 CFR 17.95) is present immediately adjacent to the Caloosahatchee basin inside of the Herbert Hoover Dike in Lake Okeechobee. The snail kite could also be found foraging in a number of native wetlands and in canals and ditches adjacent to the project area. This medium-sized raptor has a highly specific diet composed almost entirely of Florida apple snails (*Pomacea paludosa*), which are found in palustrine emergent, long hydroperiod wetlands. As a result, the snail kite's survival is directly dependent on the hydrology and water quality of its habitat (Service 1999).

The wood stork is primarily associated with freshwater and estuarine habitats for nesting, roosting, and foraging. They have nested, at one time or another, in every county in south Florida. Typical foraging sites include freshwater marshes and stock ponds, shallow, seasonally flooded roadside or agricultural ditches, narrow tidal creeks or shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Wood storks use a specialized feeding behavior called tactolocation, or grope feeding. A foraging wood stork wades through the water with its beak immersed and partially open (7 to 8 cm). When it touches a prey item, a wood stork snaps its mandibles shut, raises its head, and swallows what it has caught (Kahl 1964). This unique feeding method of the wood stork gives it specialized habitat requirements; the habitats on which wood storks depend have been disrupted by changes in the distribution, timing, and quantity of water flows in south Florida. The loss or degradation of wetlands in central and south Florida is one of the principal threats to the wood stork.

The endangered West Indian manatee (*Trichechus manatus*) is regularly found in the Caloosahatchee River and the Charlotte Harbor estuary. This large, aquatic mammal migrates along the Florida coast through fresh, brackish, and marine waters, with a seasonal distribution based on water temperatures. Waters colder than 20 degrees C increase the manatee's susceptibility to cold-stress and cold-induced mortality. Distribution is also controlled by aquatic vegetation availability, proximity to channels of at least 2 m in depth, and location of fresh water sources (Service 1999). In addition to the Service's concerns about boat-caused mortality throughout the species' range, navigational locks along the Caloosahatchee River have a history of causing manatee mortality. Sixteen navigational lock/water control structure-caused manatee deaths have been recorded near Ortona Lock (S-78) between 1980 and 2001. Throughout those same years, six were discovered near S-77 at Moore Haven, and just one in 1999 at the Franklin Lock (S-79). Existing operational protocols for the structures and locks (unaffected by project planning for the C-43 reservoirs) are important considerations in reducing these deaths. In

James C. Duck
April 11, 2002
Page 5

addition, however, the presently considered project should ensure that changes in water flows at these existing structures, and that construction, as part of this project, of any new structures in waters accessible to manatees do not increase the risks to the species.

The manatee may be affected by the water management plan to be developed in response to the increased storage of water in the reservoir(s). It is well documented that manatees require fresh water to survive. In addition to the fresh water needs, development of a draft water control plan as part of the Project Implementation Report should be based on modeling to estimate any changes in abundance and distribution of submerged aquatic vegetation (SAV) in the Caloosahatchee estuary. The distribution of these beds in proximity to warm water refugia for manatees is also an important factor. If SAV beds are eliminated close to their warm water refugia, manatees may be subject to more threats while traveling a greater distance to reach a suitable food source.

A proposed rule to de-list the threatened southern bald eagle (*Haliaeetus leucocephalus*) has been published. However, at this time, the species is still listed as threatened. The southern bald eagle is considered common and known to breed throughout the state. Nest sites are usually located near large rivers, lakes, or estuaries where they feed primarily on fish and water-dependent birds. Their distribution is influenced by the availability of suitable nest and perch sites near large, open waterbodies, typically with high amounts of water-to-land edge (Service 1999).

The threatened eastern indigo snake (*Drymarchon corais couperi*) is present throughout the state, but its abundance is reduced to a point where it is uncommon. Habitat includes pine flatwoods, scrubby flatwoods, high pine, dry prairie, tropical hardwood hammock, edges of freshwater marshes, agricultural fields, coastal dunes, and human altered habitats. Eastern indigo snakes could be encountered during construction, therefore implementation of the standard construction practices to avoid adverse effect on the species is expected.

The Florida scrub-jay (*Aphelocoma coerulescens*), a threatened species, is present in limited areas of scrub habitat in the study area. It is a relict species of fire-dominated oak scrub habitat that occurs on well-drained sand soils in peninsular Florida. Scrub-jays are extremely habitat-specific, sedentary, and territorial. Florida scrub-jays form family groups; fledglings remain with their parents in their natal territory as helpers. The Florida scrub-jay is listed as a threatened species because of loss, fragmentation, and degradation of scrub habitats throughout Florida, due primarily to urbanization, agriculture, and fire suppression. During the last 10 to 23 years, the population has declined by an estimated 25 to 50 percent, and they have been extirpated from seven counties statewide. Conservation measures for Florida scrub-jays will involve protection and long-term management of suitable scrub habitat. The Service's goal in planning assistance for the C-43 reservoirs is to ensure that the project does not affect any scrub habitats occupied by scrub-jays, and to minimize any impacts on other scrub habitats, due to their habitat value for a

James C. Duck
April 11, 2002
Page 6

number other wildlife species. Because scrub habitats occur at slightly higher elevations and have highly drained soils, these areas are typically poorly suited for siting water storage or treatment areas, so avoidance of these areas is not only ecologically sound, but is also justified by functional considerations. We would not advocate scraping down scrub areas to incorporate space for water storage or treatment.

The red-cockaded woodpecker (*Picoides borealis*) was listed as threatened in 1970. The red-cockaded woodpecker is one of 22 species of woodpeckers native to North America. Its historic range encompasses the southeastern U.S. from eastern Texas to Oklahoma to New Jersey, and it was characterized as "abundant" in the 19th century literature. Throughout the 20th century, however, the species' distribution within its historic range has become fragmented, and its total population numbers have decreased drastically due to the destruction of its habitat. The primary threat to the species continues to be destruction or degradation of its habitat as a result of timbering and other land-clearing activities. Although South Florida is not a designated recovery population for the red-cockaded woodpecker, the area contains significant support populations for recovery of the species in the southeast. Additional population surveys and research on habitat requirements within the hydric pine flatwoods of south Florida are needed to assess the current status of the birds and to adapt conservation measures used elsewhere to the distinct conditions in this area. The distribution of this species on private lands in the study area is poorly documented, and it is uncertain that the planning team members will obtain permission from private landowners to conduct surveys during plan formulation. The Service recommends minimizing the conversion of pine flatwood habitats to water storage or treatment areas.

The Florida panther (*Puma concolor coryi*), a subspecies of mountain lion, is one of the most endangered large mammals in the world. The most recent population estimate for the Florida panther is a total of 78 individuals, not including denning kittens (McBride 2001). This small population in south Florida represents the only known remaining wild population of an animal that once ranged throughout most of the southeastern United States from Arkansas and Louisiana eastward across Mississippi, Alabama, Georgia, Florida, and parts of South Carolina and Tennessee. The panther presently occupies one of the least developed areas in the eastern United States; a contiguous system of large private ranches and public conservation lands in Broward, Collier, Glades, Hendry, Lee, Miami-Dade, Monroe, and Palm Beach counties totaling more than 809,400 ha.

Geographic isolation, habitat loss, population decline, and associated inbreeding have resulted in a significant loss of genetic variability and overall health of the Florida panther population. Natural gene exchange ceased when the panther became geographically isolated from other subspecies of *Puma concolor*. Population viability projects have concluded that, under current demographic and genetic conditions, and without implementation of recovery actions, the panther would probably become extinct within two to four decades.

James C. Duck
April 11, 2002
Page 7

The Caloosahatchee basin plays an important role in the recovery of the Florida panther. The Service has organized a multi-agency subgroup of the Multi-species/Ecosystem Recovery Implementation Team (MERIT) to produce a Florida panther landscape conservation strategy. In addition to protection of habitat for adult home ranges, the strategy includes provision of corridors for dispersal of juveniles between larger areas of contiguous habitat. Dispersal across the Caloosahatchee River, between existing primary habitat south of the river and habitat that is presently only occasionally used by panthers north of the river, is considered essential for recovery of the species. The draft report of the Florida Panther Subteam is presently under technical review, but in recognition of the crucial need to coordinate the planning of the C-43 reservoir project with the MERIT efforts, we have include an illustration from their draft report as Figure 2 of this PAL. Figure 2 shows the apparent dispersal path of radio-collared Florida panther Number 84 across the Caloosahatchee River; and habitat characterized as primary, secondary, and dispersal. The dispersal habitat in Figure 2 coincides with the proposed land acquisition area in Figure 1 called the "Caloosahatchee Ecoscape." It is imperative to the continued survival of the Florida panther that facilities proposed as part of the C-43 reservoir project do not extend into the Caloosahatchee Ecoscape. The Service's planning team participant for the C-43 reservoir project will continue to coordinate with the Florida Panther Subteam of MERIT to ensure that project design is compatible with recovery efforts for the panther.

Audubon's crested caracara (*Polyborus plancus audubonii*) is another federally listed species present in the Caloosahatchee basin. It is a large, boldly patterned raptor, with a crest and unusually long legs. It is a resident, diurnal, and non-migratory species that occurs in Florida as well as the southwestern U.S. and Central America. In Florida, this species is found in the prairie area of the south-central region of the state. Because the Service anticipates that areas to be identified for reservoirs in addition to the Berry Groves property will include unimproved and improved pastures (land cover types which are preferred as habitat by the caracara and other species of wildlife), the C-43 reservoir project will likely have some impact on this species. We believe it would be impractical to set a planning goal to entirely avoid effects on this species, but rather, to direct siting of the additional reservoirs into areas with less intensive use by caracaras. Assuming that adverse effects cannot be entirely avoided, formal consultation under the ESA would be required, including provisions for incidental take for this species. In general, siting reservoirs in areas currently sustaining sugarcane or citrus, rather than unimproved and improved pastures, would reduce effects on the caracara, and other wildlife, such as the State-listed burrowing owl (*Speotyto cunicularia*) and Florida sandhill crane (*Grus canadensis pratensis*).

The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) is a subspecies of grasshopper sparrow that is endemic to the dry prairie of central and southern Florida. This subspecies is extremely habitat specific and relies on fire every two to three years to maintain its habitat. It is now known to occur only from Highlands, Okeechobee, Osceola, and Polk counties, but other populations may occur in Glades county, which may bring it into the study area considered here. Florida Natural Areas Inventory records include reports of the species from

James C. Duck
April 11, 2002
Page 8

northwestern Glades County, but little is known about the possible presence of the species on private lands in the southern part of the county, closer to the Caloosahatchee River. Similar to the red-cockaded woodpecker, the study team may be unable to gain access to conduct surveys on private lands in the plan formulation period, but unlike the red-cockaded woodpecker, the Florida grasshopper has a highly restricted range in Florida and is critically endangered. Therefore, the Service believes the planning goal for this species should be to avoid impacts not only on currently occupied habitat, but also on potential habitat that is determined to be critical to recovery of the species. As a starting point, an analysis of aerial photography by Shriver and Vickery (1999) identified potential habitat for the grasshopper sparrow, which includes some areas extending from northern Glades County south to the vicinity of the Caloosahatchee River (Figure 3). Avoidance of these areas in selecting sites for additional reservoirs is recommended, while we attempt to gather additional information from surveys of private lands in the area, if possible.

As stated above, a wintering population of piping plovers (*Charadrius melodus*) use the tidal area of the Caloosahatchee River. The piping plover was federally listed as threatened along the Atlantic coast in 1985. It is a small, migratory shorebird that breeds only in three geographic locations of North America: on sandy beaches along the Atlantic Ocean, on sand shorelines throughout the Great Lakes, and on riverine systems and prairie wetlands of the Northern Great Plains. This species does not breed in Florida, but there are three populations that winter here. Bunche Beach, at the mouth of the Caloosahatchee, has a population of wintering piping plovers and is also designated critical habitat for this species. This species will not be directly affected by the footprint of the reservoir, however, it may be indirectly affected by changes in water management.

Two endangered plants are found in or near the study area, the Okeechobee gourd (*Cucurbita okeechobeensis*) and the beautiful pawpaw (*Deeringothamnus pulchellus*). The Okeechobee gourd is a vine that is now restricted in the wild to two small disjunct populations -- one along the St. Johns River which separates Volusia, Seminole, and Lake counties in north Florida, and a second around the shoreline of Lake Okeechobee in south Florida. The beautiful pawpaw is a low shrub of the Annonaceae family that occurs in two disjunct locations in central and southwest Florida. It is found in xeric, mesic, and hydric pine flatwoods in western Charlotte and Lee counties and eastern Orange County. The Okeechobee gourd is not known to be present in the Caloosahatchee basin, but in the adjacent littoral zone of Lake Okeechobee. Therefore, the C-43 Reservoir project should be assessed only for any indirect impacts on water management in the lake, as opposed to any direct impacts of siting and construction of the reservoirs. The main documented sites for the beautiful pawpaw in Lee County are on Pine Island, which is at the periphery of the study area, and would not be a suitable location for the reservoirs. However, there is a slight chance that the species may be discovered in pine flatwoods communities north of the Caloosahatchee River. Similar to the red-cockaded woodpecker, the Service recommends that siting of reservoirs avoid pine flatwoods, and that any properties that contain pine flatwoods

James C. Duck
April 11, 2002
Page 9

which may be considered for acquisition as part of this project be thoroughly surveyed for the presence of the beautiful pawpaw prior to selection of a preferred alternative.

The Service has consultation responsibilities for sea turtle nesting, and although sea turtles are known to nest on beaches in the region, the project should have no effect on nesting. The project could have an indirect effect on marine and estuarine habitats used by sea turtles, and consultation for these potential impacts would be conducted with the National Marine Fisheries Service.

B. State-Listed Species

Our preliminary review indicates that several wildlife species are likely to occur in the study area that are listed as endangered, threatened, species of special concern, or are considered rare. Among reptiles, the American alligator (*Alligator mississippiensis*) is a species of special concern, and the gopher tortoise (*Gopherus polyphemus*) is threatened. Several wading bird colonies are present in the study area, and should be considered. Among the species known to nest in the area are the tricolored heron (*Egretta tricolor*), little blue heron (*Egretta caerula*), white ibis (*Eudocimus albus*), and the snowy egret (*Egretta thula*); these are all listed as species of special concern. The black skimmer (*Rynchops niger*), osprey (*Pandion haliaetus*), American oystercatcher (*Haematopus palliatus*), and the brown pelican (*Pelecanus occidentalis*) are all listed as species of special concern, and we expect these to be present in the Caloosahatchee estuary. The Florida sandhill crane (*Grus canadensis pratensis*) is State-listed as threatened and is widely distributed in the study area. The burrowing owl (*Speotyto cunicularia*) is a species of special concern. The Florida black bear (*Ursus americanus floridanus*) and the Big Cypress fox squirrel (*Sciurus niger avicennia*) are known to occur south of the Caloosahatchee River and are State-listed as threatened. We recommend that the Corps consult with the Florida Fish and Wildlife Conservation Commission as planning advances regarding potential impacts to State-listed wildlife.

C. Principal Habitats of the Study Area

While the Service has a statutory responsibility to ensure that Federal action agencies comply with section 7 of the ESA, we want to emphasize an ecosystem-level approach in project planning. Protection and restoration of the native habitats in the region will broadly benefit fish and wildlife, and will assist in recovery of federally listed species.

The ecological communities of south Florida represent a continuing succession beyond the primary stage (i.e. the initial development of a biological community not previously occupied), resulting in the development of a mosaic of pine forest, cypress strands, hardwood hammocks, coastal mangrove forests and salt marsh, sawgrass plains, and wet prairies (Carter *et al.* 1973). The natural systems within the Caloosahatchee basin consist of wetlands (freshwater swamps,

James C. Duck
April 11, 2002
Page 10

sloughs, marshes, and estuaries) and upland (pine flatwoods, temperate oak/palmetto hammocks, tropical hammocks, dry prairie, and xeric scrub communities) regions. Although classified as different habitats, these systems are interdependent on each other. A number of these systems are relatively pristine areas and are recognized as having regional importance. These areas serve as important habitat for a wide variety of wildlife and have numerous hydrological functions.

The major wetland system in the Caloosahatchee basin is Twelve-Mile Slough. It is located in Hendry County and is a tributary to the much larger and regionally significant Okaloacoochee Slough. The Twelve-Mile Slough covers 3,300 acres and contains a mosaic of freshwater wetlands, as well as pine flatwoods and oak/cabbage palm hammocks.

The upland communities with the Caloosahatchee basin include flatwoods and tropical hammocks. Flatwoods are the most dominant upland habitat and are divided into two types: dry and hydric. An open canopy of slash pine with an understory of saw palmetto characterizes dry flatwood communities. Hydric flatwood communities are vegetatively similar to dry flatwoods but are located in a slightly lower elevation and are seasonally inundated.

Tropical hammocks are diverse woody upland plant communities. They are scattered but not widespread throughout the Caloosahatchee basin. Tropical hammocks occur on elevated areas, often on Indian shell mounds along the coast or on marl or limestone outcroppings inland. These are among the most endangered ecological communities in south Florida.

Dry prairie is essentially treeless, a pyrogenic landscape with a ground cover diverse in regionally endemic plant taxa and dominated by wiregrass (*Aristida beyrichiana*), scattered, low, stunted saw palmetto(*Serenoa repens*), and low-growing runner oak(*Quercus minima*). The typical dry prairie has a mixture of upland and wetland plants. The portions of the study area that were historically dry prairie have been subject to drainage, conversion to pasture, and other human-caused alterations. Based upon DeSelm and Murdock (1993), Noss *et al.* (1995) considered ungrazed dry prairie of Florida as an endangered ecosystem (greater than 98 percent habitat loss and continued threat).

Upland plant communities serve as recharge areas, absorbing rainfall into soils where it is distributed into plant systems or stored underground within the aquifer. Ground water storage in upland areas reduces runoff during extreme rainfall events, while plant cover reduced erosion, and absorbs nutrient and other pollutants that might be generated during a storm event.

The Service recommends minimizing the impact of the C-43 reservoirs on native habitats as a first priority. Although grazed lands, particularly improved pastures, are not among the native habitats of Florida, they retain habitat value for a variety of fish and wildlife, most notably Audubon's crested caracara, Florida sandhill crane, Florida burrowing owl, gopher tortoise, Eastern indigo snake, short-tailed hawk (*Buteo brachyurus*), and gopher frog (*Rana capito*).

James C. Duck
April 11, 2002
Page 11

Therefore, as a second priority, we recommend that if siting of reservoirs allows a choice of lands with different agricultural land use histories, that areas supporting citrus and sugar cane be selected in preference to unimproved or improved pastures. However, we understand that given the abundance of pastures in the study area, that conversion of some pastures to reservoirs will most likely be part of the project design.

VI. Issues to Consider in Project Planning

First Issue - Establishing water reservations for the natural system

The Service is concerned about the use of the water retained in the reservoir(s) projects. During the Project Delivery Team meeting on February 28, 2002, it was stated that the water held back in these reservoirs will be used to enhance or restore the flows in the Caloosahatchee River, beyond those minimum flows and levels considered necessary to avoid ecological harm. A reservations document shall be prepared to ensure that the additional water stored in the reservoirs will enhance natural areas, primarily the Caloosahatchee estuary. The water in the reservoirs will be used for environmental needs first, before the water is allocated to urban or agricultural use. The Service will participate in efforts to establish specific ecological targets for the Caloosahatchee River and the estuary such that when these targets are not being met, the water from the reservoirs will be used to meet those needs. These goals will be developed for several components of the estuary and river, including, water quality parameters such as salinity; flow and stage data; and these will link to expected ecological benefits to important estuarine resources, such as submerged aquatic vegetation and oysters. One of the objectives of the Southwest Florida Feasibility Study (SWFFS) is to establish these targets for the estuary and Caloosahatchee basin. The C-43 Project Delivery Team should work closely with the SWFFS team to establish these goals and to ensure that the design and operation of the C-43 reservoirs are compatible with those targets.

Second Issue -Selection of other lands (in addition to Berry Groves) for reservoirs

The Service is concerned with the selection of additional lands for reservoirs. Using a variety of GIS data layers, we have performed a rough analysis of **potential** areas for siting reservoirs. We used 1995 land use, digital orthophoto quads, species richness data from the Florida Fish and Wildlife Conservation Commission (Cox *et al.* 1994, Cox and Kautz 2000), and Florida Natural Areas elements of occurrence data. We did not take into account suitability of soil type for use as a reservoir or topography, which, among other considerations, would most likely be used by engineers in siting these facilities. We have drawn several polygons labelled "additional areas to evaluate as potential reservoir sites" in Figures 2 and 3. As presented, these polygons total approximately 89,000 acres, and assuming 8,000 acres of Berry Groves will be used as a

James C. Duck
April 11, 2002
Page 12

reservoir, enough potential area appears to be available to further refine the boundaries for additional reservoirs totaling another 12,000 acres and to minimize impacts on native habitats . The Service will be involved in every step as it relates to choosing sites for additional reservoirs.

Third Issue - Contaminant assessments on the Berry Groves property and other potential reservoir sites

The Service and the SFWMD are collaborating under a draft protocol to assess contaminant risks to fish and wildlife for lands under consideration for acquisition as part of CERP components. This protocol establishes standards and procedures for Environmental Site Assessments and, when necessary, Environmental Risk Assessments. The Service's environmental contaminants section anticipates reviewing soon information for the Berry Groves site. We expect that the protocol, once finalized, will also be applied to all additional lands under consideration to obtain the necessary water storage capacity. As general guidance, the Service recommends avoidance of, as feasible, areas that are currently, or have a history of, cultivation of row crops, because these areas would have a higher probability for presence of contaminant levels that may impact fish and wildlife.

D. Fourth Issue -Federally listed species concerns

Please refer to the more specific guidance provided in Section IV.A. of this PAL regarding federally listed species. The intent of the Service with regard to the majority of these species is that through minimizing the selection of native vegetative communities for siting of reservoirs, any adverse effects on listed species would also be avoided or minimized. For the benefit of wetland-dependent listed species, such as the snail kite and the wood stork, selection of reservoir sites should also minimize impacts on wetlands, although we expect that some impacts to smaller wetlands, mainly within disturbed uplands, would likely be unavoidable.

We wish to summarize some additional special considerations. Siting and configuration of the reservoirs should be compatible with establishment and restoration of a dispersal corridor across the Caloosahatchee River for the Florida panther. Reservoir siting should also avoid or minimize effects on dry prairie and pasture lands considered to be suitable recovery habitats for the Florida grasshopper sparrow. We recognize that it may be impossible to entirely avoid placing reservoirs in areas serving as habitat for the Audubon's crested caracara, but the planning goal would be to see if it is feasible, using telemetry data, to locate facilities in areas of less intensive use by caracaras.

Thank you for this opportunity to provide recommendations for beneficial actions the Corps can take to restore, protect, or conserve fish and wildlife habitat and assist in the conservation and

James C. Duck
April 11, 2002
Page 13

recovery of Southwest Florida's threatened and endangered species. We would greatly appreciate attending any future meetings with Corps personnel as more refined plans are evaluated. Please feel free to contact Stephanie Brady at (941) 472-1100, extension 242, if you have any questions regarding this letter.

Sincerely,

for James J. Slack
Field Supervisor
South Florida Ecological Services Field Office

Enclosures

cc:
SFWMD, West Palm Beach, FL (Agnes Ramsey)
FWC, Vero Beach, FL (Joseph Walsh)
FWC, Punta Gorda, FL (James Beever)

James C. Duck
April 11, 2002
Page 14

LITERATURE CITED

Carter, M.R., L.A. Burns, T.R. Cavinder, K.R. Dugger, D.L. Fore, D.B. Hicks, H.L. Revells, and T.W. Schmidt. 1973. Ecosystems analysis of the Big Cypress Swamp and estuaries. U.S. Environmental Protection Agency, Florida Ecological Study DI-SFEP-74-51. EPA 904/9-74-002. 375 pp.

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Office of Environmental Services, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Cox, J.A., and R. Kautz. 2000. Habitat conservation needs of rare and imperiled wildlife in Florida. Office of Environmental Services, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

DeSelm, H.R. and N. Murdock. 1993. Grass-dominated communities. Pages 87-141 inW. H. Martin, S. G. Boyce, and A. C. Echternacht, eds. Biodiversity of thesoutheastern United States upland terrestrial communities. John Wiley & Sons, Inc., New York, New York.

Kahl, M.P., Jr. 1964. Food ecology of the wood stork (*Mycteria americana*) in Florida. Ecological Monographs 34:97-117.

McBride, R. 2001. Current panther distribution, population, trends, and habitat use. Report of field work: Fall 200 – Winter 2001. Unpublished report for the Florida Panther Subteam of MERIT. November 2001.

Noss, R. F., E.T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: A preliminary assessment of loss and degradation, Biological Report 28. National Biological Service; Washington, D.C.

Shriver, W.G., and P.D. Vickery. 1999. Aerial assessment of potential Florida grasshopper sparrow habitat: Conservation in a fragmented landscape. Florida Field Naturalist 27(1):1-9.

Small, J.K. 1922. Wild pumpkins. Journal New York Botanical Garden 23:19-23.

Smith, J.P., J.R. Richardson, and M.W. Collopy. 1995. Foraging habitat selection among wading birds (Ciconiiformes) at Lake Okeechobee, Florida, in relation to hydrology and vegetative cover. Arch. Hydrobiol. Spec. Issues Advanc Limnol. 45, pp. 247-285.

U.S. Fish and Wildlife Service. 1999. South Florida multi-species recovery plan. Atlanta, Georgia. 2172 pp.

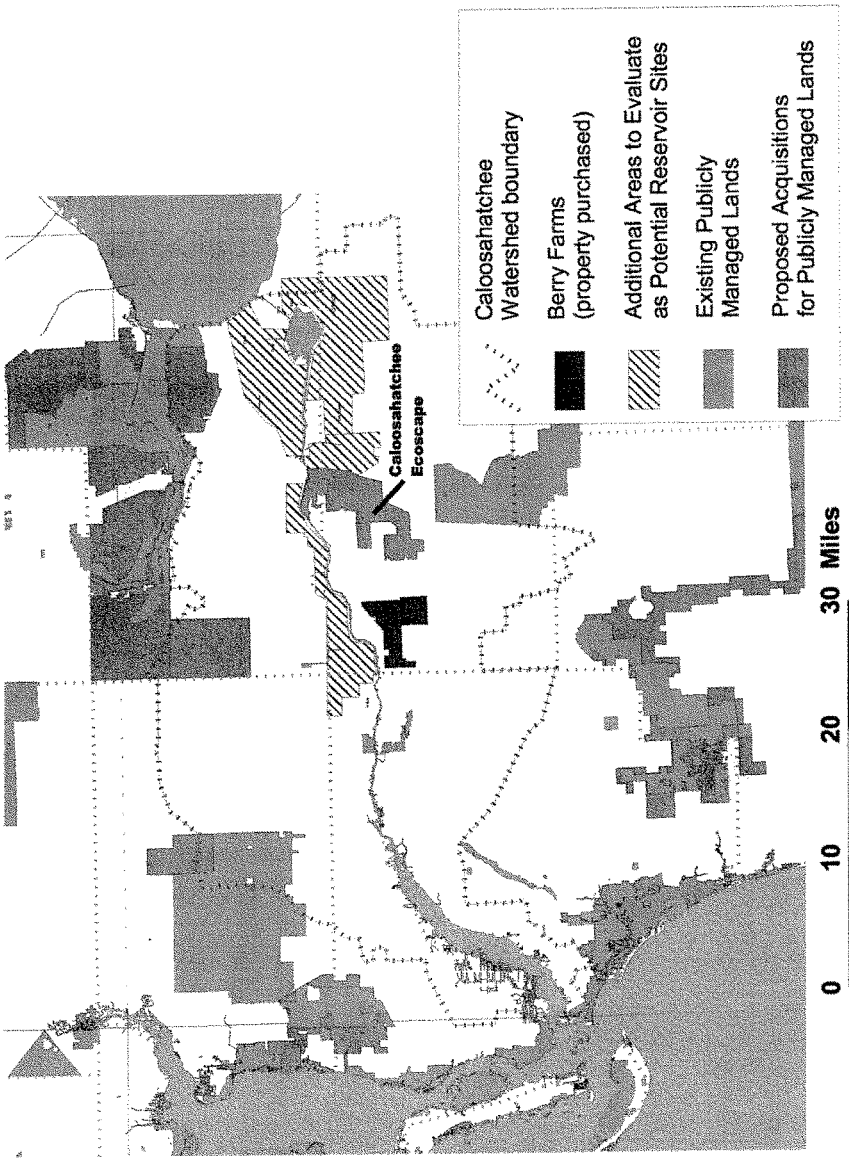


Figure 1. The study area in the Caloosahatchee basin, with recommended additional areas to evaluate as potential reservoir sites.



Figure 2. Approximate path taken by panther 84 when dispersing out of South Florida in April 2000. Path is approximate because the lines shown merely connect the dots between location records. The actual pathway followed is not known. The polygon labeled "Dispersal zone" coincides with the Caloosahatchee Ecoscape.

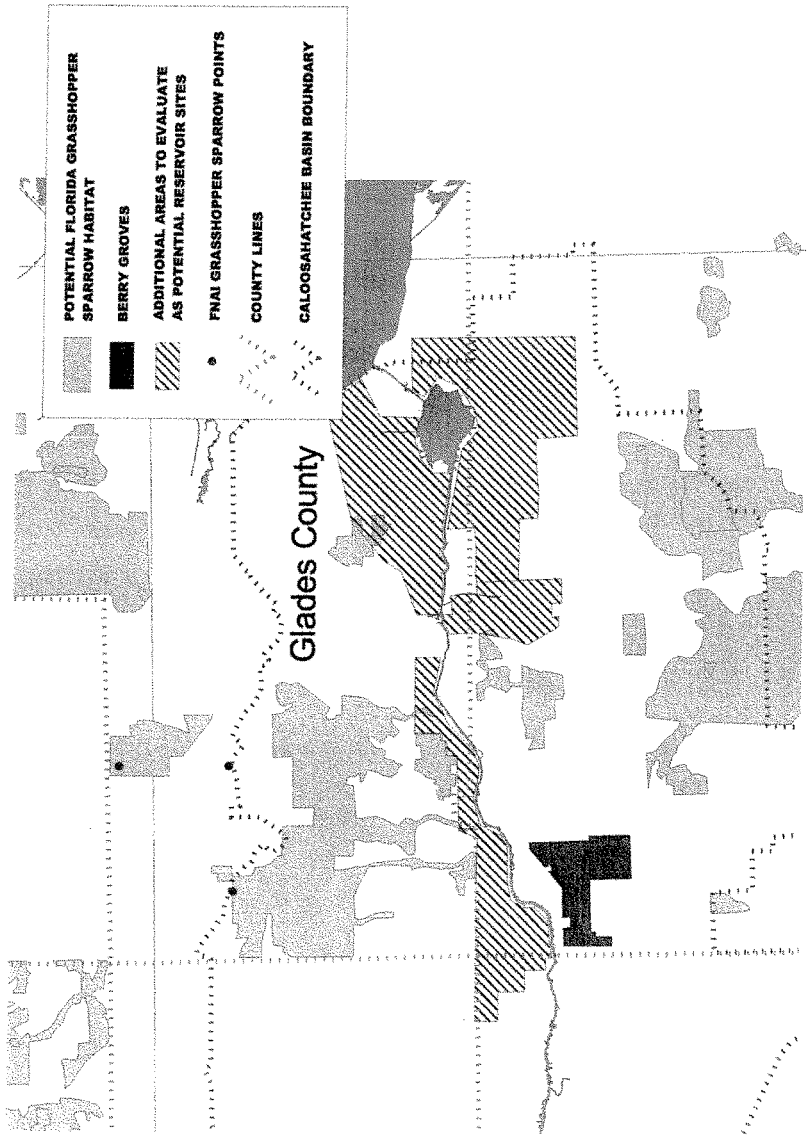


Figure 3. Potential Florida grasshopper sparrow habitat (Shriver and Vickery 1999) and additional areas to evaluate as potential reservoir sites.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

May 19, 2003

Bob Taylor
Senior Environmental Engineer
South Florida Water Management District
3970 RCA Boulevard, Suite 7401
Palm Beach Gardens, Florida 33410

Dear Mr. Taylor:

The Fish and Wildlife Service (Service) has received and reviewed the document entitled, "Phase I/II Environmental Site Assessment for Griffin Brothers (GX-100-001)" prepared by Environmental Consulting and Technology, Incorporated (ECT). This document reports the results of extensive testing, laboratory analysis, and field investigation for this 954-acre parcel located south of State Road 80 in Hendry County. This property is planned for incorporation into the Caloosahatchee River/C-43 Basin project of the Comprehensive Everglades Restoration Plan. This parcel will be part of a 20,000-acre (160,000 acre-feet of storage) water retention reservoir designed to capture Lake Okeechobee releases for water supply, flood attenuation, and water delivery to the Caloosahatchee Estuary to reduce salinity and nutrient impacts.

This letter provides the Service's comments and recommendations regarding the assessment for this property, as identified and described in the subject report.

Generally, the document is well organized and thorough. All pertinent historical and existing land use, soil, geological, environmental, and regulatory information, in addition to future plans associated with Everglades restoration, are provided and evaluated in the Phase I report for this property. The Phase II report provides sampling rationale and laboratory data for soil and groundwater media. Florida Department of Environmental Protection, Sediment Quality Assessment Guideline (SQAG) values are presented and compared to the laboratory data collected from canal sediments, cultivated areas and point-source areas located on the property. Sampling from the cultivated areas of the property was performed from twenty two 50-acre grids. Discrete samples were taken from ten 5-acre sub-grids within each grid then composited. Canal sediments were sampled from seven locations and soils were sampled from a maintenance area/chemical barn, burn area, and fertilizer mix/load area. Groundwater was sampled from a total of five temporary monitoring wells; two from the cultivated area at Winthrop property and three from each point source. Upon review of the initial composite soil sample data, extended sampling was performed from the WBI sample grid within the cultivated area to better characterize selenium (Se) contamination.

Bob Taylor
May 19, 2003
Page 2

Specific editorial remarks include:

1. The table under section 7.2.2. ("Canal Sediment Sampling") on page 7-7. The "# Detections Above" column for pentachlorophenol (last row) indicates that one of seven samples exceeded the Threshold Effects Concentration (TEC). This is incorrect. One sample exceeded the Leachability-based Soil Cleanup Target Level (SCTL) (groundwater) criteria for this constituent. There is no TEC for pentachlorophenol.

2. The detection of 4,4'-DDT ("parent product") at WBXYZ, in the absence of associated analogues (4,4'-DDE and 4,4'-DDD) is unusual, even in low concentrations. The parent product is typically degraded into analogues within a relatively short period of time after application. Assuming the landowner has been using pesticides in compliance with Federal laws (the use of 4,4'-DDT has been banned for approximately three decades), it is unlikely that 4,4'-DDT was used at this location within the past 20 years. Detections of 4,4'-DDT without corresponding analogue detections should be scrutinized closely.

Cultivated Area

Generally, barium (Ba), copper (Cu), lead (Pb), mercury (Hg), zinc (Zn), and paraquat were detected throughout the cultivated area. However, none of these analytes exhibited concentrations which exceeded the SQAG Probable Effects Concentration (PEC) and only Cu at WAP (38 mg/kg) and 4,4'-DDT at WBXYZ (6.4 ug/kg) exceeded the TEC. The 95 percent Upper Confidence Level (UCL) of the mean for all analytes was below the TEC. Selenium, for which there is no SQAG, was detected in the composite sample taken from WBI (1.3 mg/kg). This grid was subsequently resampled (March 31, 2003) to better delineate the extent and intensity of Se contamination. An expanded sampling report was submitted by ECT on April 21, 2003, indicating that all discrete subsamples of the WBI grid exhibited Se concentrations less than 1.0 mg/kg (Range = below 0.56 mg/kg to 0.63 mg/kg).

Paraquat, a persistent herbicide (half-life in soil up to 1,000 days), was detected from all composite samples (range = 0.033 - 0.74 mg/kg). No soil samples demonstrated paraquat concentrations which exceeded the site-specific SQAG developed in the Environmental Risk Assessment (ERA) presented in Appendix I.

Aldicarb, a carbamate insecticide, was detected at only one sample grid (67 ug/kg), exceeding the site-specific SQAG (1.75 ug/kg) developed in the ERA in Appendix I. The 95 percent UCL of the mean for the entire parcel also exceeded the site-specific SQAG. Aldicarb degrades quickly and would likely represent little to no risk to fish and wildlife at this property, provided that its application is discontinued at least six months before inundation.

Bob Taylor
May 19, 2003
Page 3

Based upon the resampling of WBI (Se) and anticipated rapid degradation of aldicarb, the assessment recommended that no further sampling or corrective actions be taken in the cultivated area to reduce contamination. However, ECT did recommend that a restriction on any future use of aldicarb be incorporated into a Best Management Plan to be prepared for this property.

Canal Sediments

Canal sediments sampled from the property indicate that one sample exhibited a Cu concentration (60 mg/kg) which exceeded the TEC, but not the PEC. Another sediment sample exhibited a pentachlorophenol (an organochlorine pesticide) concentration of 32 ug/kg which exceeded the leachability SCTL based on groundwater criteria (30 ug/kg). This concentration of pentachlorophenol does not exceed the surface water SCTL (200 ug/kg) and there are no SQAG criteria for pentachlorophenol. However, this pesticide is often associated with highly toxic dioxin compounds, thereby creating a potentially hazardous environment upon inundation of the property.

Although arsenic (As) (seven of seven samples), Hg (six of seven samples), and paraquat (three of seven samples) were detected in canal sediments, none exceeded PEC criteria.

The assessment recommended that no remedial actions be taken to reduce contamination in canal sediments and that applications of paraquat be discontinued upon acquisition of the property. The Service agrees with the recommendation regarding future use of paraquat, but believes that additional delineation sampling will be necessary to adequately characterize pentachlorophenol contamination in the canal.

Point Sources

One soil sample taken from the burn area indicated detections of Ba, Cu, Pb, and Zn. Only Cu (150 mg/kg) exceeded SQAG criteria (PEC).

Soil samples taken from the maintenance area/chemical barn indicated the presence of As, Ba, Cu, Pb, Hg, Zn, and several Polynuclear Aromatic Hydrocarbons (PAHs). Only the PAH constituents exceeded SQAG criteria. Benzo(a)anthracene (0.25 mg/kg), chrysene (0.37 mg/kg), and fluoranthene (1.4 mg/kg) exceeded respective TEC values. Acenapthene (7.6 mg/kg), acenapthylene (0.97 mg/kg), anthracene (1.6 mg/kg), fluorene (9.2 mg/kg), naphthalene (5.9 mg/kg), phenanthrene (22 mg/kg), and pyrene (7.7 mg/kg) exceeded PEC values.

The fertilizer mix/load area demonstrated soils contaminated with As, Hg, and Zn. Only Zn (230 mg/kg) exceeded SQAG criteria (TEC).

The assessment recommended the removal of the top 12-inches of soil from all contaminated areas of the point source locations.

Bob Taylor
May 19, 2003
Page 4

Recommended corrective actions presented in ECT's report should alleviate potential risks to fish and wildlife and their resources from sediments contaminated with Cu, Zn, aldicarb, paraquat, and PAHs at the Griffin Brothers' property. However, the Service recommends that the South Florida Water Management District perform additional delineation sampling in the canal in the vicinity of the S5 sample site. Upon review of this additional data regarding pentachlorophenol in canal sediment, the Service will provide supplemental comments and recommendations.

Thank you for the opportunity to review and provide comments regarding this Environmental Site Assessment. If you have any questions or comments, please contact Dr. Robert Frakes at 772-562-3909, extension 242, or Jim Boggs at extension 223.

Sincerely yours,

Linda S. Ferrell
Assistant Field Supervisor
South Florida Ecological Services Office

cc:
DEP, West Palm Beach, Florida (Leslie Smith)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

July 14, 2003

Bob Kukleski
Senior Environmental Engineer
South Florida Water Management District
3970 RCA Blvd, Suite 7401
Palm Beach Gardens, Florida 33410

Dear Mr. Kukleski:

The Fish & Wildlife Service (Service) has received and reviewed the document entitled "Phase I/II Environmental Site Assessment for Winthrop Citrus Investors (GX-100-005)," submitted by Environmental Consulting & Technology, Incorporated (ECT). The Service agrees with most of ECT's recommendations for site remediation.

However, the Service does not agree with ECT's conclusion with regards to the risk associated with aldrin contamination. Since the property-wide average aldrin concentration exceeds the provided low effect level (LEL), further assessment of aldrin contamination within the 50 acre grid is necessary. This should include re-sampling of 5-arcre discrete samples within the 50-acre grid, potentially followed by elutriate tests, bioassays, bioaccumulation studies, and then a risk assessment pending results of the re-sampling. The Winthrop property approximately 2,400 acres, is a large tract of land in Hendry County, Florida that is currently utilized for citrus, with some evidence that tomato row crop farming had occurred early in the property's history.

Following the Phase I Assessment, ECT concluded the site warranted further investigation due to the presence of extensive agriculture, maintenance areas, former exploratory petroleum wells, and drainage canals. The Phase II Assessment was performed according to Service protocols (47 composite samples from agricultural areas), in addition to soil and groundwater sampling near the maintenance areas and sediment sampling in the canals. A characterization of the potential risks was also provided by ECT given the presence of some contaminants at concentrations ECT considered to be of potential concern.

Site-wide contaminant levels (average for all composite values) in cultivated areas indicate some risk to benthic organisms may exist. The pesticides aldicarb and aldrin exceeded threshold concentrations developed in ECT's characterization and specified by the Ontario Ministry of the Environment, respectively. ECT recommended the best management practice of aldicarb application cessation at least 12 months prior to site inundation to ensure adequate natural pesticide attenuation. They also considered ecological risk from aldrin exposure insignificant since aldrin had been detected in a single composite sample, but no others. Extensive paraquat

Bob Kukleski
July 14, 2003
Page 2

contamination on the site, while being less than threshold effects concentrations, led ECT to recommend immediate cessation of paraquat applications due to its persistence in soils. In addition, paraquat use is not permitted on lands to be acquired by the Department of the Interior.

Point source contamination (maintenance areas, petroleum wells) also revealed potential ecological risk for sediment dwelling organisms. The soil concentrations for multiple contaminants (metals, petroleum hydrocarbons, pesticides) found in soil samples around the maintenance areas exceeded either threshold or probable effects levels. As a result, ECT recommended soil removal, up to the top 12 inches, to remediate these locations and reduce potential ecological risk.

The Service agrees that the preferred best management practice would be cessation of aldicarb and paraquat applications. Aldicarb concentrations in soils should decline with time, and paraquat contamination will not increase if applications are ceased. Soil removal may be the better remediation method for soils surrounding the maintenance areas, but the sites should be resampled following soil removal to ensure efficacy. Both of these remediation strategies should reduce the risk to benthic organisms from those contaminants if the property is inundated.

Aldrin contamination at the site is peculiar. A persistent chlorinated cyclodiene pesticide, aldrin registration was cancelled in 1987 because of the hazard it presents in the environment. While only a single *composite* sample contained aldrin, it is a composite of 10 samples collected from a 50-acre site. The contamination could be a single sub-sample with a very high aldrin concentration, a relatively homogenous distribution of aldrin contamination, or an analytical error. The actual situation is unknown without a further reassessment of the contamination. In addition, when averaged over the entire property, the upper 95 percent CI (2.53 ug/kg) exceeded a threshold effects level (LEL = 2 ug/kg, Ontario Ministry of Energy and Environment). This indicates potential risk to benthic invertebrates.

The Service is grateful for the opportunity to review this site assessment for the Winthrop property. If you have any questions regarding these comments, please contact Dr. Tim Bargar at 772-562-3909, extension 315.

Sincerely yours,

Linda S. Ferrell
Assistant Field Supervisor
South Florida Ecological Services Office

cc:
DEP, West Palm Beach, Florida (Leslie Smith)
Service, Vero Beach, Florida (Barry Rosen)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

July 1, 2004

Robert Kukleski
Senior Environmental Engineer
Center for Environmental Studies
3932 RCA Boulevard, Suite 3210
Palm Beach Gardens, Florida 33410

Dear Mr. Kukleski:

This letter has been prepared in reply to a response letter written by Environmental Consulting and Technology, Incorporated (ECT) received on September 26, 2003. That response letter was written to answer concerns expressed by the Fish and Wildlife Service (Service) about aldrin contamination on the Winthrop Citrus Investors property.

Aldrin was detected in one composite sample, out of 47 collected composites, at a concentration of 29 µg/kg. This concentration resulted in a property-wide jackknife mean of 1.52 µg/kg, and a 95 percent upper confidence level (UCL) of 2.53 µg/kg. Since no sediment quality assessment guideline (SQAG) value for aldrin was derived by MacDonald et al. (2003), equivalents of the threshold (LEL) and probable effects concentrations (SEL), from the Ontario Ministry of Energy, were utilized to determine potential ecological risk. The LEL was 2.0 µg/kg while the SEL equivalent was 80 µg/kg. The SEL was not exceeded in any soil sample, while the LEL was exceeded by the tract composite value and the property-wide 95 percent UCL.

Protocol agreed to by both the Service and the South Florida Water Management District (District) stipulates that either remediation of the contamination or further assessment be performed when the property-wide mean or 95 percent UCL equals or exceeds the threshold effects concentration (TEC). This was the basis for the Service's original recommendation of expanded sampling of the tract in which aldrin had been detected.

ECT stated in the phase I/II assessment that it did not believe aldrin presented a significant ecological risk and that further assessment was unnecessary because:

- Aldrin was detected in only one composite.
- The detection was less than the PEL.
- The 95 percent UCL (2.53 µg/kg) was only slightly above the LEL (2 µg/kg).
- Based on the District's fugacity-based food web model, no risk to piscivorous birds was predicted to result from aldrin concentrations detected in the soils.
- The property-wide average and 95 percent UCL was less than a wildlife-based SQAG of 6.39 µg/kg.
- Aldrin was not detected at any point source locations.

Robert Kukleski Page 2

Regardless of the number of detections and the degree of LEL exceedence by the 95 percent UCL, the Service maintains that further assessment of the contamination was warranted since the LEL was encompassed by 95 percent UCL. Further assessment can include a preliminary ecological risk assessment (ERA), i.e., an ERA not including site specific chemical availability information, utilizing the fugacity-based food chain model to give an approximation of risk to the Service's trust resources. A preliminary fugacity-based food chain model was done by ECT in the original phase I/II, which was not considered by the Service at the time of its original review. Results of that model indicated hazard quotients ranging from 0.01 to 0.02 for birds exposed to aldrin concentrations in soil of 29 µg/kg. These hazard quotients were independently confirmed by the Service. The hazard quotients are sufficiently less than one to indicate that aldrin concentrations on the Winthrop Citrus Investors property, likely to be encountered by piscivorous birds, will not present a significant risk. Therefore, the Service concurs that further assessment of aldrin contamination is not warranted.

If you have any questions regarding this letter, please contact Dr. Tim Bargar at 772-562-3909, extension 315.

Sincerely yours,

James J. Slack
Field Supervisor
South Florida Ecological Services Office

LITERATURE CITED

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, G. Sloane, T. Biernacki. 2003. *Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters*. Florida Department of Environmental Protection Technical Report.

bcc:Reading
TBargar:pc:07/01/04(R:\2004\July\ECT response letter reply.doc)

MEMORANDUM

TO: Ruth Clements, Deputy Department Director, Land Acquisition

FROM: Robert Taylor, Lead Engineer, Land Acquisition Support Division

DATE: August 24, 2004

SUBJECT: Phase I/Phase II Environmental Assessment
Bryan Paul Citrus, Inc (Tract No. GX 100-009)
Caloosahatchee Attenuation/C43 Project Area
Hendry County

Attached is a copy of the Phase I/Phase II Environmental Assessment (EA) of the Bryan Paul Citrus, Inc., property (Tract No. GX 100-009). Pursuant to the request of Thomas Hanaway, Tetra Tech FW, Inc. (TTFW) completed the attached report. The property is located south of State Road 80/Caloosahatchee River and west of State Road 29 Labelle, Hendry County. The property is a commercial citrus grove and consists of approximately 600 acres. This tract encompasses the eastern portion of Section 36, Township 43 South, Range 28 East, the western portion of Section 31, Township 43 South, Range 29 East, and the western portion of Section 1, Township 44 South, Range 29 East. The property can be accessed from State Road 29 through an unimproved road on the east entrance to the property. The subject parcels are proposed for acquisition as part of the Caloosahatchee Attenuation/C-43 Basin Project. The Project will enhance flood protection and stabilize water supply to the Caloosahatchee Estuary. The restoration efforts may include the filling of ditches, swales, canals and removal of site roads and pump stations. Additionally, a soil berm may be constructed on the perimeter of the site to store surface water. It is anticipated that the restoration activities will be preceded by interim land use. This interim land use will consist of continued cultivation of the citrus for a period of approximately one (1) year.

The purpose of the assessment activities was to confirm the presence or absence of soil/groundwater contamination or contaminated media associated with the previous and current activities conducted on the subject parcel. The Phase I EA was performed in general accordance with American Society for Testing and Materials Standard Practice for Environmental Site Assessments (ASTMS Practice E 1527-00). This method has been used as a guide to insure appropriate inquiry into the environmental characteristics and condition of the site consistent with good commercial and customary engineering and environmental practices.

Ruth Clements
August 24, 2004
Page 2

The results of the Phase I/II EA indicated that the property was historically used as a cattle ranch or open range land. The property was converted in the 1960s from range pasture to row crops (e.g., peppers, cucumbers, tomatoes, and watermelons). Beginning around 1972, the vegetable row crops were shifted to citrus trees. The property has been improved with a series of farm road drainage ditches, canals, and support structure.

A one-story concrete building, identified as the nursery building, is located on the western central section of the property. The nursery building is used to store agricultural pesticides. An aboveground storage tank (AST) and chemical mix area is located on the eastern central section of the property. This AST area is used to store diesel fuel, spray oil, and mix chemicals. The tanks are located within a concrete secondary containment area. Obvious stained soils were observed in this area. This area is identified as the C-1 mix station. The main support facility for this farm is located at the Bryan Paul main maintenance area, which is located on the adjacent property to the east. This area includes fuel tanks, chemical storage, and mixing as well as a maintenance repair area. This area was not investigated since it is not part of the proposed acquisition tract.

The main drainage canal for the property runs from west to east through the center of the property and is connected to the Roberts Canal which, in turn, connects to the Townsend Canal further to the west. Irrigation water for the property is provided by two large electric pumps. Water from the main canal is distributed by a series of other smaller pumps and structures to an underground irrigation piping system that runs throughout the grove. The citrus trees are individually irrigated by an in-ground drip irrigation system.

The results of the Phase I EA identified seven (7) areas as an environmental concern. These are as follows: (1) Pump Stations, (2) Former Nursery Barn, (3) C-1 Mix Station, (4) Auxiliary Tank Area, (5) Graded Area Solid Waste, (6) Burn Area, and (7) Cultivated Area.

Based on the presence of environmental concerns, a Phase II EA sampling plan was developed to evaluate each area. The scope of work for the Phase II sampling investigation was developed in conjunction with, and reviewed by, representatives of the United States Fish and Wildlife Service (FWS), Vero Beach office. A series of samples was collected at the potential point source locations. The potential regional areas of impact (citrus cultivation) were identified and plotted onto current aerial photographs. A total of 119 individual samples were collected on a 5-acre grid spacing throughout the entire 600-acre area. These 119 individual samples were mixed at the time of collection, stored in sealed jars, and then combined into groups of 10. This process resulted in a total of 12 samples that were submitted for laboratory analyses. In addition, a 500-milliliter aliquot from each of the 119 individual samples was shipped to the laboratory for archiving until the analytical results of the composite samples were

reviewed. Based on the initial sampling results, the archive samples collected from 2 grids (grids 8 and 9) were analyzed to further evaluate the grids for the presence of chlordane. This approach serves as an effective sampling methodology to evaluate relatively large areas of agricultural activities. This methodology has been embraced by the FWS as a suitable screening technique for expansive parcels and has been successfully utilized by the District on several previous projects.

Because of the projected land use, the sampling results were evaluated with respect to the recently revised Sediment Quality Assessment Guidelines (SQAGs) listed in Table 5-1 of the document prepared by McDonald Environmental Service, Ltd. in 2002. Florida Department of Environmental Protection (DEP) staff, as well as FWS staff, mandate the use of SQAGs to serve as initial screening criteria for future stormwater areas and reclaimed wetlands. The potential petroleum impacted area-sampling results and groundwater-sampling results were compared with the applicable criteria listed in Florida Administrative Code, Chapter 62-777. The cumulative sampling results were then subjected to a screening level ecological evaluation to determine whether the subject property exhibits a level of chemical contamination sufficient to warrant further evaluation of potential ecological risk. It should be noted that enhanced QA/QC protocols were implemented in the evaluation of sampling results. These QA/QC measures included the use of duplicate and split samples sent to separate laboratories.

The results of the Phase II ESA investigation confirmed that corrective action is required to render some portions of the property suitable for the District's intended land use. At your direction, the corrective action requirements/costs were bifurcated based upon two (2) acquisition scenarios. The first of these scenarios consists of a hypothetical pre-acquisition environmental assessment (and the resultant corrective action requirements/costs) based upon the continued current agricultural land use or a residential/industrial conversion. The second scenario consists of the corrective action requirements/costs triggered by the screening criteria associated with the District's projected use of the property. This exercise is solely intended to provide an additional decision making tool in the evaluation of attendant costs associated with this acquisition. This exercise is not intended to form the basis for a legal opinion as to the corrective action responsibilities of the property owner versus the District.

The following is an overview of the areas where the Phase II assessment activities were conducted and where corrective actions are required to assure the property is acceptable for the District's intended future use.

Nursery Barn

The analytical results of soil samples collected near the Nursery Barn identified the presence of arsenic, cadmium, chlorpyrifos and malathion at concentrations that would pose an unacceptable ecological risk, if left in place during the restoration. This contamination is limited to those surface soils above the water table. **Based on the assessment, the impacted soil should be excavated and disposed of off-site. Upon completion of the recommended corrective action, this portion of the property would be acceptable for the District's intended future use.**

C-1 Mix Station

The results of the Phase I/II investigation identified obvious stained soil, stressed vegetation, and strong odors in this area. The analytical results for soil/sediment and groundwater samples collected from the C-1 Mix Station identified the presence of copper, carbaryl, and petroleum constituents at concentrations that would pose an unacceptable ecological risk, if left in place during the restoration. Additionally, groundwater contamination was identified in the presence of floating petroleum product in one monitoring well. **The recommended corrective action includes the excavation and disposal of surface soil near the structure and sediment found in the catch basin. In conjunction, a system to perform groundwater treatment will be required to reduce contaminant concentration to an acceptable level. It is assumed that the groundwater treatment would be conducted during the soil excavation. Upon completion of the soil excavation and groundwater treatment, one (1) year of groundwater monitoring would be required. It is estimated that the site closure for this area will, therefore, take one (1) year from the implementation of the corrective actions. Upon completion of the recommended corrective action, this portion of the property would be acceptable for the District's intended future use.**

Auxiliary Tank Area

The results of the Phase I/II EA noted that the tank and structure in this area have been removed. Additionally, it appeared that soil in this area has been scraped and removed. According to the site operator, impacted soils were taken off-site for disposal/treatment. Analytical results of soil samples collected from the Auxiliary Tank Area indicated that a small area of surface soil near the structure has concentrations of copper that exceed the interim guidance concentration and zinc concentrations that exceed the PEC. The Phase I/II concluded that the impacted area is limited. It is recommended that, prior to any corrective action, additional soil samples be collected for these analytes to confirm the presence of impacts. **The recommended corrective actions**

include the excavation and disposal of impacted soil. Upon completion of the recommended corrective action, this portion of the property would be acceptable for the District's intended future use.

Burn Areas

The Phase I/II identified five burn areas on-site. The incineration of vegetative material and miscellaneous waste within the burn areas has the potential to cause the ash to contain elevated concentrations of metals. A soil sample was collected below the ash layer to evaluate undisturbed soils for the presence of metals contamination. The result of the soil sample analysis indicated that ash generated during the on-site burning has not impacted the underlying soils or the surrounding soils. **Therefore, it is recommended that only the ash material is excavated and disposed of offsite. Upon completion of the recommended corrective action, this portion of the property would be acceptable for the District's intended future use.**

Graded Area

Site observation conducted during the Phase I/II indicated this area was impacted with buried waste material. The analytical results of samples collected indicated that contaminants were not detected at a concentration that would pose an ecological risk. However, the obvious presence of solid waste was documented in this area. Site observations indicated that the solid waste/construction debris consisted of miscellaneous plastic, metal, wire glass and plastic items. **The recommended corrective action for this area includes the scraping and removal of solid waste. Upon completion of the recommended corrective action, this portion of the property would be acceptable for the District's intended future use.**

Existing and Former Surface Water Pump Stations

There are four (4) existing aboveground storage tanks (ASTs) and one former AST location on the property. As part of the Phase I/II, a site inspection was conducted at each location for the visible presence of contamination. Based on the site inspection, soil samples were collected adjacent to three (3) areas that exhibited visible evidence of contamination. Soil samples were collected from the south pump station, main canal pump, and a former pumping station on the main canal. **Based on the results of the Phase I/II investigation, soil excavation is recommend adjacent to the main pump station and the former pump station. Upon completion of the corrective actions, this portion of the property would be acceptable for the District's intended use.**

Canal Sediments

As part of the Phase II EA, eight (8) Sediment samples were collected from the surface water drainage canal on the property. The analytical results of the sediment samples indicated that only two of the sediment samples collected, adjacent to one of the larger burn areas on the property, exhibited concentrations of barium, copper, and silver above the SQAG TEC. Site observations indicated that ash and stained soil were present on the bank of the canal adjacent to the location of the sediment sample. The results of the assessment concluded that the impacted sediment was limited to the burn area and not representative of the typical canal sediments. **The recommended corrective action would include the excavation of ash from the bank of the canal and the sediments within the canal adjacent to the burn area. Upon completion of the recommended corrective action, this portion of the property would be acceptable for the District's intended future use.**

Cultivated Citrus Crop Areas

The analytical results of composite samples collected from areas located throughout the citrus groves on this property indicated that several areas contain high levels of chlordane, which warranted further investigation via a site-specific limited ecological risk assessment (SLERA). A SLERA was performed to evaluate the composite and individual soil samples collected from the cultivated citrus areas of the property. The results of the SLERA indicated that concentrations of chlordane above 100 ug/kg pose and ecological risk to endangered and or threatened aquatic birds. The Phase II EA determined that approximately 13 acre of the citrus grove was impacted with concentrations of chlordane above the 100 ug/kg limit. In order to ensure the protection of ecological receptors, including threatened and endangered species of wildlife, soils in this area will require corrective action. Additionally, assessment is also warranted to confirm the area of impacted soils estimated at 13 acres. Any increase or reduction of the impact area would require the corrective action cost to be revised accordingly.

Based on this risk, it is recommended that the District Project Manager and design team consider implementing a final design that would minimize the ecological risk associated with inundating/flooding this area. Design modifications that could minimize ecological risk may include shifting the boundary, site grading, and depth/time interval of flooding. This step should be conducted prior to developing/implementing a corrective action plan to address impacted soil. It is important to note that in the event the boundary is moved, an equivalent ecological risk may be realized on the adjacent property if they are allowed to passively flood as part of the restoration activities.

In the event that relocating the boundary to exclude the impacted area is not a reasonable alternative, corrective actions will be required to minimize the potential risks to ecological receptors. Prior to conducting any corrective actions, chlordane impacted soils will need to be further delineated. An additional 80 to 100 soil samples should be collected in the cultivated areas where elevated chlordane was detected. Soil samples should be collected from 0-6 inches, and a select number of samples collected from 6-inches to 2-feet to evaluate the vertical extent of impacts.

Corrective actions of soil impacts could consist of the following options: 1) excavating the chlordane impacted soils; 2) capping the impacted soils with clean fill; 3) soil inversion; 4) reuse of soil as berm material, and 5) formal consultation under Section 7 of the Endangered Species Act with the FWS.

Option #1: The cost to excavate and transport impacted soils (approximately 13 acres to a depth of one foot, or 21,519 cubic yards) off-site for disposal is approximately $1,410,202. Based on the cost to excavate and transport impact material offsite, this option was not considered feasible.

Option # 2: This option requires that the impacted area would be covered with 2 feet of clean fill. A management plan would be necessary to ensure that the impacted soil is not uncovered during the construction or operation of the restoration project. This alternative may be a less favorable option considering that impacted soils may be located in a sensitive ecological area during the site restoration. Additionally, long-term management of the area would be required to minimize any future risk associated with exposing the impacted soil to surface water. The estimated cost to cap the impacted soils with 2-feet of clean soil is the $645,177.

Option #3: Soil inversion is a relatively new concept that the District is considering. It was initially considered for citrus groves where untilled soils had been impacted with copper. It should be noted that since soils in these former vegetable cultivated areas would have been tilled as part of the agricultural process, it is likely that this technique would not be as effective as with soils that have not been tilled previously. The soil inversion could be conducted with a plow or standard excavating equipment. A pilot test would be necessary to evaluate the effectiveness of the soil inversion using either a plow or excavator. The approximate cost for soil inversion of 13 acres is $645,177.

Option #4: This option would require that the identified impacted soils (approximately 13 acres to a depth of one foot, or 21,519 cubic yards) would be excavated and used in an area where they would not pose an ecological risk. An example would be the access roads, building/pump station foundations, or the interior portions of an earthen berm or levee that will be constructed as part of the restoration. The utilization of the impacted soils in construction of the berm,

levees, roads, or foundations would reduce/eliminate the potential ecological risk in an efficient and effective manner. The estimated cost to relocate approximately 21,519 yards of impacted soil is $282,700.

Option #5: In the event that the District elects not to implement corrective actions or if corrective action is determined to be ineffective and/or infeasible, formal consultation under Section 7 of the Endangered Species Act with the FWS will be required to proceed with the construction of the reservoir. Formal consultation is required if District actions may affect a listed species (designated as threatened or endangered under the Endangered Species Act). Based on discussion with District staff, this option is consider problematic based on required timeframes, potential for legal challenge, and the availability of engineered controls for mitigation.

Well/Septic Tank Closure

The Phase I/II identified the presence of four (4) irrigation wells on-site. The irrigation wells are approximately 12-inches in diameter and 200 feet deep. Additionally, one septic tank is presumed to be present in the vicinity of the nursery barn. **The recommend corrective action would include the abandonment of the four (4) irrigation wells and the proper closure of the septic tanks.**

Best Management Plan

Based on the results of the Phase I/II EA and the proposed use of the property, development and implementation of a BMP for the site is recommended. The purpose of the BMP is to assure that the interim use activities will not degrade (further contaminate) soil /sediment conditions. It is recommended that an Agricultural Management Plan be developed for the continued interim use of the subject property. This plan should incorporate Best Management Practices for the storing, handling, mixing, and application of agrochemicals and petroleum products. It is suggested that a Mutual Land Stewardship Program Monitoring Plan also be developed and implemented. This Monitoring Plan would serve as an adjunct to an Agricultural Management Plan and would include an inspection/sampling component. The objective of these efforts would be to preclude environmental degradation during the interim use period, which would render the acquired land unsuitable for the intended project. The cost projection included in this report is based upon an anticipated one (1) year interim use period. With respect to the potential environmental impairment insurance associated with the interim land use, the exposure appears to be at the medium range of the matrix due to the document agricultural improvements. The continued operation of the pump stations,

storage tanks, mix area, and storage building warrants the $500,000 minimum coverage.

The following Table 1 provides a breakdown of the recommended additional assessment or corrective action activities that are necessary to prepare the property for its intended use.

Table 1
Corrective Action Cost by Area

Area of Concern	Estimated Cost
Nursery Barn	$ 35,600
C-1 Mix Station	$ 51,900
Graded Area	$ 5,200
Auxiliary Tank Area	$ 6,600
Former and Main Pump Stations	$ 2,400
Confirmation Sampling and Development of Corrective Action Plan	$135,200
Cultivated Citrus Crop Areas: Relocation of Impacted Soil To Acceptable Area *	$282,700*
Well/Septic Tank Closures	$13,100
Canal Sediment Removal	$10,900
Burn Area Ash Removal	$6,900
AST Closures	$10,100
BMP for Interim Use	$ 4,500
Total	**$565,100**

* Assumes that impacted soils could be relocated onsite in areas where they would not pose an ecological risk. In the event that this is not an acceptable alternative, additional corrective action cost would be incurred.

Detailed information concerning the costs for the proposed corrective actions is included in Section 9 of the EA report. The EA also includes several options and their associated costs to address the chlordane impacted soils in the cultivated area.

The following Table 2 bifurcates the corrective action requirements/costs based upon a hypothetical continued agricultural land use or conversion to a residential/industrial setting versus the District's projected use as a water attenuation reservoir, STA, or reclaimed wetlands. The triggering mechanism for the agricultural/residential/industrial land use is in exceedance of the Soil Cleanup Target Levels defined in FAC, Chapter 62-777. The previously described SQAGs trigger inclusion into the Water Attenuation Reservoir/STA/reclaimed wetlands column.

Table 2
Corrective Action Costs by Land Use

Recognized Environmental Condition	Approximate Remedial Cost	Agricultural and Residential Use	Water Storage and Natural Use
Nursery Barn	$35,600	X	
C-1 Mix Station	$51,900	X	
Graded Area	$5,200		X
Auxiliary Tank Area	$6,600		X
Pump Stations	$2,400	X	
Confirmation Sampling and Development of Corrective Action Plan	$135,200		X
Cultivated Citrus Crop Area	$282,700		X
Well/Septic Tank Closures	$13,100		X
Canal Sediment Removal	$10,900		X
Ash Removal	$6,900		X
AST Closures	$10,100		X
BMP for Interim Use	$4,500		X
Total	**$565,100**	**$89,900**	**$474,500**

In summary, it is important to note the Phase I/II identified point sources on the property that will require the implementation of corrective actions to render the property suitable for the projected use. The EA also identified the presence of approximately 13 acres of impacted soils which will require corrective actions prior to the conversion of the site to its intended use. The total environmental liability associated with conditions identified within the Phase I/Phase II EA is estimated to be $565,100. The FWS review and concurrence of the EA is pending. It is anticipated that their review will be completed in four weeks. In the event that FWS requests additional assessment/corrective actions, the projected cost may need to be revised.

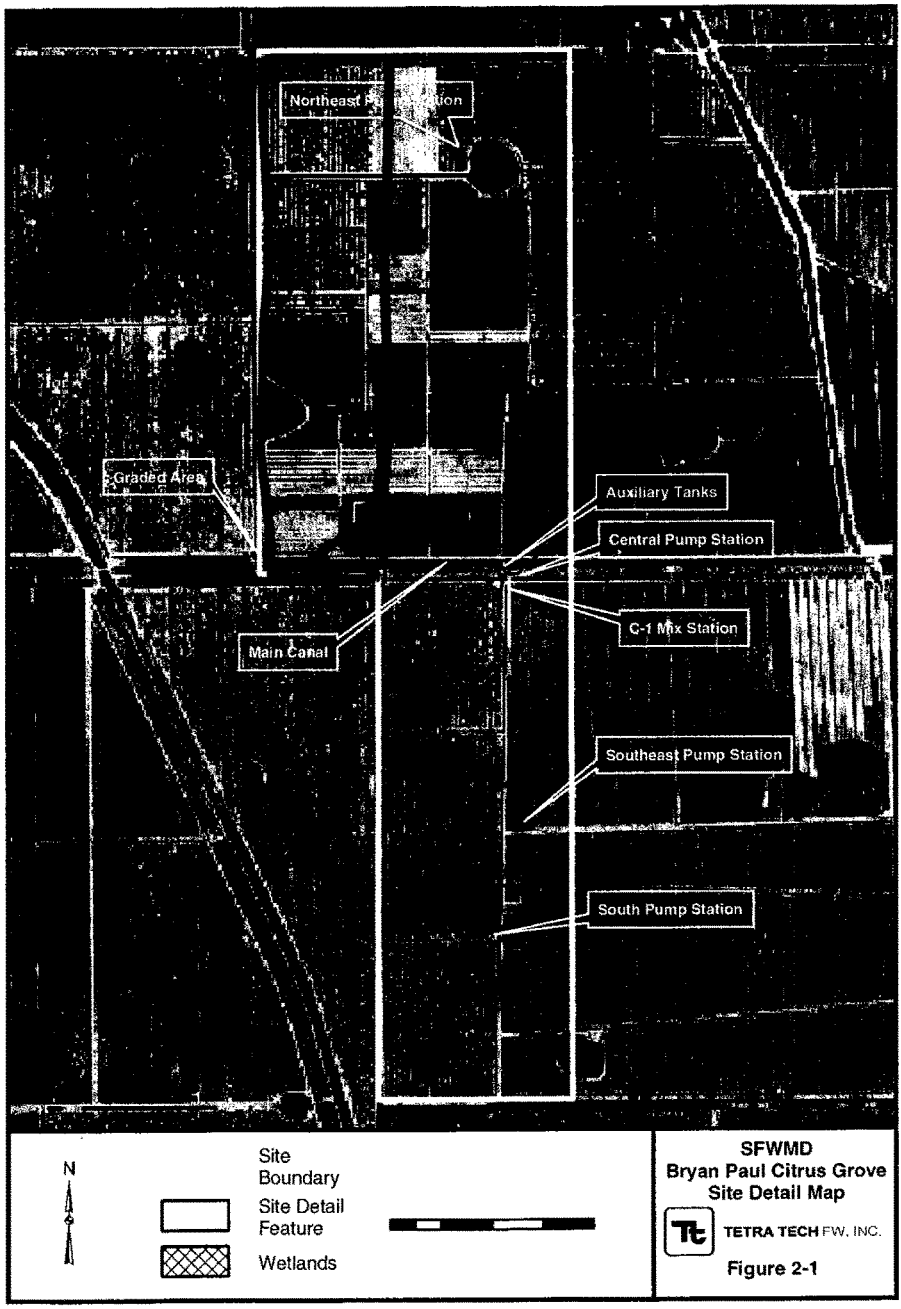
Upon completion of the recommended corrective action, the property would be suitable for the District intended future use.

The Environmental Engineering Unit will await your direction as to the appropriate timeframe to implement the required corrective actions that are deemed the District's responsibility. Costs associated with the Phase I/Phase II Environmental Assessment described in this memo total $125,728. These expenditures were addressed in C-12452 Work Order No. 18.

Copies of this report have also been transmitted to Bob Frakes, FWS/Vero Beach office and Jeff Gould, DEP/Fort Myers. Should you have any questions or require additional information, please contact me at extension 2264.

RT\lmr
Attachment

c:
Tom Hanaway
Steve Roth
Bob Kukleski (w/o attachment)
Fred Davis (w/o attachment)
Jim Bridgeman (w/o attachment)
Agnes Ramsey (w/o attachment)
Bob Frakes, FWS/Vero Beach
Jeff Gould, DEP/Ft. Myers


Northeast Pump Station
Graded Area
Auxiliary Tanks
Central Pump Station
C-1 Mix Station
Main Canal
Southeast Pump Station
South Pump Station
N
Site Boundary
Site Detail Feature
Wetlands
SFWMD
Bryan Paul Citrus Grove
Site Detail Map
TETRA TECH FW, INC.
Figure 2-1

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

September 20, 2004

Robert Kukleski, Senior Environmental Engineer
South Florida Water Management District
c/o Florida Center for Environmental Studies
3932 RCA Boulevard, Suite 3210
Palm Beach Gardens, Florida 33410

Dear Mr. Kukleski:

The Fish and Wildlife Service (Service) has received and reviewed the document entitled "Phase I and Phase II Environmental Site Assessment, Bryan Paul Citrus, Inc., 4930 State Road 29 South, Labelle, Hendry County, Florida," prepared by Tetra Tech FW, Incorporated (Tetra Tech). This document reports the results of the sampling investigation conducted on this 600-acre property proposed for incorporation into the Comprehensive Everglades Restoration Plan Caloosahatchee River/C-43 Canal Basin Project. Historically, the property has been used for cattle ranching, row cropping (1960's and 1970's), and citrus production.

The Phase I Environmental Site Assessment for the subject property identified eight areas of concern that required Phase II investigations. These areas include pump stations, a nursery barn, a mix station, an auxiliary tank area, a graded area, active citrus grove, burn areas, and irrigation canals. Discrete soil, sediment, and groundwater samples were collected to evaluate possible soil contamination in areas of concern. Analytical results were compared to Florida Department of Environmental Protection Sediment Quality Assessment Guidelines (SQAG), the Florida Administrative Code Soil Cleanup Target Levels (SCTL), and Groundwater Cleanup Target Levels.

Soil samples were collected from aboveground storage tanks at each of the three pump stations. The sample collected from the south pump station was not analyzed for copper; however, shortly after sampling the property owners removed this pump station, excavated, and disposed of the surrounding soils. Metals were found at concentrations below their probable effects concentrations (PEC) in samples from the main canal pump stations, but it was noted that in one of these samples selenium had a detection limit (1.9 mg/kg) above the Service's interim threshold toxicity screening level (1 mg/kg). Table 8-5, which presented results for the pump station samples, incorrectly reported the SCTL units for polynuclear aromatic hydrocarbons (PAH) (reported as µg/kg, instead of mg/kg). This error confounded the ability to properly evaluate PAH results from the pump stations. As a means of remediation, Tetra Tech proposed to excavate soil from contaminated areas around the pump stations.

Two samples were collected from the nursery barn, where chemicals were stored at the time of the assessment. Chlorpyrifos (2.1 mg/kg and 6,000 mg/kg), which currently has no SQAGs, and malathion (1 mg/kg), which has no PEC, were found at concentrations above the SCTL (0.001 mg/kg chlorpyrifos and 0.003 mg/kg malathion) and TEC (0.00067 mg/kg malathion). In addition, paraquat (0.366 mg/kg) was detected at concentrations below the SCTL (230 mg/kg). After review of the analytical results, it was noted that the detection limit used for malathion (0.015 mg/kg) in one of the samples was above the SCTL and threshold effects concentrations (TEC). Tetra Tech plans on excavating and removing contaminated soils from the nursery barn area.

The samples from the drain in the mix station detected concentrations of copper (590 mg/kg), toluene (20,000 mg/kg), and total petroleum hydrocarbon (100,000 mg/kg) above their respective screening values. In addition, paraquat was present at a concentration of 48.7 mg/kg. Some of the samples collected from the mix station were not analyzed for acenaphthene and carbaryl. Two of the samples analyzed for carbaryl were performed outside of the holding time and analyte was also detected in the method blank. The detection limits used for acenaphthene (110 µg/kg and 120 µg/kg) were above the PEC (89 µg/kg). Blank contamination was also a problem in analyses for arsenic, lead, and selenium. Despite these problems with laboratory analysis, Tetra Tech plans on removing contaminated soil and sediment from the mix station.

The auxiliary tank area, which contained two polyethylene chemical storage tanks, had a concentration of copper (110 mg/kg) in exceedance of the 85 mg/kg threshold value. The SCTL (based on surface water leachability) for toluene and paraquat were incorrectly reported in Table 8-4. The correct values are 5.6 mg/kg and 230 mg/kg, respectively. The Service agrees with Tetra Tech's suggestion to remove the copper contamination in the soil.

Partially buried metal debris and concrete were found in the graded area. Metals were detected at concentrations below their respective TECs, with the exception of selenium. The sample from this area was supposed to be analyzed for selenium and pesticides, specifically organochlorines; however, no results were presented. Tetra Tech proposed removal of the debris located in the graded area.

Using standard Service procedures for field sampling in agricultural areas, composite samples were collected from 12 50-acre grids in the citrus grove. Two of the composite samples contained concentrations of chlordane (100 µg/kg and 22.5 µg/kg) above the PEC (18 µg/kg). Archived aliquots from each of the discrete samples that compose the composites were analyzed to delineate the exact location of chlordane contamination. The analytical holding time for these analyses was exceeded; however, chlordane is unlikely to significantly degrade during the relatively short period of time (30 days) that the samples were held by the laboratory. To ensure that these samples were still comparable to the original analyses, one of the composites was extracted and reanalyzed with the discrete samples and the results were compared to the original composite values. While the chlordane concentration on this reanalysis was lower than the original (63 µg/kg vs. 100 µg/kg), it still exceeded the PEC. Analysis of these discrete samples showed that the area of chlordane contamination above the PEC was confined to just two

adjoining discrete samples (approximately 13 acres), with a mean concentration of 994 µg/kg. Tetra Tech suggested excavating this 13-acre area and disposing the soil on an area of the property that will not be inundated.

The burn area that was sampled contained no metals at concentrations in excess of the TEC; however, no results were presented for selenium, cadmium, or silver. Because of the historical practice of burning plastic chemical containers, Tetra Tech proposed to excavate and dispose of the ash at all five of the burn areas on the property.

Six samples were collected from the drainage canals throughout the property, none of which contained concentrations of contaminants above the PEC. The detection limit used for selenium (1.9 mg/kg) in one of the samples was above the Service's interim threshold toxicity screening level (1 mg/kg). Paraquat was detected in sediment samples at a maximum concentration of 1.76 mg/kg, near a possible burn area. Tetra Tech proposed to excavate sediments in the canal near this possible burn area.

In order to accurately evaluate soil sample data for the protection of ecological resources, the Service requests that non-detects (NDs) be reported as less than the practical quantitation limit (PQL) (<PQL), not less than the methods detection limit (MDL). While US Biosystems' lab reports NDs as <PQL, Millennium Laboratories, Incorporated is apparently still reporting NDs as <MDL.

After reviewing the analytical data, the Service agrees with Tetra Tech's recommendations for remediation at the pump stations, nursery barn, mix station, auxiliary tank area, graded area, burn areas, and canal sediments. The Service has reservations about the proposed plan to move the chlordane contaminated soil from the grove to an area that is not to be inundated. It is unclear from the report exactly where this non-inundated area is located, and with what assurance the area will not be exposed to water. If there is in fact an area where no inundation is guaranteed, the contaminated soils will, at the very least, need to be capped. We also suggest that post-remediation confirmatory sampling be performed to ensure that all contaminants of concern have been reduced to levels that do not present ecological threats to fish and wildlife resources. Assuming that all remediation is completed as proposed and the use of agricultural chemicals is in accordance with the Service's interim use pesticides, we believe that the Bryan Paul Citrus property is suitable for its intended use in the Caloosahatchee River/C-43 Canal Basin Project.

Thank you for the opportunity to provide comments regarding this assessment at Bryan Paul Citrus Grove. If you have any questions, please contact Emily Boughner at 772-562-3909, extension 335.

Sincerely yours,

James J. Slack
Field Supervisor
South Florida Ecological Services Office

Robert Kukleski Page 4

cc:
Tetra Tech FW, Incorporated, Stuart, Florida (Gregory New)
DEP, West Palm Beach, Florida (Leslie Smith)

Annex A

Fish and Wildlife

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

October 13, 2004

Robert Taylor, Senior Environmental Engineer
c/o Florida Center for Environmental Studies
South Florida Water Management District
3932 RCA Boulevard, Suite 3210
Palm Beach Gardens, Florida 33410

Dear Mr. Taylor:

The Fish and Wildlife Service (Service) has received and reviewed the letter "United States Fish and Wildlife Service (USFWS) May 19, 2003 Review Letter Related to the Griffin Brothers Property," dated August 11, 2004. This letter supplements a previously submitted document entitled "Phase I/II Environmental Site Assessment for Griffin Brothers (GX-100-001)" (ESA) prepared by Environmental Consulting and Technology, Incorporated (ECT). The letter, also submitted by ECT, addresses Service concerns regarding residual pentachlorophenol (PCP) detected in canal sediments on the property. This property is planned for incorporation into the Caloosahatchee River/C-43 Basin project of the Comprehensive Everglades Restoration Plan (CERP). This parcel will be part of a 20,000-acre (160,000 acre-feet of storage) water retention reservoir designed to capture Lake Okeechobee releases for water supply, flood attenuation, and water delivery to the Caloosahatchee Estuary to reduce salinity and nutrient impacts. This letter provides our comments on the follow-up investigation regarding PCP at the Griffin Brothers property.

The Service agrees with ECT's contention regarding the likely source of this chemical and its low distribution across the property. Likewise, we also find ECT's calculation of a site-specific effect level (617 ug/kg in sediment) is derived appropriately and the result appears consistent with other toxicity reference literature regarding PCP levels which cause adverse effects to receptor species (Hazardous Substance Data Base, National Library of Medicine, National Institutes of Health). As such, the 32 ug/kg of PCP detected at the S5 sample site, as reported in the Phase I/II ESA, does not represent a level of contamination which could adversely affect benthic macroinvertebrates, fish, birds, or mammals which would use hydrologic features proposed for construction and operation at Griffin Brothers property.

It is not anticipated that the construction and/or operation of proposed hydrologic features at Griffin Brothers property will create an attractive nuisance to Service trust resources (including federally listed threatened and endangered species) from PCP contamination. Therefore, the Service agrees with South Florida Water Management District and ECT that this property is suitable for its intended use under CERP.

Robert Taylor, Senior Environmental Engineer Page 2

Thank you for the opportunity to review and provide comments regarding the letter and ESA. If you have any questions or comments, please contact Mr. Jim Boggs at 772-562-3909, extension 223.

Sincerely yours,

James J. Slack
Field Supervisor
South Florida Ecological Services Office

cc:
DEP, West Palm Beach, Florida (Leslie Smith)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

July 1, 2005

Robert Taylor
Lead Environmental Engineer
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

Dear Mr. Taylor:

The Fish and Wildlife Service (Service) has received and reviewed the document entitled "Phase I/II Environmental Site Assessment for Bob Paul Citrus, Inc., 4930 State Road 29 South, Labelle, Hendry County, Florida (Tract No. GX100-015)," prepared by Tetra Tech FW, Incorporated (Tetra Tech). This document reports the results of the sampling investigation conducted on this 2,025-acre property that is proposed for incorporation as a component of the Comprehensive Everglades Restoration Plan Caloosahatchee River/C-43 Canal Basin Project. Historically, the property was used as cattle ranchland or open range land and, starting around 1972, the land was shifted towards citrus production.

The Phase I Environmental Site Assessment for the subject properties identified 13 areas of concern that required Phase II investigations. These areas include a maintenance area, chemical storage building, pole barn, shop, above ground storage tanks (ASTs), dispenser island, equipment staging area, storage area, irrigation pump stations, burn areas, former airstrip, irrigation canals, and cultivated area. Discrete soil, sediment, and groundwater samples were collected from point source locations to evaluate possible soil contamination in areas of concern. Using established procedures for field sampling in agricultural areas, composite samples were collected from 21 50-acre grids throughout the property. Within the grid that contained a 30-acre former row crop area, each discrete sample was analyzed for organochlorine pesticides and copper. Analytical results were compared to Florida Department of Environmental Protection Sediment Quality Assessment Guidelines (SQAG) and the Florida Administrative Code Soil Cleanup Target Levels (SCTL) and Groundwater Cleanup Target Levels (GCTL).

Out of the 21 composite samples that were collected from the agricultural area, 15 exceeded the threshold effects concentration (TEC) for copper (32 milligrams per kilograms [mg/kg]). Copper concentrations ranged from 19 mg/kg to 52 mg/kg, with a mean of 34.5 mg/kg. Each discrete soil sample that comprised the composite samples was also analyzed for copper. Six of these discrete samples had copper concentrations above the 85 mg/kg interim screening value for the protection of the endangered Everglade snail kite (*Rostrhamus sociabilis plumbeus*); however, none of the calculated means for the grids exceeded 85 mg/kg. Concentrations of the carbamate pesticides aldicarb (0.67 microgram per kilogram [µg/kg] to 27 µg/kg) and carbaryl (0.94 µg/kg to 2.4 µg/kg), which currently have no SQAG, were above their respective SCTLs (4 µg/kg and

0.7 µg/kg) in several of the composite samples. Concentrations of the organochlorine pesticides alpha- and gamma-chlordane (6.8 µg/kg and 5.3 µg/kg) exceeded their TECs (3.2 µg/kg) in one of the composite samples (#5036). It was noted that this sample, along with three others, was analyzed after the acceptable holding time. Another composite sample (#5007) also detected 4,4′-DDE (4.3 µg/kg) above its TEC (3.2 µg/kg) from the citrus grove. To determine the distribution of organochlorine contamination in grids #5036 and #5007, Tetra Tech decided to analyze the individual discrete samples with the understanding that these samples had exceeded their holding time. Out of these 20 discrete samples, 10 exceeded the TEC for 4,4′-DDE (3.2 µg/kg), 1 exceeded the probable effects concentration (PEC) (18 µg/kg), 3 were above the TEC (3.2 µg/kg) for alpha-chlordane, and 3 exceeded the TEC (3.2 µg/kg) for gamma-chlordane. A screening level ecological risk assessment (SLERA) determined that concentrations of chlordane, aldicarb, and carbaryl do not present unacceptable risk (hazard quotients (HQ) < 1) for any of the nine avian receptors of concern. In contrast, the maximum concentration of 4,4′-DDE did indicate risk for each of the receptors (HQs > 1). To determine the risk from individual grids, preliminary remediation goals (PRG) were calculated as the concentration of 4,4′-DDE in soil that corresponds to a HQ of 1. Results from this found that grid #5007 exceeded the no observed adverse effect level PRG and, therefore, suggest possible toxic exposures to avian species with small home ranges, such as the clapper rail (*Rallus longirostris*). Tetra Tech recommended further delineation of 4,4′-DDE contamination in grid #5007 and adjacent areas followed by soil inversion.

The one sample that was analyzed from the maintenance building had concentrations of copper (59 mg/kg) above the TEC (32 mg/kg) and total recoverable petroleum hydrocarbons (TRPH) (1n700 mg/kg) above the SCTL (340 mg/kg). Recommended corrective actions include soil removal and disposal to areas of the property that will not be inundated.

The sample from the chemical storage building detected concentrations of alpha- and gamma-chlordane (280 µg/kg and 300 µg/kg) and dieldrin (2,700 µg/kg) above their respective PECs (18 µg/kg, 18 µg/kg, and 62 µg/kg). Hepatochlor epoxide and endrin were found at levels above their TEC and aldrin (730 µg/kg), which currently has no SQAG, was detected at a concentration above the SCTL (10 µg/kg). In addition, copper was detected at a concentration of 15,000 mg/kg, a value three orders of magnitude above the screening level (85 mg/kg). Tetra Tech recommended removing soil and disposing it in an area not to be inundated.

The pole barn, shop/storage building, and three ASTs were all located adjacent to each other. The pole barn sample did not detect any contaminants at values above the SQAG, while the samples from the shop and ASTs had concentrations of 4,4′-DDE (20 µg/kg) above the TEC (3.2 µg/kg) and levels of TRPH (3,700 mg/kg) above the SCTL (340 mg/kg). One sediment sample collected from the drain near the pole barn contained concentrations of 4,4′-DDT, 4,4′-DDE, 4,4′-DDD, and alpha-chlordane above their respective TECs. Suggested remedial actions include soil removal and disposal in an area not to be inundated.

The diesel AST, gas/diesel AST, and dispenser island did not detect TRPH at levels above the SCTL. No further corrective actions are recommended for these ASTs. The samples collected from the spray oil AST detected concentrations of TRPH above the SCTL and GCTL. Recommended actions include soil removal and air sparging of groundwater.

The maintenance staging area had concentrations of 4,4'-DDE (97 µg/kg and 56 µg/kg) above its PEC (31 µg/kg) and gamma-chlordane (4.1 µg/kg) above its TEC (3.2 µg/kg). The sample from the fenced staging area detected alpha- and gamma-chlordane and copper at concentrations above their respective TECs. To remediate contamination in the staging areas, Tetra Tech recommended soil removal and disposal in an area not to be inundated.

Concentrations of 4,4'-DDE (3.8 µg/kg) and alpha- and gamma-chlordane (12 µg/kg and 13 µg/kg) were above their respective TECs and TRPH (12,000 mg/kg) was above the SCTL (340 mg/kg) in soil samples collected from the building in the grove. Limited soil excavation and disposal is recommended.

None of the 10 samples from the irrigation pump stations had concentrations of TRPH above the SCTL. No remedial actions are necessary for the pump stations.

Copper was detected at a concentration in exceedance of the TEC in one of the four burn areas. Tetra Tech recommended removing the ash from all of the burn areas.

Three of the 13 soil samples collected from the approximately 4,000 foot long former airstrip detected organochlorine pesticides at concentrations in excess of the SQAG. Concentrations of 4,4'-DDE (25 µg/kg, 8.4 µg/kg, and 90 µg/kg) were above the TEC (3.2 µg/kg) in three samples, one of which also exceeded the PEC (31 µg/kg). Alpha- and gamma-chlordane (48 µg/kg and 43 µg/kg) were in excess of the PEC (18 µg/kg) in one soil sample. All three of these samples were located in the eastern turn-around section of the airstrip. Tetra Tech recommends removal of the contaminated soil and disposal in an area not to be inundated.

Of the 11 sediment samples collected from the irrigation canals, 4 contained copper (mean of 26.6 mg/kg) at concentrations above the TEC (32 mg/kg). In two samples, 4,4'-DDE (mean of 15.0 µg/kg) was detected above the TEC and in excess of the PEC in one sample. In addition, TRPH (780 mg/kg) were detected above the SCTL (340 mg/kg) in one sediment sample. The samples containing organochlorine pesticide contamination were all located adjacent to the two turn-around areas of the airstrip. Corrective actions to remove organochlorine pesticide contamination include removal of sediments and disposal in an area not to be inundated.

Service Comments

After reviewing the analytical data, the Service agrees with Tetra Tech's recommendations for remediation at the spray oil AST, building in the grove, and burn area. However, the proposed actions to remediate the chemical storage area, ASTs, staging area, airstrip, and canals by way of soil removal and disposal in an area not to be inundated presents concerns. While burying

contaminated soil would limit its bioavailability to fish and wildlife resources, it would not remove the potential risk for groundwater contamination. Many of the contaminants that were proposed for onsite burial exceeded their SCTL for the protection of groundwater and, therefore, require special engineering controls that prevent lechate infiltration into groundwater. We suggest consultation with Florida Department of Environmental Protection (DEP) regarding the onsite burial of contaminated soil. The Service believes the low levels of copper contamination that were detected in the irrigation canals requires no further assessment or remediation, given that the mean (23 mg/kg) and 95 percent upper confidence limit (UCL) (33 mg/kg) for the site were below the interim screening value (85 mg/kg). According to established procedures, if the 95 percent UCL for a contaminant is below the TEC or interim screening value, then no further action is necessary.

Contamination in the grove area was limited to detections of aldicarb and carbaryl, which currently have no SQAG, and TEC exceedances for copper, 4,4'-DDE, and alpha- and gamma-chlordane; however, no discrete results were presented for the former row crop area. Because the mean concentrations in each of the 21 grids was below the TEC for 4,4'-DDE and alpha- and gamma-chlordane, and below the interim threshold value for copper (85 mg/kg), we believe these contaminants would not present an ecological risk to fish and wildlife resources after implementation into the canal basin project. A SLERA showed the concentrations of aldicarb and carbaryl in the grove do not present a risk to ecological resources. The Service feels no further assessment is necessary for the cultivated area.

Assuming all remediation is completed as proposed and DEP is consulted regarding onsite burial of contaminated soil, we believe the Bob Paul Citrus property is suitable for its intended use in the Caloosahatchee River/C-43 Canal Basin Project.

Thank you for the opportunity to provide comments regarding this assessment at Bob Paul Citrus. If you have any questions, please contact Emily Boughner at 772-562-3909, extension 335.

Sincerely yours,

Robert Drahn

for James J. Slack
Field Supervisor
South Florida Ecological Services Office

cc:
Tetra Tech, Stuart, Florida (Cheri Hughes)
DEP, West Palm Beach, Florida (Leslie Smith)
Service, Vero Beach, Florida (Barry Rosen)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

August 9, 2006

Robert Kukleski
South Florida Water Management District
3301 Gun Club Road
Palm Beach Gardens, Florida 33406

Dear Mr. Kukleski:

The Fish and Wildlife Service (Service) has reviewed the document entitled "Additional Soil Assessment, Bryan Paul Citrus Grove, 4930 State Road 29 South, Labelle, Hendry County, Florida," prepared by URS Corporation (URS). This document reports the results of the additional sampling investigation conducted on this 600-acre property proposed for incorporation into the Comprehensive Everglades Restoration Plan Caloosahatchee River/C-43 Canal Basin Project. Historically, the property has been used for cattle ranching, row cropping (1960's and 1970's), and citrus production.

The 2004 Phase I/II Environmental Site Assessment (ESA) conducted by Tetra Tech FW, Incorporated, identified a 13-acre area in the citrus grove that contained chlordane contaminated soils. Initial composite samples from 2 of the 12, 50-acre grids contained concentrations of chlordane (100 µg/kg and 22.5 µg/kg) above the Florida Department of Environmental Protection Sediment Quality Assessment Guidelines (SQAG) probable effects concentration (PEC) (18 µg/kg). Analysis of the individual discrete samples that comprised the two composite samples found that the area of chlordane contamination above the PEC was confined to just two adjoining discrete samples (8B and 9A) at concentration of 1,770 µg/kg and 218 µg/kg.

The present assessment was conducted to further evaluate the lateral and vertical extent of chlordane concentrations surrounding the identified area of contamination. It was noted that when URS collected the additional soil samples, all of the citrus trees had been cleared and the land disked. Two subsurface (6 inches to 2 feet below ground surface) soil samples were collected from 8B and 9A and 11 surficial (0 to 6 inches below ground surface) soil samples were collected in the area surrounding these locations.

Results from this sampling investigation found concentrations of chlordane, 4,4`-DDE, and 4,4`-DDT above their respective SQAG threshold effects concentration (TEC), but below their corresponding PEC in samples surrounding the previously identified chlordane contaminated area. No chlordane was detected in the subsurface sample at 8B and a concentration (6.5 µg/kg) slightly above the TEC (3.2 µg/kg chlordane) was detected at 9A. URS estimated the chlordane impacted (concentrations above 18 µg/kg) soils to be within a 20-acre area. The proposed remedial action included removing the top two feet of soil in the contaminated area and relocating it in dams constructed for the creation of the C-43 water retention reservoir.

Robert Kukleski Page 2

After reviewing the analytical data, the Service concurs with the 18 µg/kg cleanup target level for chlordane. The 100 µg/kg chlordane cleanup target level, which has been used for other properties, is based on a total organic carbon (TOC) content of 1.6 percent. The TOC content at Bryan Paul Citrus is 0.5 percent. Since there is an inverse relationship between TOC and bioavailability, we feel that the 100 µg/kg chlordane cleanup target level would not adequately protect benthic invertebrates, fish, and wildlife resources. In addition, we concur with the recommended remedial action of using chlordane contaminated soils for the construction of dams on the property. We suggest capping contaminated soils and post-remediation confirmatory sampling to ensure that all contaminants of concern have been reduced to levels that do not present ecological threats to fish and wildlife resources.

Thank you for the opportunity to provide comments regarding this assessment at Bryan Paul Citrus Grove. If you have any questions, please contact Emily Boughner at 772-562-3909, extension 335.

Sincerely yours,

Robert Fraden

for Paul Souza
Acting Field Supervisor
South Florida Ecological Services Office

cc:
URS Corporation, Boca Raton, Florida (Edward Leding)

September 14, 2006

Robert Taylor
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

Dear Mr. Taylor:

The Fish and Wildlife Service (Service) has reviewed the document entitled, "Additional U.S. Fish and Wildlife Service Soil Investigations Berry Labelle – Congen Groves," submitted to the South Florida Water Management District (District) by URS Corporation (URS). This 8,682-acre property, located in Hendry County, Florida, is an active citrus grove of both oranges and grapefruit. It is slated to be included within the Caloosahatchee Attenuation Project as a deep water retention reservoir for regulating freshwater flow into the Caloosahatchee River Estuary.

Assessment of contamination on this property began in 1999 and has been ongoing for several years. The original phase II assessment involved the collection of 17 composite soil samples that were collected to a depth of 2 feet below ground surface. Subsequent development of a new site assessment protocol led to a recommendation to reassess contamination on the property in 2002. Because of both the magnitude and spatial extent of its presence on the property, only Cu was determined to be a contaminant of potential ecological concern. Copper concentrations in composite samples collected during the reassessment ranged from 13.1 (Grid 100) to 169 mg/kg (Grid 125), resulting in a contractor calculated geometric mean of 51.9 mg/kg (95 percent upper confidence level of 56.6), which exceeds the threshold effects concentration (TEC, 32 mg/kg) for effects on benthic invertebrates. In fact, 75 of 89 50-acre grids exceeded the TEC. Since Cu concentration in Grids 58, 124, 125, and 134 exceeded the probable effect concentration (PEC) of 108 mg/kg, discrete samples were collected in 2002 from those grids to look for potential contamination hot spots. In 2003, the Florida Department of Environmental Protection adopted a new PEC for Cu (150 mg/kg) reducing the number of grids with Cu concentrations exceeding the PEC to one (Grid 125). Also in 2003, URS performed an ecological risk assessment and concluded that impacts were likely for the benthic community. It also predicted potential risk for the Everglade snail kite (*Rostrhamus sociabilis*) if Cu concentrations in soil exceed 85 mg/kg (interim screening concentration for risk to the snail kite). Contamination in Grids 56 and 145, in addition to the above noted four grids, exceeded 85 mg/kg. Therefore, in 2005, discrete samples were collected from Grids 145 and 56 to locate potential contamination hot spots. Lastly, also in 2005, delineation sampling of Cu contamination in the above-noted six grids was performed. The delineation sampling indicated Cu exceeded 85 mg/kg in Grid 135 as well, but was less than 85 mg/kg in Grid 145. URS recommended remediation of Cu contamination in soils of Grids 56, 58, 124, 125, 134, and 135.

After review of the delineation performed in 2005, the Service recommended a second delineation. This delineation involved composite sampling in nine previously unsampled grids (59, 74, 77, 78, 115, 116, 126, 142, and 143) that were adjacent to Grids 56, 58, 124, 125, 134, and 135. Copper concentrations in the nine grids ranged from 22 (Grid 74) to 120 mg/kg (Grid 143). Grid 143 was the only one of the nine grids with Cu exceeding 85 mg/kg. Copper concentrations in the remaining eight grids were less than 63 mg/kg. URS subsequently recommended including Grid 143 with Grids 56, 58, 124, 125, 134, and 135 in the proposed remediation.

URS stated the District plans to excavate the top 1 foot of soil from the areas to be remediated and reutilize that soil within the levees around the future reservoir, burying the soils such that surface water will not contact the Cu contaminated soil.

Service Comments and Recommendations

- The Service concurs that Cu contamination in Grids 56, 58, 124, 125, 134, 135, and 143 is adequately delineated.

- The Service recommends remediation for the entirety of Grids 124, 125, 134, 135, and 143 (250 acres); and for the entirety of Grids 56 and 58 that will be within the future reservoir. The proposed remediation should adequately reduce Cu concentrations in the above noted grids to below the interim screening value for risk to the snail kite.

- Development of the future benthic community may be impacted by Cu contamination in the sediments. The property-wide average Cu concentration (45 mg/kg, Service calculated arithmetic mean) would still exceed the TEC for Cu after remediation. In addition, Cu concentrations in soils of 10 to 15 percent of the sampled grids exceed 64 mg/kg, the concentration at which adverse effects to benthic organisms were demonstrated in toxicity testing during the risk assessment. Copper contamination in the unsampled grids may equal or exceed 64 mg/kg. While risk to the snail kite may be reduced by the proposed remediation, impacts to the benthic community are not likely to be significantly reduced. Therefore, the food base for the Service's trust resources that utilize the future reservoir may be affected.

In summary, while direct impacts to the Service's trust resources are not likely, indirect impacts through a reduction in the food base for the trust resources may occur due to existing Cu contamination in soils. The Service assumes that continued Cu applications during the interim use period will add to the current contamination levels in soils and recommends that the proposed remediation not commence until the end of the interim use period. In addition, the Service recommends no further Cu application be permitted in Grids 38, 39, and 145 since Cu concentrations in soils from those grids were close to the interim screening value.

Robert Taylor Page 3

Thank you for the opportunity to review this additional sampling investigation report for the Berry Labelle-Congen Grove Property. If you have any questions regarding these comments, please contact Dr. Tim Bargar at 772-562-3909, extension 315.

Sincerely yours,

Paul Souza
Acting Field Supervisor
South Florida Ecological Services Office

cc: URS, Boca Raton, Florida (Ed Leding)

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
SOUTH FLORIDA RESTORATION PROGRAM OFFICE
1400 CENTREPARK, SUITE 750
WEST PALM BEACH, FLORIDA 33401

REPLY TO
ATTENTION OF

January 10, 2007

Special Project/Enforcement Branch
SAJ-2005-5958(IP-TKW)

David Bernhart
Assistant Regional Administrator
Protected Resources
National Marine Fisheries Service
263 13th Avenue South
St. Petersburg, FL 33701

Dear Mr. Bernhart:

Pursuant to the Endangered Species Act (ESA), below is our determination of effects for potentially affected federally threatened and endangered species for the C-43 West Storage Reservoir Project located in Hendry County, Florida.

Scheda Ecological Associates, Inc. has prepared a Biological Assessment (BA) for the project on behalf of the South Florida Water Management District (SFWMD). The BA includes the information described in 50 CFR §402.12. This letter serves to transmit the BA and effects determination for the project. Also included with this letter is a copy of the permit application which further describes the project. The U.S. Army Corps of Engineers (Corps) has determined that the proposed project would cause the following effects on federally listed species:

No affect: The Corps has determined the proposed project will not affect threatened bald eagle (*Haliaeetus leucocephalus*), threatened Florida scrub jay (*Aphelocoma coerulescens*), endangered Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), endangered red cockaded woodpecker (*Picoides borealis*), endangered Okeechobee gourd (*Cucurbita okeechobeensis*) or threatened Florida scrub-jay (*Aphelocoma coerulescens*).

May affect not likely to adversely affect: The Corps has determined the project may affect but is not likely to adversely affect the endangered smalltooth sawfish (*Pristia pectinata*), endangered American crocodile (*Crocodylus acutus*), endangered green sea turtle (*Chelonia mydas*), endangered leatherback sea turtle (*Dermochelys coriacea*), endangered Kemp's ridley sea turtle (*Lepiodchelys kempii*), endangered hawksbill turtle

(*Eretmochelys imbricata*), threatened loggerhead sea turtle (*Caretta caretta*), endangered Everglade snail kite (*Rostrhamus sociabilis*), threatened piping plover (*Charadrius melodus*), endangered wood stork (*Mycteria Americana)*, and endangered West Indian manatee (*Trichechus manatus latirostris*).

May adversely affect: The Corps has determined the project may adversely affect the endangered Florida panther (*Felis concolor coryi*), threatened Audubon's crested caracara (*Polyborus plancus audubonii*), and threatened eastern indigo snake (*Drymarchon corais couperi*).

It should be noted that the SFWMD has restricted the use of copper on the site and plans to conduct all required corrective actions as recommended by the U.S. Fish and Wildlife Service prior to commencement of construction. Therefore, the Corps' determination for the snail kite in this cover letter supersedes the determination for the snail kite as specified in the BA.

The Corps has requested the U.S. Fish and Wildlife Service initiate formal consultation for the Florida panther, Audubon's crested caracara, and eastern indigo snake. Additionally, we request your written concurrence with our "may affect not likely to adversely affect" determination for those species that are within the purview of the National Marine Fisheries Service. If you need additional information or have any questions, please Tori White at the letterhead address, at 561-472-8888 or by e-mail at tori.white@saj02.usace.army.mil.

Sincerely,

Tori K White

for David S. Hobbie
Chief, Regulatory Division

Enclosures

Identical Letter Sent to:
Mr. Paul Souza, Field Supervisor, South Florida Ecological Services Office, USFWS, 1339 20th St., Vero Beach, FL 32960

Copy Furnished w/o Enclosures:
Susan Conner, Corps, PO Box 4970, Jacksonville, FL 32232
John Mitnik, SFWMD, 3301 Gun Club Rd., W. Palm Beach, FL 33410

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
SOUTH FLORIDA RESTORATION PROGRAM OFFICE
1400 CENTREPARK, SUITE 750
WEST PALM BEACH, FLORIDA 33401

REPLY TO
ATTENTION OF

January 10, 2007

Special Project/Enforcement Branch
SAJ-2005-5958(IP-TKW)

Mr. Paul Souza, Field Supervisor
South Florida Ecological Services Office
U.S. Fish and Wildlife Service
1339 20th Street
Vero Beach, Florida 32960

Dear Mr. Souza:

Pursuant to the Endangered Species Act (ESA), below is our determination of effects for potentially affected federally threatened and endangered species for the C-43 West Storage Reservoir Project located in Hendry County, Florida. A copy fo the Department of the Army permit application for the project was provided to Ms. Joyce Mazourek of your office on or about November 20, 2006.

Scheda Ecological Associates, Inc. has prepared a Biological Assessment (BA) for the project on behalf of the South Florida Water Management District (SFWMD). The BA includes the information described in 50 CFR §402.12. This letter serves to transmit the BA and effects determination for the project. The BA is also available in documentum at the following link: documentum\Docbases\CERPDoc_saj\Project Teams\RD-Acceler8\C-43 Basin Storage Reservoir\Transfer. The U.S. Army Corps of Engineers (Corps) has determined that the proposed project would cause the following effects on federally listed species:

No affect: The Corps has determined the proposed project will not affect the threatened bald eagle (*Haliaeetus leucocephalus*), threatened Florida scrub jay (*Aphelocoma coerulescens*), endangered Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), endangered red cockaded woodpecker (*Picoides borealis*), endangered Okeechobee gourd (*Cucurbita okeechobeensis*) or threatened Florida scrub-jay (*Aphelocoma coerulescens*).

May affect not likely to adversely affect: The Corps has determined the project may affect but is not likely to adversely affect the endangered smalltooth sawfish (*Pristia pectinata*), endangered American crocodile (*Crocodylus acutus*), endangered

green sea turtle (Chelonia mydas), endangered leatherback sea turtle (*Dermochelys coriacea*), endangered Kemp's ridley sea turtle (*Lepiodchelys kempii*), endangered hawksbill turtle (*Eretmochelys imbricata*), threatened loggerhead sea turtle (*Caretta caretta*), endangered Everglade snail kite (*Rostrhamus sociabilis*), threatened piping plover (*Charadrius melodus*), endangered wood stork (*Mycteria Americana)*, and endangered West Indian manatee (*Trichechus manatus latirostris*).

May adversely affect: The Corps has determined the project may adversely affect the endangered Florida panther (*Felis concolor coryi*), threatened Audubon's crested caracara (*Polyborus plancus audubonii*), and threatened eastern indigo snake (*Drymarchon corais couperi*).

It should be noted that the SFWMD has restricted the use of copper on the site and plans to conduct all required corrective actions as recommended in your September 14, 2006, letter prior to commencement of construction. Therefore, the Corps' determination for the snail kite in this cover letter supersedes the determination for the snail kite as specified in the BA.

By action of this letter, we request initiation of formal consultation for the Florida panther, Audubon's crested caracara, and eastern indigo snake. Additionally, we request your written concurrence with our "may affect not likely to adversely affect" determination for those species that are within the purview of the U.S. Fish and Wildlife Service. If you need additional information or have any questions, please Tori White at the letterhead address, at 561-472-8888 or by e-mail at tori.white@saj02.usace.army.mil.

Sincerely,

for David S. Hobbie
Chief, Regulatory Division

Enclosure

Identical Letter Sent to:
David Bernhart, Assistant Regional Administrator, Protected Resources, NMFS, 263 13th Ave. South, St. Petersburg, FL 33701

-3-

Copy Furnished w/ Enclosure:
Susan Conner, Corps, PO Box 4970, Jacksonville, FL 32232
Joyce Mazourek, USFWS, JN Ding Darling NWR, 1 Wildlife Dr., Sanibel Island, Fl 33957

Copy Furnished w/o Enclosure:
John Mitnik, SFWMD, 3301 Gun Club Rd., West Palm Beach, FL 33410

FINAL

BIOLOGICAL ASSESSMENT

C-43 WEST STORAGE RESERVOIR PROJECT

HENDRY COUNTY, FLORIDA

SFWMD Contract No. C-C10401P-WO11

Prepared for:
South Florida Water Management District
and
Stanley Consultants, Inc.

Prepared by:
Scheda Ecological Associates, Inc.
5892 East Fowler Avenue
Tampa, Florida 33617

December 2006

VOLUME I OF II

TABLE OF CONTENTS

Section **Page**

EXECUTIVE SUMMARY ..... **V**
1.0 PROJECT DESCRIPTION **1-1**
1.1 EXISTING ENVIRONMENTAL CHARACTERISTICS 1-2
2.0 METHODOLOGY **2-1**
2.1 PRELIMINARY DATA COLLECTION 2-1
2.2 SURVEY METHODOLOGY 2-2
3.0 RESULTS **3-1**
3.1 FEDERAL PROTECTED SPECIES 3-1
3.1.1 Fish 3-1
3.1.1.1 Smalltooth Sawfish 3-1
3.1.2 Reptiles and Amphibians 3-2
3.1.2.1 American Alligator 3-2
3.1.2.2 American Crocodile 3-2
3.1.2.3 Sea Turtles 3-3
3.1.2.4 Eastern Indigo Snake 3-3
3.1.3 Birds 3-4
3.1.3.1 Bald Eagle 3-4
3.1.3.2 Audubon's Crested Caracara 3-5
3.1.3.3 Snail Kite 3-9
3.1.3.4 Wood Stork 3-11
3.1.3.5 Florida Scrub Jay 3-13
3.1.3.6 Florida Grasshopper Sparrow 3-14
3.1.3.7 Red-Cocaded Woodpecker 3-14
3.1.3.8 Piping Plover 3-15
3.1.3.9 Colonial Nesters and Other Birds 3-15
3.1.4 Mammals 3-17
3.1.4.1 West Indian Manatee 3-17
3.1.4.2 Florida Panther 3-20
3.1.5 Plants 3-28

3.1.5.1 Florida Panther 3-28
3.1.5.2 Beautiful Pawpaw 3-29
3.2 PROTECTED SPECIES WITH STATE DESIGNATION ONLY 3-29
3.2.1 Reptiles and Amphibians 3-29
3.2.1.1 Gopher Tortoise 3-29
3.2.1.2 Gopher Frog 3-30
3.2.2 Birds 3-30
3.2.2.1 Florida Burrowing Owl 3-30
3.2.2.2 Florida Sandhill Crane 3-30
3.2.2.3 Southeastern American Kestrel 3-32
3.2.2.4 Peregrine Falcon 3-32
3.2.2.5 Least Tern 3-32
3.2.2.6 Other Wading Birds 3-32
3.2.3 Mammals 3-33
3.2.3.1 Florida black bear 3-33
3.2.3.2 Big Cypress Fox Squirrel and Sherman's Fox Squirrel 3-33
3.2.3.3 Sherman's Short-tailed Shrew 3-34
3.2.3.4 Florida Mastiff Bat 3-34
3.2.4 Plants 3-34
4.0 IMPACT ASSESSMENT 4-1
4.1 ANALYSIS OF POTENTIAL PROTECTED SPECIES IMPACTS 4-1
4.1.1 Direct Effects Within the Project Footprint 4-1
4.1.2 Direct Effects Outside the Project Footprint 4-2
4.1.3 Indirect, Secondary, and Cumulative Impacts 4-3
5.0 CONCLUSIONS 5-1
6.0 REFERENCES 6-1

LIST OF FIGURES

Figure

Figure 1 Project Location Map
Figure 2 Existing Land Cover/Use Map
Figure 3 Existing Land Cover/Use within a 25-Mile Radius of the Project
Figure 4 Protected Species Occurrences Within and Around the Project Area
Figure 5 Caracara Occurrences and Protection Zones Within and Around the Project Area
Figure 6 Florida Panther Telemetry Data and MERIT Zones
Figure 7 Florida Panther Telemetry Data and MERIT Zones (25-Mile Project Radius)

LIST OF TABLES

Table

Table 1 Protected Faunal Species Which May Occur Within the Project Study Area
Table 2 Protected Floral Species Which May Occur Within the Project Study Area
Table 3 Potential Habitat Impacts Based Upon Existing Land Cover/Use (FLUCCS) Within the Study Area
Table 4 Florida Panther Habitat Matrix – Panther Habitat Units for C-43 West Storage Reservoir

ATTACHMENTS

CERP Landscape Level Project Planning/Siting Map for Panther Conservation
Map Metadata

APPENDICES

Appendix

A Project Correspondence
B Complete List of Faunal Species Observed within the Project Study Area
C Eastern Indigo Snake Construction Guidelines
D Florida Panther Cumulative Impact Analysis
E Final Audubon's Crested Caracara Species-Specific Survey Report
F Copper Concentration Sampling Map
G Habitat Guidelines for the Wood Stork in the Southeast Region
H Manatee Protection Guidelines
I Panther Prey Item Survey Report

EXECUTIVE SUMMARY

The C-43 West Storage Reservoir project comprises one of the management measures included in C-43 Basin Project Implementation Report (PIR) planning effort, and consists of approximately 10,360 acres located in Hendry County west of LaBelle. Design for the C-43 West Storage Reservoir site includes construction of a 170,000 acre-feet above ground storage reservoir and associated appurtenances. The purpose of the C-43 West Storage Reservoir project is to provide water storage for the Caloosahatchee Estuary. The South Florida Water Management District (SFWMD) has completed preliminary environmental investigations, impact analysis, 30 percent design, a Basis of Design Report (BODR), and a Preliminary Design Report (PDR).

During the review of the BODR, a public concern was raised on the actual amount of seepage to be expected. A test cell program, consisting of 2 cells within the footprint of the C-43 site and consisting of approximately 267 acres, was recommended to assess this concern. The test cell project was permitted in December 2005 by the United States Army Corps of Engineers (USACE) and Florida Department of Environmental Protection (FDEP) following a Biological Assessment, agency coordination, pre-construction surveys for specific listed species, and formal consultation with the United States Fish and Wildlife Service (USFWS). At the time of this report, the test cell project has been constructed and the 9-month seepage and water quality monitoring program is underway.

A listed species assessment is being conducted in four phases for the C-43 West Storage Reservoir project. The first phase consisted of initial data collection to develop a project overview, agency coordination, and determining if any species-specific surveys would be required. The second phase consisted of developing the appropriate methodology and conducting preliminary surveys for a Listed Species Report (November 2004). Following agency coordination, it was determined that a specific wildlife survey for the Audubon's crested caracara (*Polyborus plancus audubonii*) should be conducted (third phase). This survey was conducted in spring of 2006 as per USFWS guidelines to evaluate the presence of nests and utilization of the project area by the caracara. The fourth phase involved the update and compilation of data for this Biological Assessment.

The following is a list and brief description of state and federally listed species which may potentially occur within, or which may be affected by, the C-43 West Storage

Reservoir project. Species that are more likely to occur in or near the project are discussed in greater detail within this report.

PROTECTED SPECIES WITH BOTH FEDERAL AND STATE DESIGNATION

Fish

The **smalltooth sawfish** (*Pristia pectinata*) is listed by the USFWS as endangered; while it is protected by some fishing regulations in the state of Florida, it is not a state-listed species. The species is usually found in shallow waters very close to shore over muddy and sandy bottoms, in areas such as sheltered bays and in estuaries or river mouths, such as the Caloosahatchee River. The smalltooth sawfish may benefit from indirect project impacts which include salinity regime improvements to the downstream Caloosahatchee Estuary. The project may affect, but is not likely to adversely affect, and may actually benefit the smalltooth sawfish.

Reptiles and Amphibians

The project study area contains suitable habitat for the e**astern indigo snake** (*Drymarchon corais couperi*), listed by both the USFWS and the Florida Fish and Wildlife Conservation Commission (FWC) as a threatened species. Although the eastern indigo snake was not observed, habitat exists on the project site; therefore, it could potentially occur. The species is known to utilize a variety of habitat types including citrus grove. Construction precautions will be used to protect the Eastern indigo snake during construction. It is anticipated that the project may adversely affect the eastern indigo snake.

The **American alligator** (*Alligator mississippiensis*) is listed by the USFWS as threatened due to its similarity of appearance to the **American crocodile** (*Crocodylus acutus*) and by the FWC as a species of special concern. Since there is substantial additional foraging and nesting area in close proximity to the proposed impacts, and the wetland impacts will be appropriately addressed, it is anticipated that the project will have no effect on the American alligator.

The **American crocodile**, listed as endangered by the USFWS and FWC, has not been documented in Hendry County but is present in mangrove and seagrass habitats of coastal counties of the Caloosahatchee River basin. The American crocodile may benefit from indirect project impacts which include salinity regime improvements to the

downstream Caloosahatchee Estuary. The project may affect, not likely to adversely affect, and may actually benefit the American crocodile.

Sea turtles including the **Atlantic loggerhead turtle** (*Caretta caretta*), **Atlantic green turtle** (*Chelonia mydas*), **leatherback turtle** (*Dermochelys coriacea*), **Kemp's ridley turtle** (*Lepidochelys kempii*), and **hawksbill turtle** (*Eretmochelys imbricata*) are listed as endangered by the USFWS and FWC with the exception of the loggerhead turtle, which is listed as threatened. These are marine species with a presence in south Florida waters and are known to utilize bays and estuarine habitats, such as the Caloosahatchee Estuary, for feeding and resting. Sea turtles may benefit from indirect project impacts which include salinity regime improvements to the downstream Caloosahatchee Estuary. The project may affect, but is not likely to adversely affect, and may actually benefit sea turtles.

Avifauana

Audubon's crested caracara (*Polyborus plancus audubonii*) is listed as threatened by both the USFWS and the FWC. The project falls within the caracara USFWS Consultation Area (CA). One caracara nest site was confirmed to the north of the project during spring 2006 surveys. This nest is located along the southern edge of the SR 80 right-of-way (ROW) and approximately 4,750 feet north of the project boundary. While individuals were not observed foraging in the project footprint, a portion of the project falls within 2000 meters (secondary zone) of this nest, as defined in the Standard Local Operating Procedures for Endangered Species (SLOPES). In addition, a possible nest was identified approximately 1,065 feet south of the project boundary, within a pasture of the A. Duda & Sons, Inc. property. Individuals from the possible nest site were seen flying into and out of the C-43 project site. While the C-43 project area provides only sub-optimal foraging habitat for the species, and individuals were only observed utilizing the project area in the southeast portion of the footprint, it does fall within the home range of both the confirmed and possible nests. Given the above information, it is anticipated the project may affect Audubon's crested caracara.

The **bald eagle** (*Haliaeetus leucocephalus*) is currently listed as threatened by both the USFWS and the FWC. Data obtained from the FWC 2004 Eagle Nest Database indicate that the closest documented bald eagle's nest, HE002, is located 3.4 miles east of the project, eastward of SR 29. This nest is documented to be last active as of the 2003 nesting season (was not active in the 2004 nesting season). It is anticipated that the proposed project will have no effect on the bald eagle.

The **Florida scrub jay** (*Aphelocoma coerulescens*) is listed as threatened by both the USFWS and the FWC. No individuals, nests, or appropriate habitat were detected in the project footprint. The nearest documented Florida scrub jay habitat and population occurs 1.1 miles west of the project area. This colony is beyond the foraging distance for the species to access the project area and is well outside the SLOPES protection zone. While the project falls within the Florida scrub jay USFWS CA, based on the above information, the project is anticipated to have no effect on the Florida scrub jay.

Florida grasshopper sparrows (*Ammodramus savannarum floridanus*) are listed as endangered by both the USFWS and FWC, due to habitat degradation and loss. The species is not known to occur in Hendry County but populations may occur in nearby Glades County. Mapping of potential Florida grasshopper sparrow habitat (Shriver and Vickery, 1999) shows marginal habitat zones to the northeast and southeast of the project, and the project area falls within the Florida grasshopper sparrow USFWS CA. However, the nearest marginal habitat zone is located approximately 2.5 miles to the southeast of the project footprint. No grasshopper sparrows were observed during field surveys and no suitable habitat exists in the project area. Based on the above information, this project is anticipated to have no effect on the Florida grasshopper sparrow.

The **snail kite** (*Rostrhamus sociabilis*) is a medium-sized hawk listed as endangered by both the USFWS and FWC. One snail kite was observed on a wire and eating a snail along SR 80 during a February 2006 survey. This location was approximately 0.75 miles west of the project footprint. In addition, during several field visits 2004-2006, populations of two species of apple snails, the Florida apple snail (*Pomacea paludosa*) and the exotic ramshorn apple snail (*Marisa cornuarietis*) were observed in large ditches of the project site. The network of large agricultural ditches provides suitable foraging opportunities but evidence of foraging/feeding (shell discards) was not observed. There are substantial additional foraging areas in close proximity to the proposed impacts, and the wetland impacts will be appropriately addressed. However, some tested copper concentrations in the project area were noted to exceed the interim Effects Level; bioaccumulation of copper through snail kite prey is therefore possible. It is anticipated this project may adversely affect the snail kite.

The **red-cockaded woodpecker** (RCW) (*Picoides borealis*) is currently listed as endangered by the USFWS and as a species of special concern by the FWC. The nearest documented RCW population occurs approximately 14 miles northwest of the

project area (FWC data). Based on lack of suitable habitat within the project area, it is anticipated that the project will have no effect on the RCW.

The **piping plover** (*Charadrius melodus*) is listed as threatened by both the USFWS and the FWC. The USFWS established critical habitat areas for the species, which include several locations on barrier islands west of the Caloosahatchee Estuary. The nearest piping plover critical habitat zone to the project area includes Punta Rassa, a mainland location at the southwestern edge of the Caloosahatchee Estuary, and Bunch Beach. The species may benefit from indirect project impacts which include salinity regime improvements to the downstream Caloosahatchee Estuary. The project may affect, but is not likely to adversely affect, and may actually benefit the piping plover.

The **wood stork** (*Mycteria americana*) is listed as endangered by both the USFWS and the FWC. Portions of this project fall just inside the 18.6-mile core foraging areas (CFA) of two colonies. Individuals were observed foraging and loafing onsite. Since there are substantial additional foraging areas in close proximity to the proposed impacts, and the wetland impacts will be appropriately addressed, it is anticipated that this project may affect, but is not likely to adversely affect, the wood stork.

Colonial nesting birds protected under the Migratory Bird Treaty Act (MBTA) that may occur in the project area include wading birds, some of which are state listed as species of special concern. These species were commonly observed in the project area but no rookeries were identified during field surveys. The nearest, documented active wading bird rookery is located approximately 1 mile south of the project (#619317). In addition, nests of the state listed, threatened least tern (*Sterna antillarum*) are similarly protected under the MBTA. Because terns select open, sandy areas for nesting, construction sites have been known to cause temporal effects to the species by attracting terns to nest. Successful tactics have been used to deter least terns from nesting in construction sites. The project is not anticipated to have adverse effects on wading bird rookeries or least tern nests.

Mammals

The **West Indian manatee** (*Trichechus manatus latirostris*) is listed by both the USFWS and FWC as endangered. Manatees have been known to utilize the Townsend Canal, which lies immediately adjacent and to the west of the project footprint. During times of inflow from the Caloosahatchee River, manatees are capable of passing over the weir and traveling southward into the Townsend Canal. Individuals have been observed at the outfall area immediately west of the project boundary as well as at the mouth of the

canal in the Caloosahatchee River. However, manatees cannot access the main distribution canal (i.e., Header Canal) for the grove property due to differences in elevation.

The Townsend canal will be retained in the post-construction condition (reservoir) and will deliver more fresh water to the Caloosahatchee River than it does currently. Given this fact, it is anticipated that the proposed project may affect, but is not likely to adversely affect the manatee.

The **Florida panther** (*Felis concolor coryi*) is listed by both the USFWS and the FWC as endangered. The proposed project is located within the USFWS CA and the project proposes impacts to areas within the panther primary, secondary, and "other" zones, as identified by the Florida panther subteam of the Multi-Species/Ecosystem Recovery Implementation Team (MERIT) and USFWS CA updates. The most recent available FWC telemetry data of radio collared Florida panthers, current through 2006, depicts four (4) Florida panthers and one (1) Texas cougar (*Felis concolor*) within a five-mile radius of the project area. A more landscape-level inspection (25-mile radius) identifies habitat utilization by several additional panthers, particularly within Okaloacoochee Slough and other conservation lands.

The USACE has made a determination that the C-43 West Storage Reservoir (WSR) project may adversely affect the Florida panther under Section 7 of the Endangered Species Act. As one of the SFWMD CERP Projects on the Band 1 list of the Master Implementation Sequencing Plan (MISP), impacts to the Florida panther were estimated by the USFWS as 21,825 panther habitat units (PHU), as referenced in the November 30, 2005 Test Cell Biological Opinion. Since this estimate, the project footprint has been slightly modified and land cover types and exotic species coverage have been further refined. Using the panther habitat unit analysis example in the USACE July 28, 2006 Picayune Strand Road Removal concurrence letter, as well as the complete table of habitat suitability values provided in the USFWS November 30, 2005 Test Cell Biological Opinion, panther impacts are currently estimated at 20,719 PHUs.

The USFWS determined that SFWMD offsite acquisition and restoration of approximately 101,066 acres of habitat in primary and "other" zones for Band 1/Acceler8 projects will compensate for the loss of panther habitat in the C-43 project. The SFWMD land is located in the core area of panther-occupied habitat, the majority is adjacent to other larger tracts of natural and preserve lands, and will assist in the long-term protection of the species.

Plants

The **Okeechobee gourd** (*Curcurbita okeechobeensis* ssp. *okeechobeensis*) is a federal endangered species, as listed by the Federal Register, July 12, 1993 Clarification, Federal Register, April 1, 1994. It is also a state endangered species, as listed by the Florida Department of Agriculture and Consumer Services' Chapter 5B-40, Florida Administrative Code. No Okeechobee gourds or appropriate habitat were observed during field reconnaissance. Given the above information, the project will have no effect on the Okeechobee gourd.

The **beautiful pawpaw** (*Deeringothamnus pulchellus*) is a federal endangered species, as listed by the Federal Register, September 26, 1986 Clarification, Federal Register, May 18, 1999. It is also a state endangered species, as listed by the Florida Department of Agriculture and Consumer Services' Chapter 5B-40, Florida Administrative Code. No appropriate habitat or beautiful pawpaw plants were observed during field reviews. Given the above information, the project will have no effect on the beautiful pawpaw.

1.0 PROJECT DESCRIPTION

C-43 West Storage Reservoir

The C-43 West Storage Reservoir project comprises one of the management measures included in C-43 Basin Project Implementation Report (PIR) planning effort. The C-43 West Storage Reservoir site is comprised of approximately 10,360 acres located in Hendry County west of LaBelle. Design for the C-43 West Storage Reservoir site includes construction of a 170,000 acre-feet above ground storage reservoir and associated appurtenances. When completed, the C-43 West Storage Reservoir Project will comprise a significant amount of the overall basin storage requirements as established for the Comprehensive Everglades Restoration Plan (CERP).

Environmental considerations played a large role in the ultimate C-43 site selection (Figure 1). The project began a few years ago by assessing approximately 20 potential sites for the C-43 project. Potential sites were eliminated over time when environmental issues, such as impacts to wildlife and wetlands, were considered too significant. Once the current C-43 location was selected, the project boundary was further assessed and modified, again to reduce impacts to wildlife and natural wetland systems. Of note was a significant reduction of the footprint in the southeast corner, where habitat impacts to the Florida panther (*Felis concolor coryi*) and other wildlife would have been too great.

Test Cell Project

During the review of the Basis of Design Report (BODR) a public concern was raised on the actual amount of seepage to be expected. A test cell program, consisting of two cells within the footprint of the C-43 site and consisting of approximately 267 acres, was recommended to assess the concern. The test cells are designed to model the recommended embankment and seepage control system, provide real time baseline model calibration with some key design elements extrapolated, and to provide a platform to evaluate water quality components of the reservoir system.

The C-43 Test Cell Project was permitted in December 2005; site clearing and cell construction began shortly thereafter. As of the time of this report, the cells have been filled and the seepage and water quality monitoring has commenced. Monitoring of the test cells is scheduled to last nine months.

Listed Species Assessment

A listed species assessment was being conducted in four phases for the C-43 West Storage Reservoir project. The first phase consisted of initial data collection to develop a project overview, agency coordination, and determining if any species-specific surveys would be required. The second phase consisted of developing the appropriate methodology and conducting preliminary surveys for a Listed Species Report (November 2004). Following agency coordination, it was determined that a specific wildlife survey for the Audubon's crested caracara (*Polyborus plancus audubonii*) should be conducted (third phase). This survey was conducted in spring of 2006 as per United States Fish and Wildlife Service (USFWS) guidelines to evaluate the presence of nests and utilization of the project area by the caracara. The fourth phase involved the update and compilation of data for this Biological Assessment.

1.1 EXISTING ENVIRONMENTAL CHARACTERISTICS

Existing Land Use / Land Cover

Natural/biological features and land use within the C-43 West Basin Reservoir project area were initially reviewed using the 2000 Florida Land Use, Cover and Forms Classification System (FLUCCS) Geographic Information System (GIS) data layer available from the South Florida Water Management District (SFWMD) (Figures 2 and 3). Citrus grove (FLUCCS 2210) covers approximately 90 percent of the study site, more than any other land cover type. The citrus grove land use classification includes acreage covered by citrus trees, grove maintenance roads, and small berms, brush piles, and other small features related to citrus grove operations. Water (FLUCCS 500 series) comprises 8.9 percent of the site and includes extensive agricultural canals/ditches, classified as Streams and Waterways (FLUCCS 5100), and excavated ponds, classified as Reservoirs less than 10 acres in size (FLUCCS 5340). Wetland (FLUCCS 600 series) comprises 1.1 percent of the site and includes Mixed Wetland Hardwoods (FLUCCS 6170), Willow and Elderberry (FLUCCS 6180), Exotic Wetland Hardwoods (FLUCCS 6190), Cypress (FLUCCS 6210), Wetland Shrub (FLUCCS 6310), and Freshwater Marsh (FLUCCS 6410).

Citrus groves, row crops (FLUCCS 2140), and improved pasture (FLUCCS 2110), with scattered cypress and mixed wetland hardwoods flank the project to the north, east, and south. The northern portion of the study area also contains some low-density residential areas (FLUCCS 1100). Forested uplands (parceled into low-density residential lots, various stages of development) such as pine flatwoods (FLUCCS 4110),

longleaf pine-xeric oak (FLUCCS 4120), sand pine (FLUCCS 4130), and xeric oak (FLUCCS 4210) are adjacent to the west of the project. At a landscape level, the C-43 project is surrounded by a matrix of agricultural, forested, and wetland land covers with pockets of urban land use (Figure 3). Urban areas are present to the southwest and northeast of the project area with small parcels along the Caloosahatchee River. Regions to the northwest and southeast of the project area are generally undeveloped.

2.0 METHODOLOGY

2.1 PRELIMINARY DATA COLLECTION

Initially, a comprehensive literature search was conducted for the C-43 project to determine if protected species or critical habitat was present within the study area. The literature search included standard Florida references such as the Rare and Endangered Biota of Florida series, the Florida Atlas of Breeding Sites for Herons and their Allies (1991), the Florida Natural Areas Inventory (FNAI) (1999, 2003), SFWMD and Florida Geographic Data Library (FGDL) GIS databases, and the Florida Fish and Wildlife Conservation Commission (FWC) list of protected species. Detailed inspection of Land Boundary Information System (LABINS) 1999 aerial photography in conjunction with field surveys was then performed to confirm the various existing habitat types within the study area.

Following the literature search and preliminary field verification, a potentially occurring protected faunal and floral species list was developed for the C-43 project area and modified over the course of agency communications (Tables 1 and 2). Coordination with the FWC and USFWS was initiated and includes:

- Two Planning Aid Letters (PALs) received from USFWS;
- A Pre-application Conference held in accordance with Florida Statutes (F.S.) 373.1501(5)(c)(a), on May 20, 2004;
- A data collection meeting held on July 20, 2004 with FWC to gather additional information on protected species in the area;
- A C-43 listed species meeting was held on March 22, 2005 with USFWS and FWC to discuss listed species field findings to date and agency comments on the draft Listed Species Report;
- A C-43 listed species meeting (for the full project site and the test cell) was held on May 26, 2005 to discuss the Florida panther and habitat compensation assessment as well as the test cell project design and permit needs;
- A C-43 meeting was held on November 9, 2005 with USFWS and FWC to discuss the current status of littoral zone planning and their preliminary design; and

3.0 RESULTS

3.1 FEDERAL PROTECTED SPECIES

Based on survey data, 4 federally listed faunal and 0 federally listed floral species were either observed or reported within the C-43 project study area. Figures 4 and 5 show the approximate location of protected faunal species observations during field surveys and/or historically documented occurrences within an approximate 4-mile radius of the C-43 project area. The following is a discussion of federally protected species that may be affected by the project and/or received specific field survey efforts. Faunal species discussed include the smalltooth sawfish (*Pristia pectinata*), American alligator (*Alligator mississipiensis*), American crocodile (*Crocodylus acutus*), sea turtles including the Atlantic loggerhead turtle (*Caretta caretta*), Atlantic green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), Kemp's ridley turtle (*Lepidochelys kempii*), and hawksbill turtle (*Eretmochelys imbricata*), eastern indigo snake (*Drymarchon corais couperi*), bald eagle (*Haliaeetus leucocephalus*), Audubon's crested caracara, snail kite (*Rostrhamus sociabilis*), wood stork (*Mycteria americana*), Florida scrub jay (*Aphelocoma coerulescens*), Florida grasshopper sparrows (*Ammodramus savannarum floridanus*), red-cockaded woodpecker (RCW) (*Picoides borealis*), piping plover (*Charadrius melodus*), colonial nesters and other nesting birds, West Indian manatee (*Trichechus manatus latirostris*), and Florida panther. Floral species include the Okeechobee gourd (*Curcurbita okeechobeensis* ssp. *okeechobeensis*) and beautiful pawpaw (*Deeringothamnus pulchellus*).

For each species discussed, anticipated project-related effects are provided. For federally listed species, a "determination of effect" is made by the federal action agency (USACE) based on the proposed activities. In very general terms, project activities typically have no effect to species or various degrees of adverse effects, based on project and construction specifications as well as species and habitat factors. A determination of a beneficial effect is somewhat rare and occurs only if the project conditions provide greater habitat quantity or quality and outweigh any temporal impacts to species during the construction phase.

3.1.1 Fish

3.1.1.1 Smalltooth Sawfish

The smalltooth sawfish is listed by the USFWS as endangered; while it is protected by some fishing regulations in the state of Florida, it is not a state-listed species. Sawfish

are elasmobranches: modified rays with shark-like bodies, skeletons made of cartilage, and gill slits on the ventral side. They get their name from their "saws"—long, flat snouts edged with pairs of teeth which are used to locate, stun, and kill prey. Sawfish species inhabit shallow coastal waters of tropical seas and estuaries throughout the world. They are usually found in shallow waters very close to shore over muddy and sandy bottoms, in areas such as sheltered bays and in estuaries or river mouths, such as the Caloosahatchee River (Simpfendorfer, 2006). The smalltooth sawfish's current range is peninsular Florida and is relatively common only in the Everglades region at the southern tip of the state.

The smalltooth sawfish may benefit from indirect project impacts which include salinity regime improvements to the downstream Caloosahatchee Estuary. This potential beneficial effect is supported by findings in Simpfendorfer (2006); this study suggests that the species may travel upstream in the Caloosahatchee River in the spring when flow is limited. It is anticipated that the project may affect, but is not likely to adversely affect, and may actually benefit the smalltooth sawfish. The USACE will complete Essential Fish Habitat (EFH) consultation with the National Marine Fisheries Service (NMFS) on the species.

3.1.2 Reptiles and Amphibians

3.1.2.1 American Alligator

The American alligator is listed by the USFWS as threatened due to its similarity of appearance to the American crocodile and is listed by the FWC as a species of special concern. This species is known to inhabit most permanent bodies of water including swamps, lakes, marshes, and canals. The American alligator was observed many times throughout the course of field surveys in agricultural ditches and "rim ditches" of cypress swamps (Figure 4). Since there is substantial additional foraging and nesting areas in close proximity to the proposed impacts, and the wetland impacts will be appropriately addressed, the project will have no effect on the American alligator.

3.1.2.2 American Crocodile

The American crocodile is listed by the USFWS and FWC as an endangered species. The crocodile inhabits areas where fresh and salt waters mix, such as coastal wetlands and canals. They are also known to inhabit mangrove and seagrass habitats in coastal areas of south Florida. The crocodile has not been documented in Hendry County but is present in coastal counties of the Caloosahatchee River basin, namely Lee and

Collier Counties. The nearest documented individual occurrence to the project is on Sanibel Island in Lee County. The American crocodile may benefit from indirect project impacts which include salinity regime improvements to the downstream Caloosahatchee Estuary. The project may affect, not likely to adversely affect, and may actually benefit the American crocodile.

3.1.2.3 Sea Turtles

Sea turtles including the Atlantic loggerhead turtle, Atlantic green turtle, leatherback turtle, Kemp's ridley turtle, and hawksbill turtle are listed as endangered by the USFWS and FWC with the exception of the loggerhead turtle, which is listed as threatened. These are marine species with a presence in south Florida waters and are known to utilize bays and estuarine habitats, such as the Caloosahatchee Estuary, for feeding and resting. Sea turtles may benefit from indirect project impacts which include salinity regime improvements to the downstream Caloosahatchee Estuary. The project may affect, but is not likely to adversely affect, and may actually benefit sea turtles.

3.1.2.4 Eastern Indigo Snake

The eastern indigo snake is listed by the USFWS and the FWC as a threatened species. Eastern indigo snakes require a mosaic of habitats. A study in southern Georgia found that interspersion of tortoise-inhabited sandhills and wetlands improve habitat quality for the snake (Landers and Speake 1980). Eastern indigo snakes require sheltered retreats from winter cold and desiccating conditions, and often use burrows of the gopher tortoise when available (Speake et al. 1978, Layne and Steiner 1996). In habitats lacking gopher tortoises, snakes may take shelter in hollowed root channels, hollow logs, or the burrows of rodents, armadillos, or land crabs (Lawler 1977, Moler 1985b, Layne and Steiner 1996). In its Florida range, the eastern indigo snake frequents diverse habitats, including pine flatwoods, scrubby flatwoods, floodplain edges, sand ridges, dry glades, tropical hammocks, edges of freshwater marshes, muckland fields, coastal dunes, and xeric sandhill communities (Service 1999). Eastern indigos also use agricultural lands and various types of wetlands, with higher population concentrations occurring in the sandhill and pineland regions of northern and central Florida.

Because eastern indigo snakes are found throughout Florida and use a variety of habitat types, including citrus groves, its presence in the project area is likely. No individuals have been observed during project field surveys; while no gopher tortoise

burrows have been observed, armadillo burrows have been frequently observed along canal banks and may provide refuge for indigo snakes.

Snakes may be injured or killed during construction by heavy equipment. This activity may cause individuals to leave the area, abandon den sites, and possibly miss foraging and mating opportunities. Above ground refugia may be lost during project construction. Individual snakes fleeing the area may be more vulnerable to predation but some snakes may seek underground refugia, if available. To minimize adverse impacts to the species, the project team will commit to an initial flooding of the reservoir site at as slow a rate as possible. This slow filling process will provide an opportunity for the eastern indigo snake, as well as other ground-dwelling wildlife, to vacate the project area and find suitable habitat outside the reservoir footprint. In addition, the USFWS Standard Indigo Snake Protection Conditions will be implemented during construction to minimize potential adverse impacts to the species. Construction guidelines are provided in Appendix C.

Following construction, very minimal to no habitat for the eastern indigo snake will be available in the project area. The interior slopes of the reservoir cells will be lined with soil cement, thus making the majority of the reservoir site unsuitable for the species. In addition, the access road and other maintenance roads will mainly be all-weather roads consisting of a limerock base with gravel substrate surface. The entrance road and small portions of the perimeter access road and maintenance roads will be paved. The only portions of the C-43 West Storage Reservoir (WSR) that may provide limited habitat for the eastern indigo snake are the embankments that will be constructed between the crest of the dam and the project boundary except for the perimeter canal and the maintenance road. These embankments will consist of overburden from the project area and a maintained sod. Because these embankments will be regularly mowed, they will not provide highly desirable cover or habitat for the species. Based on the above information, the proposed project may adversely affect the eastern indigo snake.

3.1.3 Birds

3.1.3.1 Bald Eagle

The bald eagle is currently listed as threatened by both the USFWS and the FWC. A proposed rule to de-list the species may be considered but no change in status has yet occurred. The bald eagle prefers forested riparian habitats associated with lakes, rivers or coastal areas. One bald eagle was observed soaring over a pasture approximately

1.8 miles east of the project (near SR 29). Data obtained from the FWC Eagle Nest Database (most recent data from 2004) indicate that the closest documented bald eagle nest, HE002, is located 3.4 miles east of the project, east of SR 29. This nest location is depicted in Figure D-5 of the Florida Panther Cumulative Impact Analysis package (Appendix D). This nest is documented to be last active as of the 2003 nesting season (was not active in the 2004 nesting season). No other nests were observed in the project vicinity during summer 2004 or spring 2006 field efforts; USFWS construction monitoring procedures will therefore not be required. It is anticipated that the proposed project will have no effect on the bald eagle.

3.1.3.2 Audubon's Crested Caracara

The Audubon's crested caracara is listed as threatened by both the USFWS and the FWC. This large raptor opportunistically feeds on carrion, fish, small mammals, small turtles, turtle eggs, and invertebrates. In Florida, the caracara historically occupied native prairies, but fire suppression has caused widespread conversion of prairies to open brushland. Currently, the bulk of Florida's caracara population has been found on large cattle ranches with improved pastures and scattered cabbage palms. Dry prairies with wetter areas and scattered cabbage palm comprise typical habitat. Caracaras also occur in some improved pasturelands and even in lightly wooded areas with more limited stretches of open grassland. Within these habitats, caracaras exhibit a propensity for nesting in cabbage palms, followed by live oaks, during a nesting season that typically continues from September through June with a concentration during November to April (Rodgers et al., 1996; Morrison, 2001).

Caracaras forage within a variety of habitats including improved pastures, adjacent to dwellings and farm buildings; newly plowed or burned fields; agricultural lands, including sod and cane fields, citrus groves, and dairies; and wetland habitats (Morrison 1996). The caracara is a diet generalist and opportunistic feeder. They consume carrion, such as road-kill (raccoon, opossum, and armadillo), and a wide variety of live prey. Prey species include invertebrates such as crayfish, beetles, grasshoppers and small mammals, amphibians, reptiles, fish, and birds (Morrison 1998).

Caracaras are non-migratory and may be found in their home range year round. Home ranges average approximately 1,200 ha (approximately 3,000 acres), corresponding to a radius of 2 to 3 kilometers (1.2 to 1.9 miles) surrounding the nest site (Morrison and Humphrey 2001). Foraging typically occurs throughout the home range during nesting and non-nesting seasons.

The project falls within the caracara USFWS Consultation Area (CA). As per USFWS request, a specific survey for the caracara was conducted in spring of 2006. The final report is provided in Appendix E. The C-43 project site was not documented to support any Audubon's crested caracara nests, and provides little to no nesting habitat. Very few cabbage palms and other appropriate nest tree types are present within the property. Those that do exist flank cypress domes and other forested wetlands that remain in the citrus groves. These areas were examined for the species and associated nests but none were noted.

Caracaras have been documented to utilize the southeast portion of the site for foraging opportunities. The groves likely provide populations of small amphibians, reptiles, and mammals, that caracara can use as a food source. During field surveys, adults were observed on several occasions flying into and out of the southeast groves of the C-43 project site; one time, food was seen in an individual's beak as it flew from the site.

Two caracara nests were identified in the vicinity of the project. A confirmed nest is located approximately 4,750 feet north of the project boundary, along the southern edge of the SR 80 ROW (Figure 5). Individuals were not seen flying into the C-43 project boundary. Field surveys suggest that the caracara at this confirmed nest location utilize habitats within the primary zone (defined as 300 meters, or 985 feet radius of the nest tree as per Standard Local Operating Procedures for Endangered Species (SLOPES)), but do not commonly use habitats within the secondary zone (defined as 2000 meters, or 6,600 feet radius of the nest tree as per SLOPES) for foraging opportunities. No portion of the project area falls within the primary zone of this nest but 264 acres of the project area fall within the standard secondary protection zone.

While there is not enough survey information to rule out the possible utilization of the secondary zone of this confirmed nest, a reduction in the secondary zone radius is proposed. During the course of nine days of caracara surveys in the project area, adult and juvenile caracaras were observed flying to the north across SR 80 to a pasture, and to the south, east and west to citrus groves, to forage. Based on carcasses found under the nest tree, it is likely that the caracaras additionally forage within the SR 80 ROW for roadkill. However, at no time were individuals observed flying southward far enough to reach the project footprint. There is ample citrus grove immediately adjacent to the nest (approximately 2,012 acres of citrus grove fall within the secondary zone of the nest); the 264 acres of grove that fall within the secondary zone and project area is only 13 percent of this citrus grove acreage sum. Therefore, we do not believe that the caracara depend on or even utilize the habitat in the project area. A reduction of the

secondary zone for this nest from the standard 6,600 feet to 4,750 feet is therefore proposed. This modification is not anticipated to impact the nest since the nest tree will not be removed for the project, the primary zone will not be affected, and the majority of the secondary zone will not be affected.

A second nest is likely to occur within the A. Duda & Sons, Inc. pasture, approximately 1,065 feet south of the project boundary (Figure 5). Individuals from the possible nest site were seen flying into and out of the C-43 project site. If this is an accurate nest location, approximately 1,100 acres of the C-43 project area falls within the secondary protection zone of this nest. Based on field observations, the caracaras utilize some habitats within this secondary zone for foraging opportunities. However, this secondary zone impact is only an estimate based on a probable but unconfirmed nest location. Also, due to the uncertainty of the nest, a primary zone was not established. However, the project area is unlikely to fall within the primary zone of this possible nest site.

If this possible nest is re-examined during the nesting season and is confirmed, a reduction in the secondary zone will also be proposed based on field observations of caracara along the project footprint periphery only. Caracaras were not observed to venture far from the edge and the groves along the project edge likely provide adequate foraging opportunities for the species.

No caracara observations were made in regions west of the project site. Land use and habitat in this area consists primarily of forested upland communities, most of which contains street patterns with a recent boom of housing construction activity. No open pastures or other appropriate foraging areas exist for the caracara. Therefore, caracaras are very unlikely to utilize this region.

Lastly, no caracara observations were made in regions south of the project. The permissible survey region south of the project area was limited to 1,000 feet which may have contributed to the lack of observations. However, appropriate habitat in this southern region was somewhat limited as citrus groves, spotted with forested wetlands, is the typical landscape. In addition, no caracara were observed flying southward in this region. Surveys conducted from the permissible survey region were in good view range from which biologists could detect flying caracara up to 0.5 miles away. While the possibility of a caracara nest existing in the southern limits of the wildlife survey area cannot be eliminated completely, a nest is very unlikely to be located there.

In summary, very little suitable nesting habitat (i.e., a few cabbage palms adjacent to cypress domes and surrounded by citrus grove) occurs within the project. However,

suitable nesting habitat does exist outside of and adjacent to the southeast corner of the project footprint and two nests (one confirmed, one possible) were identified. Caracaras were documented to utilize foraging habitat within the C-43 project in the southeast corner of the footprint only. Based on observations of the confirmed nest at SR 80, a reduction in that nest's secondary zone is proposed (4,750-foot radius). If the possible nest is later confirmed, a reduction of its secondary zone will also be proposed. The project will not disturb nesting caracaras or remove nest trees, will not affect primary zones, and foraging habitat would not be significantly reduced since adjacent habitats provide ample foraging opportunities for the caracara. In addition, the following construction guidelines will be put into practice for known caracara nest sites during nesting season (November – April) (Based on Habitat Management Guidelines for the Audubon's Crested Caracara in Central and Southern Florida, USFWS, 2002).

1. Construction activities will not take place within the 300-m (985-foot) primary zone extending outward from the nest tree.

   Restrictions that will be put into effect in the **primary zone** consist of:

   - removal of pasture or natural or man-made wetlands within pastures
   - removal of nest trees, cabbage palms or oaks
   - removal of other vegetation in the general vicinity of the nest tree that would result in the loss of protective cover in the nesting area used by fledged chicks
   - construction of any buildings, roadways, power lines, or canals
   - changes in land management activities such as removal of cattle or reduction in burning or mowing
   - use of chemicals that are harmful to wildlife, including pesticide applications

2. Construction Best Management Practices (BMP) will be followed throughout the project area, including:

   - The construction team will be educated regarding nesting and foraging habits and nest trees and their potential inhabitants at a pre-construction conference and team meeting. Issues such as the minimization of tailgate slamming near the protection zone during nesting season will be addressed at the conference and subsequent team meetings. Updates throughout project construction will be made as appropriate to educate personnel regarding nest tree status, new nest sites, and construction BMPs.
   - The protection zone will be designated as a no-parking/staging/storage area on the construction plan sheets to reduce the potential for noise and

disturbance. Noise reduction in this zone will be a component of the monitoring program.

3. The construction team will need to comply with any permits issued by the state or federal government.
4. In the unlikely event that construction may encroach upon the protection zone during nesting season, the USFWS will be contacted for consultation and associated reports prepared according to the Audubon Crested Caracara SLOPES.

Given the above information, the proposed project may affect the Audubon's crested caracara.

3.1.3.3 Snail Kite

The snail kite is a medium-sized hawk listed as endangered by both the USFWS and FWC. The original species listing pursuant to the Endangered Species Conservation Act in 1967 referred to the snail kite as Everglade snail kite. Although the listing has remained unchanged, the official common name is now simply snail kite. The snail kite is known to occur in the Caloosahatchee basin and critical habitat has been identified adjacent to the Caloosahatchee basin in Lake Okeechobee. The species is dependent on appropriate hydrology and water quality of the wetland habitats it utilizes. The species inhabits relatively open, freshwater marshes that support adequate populations of apple snails. Favorable areas consist of extensive shallow open water such as sloughs and flats, vegetated by sawgrass (*Cladium jamaicense*) and spikerush (*Eleocharis* spp.). These areas are often interspersed with tree islands or small groups of scattered shrubs and trees that serve as perching and nesting sites. The water level must be sufficiently stable to prevent loss of the food supply through drying out of the surface. Although open freshwater marshes are absent from the project area, other water features (canals and stormwater ponds) may provide foraging habitat for the snail kite depending on their water regimes.

Although no snail kites were observed within the project footprint, one individual was observed on a wire and eating a snail along SR 80 during a February 2006 survey. This location was approximately 0.75 miles west of the project footprint (Figure 4). Populations of two species of apple snails, the Florida apple snail (*Pomacea paludosa*) and the exotic ramshorn apple snail (*Marisa cornuarietis*), were observed in several of the larger ditches throughout the C-43 project site. Ms. Joyce Mazourek (USFWS) also indicated observations of snails in one wetland in the northeastern portion of the C-43 project area. SEA did not detect apple snails in this location at the time of the field

surveys. Although suitable foraging opportunities exist within the C-43 network of larger ditches, evidence of foraging/feeding (shell discards) was not observed.

While the design of the C-43 reservoir cells is still underway, it is anticipated that water levels will vary greatly from month to month and year to year. An evaluation of reservoir stages for an 8-year period model finds that water levels in the cells will vary from approximately 20-42 feet in elevation with an average of 34.7 feet and the majority of water levels between 30-40 feet. Typically, 5-10 foot fluctuations occur every few months. Constant water levels are anticipated to be rare; in the eight-year period, a steady state was noted for approximately four months in Cell 2 but a similar constant was not noted in Cell 1. This hydrological regime will not be suitable for apple snails. There will however, be approximately 160 acres of habitat available in the perimeter canal, where water levels will not fluctuate as greatly. The Florida apple snail lays clusters of eggs on plant stems about 8 inches above the water's surface during March-May. A rise in water depth above the level of the eggs during the period of maturation (approximately 16-22 days) will drown the eggs, while a drydown to levels below 4 inches during this period will interrupt egg production and cause mortality of newly-hatched snails.

CERP projects, such as the C-43 West Storage Reservoir, involve the creation of reservoirs and stormwater treatment areas (STA) on land previously used for citrus cultivation. Citrus grove operations have routinely included the application of heavy concentrations of copper as a fungicide. Wetlands created in contaminated areas may release copper from the soil, which can bio-accumulate in the food chain. Preliminary studies indicate a positive relationship between copper concentrations in soil sediments and copper concentrations in apple snails (Bargar et al. 2005). Apple snails are a primary food source of the snail kite; therefore, there is concern that the snail kite may be impacted by copper levels through their prey.

Copper concentrations in sampling points within the project area range from 13.1 – 169.0 mg/kg (URS Corporation 2003). A map of the project area and copper sampling points (URS Corporation 2003) is provided in Appendix F. Approximately 9 percent of the sample concentrations within the project area exceed the interim Effects Level of 85 mg/kg agreed upon by the USFWS and SFWMD until a study to evaluate that value for the snail kite is completed. Therefore, some portions of the project area contain copper concentrations that are high enough to potentially bio-accumulate in apple snails.

At this time, the USFWS is still evaluating the bioaccumulation of copper in the food chain for snail kites. Therefore, based on the pending evaluation, the above information, and the presence of substantial additional foraging areas in close proximity to the project footprint, this project may adversely affect the snail kite.

3.1.3.4 Wood Stork

The wood stork is listed as endangered by both the USFWS and the FWC. This wading bird is opportunistic, utilizing various open hydric pine-cypress habitats and man-made wetlands (i.e., ditches, canals, stormwater ponds, and seasonally flooded roadside areas). The species feeds almost exclusively on small fish between 1 and 8 inches in length. Ideal feeding conditions are in shallow wetland areas where fish are concentrated in pockets. Sudden water level increases are detrimental to the species because it is difficult for them to capture their prey in deep water. Nesting seasons vary annually and geographically because they are dependent upon water levels. The nesting season in south Florida is typically from November to June, starting when water levels decline, and ending when water levels rise.

The closest documented wood stork nesting colony (619141) is present 16.6 miles to the south of the project. The wood stork SLOPES published by the USFWS identifies an 18.6-mile foraging range, or core foraging area (CFA), surrounding each wood stork nest colony. This radius is an average given that the species forages from 5 to 40 miles away from the nest colony during breeding/nesting season. Approximately 2,728 acres or 26 percent of the project footprint (27 percent excluding the previously-permitted test cell) falls within the CFA of this rookery. Figure D-6 of the Florida Panther Cumulative Impact Analysis package (Appendix D) depicts wood stork rookery and CFA locations in south Florida. An additional wood stork nesting colony (619041) to the project footprint is located in Lee County, approximately 17 miles west of the project. Approximately 2,412 acres or 23 percent of the C-43 project area falls inside the CFA of this rookery (Figure 4). This does not include the 267 acres of the previously permitted test cell project that also was contained within the CFA of colony 619041; therefore, 1 percent has already been permitted.

Potential foraging areas within the project area for the wood stork may include the citrus grove ditches and excavated waters, but these systems, due to typical agricultural water management practices, do not concentrate prey species necessary for the stork's tactile feeding behavior. Within the C-43 project, several wood storks were observed flying overhead, several were seen 'loafing' near a citrus grove maintenance road, and one individual was noted opportunistically feeding on small animals/fish trapped in piles of

common water hyacinth (*Eichhornia crassipes*) and water-lettuce (*Pistia stratiotes*) cast-aside during mechanical ditch maintenance (Figure 4). Wood storks are also highly mobile and the surrounding land use currently provides ample foraging opportunity.

A total of 499.9 acres of waters of the United States in the C-43 project area fall within wood stork CFAs; heavily vegetated shrub and forested wetlands, open-water borrow areas, and primary, secondary, and tertiary drainage ditches, would be impacted primarily by flooding activities. The majority of these waters do not provide reasonable foraging opportunity because the primary and secondary drainage ditches as well as excavated ponds are steep-sided, hold deep water, and are dominated by floating-leaved plants which interfere with the wood stork's ability to capture prey. The palustrine shrub and forested systems also provide poor feeding habitat as they contain dense ground and/or shrub vegetation, and only a small number of the systems have any emergent marsh component at all.

The tertiary drainage ditches have shallow slopes, reasonably shallow water (up to 3 feet) and contain emergent, submergent and floating-leaved vegetation. While the foraging quality of these ditches in actively maintained citrus grove is low (chemical run-off, altered hydrology), wood storks may forage on small fish, invertebrates, and amphibians that may occur in these ditches. Therefore, a total loss of 274.1 acres of wood stork foraging habitat would occur as a result of the project (tertiary ditches only). This does not include the loss of 17.2 acres of tertiary ditches that was previously permitted for the test cell project.

The loss of wood stork foraging habitat will be mitigated in kind by the proposed C-43 West Reservoir Project and by other Acceler8 projects. The shallow-sloped littoral zones along portion of the C-43 project will provide approximately half of the compensation for the loss of wood stork habitat. At this time, an estimated 40 acres of littoral zone will be created. Of these 40 acres, 9.5 acres is designated for compensation of the test cell project wood stork foraging habitat impacts (17.2 acres of tertiary ditches). During the permitting process for the test cell project, WRAP was utilized to assess the functional wetland loss from the tertiary ditches and the functional wetland credit from the littoral zones. The remaining 30.5 acres of littoral zone will be applied to offset impacts to wood stork foraging habitat resulting from the C-43 project.

Narrow, elongated littoral zones along the perimeter canal are intended to vary in water depth, ranging from 0 to 48 inches of water. These may become deeper or dry depending on the seasons and operational plan for the perimeter canal structures. The

design for littoral zones will anticipate a wide variety of changes in water depth so as to benefit fish and wildlife, including the wood stork. The wood stork forages most successfully in sites where water is 2-15 inches in depth, the water is relatively calm, and dense thickets of aquatic vegetation are absent. Therefore, the littoral zones of the C-43 WSR project will likely provide suitable foraging habitat for the wood stork.

In addition, it is anticipated that the C-43 WSR project will provide wood stork foraging habitat within the reservoir cells during times of drawdown. A dropping water level is beneficial to concentrate fish at suitable densities. In sites where water rises, especially quickly, fish disperse and the site is less suitable for the species. Fluctuations in water levels are anticipated to occur regularly in the reservoir cells; typical fluctuations of 5-10 feet will occur every few months according to modeling data. The largest noted fluctuations in the model are a 17-foot and 20-foot change in a period of 3 months for Cells 1 and 2, respectively. Constant water levels are anticipated to be rare; the 8-year water level model noted only one constant water level for approximately 4 months in one of the reservoir cells. During times of dry cells, deep water refugia within the cells will continue to provide foraging habitat for the wood stork.

Current USFWS Habitat Management Guidelines for the Wood Stork in the Southeast Region (1990) recommend restrictions to activities that would alter water elevations or wetland acreage within the colony location, primary zone (500 to 1,500-foot radius) or secondary zone (2,500-foot radius) in nesting and non-nesting season cycles. Because the project area is located far from wood stork colonies, the project or reservoir operations will not likely affect hydrology in the primary and secondary zones; modeling is still underway to assess hydrological affects. The proposed project will comply with USFWS standard guidelines for the wood stork which are provided in Appendix G. Since there is substantial additional foraging and nesting areas in close proximity to the proposed impacts, and the wetland impacts will be appropriately addressed, this project may affect, but is not likely to adversely affect the wood stork.

3.1.3.5 Florida Scrub Jay

The Florida scrub jay is listed as threatened by both the USFWS and the FWC due to loss of its preferred habitat. Optimal scrub jay habitat consists of low growing, scattered scrub canopy species with patches of bare sandy soil such as those found in sand pine scrub, xeric oak scrub, scrubby flatwoods, and scrubby coastal strand habitats. In areas where these types of habitats are unavailable, Florida scrub jays may be found in

less optimal habitats such as pine flatwoods with scattered oaks. Scrub jays live in family groups and defend territories that typically average 23 acres in size.

No individuals, nests, or appropriate habitat were detected in the project footprint. The nearest documented Florida scrub jay habitat and population occurs 1.1 miles west of the project area. This colony is beyond the foraging distance for the species to access the project area and is well outside the SLOPES protection zone. While the project falls within the Florida scrub jay USFWS CA, based on the above information, the project is anticipated to have no effect on the Florida scrub jay.

3.1.3.6 Florida Grasshopper Sparrow

The Florida grasshopper sparrow is a small, short-tailed bird listed as endangered by both the USFWS and FWC, due to habitat degradation and loss. The species is not known to occur in Hendry County but populations may occur in nearby Glades County (USFWS 4-11-02 PAL). The nearest Florida grasshopper sparrow record in the 1999 FNAI database is a 1984 observation located 17.3 miles north of the project. Mapping of potential Florida grasshopper sparrow habitat (Shriver and Vickery, 1999) shows marginal habitat zones to the northeast and southeast of the project, and the project area falls within the Florida grasshopper sparrow USFWS CA. However, the nearest marginal habitat zone is located approximately 2.5 miles to the southeast of the project footprint. No grasshopper sparrows were observed during field surveys and no suitable habitat exists in the project area. Based on the above information, this project is anticipated to have no effect on the Florida grasshopper sparrow.

3.1.3.7 Red-Cocaded Woodpecker

The RCW is currently listed as endangered by the USFWS and as a species of special concern by the FWC. The RCW is a small woodpecker that once was common throughout the southeast US, but is now more limited due to extensive logging and destruction of older pine forests. Preferred habitat for the RCW consists of open stands of older pine or pine-hardwood (50 percent or more pine) that are 30 years or older (Henry, 1989). RCW populations typically require a minimum of 5-10 acres of habitat for a tree cavity aggregate (cluster). No suitable RCW habitat exists on-site or near the project. The nearest documented RCW population occurs approximately 14 miles northwest of the project area (FWC data). Based on lack of suitable habitat within the project area, the project will have no effect on the RCW.

3.1.3.8 Piping Plover

The piping plover is listed as threatened by both the USFWS and the FWC. The USFWS established critical habitat areas for the species, which include several locations on barrier islands west of the Caloosahatchee Estuary. The nearest piping plover critical habitat zone to the project area includes Punta Rassa, a mainland location at the southwestern edge of the Caloosahatchee Estuary, and Bunch Beach. The species may benefit from indirect project impacts which include salinity regime improvements to the downstream Caloosahatchee Estuary. The project may affect, but is not likely to adversely affect, and may actually benefit the piping plover.

3.1.3.9 Colonial Nesters and Other Birds

The Migratory Bird Treaty Act (MBTA) governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts and nests. Nests and rookeries are protected during the nesting season from construction activities that would otherwise destroy them, but can be taken during non-nesting seasons when they are not utilized by the species.

Wading birds, some of which are state listed as species of special concern, were commonly observed in the project area but no rookeries were identified during field surveys. The nearest, documented active wading bird rookery is located approximately 1 mile south of the project (#619317). Observations at this rookery were last recorded in 1989 and included the little blue heron (*Egretta caerulea*), great egret (*Casmerodius albus*), and anhinga (*Anhinga anhinga*). The project is not anticipated to have adverse effects on wading bird rookeries.

Nests of the state listed, threatened least tern (*Sterna antillarum*) are similarly protected under the MBTA. No least terns were observed during field surveys and no data records exist for the species near the project. Because terns select open, sandy areas for nesting, construction sites have been known to cause temporal effects to the species by attracting terns to nest. Trained dogs have been successfully utilized in construction projects to prohibit birds from nesting in the open areas. This tactic can be further investigated if necessary. The project is not anticipated to have adverse effects on least tern nests.

The Florida sandhill crane is a large wading bird listed as threatened by the FWC, but remains unlisted by USFWS. The species typically constructs nests on a platform of vegetation surrounded by water within an herbaceous wetland. Extremely marginal

nesting and foraging habitat is present within the project. No documented Florida sandhill crane nests exist within the project study area and no individuals were observed in flight over or foraging within the project area. However, large-scale construction projects in Florida have been known to have temporal effects on sandhill cranes by attracting them to nest in work areas of the site. If sandhill cranes stay and build nests in standing water areas of construction sites, the following protection guidelines will be employed to avoid nest disturbance:

- Nest protection should include measures to prevent disturbance of incubating adults by providing spatial and/or visual separation between nests and construction activities. FWC biologists have recommended a 400-foot buffer around nests. If construction activities are required closer than 400 feet from a nest, monitoring should be provided to ensure the activity does not result in nest abandonment or disturbance of incubating adults;
- During incubation, adults may be expected to be continuously present at the nest. If adults are not present at an active nest for two consecutive 15-minute periods or are exhibiting agitated behavior or vocalization, surrounding activities should be evaluated to identify and correct the cause of incubation disruption;
- Artificial alteration of water levels in wetlands supporting active nests may contribute to nest failure and must be avoided. Dewatering of a nest wetland may increase the risk of the nest to predation. Adding water to a nest wetland may drown eggs. Any activity that would alter a nest wetland's hydrology should not be undertaken while an active nest is present and should be delayed as long after hatching as possible if the wetland is used for night roosting;
- Silt fences may be used to create barriers to prevent adults and chicks from entering work areas, haul roads, or drainage ditches. Where adults and chicks are present within work areas, openings in silt fences will allow dispersal to alternative foraging or roosting habitats; and
- Posting of sandhill crane warning signs within work areas and along haul routes near foraging or nesting habitats and education of construction staff will help to minimize risk to sandhill cranes.

Given the above information, and since there is substantial additional foraging and nesting areas in close proximity to the proposed impacts, and the wetland impacts will be off-set appropriately, the project is not anticipated to have adverse effects on Florida sandhill crane nests.

Field surveys did identify two red-shouldered hawk nests (*Buteo lineatus*) in the eastern portion of the project. This hawk is the most common hawk species in Florida and typically nests in large, mature trees. The species breeds from January through May or June, incubates eggs for approximately 33 days, and fledges at 40 to 45 days of age. Construction activity will not disrupt active nests during the nesting season (approximately January through July). The project is not anticipated to have adverse effects on the red-shouldered hawk nests observed in the project area.

3.1.4 Mammals

3.1.4.1 West Indian Manatee

The manatee is listed by both the USFWS and FWC as endangered. The species occurs in all south Florida coastal waters and is known to utilize the Caloosahatchee River as a winter aggregation area. Manatees have been known to utilize the Townsend Canal, which lies adjacent to the western side of the project footprint. During times of inflow from the Caloosahatchee River, manatees are currently capable of passing over the weir or through a flap gate and traveling southward into the Townsend Canal at the Berry Groves main pump station. Manatees have been observed in the Townsend Canal and at the outfall to the Caloosahatchee River.

The following provides specific information on structure designs as they relate to manatees.

Confluence of the Townsend Canal and the Caloosahatchee River

The existing weir structure located in this area has an elevation of 2.74. It provides 10 'windows' with flap gates on the upstream side, each 6' by 6', through which manatees can pass during inflow conditions, when the flaps open inward simply due to the inflow condition resulting from pumping. In the existing condition, it is then possible for manatees to become trapped in the Townsend Canal when pumping is ceased, the condition becomes an outflow condition, and the flaps close. In this area, the weir elevation is 2.74, normal water level (NWL) in the canal is approximately 3, and the canal bottom ranges from -6 to -10.

It is not known at this time if this weir structure will need to be replaced. If it does, provisions to prevent manatee entrapment will be examined. It the existing structure can be used in the future condition the system will be modeled to show the effects of removing one of the flaps permanently. At this time, this action would not have a negative affect on reservoir operations.

Intake Locations of Pump Stations - C43-PS-1 and C43-PS-4

At the main pump station, C43-PS-1, there will be an inlet channel with a separate vehicular bridge upstream and away from the pump station. This bridge supports the trash rake and the vehicles needed to clean trash collected along the rake. The trash rake system (screen) consists of vertical bars spaced approximately 6-8 inches apart; the system extends from above the water surface to the bottom. Due to the positioning of this trash rake, manatees will not be able to approach the intake pipes. Various trash collection systems have been designed to clean the trash rake, and a system will be selected to minimize the potential for harm to manatees (refer to plan sheet 83 for the location of the vehicular bridge and trash rake system). Note that there is potential for the separate vehicular bridge to be eliminated. If that happens, the trash rake system will be attached to the service bridge at the pump station. Regardless of the location of the trash rake system, the screen will be included.

At the smaller pump station, C43-PS-4, the suction end of the intake pipe(s) will be screened with a trash rake-type screen. This same screen will prevent manatees from entering the intake pipe (refer to plan sheet 86 and the pump station sections on sheets 169, 170, and 239).

Main outfall structure – C43-S-11

Due to the vertical difference between the NWL of 3 feet in the Townsend Canal and the NWL of 15 feet in the perimeter canal on the upstream side of C43-S-11, along with the lowest weir elevation at the bottom of the roller gate at 10.5, it will not be possible for manatees to enter the perimeter canal through the C43-S-11 structure (refer to plan sheets 85 and 191).

Structures C43-S-7 and C43-S-9 (Banana Branch and Fort Simmons Branch, respectively):

These structures are gated, double box culverts. Flows in one of the box culverts are controlled by a slide gate. Except under extreme high flow conditions, these slides gate will remain closed. The upstream NWL in the perimeter canal and the flows in the other box culvert will be controlled by a weir gate. Each weir gate is supported by a "knee wall" at the upstream end of the box culvert (refer to section M on sheet 209). The "knee wall" is 5-foot and 3-foot high in structures C43-S-7 and C43-S-9, respectively. In order for the manatees to reach the perimeter canal through these structures, they would need to overcome the 3 or 5-foot vertical walls.

Structures C43-S-14 and C43-S-15:

These structures take water from the Header Canal and Roberts Canal, respectively, into the perimeter canal for routing around the project (Plan Sheets 115 and 118). Since manatees are not known to occur in the Header or Roberts Canals, these structures should not be a concern.

The management of the reservoir will include regulated water releases into the Caloosahatchee River and ultimately, to the Caloosahatchee Estuary. The estuarine environment is sensitive to freshwater releases and disruptions of the volume, distribution and temporal patterns of freshwater discharge. In addition, increased nutrient levels, particularly nitrogen and phosphorus, reduce light penetration and restrict growth of submerged aquatic vegetation (SAV) such as seagrass (Barnes, 2003). Beneficial effects to the estuary water quality from the project are anticipated via salinity regime improvements; nutrient level improvements are possible, but not known. Freshwater, estuarine, marine, and coastal species that utilize the Caloosahatchee Estuary are therefore likely to experience improved habitats. One example of an anticipated estuary improvement is the re-establishment of a Valued Ecosystem Component (VEC) species, tape grass (*Vallisneria americana*). This species has been experiencing die-offs with the increased salinity and nutrient levels in the Caloosahatchee Estuary. Tape grass beds are utilized by a variety of freshwater and estuarine invertebrates and vertebrates including recreational fishes and the Florida manatee.

Protection measures for the manatee will be implemented during any construction in water and will follow the guidelines set forth in the USFWS 2005 Standard Manatee Conditions for In-Water Work. Conditions include education of construction personnel, posting of temporary notification signs, operation of vessels at "idle speed/no wake", use of siltation or turbidity barriers, and maintenance of a 50-foot barrier between construction activity and manatees. Secondly, project culverts will be designed in compliance with the Manatee Protocols for Existing and New Culverts Located in Manatee-Accessible CERP Projects. New culverts less than 36 inches in diameter will require grating to preclude manatee passage, and culverts are not advised to exceed 200 feet in diameter. Manatee guidelines are provided in Appendix H.

Based on the project design to preclude manatees from the reservoir, potential water improvements to the Caloosahatchee River and Estuary, and compliance with the standard manatee protection guidelines, the project may affect, but is not likely to adversely affect the manatee.

3.1.4.2 Florida Panther

The study area is located within the designated Florida panther USFWS CA per the USFWS SLOPES (USFWS, 2000) and as depicted in the USFWS' Draft CERP Landscape Level Project Planning/Siting Map for Panther Consultation dated February 18, 2004 (included in attachments; also see Figure D-7 of Appendix D). The CA boundary roughly extends from I-75 in Lee County east to US 27 in Palm Beach County, north to the southern boundaries of DeSoto and Highlands Counties, and south to the mangrove edge of the Everglades in Monroe and Dade Counties.

The Florida panther is listed by both the USFWS and the FWC as endangered. This species inhabits a variety of forested land cover types, including pine flatwoods, cabbage palm and live oak hammocks, and cypress wetlands. Although not preferred habitat types, the Florida panther will also utilize freshwater marshes and willow swamps as well as agricultural and disturbed lands.

The current verifiable Florida panther population, not including kittens, is estimated at 87 individuals in southern Florida (Land et al. 2003). In terms of population size and occupied range, the Florida panther population is at least stable and at best expanding as evidenced by natality rates exceeding mortality rates and by recent dispersals north of the Caloosahatchee River (Land et. al. 2000). From 1999 to 2000, the number of births in the radio-collared population has exceeded the number of deaths by a factor of three, and the primary cause of Florida panther mortality from 1979 to 2003 was intra-specific aggression (Land et al. 2003). There has been a misconception that vehicular trauma causes most Florida panther mortalities, but this is the result of sampling bias because un-collared panther mortalities are only found if caused by humans (Land et al. 2000).

Male and female panther home range size is inversely related to habitat quality; the greater the extent of agricultural land and wetland habitats the larger the home range, and the greater the extent of mixed hardwood forests and dry pine forests the smaller the home range. High-quality habitat produces abundant prey and promotes female panther reproductive success (Maehr 1992b, Maehr et al. 1989).

The following sections provide information on habitat utilization and impacts related to the C-43 project. Additional information is provided in graphical and tabular format in Appendix D (Florida Panther Cumulative Impact Analysis package).

Florida Panther Habitat Use in the Project Vicinity

The most recent available FWC telemetry data of radio collared Florida panthers current through 2006 depict 4 Florida panthers and 1 Texas cougar (*Felis concolor*) within a five-mile radius of the project area (refer to Figure 6 of this Biological Assessment and Figure D-8 and Table D-3 of Appendix D). These were Florida panther numbers 28, 65, and 74, 137, and Texas cougar TX101.

Telemetry data for these animals had been recorded over a period of 16 years with the oldest record from Florida panther No. 28 on May 8, 1989 and the most recent from Florida panther number 137 on March 7, 2005. The following is a brief history of each of the above listed panthers:

Florida panther number 28 was a juvenile male that was struck and injured by a vehicle on Daniels Road near the Southwest Florida International Airport on November 29, 1988. The animal was rehabilitated, instrumented with a radio-collar, and released in the Corkscrew Swamp Sanctuary on March 15, 1989 (Figure D-12 of Appendix D). He then moved north to the Caloosahatchee River, east along the river, and then southeast in a counterclockwise direction around the project area where he established a home range in the primary zone. Panther number 28 was later killed in a territorial dispute with another adult male on approximately September 24, 1992.

Florida panther number 65 is a juvenile male offspring of Texas cougar number 101. A large amount of telemetry data points exist for this individual. In 1999, Florida panther number 65 traveled north from the Big Cypress Seminole Indian Reservation, through the primary zone to the southeast of the project area to the Caloosahatchee River. It is unclear from telemetry data if the panther traveled through or around the project area to reach the river; telemetry points only exist at the edges of the project area. After spending approximately one month moving east and west along the south side of the Caloosahatchee River, he returned to the primary zone and dispersal zone to the southeast of the project area and moved northward across the Caloosahatchee River. The individual moved northward along US 27 in the area of Fisheating Creek, Palmdale, and beyond. The panther later traveled southward through the dispersal zone to the Big Cypress Seminole Indian Reservation where he established a territory.

Florida panther number 74 was a juvenile male that dispersed from the Big Cypress Seminole Indian Reservation. A good history of tracking data exists for this panther before its death in 1999. The following is a summary of Florida panther number 74's dispersal pattern as described in Land et al. (1999):

> "Male panther number 74, radio collared on 12 November 1998, began his dispersal event from the Big Cypress Seminole Indian Reservation in early February 1999. This young male moved northwest from the Big Cypress Seminole Indian Reservation and crossed the L-28 interceptor and feeder canals. He then moved north of CR 846 and traveled through Okaloacoochee Slough (Figure D-12 of Appendix D). In late February, he was south of SR 80 approximately 3 miles east of Goodno. During March, number 74 made multiple trips across SR 29 traveling between areas north of Okaloacoochee Slough to the Hickey Creek area southwest of Alva in Lee County. On the weekend of 8-9 May 1999, number 74 became the second radiocollared panther documented crossing the Caloosahatchee River near Goodno on 7 May 1999. On 10 May 1999, number 74 was found 11 miles north along Fisheating Creek west of Palmdale."

During this panther's travels, he moved through the primary zone to the southeast of the project area to the Caloosahatchee River. Similar to Florida panther #65, it is unclear from telemetry data if this panther traveled through or around the project area to reach the river; telemetry points only exist at the edges of the project area. He did not cross the Caloosahatchee River at this location. He instead backtracked southeast to the primary zone and utilized the dispersal zone to cross the river. Florida panther number 74 then died from vehicular trauma on US 27 north of Palmdale on September 8, 1999.

Florida panther number 137 has established a home range within the Okaloacoochee Slough State Forest and WMA, and the adjoining Spirit of the Wild WMA (Figure D-12 of Appendix D). This area is located southeast of the C-43 project area and is in Florida panther primary zone habitat. Telemetry data for this individual are recent, from 2005 to June 2006.

Texas cougar number 101 utilized the Big Cypress area and was documented as dead in March of 2000 from unknown causes (Land et al., 2000). Earlier 1995 telemetry data for this panther shows that he utilized habitat within the secondary, primary and dispersal zones to the east of the project area and south of the Caloosahatchee River.

In addition to the above described telemetry data near the project, Figure D-10 and Table D-4 of Appendix D present mortality and injury data for panthers within 25 miles of the C-43 project. Home ranges of panthers near the project area are depicted in Figure D-11 and described in Table D-5 of Appendix D. Note that home ranges are determined by statistical methods using telemetry data, but are not a direct reflection of telemetry data. Therefore, not all panthers with telemetry points near the C-43 project

are displayed as having a home range that includes the project site. For example, if a panther was noted to travel near the project site but did not have multiple data points in the vicinity, the home range for that individual would likely not include the project area. However, if a panther was not noted to occur very close to the project, but was observed to strongly utilize a region adjacent to the project, the home range for that individual would likely include the project area based on the potential for that animal to utilize habitats within a significant distance of its established home range.

Florida Panther Habitat Use at a Landscape Level

Examination of the project area at a landscape level depicts it at the northern periphery of the geographic range of the panther's breeding population in south Florida, as well as the northern limit of the majority of Florida panther Multi-Species/Ecosystem Recovery Implementation Team (MERIT) zones and telemetry data points (Figure 7 of this Biological Assessment and Figure D-9 and Table D-2 of Appendix D). A large area to the southeast of the project that falls within Florida panther primary and secondary habitat zones and within several preserve areas (Okaloacoochee Slough and Save Our Everglades CARL Project Macrosites, Big Cypress Indian Reservation) provides good habitat support for panthers (Figure D-12 and Table D-6 of Appendix D). Adjacent on the north side of this large expanse, and eastward of the project, lays a panther dispersal zone (Caloosahatchee Ecoscape CARL Project Macrosite). Telemetry data suggest that this zone may provide the most appropriate location for panthers to cross the Caloosahatchee River. Panthers utilizing the dispersal zone to cross the Caloosahatchee River include numbers 65 and 74, as previously detailed; and likely panther number 62, although telemetry points do not positively confirm this (Figure 6).

The project area does not appear to be in a high traffic zone for the panther. No panther-preferred habitat exists on-site. Radio telemetry data collected in 1998-1999 from collared Florida panthers indicate their occurrence near and on the edges of the project area. Panthers have not been documented directly in the project site, nor have they been documented with much frequency in the secondary habitat to the south. The project area therefore does not appear to play a role in panther movement along the south side of or across the Caloosahatchee River. It is unknown if panther utilization of the project area is limited simply because it lies outside the species desired travel route or because the project area is undesirable to the panther in terms of habitat (citrus grove) or accessibility (large canals surround the area).

Proposed Florida Panther Habitat Impacts

The USFWS has developed two plans, with maps, that identify important panther habitat areas in south Florida. The first is the Florida Panther Habitat Preservation Plan (FPHPP) (Logan et al., 1993), and the second is the Multi-Species Recovery Plan for South Florida (USFWS, 1999). The Multi-Species Recovery Plan was updated on September 6, 2001 by the Florida panther subteam of the MERIT. The FPHPP showed no Priority 1 or Priority 2 type habitats within the project area. Priority 1 type habitat is identified approximately 4.8 miles southeast of the project footprint. The more recent MERIT subteam map, however, identifies 1.4 percent (144.2 acres) of the C-43 project site as occurring within Florida panther primary habitat zone, 51.1 percent (5,290.6 acres) in secondary habitat zone, and 47.5 percent (4,925.2 acres) in "other" habitat zone (Figure 6). Of these impacts, 54 acres in the secondary zone and 213 acres in the "other" zone are part of the C-43 test cell project. Impacts associated with the test cell project totaled 388 PHUs (971 PHUs using the base multiplier of 2.5) as calculated by the USFWS and presented in their November 30, 2005 Biological Opinion for the C-43 Test Cell Project.

As one of the SFWMD CERP Projects on the Band 1 list of the Master Implementation Sequencing Plan (MISP), C-43 WSR impacts to the Florida panther were estimated by the USFWS as 21,825 PHUs, as referenced in the November 30, 2005 Test Cell Biological Opinion. Since this estimate, the project footprint has been slightly modified and land cover types and exotic species coverage have been further refined. Table 4 provides anticipated PHU impacts for the C-43 project. Using the panther habitat unit analysis example in the USACE July 28, 2006 Picayune Strand Road Removal concurrence letter, as well as the complete table of habitat suitability values provided in the USFWS November 30, 2005 Test Cell Biological Opinion, panther impacts are currently estimated at 20,719 PHUs. Like the USFWS 2005 estimate of panther habitat impacts, a base multiplier has not been applied to this estimate of 20,719 PHUs.

Prey Base

The ecological benefits currently provided by the proposed project may be related to availability of prey species, rather than habitat. Feral hog (*Sus scrofa*), white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), nine-banded armadillo (*Dasypus novemcinctus*), and cottontail rabbit (*Sylvilagus floridanus*) are all common species in citrus groves and serve as a food source for the panther. In a study of panther diet, deer and hogs accounted for 85.7 percent of consumed biomass of panthers north of I-

75, with hogs dominating the diet in terms of estimated biomass and numbers (Maehr et al. 1990a). Deer and hog densities often exceed 1 animal per 20 hectares north of I-75. South of I-75, deer and hog densities rarely exceed 1 per 40 hectares. Panthers struggle when only deer are present and their density is below 1 per 40 hectares. As a result, panther density, average body weight, and reproduction success south of I-75 is lower than north of the interstate.

Interestingly, no recreational infrastructure currently exists in the project area. Recreational hunting is not allowed, which is perhaps unusual for a Florida citrus grove. Many groves throughout the state experience significant fruit and tree loss from deer and hogs and therefore encourage recreational hunting. It is therefore reasonable to conclude that if deer and hogs are not a significant problem on-site, populations of these species are relatively small as compared to other groves. However, field surveys in the C-43 project area have noted increasing numbers of observations of hogs from 2004 to 2006.

Field surveys for Florida panther prey items in the C-43 WSR project site as per SFWMD direction and USFWS requirements was conducted September-October 2006. The purpose of these surveys was to estimate the population size of white-tailed deer and feral hog in the project area, as these two species are primary prey items of the Florida panther. The following paragraphs summarize the survey findings and the complete report is provided in Appendix I.

Results from track counts indicated that the C-43 WSR site supports an early fall population of 3.9 deer or 9.6 deer depending on the statistical formula utilized. This corresponds to a density of 0.24 deer/mi^2 and 0.59 deer/mi^2, respectively. Similarly, the site supports an early fall population of 168.4 hog or 194.3 hog depending on the statistical formula utilized. This corresponds to a density of 10.4 hog//mi^2 and 12.0 hog//mi^2, respectively.

The estimates for a white-tailed deer population may seem low given the size of the C-43 WSR project, but considering the time of year of the survey and lack of preferred food sources in the grove, few sightings of deer by project biologists over the past two years of working on the site, and anecdotal evidence from the grove manager, it seems reasonable. In addition, a review of the scientific literature on white-tailed deer population densities in Florida identified many estimates, some of which approximated the population estimate on the C-43 WSR project.

It is important to keep in mind that our population density estimates for the white-tailed deer in the C-43 project are based on several assumptions. The first assumption is that deer do not utilize habitat equally throughout the year and seasonality affects their movement. The second assumption is that tracks are readily interpreted on transects, made possible by rain events prior to survey mornings that smooth the sand. Similarly, there are assumptions for the feral hog population density estimates that include hog daily average range, seasonality of population density, and rain prior to survey events.

The post-development condition will likely be attractive to aquatic and aquatic-dependent species, including invertebrates, fish, amphibians, and birds but may be less attractive to mammalian species, particularly during times of highwater storage. As a result, the typical prey base for the Florida panther, namely hogs and deer, may be less likely to utilize the project area in its post-construction condition (reservoir) than in its current condition (grove). These species typically prefer a mix of forested areas such as pine flatwoods and open, freshwater wetlands. There will be times in which water levels in the project area would be on the decline, or soils will only be saturated; during these times, hogs and deer would likely forage. Panthers and other predators, in turn, would be successful in locating prey. However, during times of high water storage, hogs and deer as well as other mammals may utilize other habitats for foraging, thereby decreasing the prey base available to panthers in the reservoir. It is difficult to assess how much, if any, prey base decline would result from the post-development condition, given the unknown habitat utilization of the post-condition. It is, however, anticipated that the prey base will fluctuate on a yearly basis with the rainy and dry seasons as well as on a larger time scale with wet and dry years.

Panther Accessibility

In the post-development condition, the project area may be more traversable by the panther. The high anthropogenic activity associated with grove operations will be eliminated including human presence, vehicle traffic and insecticide spraying. The absence of these disturbances to the Florida panther will provide a quieter and more attractive landscape for them to travel. Panthers would be able to cross the reservoir cells via embankments, dry wetland edges, and maintenance roads. Terrestrial access across the C-43 perimeter canal will be possible at 3 canal structure locations including S-10 and S-11 at the north and S-3 in the southeast corner.

The amount of construction traffic on adjacent roadways is not expected to create a dramatic increase from current volumes. A primary reason for this is the fact that fill-dirt

will not be hauled to the site. Onsite materials will be used to create the embankments for the reservoir cells and perimeter canal. Following construction, the reservoir pumps will be operated remotely. Occasional, scheduled maintenance work will be required but will not have any noticeable impact on traffic.

During construction, temporal effects to panther movement and foraging are possible. Approximately 200-300 construction personnel will be employed for approximately 3.5 years. Construction noise, ground vibrations, and truck and equipment presence may alter travel patterns of the species, particularly in area located to the southeast of the site, where panther habitat and activity is more prevalent. The project construction will have greater potential for disturbing wildlife than existing grove operations activity. However, there will be no long-term effects as construction disturbance will terminate with the completion of the reservoir and maintenance activities will be minimal.

Currently, no designated recreational areas or infrastructure are present within the project area as it is solely used as citrus grove operations. While the C-43 WSR is a civil works project, there is potential for incorporating recreational features into the project. Potential recreational opportunities include wildlife viewing, birding, hiking, biking, equestrian activities, fishing, and picnicking. Canoeing and other non-motorized boating is also under consideration. Recreational hunting of deer and hogs is not planned for the project area. Because grove operations activities have been in place for many years, none of these potential recreational features are anticipated to create a change in the anthropogenic effects of the project area.

Development Within 25 Miles of the Project

Pending development near the project is centered in Lee County, where Planned Unit Developments (PUD), Developments of Regional Impact (DRI), and Environmental Resource Permits (ERP) are most prevalent between SR 82 and SR 80, east of I-75. This region falls within the Florida panther CA. Development in Hendry, Glades, Charlotte, and northern Collier Counties is limited. Figure D-13 through D-18 and Tables D-7 through D-10 in Appendix D present development information. Future road projects are limited to southeastern Lee and northwestern Collier Counties (Figure D-19 of Appendix D).

Because of the nature of this project, additional land use changes are not anticipated. However, residential and commercial development may continue to spread eastward from Lee County into Hendry County. At this time, the total acreage of upland parcels

within a 25-mile radius of the project area is 866,093.80 acres (Figure D-13 of Appendix D). This quantity of land could be developed without USACE permit involvement.

Florida Panther Effect Determination

According to the Draft Florida Panther Effect Determination Key, dated July 1, 2003, the USACE initially determined that the C-43 WSR project may affect the Florida panther. With this determination, the USFWS was requested to initiate Section 7 Consultation. Following this consultation, the project may adversely affect the Florida panther.

The USFWS determined that SFWMD offsite acquisition and restoration of approximately 101,066 acres of habitat in primary and "other" zones for Band 1/Acceler8 projects will compensate for the loss of panther habitat in the C-43 project. The SFWMD land is located in the core area of panther-occupied habitat, the majority is adjacent to other larger tracts of natural and preserve lands, and will assist in the long-term protection of the species.

Due to the appropriate offsite land acquisition, paucity of suitable land cover types in the project area, small acreage of primary habitat zone in the project area, conversion of citrus to reservoir (not development, per se) and documented historical use by the panther on the project edges only, the project will not likely jeopardize the survival and recovery of the Florida panther. However, the USACE has made the determination that this project may adversely affect the Florida panther under Section 7 of the Endangered Species Act.

Additional panther-related information is located in Appendix D.

3.1.5 Plants

3.1.5.1 Florida Panther

The Okeechobee gourd is a federal endangered species, as listed by the Federal Register, July 12, 1993 Clarification, Federal Register, April 1, 1994. It is also a state endangered species, as listed by the Florida Department of Agriculture and Consumer Services' Chapter 5B-40, Florida Administrative Code. This species is a fibrous-rooted, high-climbing vine with tendrils. Historically, the Okeechobee gourd was associated with Tory muck soils and found in pond apple forests surrounding Lake Okeechobee. Presently, the Okeechobee gourd can be found in Palm Beach and Glades Counties inside the levee that encircles Lake Okeechobee, rarely along canal banks south of the lake, and on the St. John's River in Volusia County. The gourd is now linked with

natural or man-made disturbance and has been associated with alligator nests and thickets of elderberry and willow. No Okeechobee gourds or appropriate habitat were observed during field reconnaissance. Given the above information, the project will have no effect on the Okeechobee gourd.

3.1.5.2 Beautiful Pawpaw

The beautiful pawpaw is a federal endangered species, as listed by the Federal Register, September 26, 1986 Clarification, Federal Register, May 18, 1999. It is also a state endangered species, as listed by the Florida Department of Agriculture and Consumer Services' Chapter 5B-40, Florida Administrative Code. The species is a low-growing, diminutive shrub that occurs in the vicinity of Charlotte Harbor and the Caloosahatchee River from Punta Gorda to Fort Myers in southwestern Florida. The beautiful pawpaw is native to longleaf pine (*Pinus palustris*) and slash pine (*P. elliotii*) flatwoods consisting of grasses and low shrub species. No appropriate habitat or beautiful pawpaw plants were observed during field reviews. Given the above information, the project will have no effect on the beautiful pawpaw.

3.2 PROTECTED SPECIES WITH STATE DESIGNATION ONLY

The following is a summary of several state listed species with a potential to occur onsite. While the federal action agency (USACE) does not comment on these species, they were considered during field reviews, and, as in the case of the gopher tortoise, were identified as requiring particular surveys by the FWC. These species include the gopher tortoise (*Gopherus polyphemus*), gopher frog (Rana capito), Florida burrowing owl (*Speotyto cunicularia floridana*), sandhill crane (*Grus canadensis pratensis*), southeastern American kestrel (*Falco sparverius paulus*), peregrine falcon (*Falco perigrinus*), least tern, other wading birds such as the limpkin (*Aramus guarana*), white ibis (*Eudocimus albus*), little blue heron, snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), and the roseate spoonbill (*Platalea ajaja*), Florida black bear (*Ursus americanus floridanus*), Big Cypress fox squirrel (*Sciurus niger avicennia*), Sherman's fox squirrel (*Sciurus niger shermani*), Florida mastiff bat (*Eumops glaucinus floridanus*), and state-listed plants.

3.2.1 Reptiles and Amphibians

3.2.1.1 Gopher Tortoise

The gopher tortoise is not listed by the USFWS, but is listed by the FWC as a species of special concern. Declining numbers of gopher tortoises are due to a number of

variables including loss of habitat, low reproductive rates, predation, and disease. These tortoises are known to utilize a variety of habitats including pine flatwoods, but prefer well-drained soils that enable burrowing and support a high diversity of low-growing herbs. The gopher tortoise is known to be relatively rare in Hendy County as compared to other parts of Florida. Auffenberg and Franz (1982) described Hendry County as one of two counties in Florida lacking the species, but Diemer (1987) documented a few gopher tortoise burrows in northwest Hendry County. While some well-drained soils are present within the project boundary, these soils are present in highly maintained citrus grove. No natural habitats preferred by the gopher tortoise are present in the project footprint. Pre-construction surveys were conducted within the test cell project footprint as per FWC request in June 2005 for burrows and individuals; species presence was not detected. Similar surveys will be conducted within the C-43 project prior to construction. Given the above information, the project is not anticipated to have adverse effects on the gopher tortoise.

3.2.1.2 Gopher Frog

The Florida gopher frog is commensal with the gopher tortoise and is listed by the FWC as a species of special concern. Due to the absence of suitable habitat and gopher tortoise burrows within the project footprint, the project is not anticipated to have adverse effects on the Florida gopher frog.

3.2.2 Birds

3.2.2.1 Florida Burrowing Owl

The Florida burrowing owl is a small owl listed as a species of special concern by the FWC. The only areas within the project boundary that consisted of open, treeless, and sandy habitat were edges of grove maintenance roads and small parcels of open space at the end of some citrus rows used for grove maintenance operations. These areas were considered to be extremely marginal habitat for the species; they were examined for the presence of burrowing owls and no burrows or individuals were detected. Given the above information, the project is not anticipated to have adverse effects on the Florida burrowing owl.

3.2.2.2 Florida Sandhill Crane

The Florida sandhill crane is a large wading bird listed as threatened by the FWC, but remains unlisted by USFWS. Sandhill cranes forage in open habitats, e.g., improved

pastures and herbaceous marshes. The species typically constructs nests on a platform of vegetation surrounded by water within an herbaceous wetland. Extremely marginal nesting and foraging habitat is present within the project. No documented Florida sandhill crane nests exist within the project study area and no individuals were observed in flight over or foraging within the project area. However, large-scale construction projects in Florida have been known to have temporal effects on sandhill cranes by attracting them to nest in work areas of the site. If sandhill cranes stay and build nests in standing water areas of construction sites, the following protection guidelines will be employed to avoid nest disturbance:

- Nest protection should include measures to prevent disturbance of incubating adults by providing spatial and/or visual separation between nests and construction activities. FWC biologists have recommended a 400-foot buffer around nests. If construction activities are required closer than 400 feet from a nest, monitoring should be provided to ensure the activity does not result in nest abandonment or disturbance of incubating adults;
- During incubation, adults may be expected to be continuously present at the nest. If adults are not present at an active nest for two consecutive 15-minute periods or are exhibiting agitated behavior or vocalization, surrounding activities should be evaluated to identify and correct the cause of incubation disruption;
- Artificial alteration of water levels in wetlands supporting active nests may contribute to nest failure and must be avoided. Dewatering of a nest wetland may increase the risk of the nest to predation. Adding water to a nest wetland may drown eggs. Any activity that would alter a nest wetland's hydrology should not be undertaken while an active nest is present and should be delayed as long after hatching as possible if the wetland is used for night roosting;
- Silt fences may be used to create barriers to prevent adults and chicks from entering work areas, haul roads, or drainage ditches. Where adults and chicks are present within work areas, openings in silt fences will allow dispersal to alternative foraging or roosting habitats; and
- Posting of sandhill crane warning signs within work areas and along haul routes near foraging or nesting habitats and education of construction staff will help to minimize risk to sandhill cranes.

Given the above information, and since there is substantial additional foraging and nesting areas in close proximity to the proposed impacts, and the wetland impacts will

be off-set appropriately, the project is not anticipated to have adverse effects on the Florida sandhill crane.

3.2.2.3 Southeastern American Kestrel

The southeastern American kestrel is a small raptor currently listed as threatened by the FWC. Sub-optimal foraging habitat (citrus grove) for the southeastern American kestrel is present onsite. Field surveys did confirm the species in the project footprint. Although the possibility of species presence cannot be completely eliminated based on the existence of foraging habitat, the project is not anticipated to have adverse effects on the southeastern American kestrel.

3.2.2.4 Peregrine Falcon

The peregrine falcon is listed as endangered by the FWC. The species does not nest in Florida, but does pass through the state on its way from breeding habitats in the north to wintering habitats in Central and South America. Some peregrine falcons stay in Florida for the winter, including the coastal panhandle region and the Florida Keys (Boot and Pigeon Keys). The peregrine falcon was not observed during field surveys and no data records exist for the species near the project site. The project is not anticipated to have adverse effects on the peregrine falcon.

3.2.2.5 Least Tern

The least tern is listed as threatened by the FWC. No least terns were observed during field surveys and no data records exist for the species near the project. Because terns select open, sandy areas for nesting, construction sites have been known to cause temporal effects to the species by attracting terns to nest. Trained dogs have been successfully utilized in construction projects to prohibit birds from nesting in the open areas. This tactic can be further investigated if necessary. The project is not anticipated to have adverse effects on the least tern.

3.2.2.6 Other Wading Birds

Other wading birds such as the limpkin, white ibis, little blue heron, snowy egret (*Egretta thula*), tricolored heron, and the roseate spoonbill (*Platalea ajaja*) are not listed as protected by the USFWS, but are listed by the FWC as species of special concern. Avian field surveys noted that wading birds were detected within the C-43 project area more often during times of ditch maintenance (mechanical clean-out of water lettuce and water hyacinth), rainfall (structural point source discharges delivering numerous

prey items trapped in strong currents), or the operation of pumps (same results as rainfall). Concentrations of wading birds were therefore observed in several locations near desirable forage areas as described above. The nearest active wading bird rookery is located approximately 1 mile south of the project (#619317). Observations at this rookery were last recorded in 1989 and included both listed species (little blue heron) and unlisted species. Potential impacts to these species are anticipated to be temporal only. Due to the nature of this project and these species' high mobility, the project is not anticipated to result in any adverse effects to these species. Since there is substantial additional foraging and nesting areas in close proximity to the proposed impacts, and the wetland impacts will be appropriately addressed, the project is not anticipated to have adverse effects on wading bird species of special concern.

3.2.3 Mammals

3.2.3.1 Florida black bear

The Florida black bear is designated as a threatened species by the FWC, but is not federally listed. Information on the occurrence of Florida black bears in the project area between 1976 and 2002 (FWC telemetry data) indicates that activity occurs north of the project, north of the Caloosahatchee River. No black bear occurrence data exists within the project footprint or in its general vicinity south of the Caloosahatchee River. Field surveys conducted during this study did not detect signs of Florida black bear occurrence in the project area. However, marginal black bear habitat is present on-site as they have been known to utilize citrus groves to forage on the fruits. The project is not anticipated to have adverse effects on the Florida back bear.

3.2.3.2 Big Cypress Fox Squirrel and Sherman's Fox Squirrel

The Big Cypress fox squirrel is listed by the FWC as threatened. It is not currently listed by the USFWS. The Sherman's fox squirrel is distinctly larger than the Big Cypress fox squirrel, and is listed as a species of special concern by the FWC. It is not currently listed by the USFWS. No suitable habitat for either species is present in the project area and field surveys did not detect the species. Based on the above information, the project is not anticipated to have adverse effects on the Big Cypress or Sherman's fox squirrels.

3.2.3.3 Sherman's Short-tailed Shrew

The Sherman's short-tailed shrew is listed by the FWC as a species of special concern. Little is known about the species but it has been identified in southwest Florida. No Sherman's short-tailed shrews were observed during field surveys and no data records exist for the species near the project site. While species presence onsite is possible, it is very unlikely given the land use practices such as pesticide application, heavy equipment usage, etc. Based on the above information, the project is not anticipated to have adverse effects on the Sherman's short-tailed shrew.

3.2.3.4 Florida Mastiff Bat

The Florida mastiff bat is listed by the FWC as endangered. The species occurs in the southern quarter of the state and observations are very limited. A tree/building nester, it typically roosts and nests at high elevations in trees and tall buildings. No individuals or suitable habitat were identified during field surveys, and no data records exist for the species near the project site. Based on the above information, the project is not anticipated to have adverse effects on the Florida mastiff bat.

3.2.4 Plants

In addition to faunal surveys, the proposed project area was surveyed for protected flora. Small populations of wild pine (*Tillandsia fasciculata*), a state endangered species, and reflexed wild-pine (*T. balbisiana*), a state threatened species, as listed by the Florida Department of Agriculture and Consumer Services' Chapter 5B-40, Florida Administrative Code, were observed within a few of the forested wetlands. The listing of these species is due to the introduction of the Mexican bromeliad weevil (*Metamasius callizona*) also known as the 'evil weevil' that eats and destroys large *Tillandsia* species. A single individual of giant orchid (*Pteroglossaspis ecristata*), a state threatened species may have been observed (Wetland 281214). However, the plant was not in flower, which is necessary for accurate species identification since wild coco (*Eulophia alta*), an unprotected terrestrial orchid, is remarkably similar vegetatively. Four commercially exploited species were observed within the proposed project area: Florida butterfly orchid (*Encyclia tampensis*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*O. regalis* var. *spectabilis*), and netted chain fern (*Woodwardia areolata*). The Florida butterfly orchid was limited to a single specimen (Wetland 280847), while the netted chain fern observation was limited to a population within one wetland (Wetland 280848). The cinnamon fern and the royal fern were more common in the project area, as they are throughout the state.

Due to the limited acreage of natural habitats, and lack of rare or endangered habitats, the number of individuals of threatened and endangered species is low and adverse affects to the listed plant species are not anticipated to result from the proposed project.

- A C-43 listed species meeting was held on February 6, 2006 with USFWS and FWC to discuss updates from the March 22, 2005 meeting and survey methodology for specific species.

Appendix A contains copies of pertinent letters and meeting minutes.

2.2 SURVEY METHODOLOGY

Project scientists conducted field reviews on June 30, July 1, 21, 22, 23, and August 9, 10, 11, 2004; June 27, 2005; February 27, 28, March 1, 14, 15, 16, 17, 28, 29, 30, and May 17, 18, 2006. Using meandering pedestrian and vehicular (including all-terrain vehicle (ATV)) transects as well as stationary observation points, all appropriate habitat in and, in some cases, adjacent to the C-43 study area, was visually scanned for evidence of listed species, their habitats and general wildlife. Various upland and wetland habitats within the project study area were also classified during this period using FLUCCS and NWI.

Wildlife surveys were generally conducted in the morning and late afternoon, while surveys for avifauna were conducted in the early morning to assess roosting areas and peak foraging times. Observation points were depicted on project aerial photography and all observations of wildlife were recorded. These observations included direct sighting of species or signs of their presence including tracks, burrows, dens, scat, nests, or calls (typically with avifauna).

The identification or potential presence for species of special concern, threatened species, or endangered species was given special attention. This included efforts to survey all appropriate habitat for the species listed in Tables 1 and 2. Following the general field survey efforts, a complete list of fauna observed or known to occur within the C-43 project study area was compiled (Appendix B).

4.0 IMPACT ASSESSMENT

4.1 ANALYSIS OF POTENTIAL PROTECTED SPECIES IMPACTS

4.1.1 Direct Effects Within the Project Footprint

Table 3 and Figure 2 detail the current land uses that will be impacted by the project.

Project impacts (90.04 percent; 9088.4 acres) will be to the existing citrus grove (FLUCCS 2210). Water (FLUCCS 500 series) comprises 8.87 percent (895.58 acres) of the site and includes extensive agricultural canals/ditches, classified as Streams and Waterways (FLUCCS 5100), and excavated ponds, classified as Reservoirs less than 10 acres in size (FLUCCS 5340). Wetland (FLUCCS 600 series) comprises 1.09 percent (109.67 acres) of the site and includes Mixed Wetland Hardwoods (FLUCCS 6170), Willow and Elderberry (FLUCCS 6180), Exotic Wetland Hardwoods (FLUCCS 6190), Cypress (FLUCCS 6210), Wetland Shrub (FLUCCS 6310), and Freshwater Marsh (FLUCCS 6410). Current land use types, totaling 10,093.66 acres, will be converted to aquatic habitat, wetlands, cell berms, maintenance access roads, and structures. The 267-acre test cell footprint is not included in this acreage summary as it was previously permitted.

Citrus groves provide poor habitat for wildlife in general. This principle may be more readily applied to protected species, which frequently demand stringent habitat criteria that are not met by land uses such as citrus grove. Additionally, the proposed wetland impacts are mostly to man-made surface waters (excavated ditches and ponds), all of which have been moderately to highly disturbed by citrus grove operations (hydrological alteration, infestation of nuisance/exotic species, nutrient loading, etc.).

The post-development condition will likely be attractive to aquatic and aquatic-dependent species, including invertebrates, fish, amphibians, and birds. Impacts to the large majority of listed species are expected to be temporal only during the project construction. These temporal impacts are expected to be offset by the long-term benefits to the listed wildlife species based upon multiple observations of other similar projects such as the SFWMD STAs.

The adjacent wetland and upland habitats should provide foraging, roosting, and/or nesting for many of the species that would be temporarily displaced by the proposed project. Further, the reduced anthropogenic activity within the project and the adjacent

areas should allow greater undisturbed wildlife utilization during the post-development condition.

No listed species nests or rookeries were observed or are known to occur in the C-43 project area. Two red-shouldered hawk nests were identified within the project footprint. While not a protected species per se, active nests are protected during the nesting season by the MBTA.

Listed wading birds were observed utilizing the canals and ditches within the citrus grove and the American alligator was observed in a few ditch/canal locations. A few wood storks were observed loafing in an open field but the closest rookery is approximately 17 miles away. One confirmed Audubon's crested caracara nest was identified to the north of the project along SR 80. A small portion of the project falls within the secondary protection zone of the nest but a reduction of this zone is proposed which would eliminate overlap with the project footprint. A second, possible nest was identified but not confirmed to the southeast of the project.

Review of FWC and FNAI species occurrence records for the project area and adjacent areas revealed the closest active wading bird (little blue heron) rookery approximately 1 mile to the south of the project area, the closest active bald eagle nest approximately 3.4 miles to the east of the project area, and no other listed avian nest sites within at least one mile of the C-43 project area.

4.1.2 Direct Effects Outside the Project Footprint

From a landscape perspective, the project is surrounded by a matrix of land uses including Urban and Built-Up (FLUCCS Series 100), Agricultural (200), Upland Forests (400), and Wetlands (600). Figure 3 depicts land use within a 25-mile buffer of the project. Currently, urban development is focused in coastal areas west of the project, and less so along the Caloosahatchee River. South of the river, where the project is situated, the predominant land uses are agricultural and wetlands. North of the river, the most common land uses include agriculture, wetlands, and upland forests. Because of the nature of the project, no additional land use changes will result.

Direct positive effects from the project may occur in the downstream Caloosahatchee Estuary as previously described in this report. The C-43 WSR will reduce high flows during the wet season by capturing and storing excess water. The water would then be released in a manner that is beneficial to the estuary during the dry season. Reducing the variability of freshwater releases to the estuary will support the restoration of salinity

ranges and habitat in the system. The effects may potentially benefit the Florida manatee, American crocodile, smalltooth sawfish, and sea turtles including the Atlantic loggerhead turtle, Atlantic green turtle, leatherback turtle, Kemp's ridley turtle, and hawksbill turtle.

Protected species including the bald eagle, snail kite, wood stork, Audubon's crested caracara, and Florida panther have large foraging ranges and subsequent large protection zones. As a result, they have a greater potential to be affected by development projects. This Biological Assessment has addressed these species and the potential project effects.

4.1.3 Indirect, Secondary, and Cumulative Impacts

Indirect and secondary impacts are adverse effects that may be reasonably expected to occur in or near the project subsequent to construction that are a result of the project. Cumulative impacts include all past, present, or future development adverse effects that can be reasonably attributed to occur in the project's area of influence.

Due to the limited habitat available with the existing land use types, the indirect, secondary, and cumulative impacts attributed to the project are estimated as negligible for most listed species that can reasonably be expected to utilize the project area.

Project area utilization by the Florida panther in its current condition is very low. Radio telemetry data obtained from FWC indicates that one known panther has been documented adjacent to and on the edge of the C-43 project boundary approximately 6 years ago. Panthers have not been documented within the project footprint. In addition, review of the land use clearly demonstrates that the project site currently provides poor quality habitat.

Small indirect, secondary, and/or cumulative impacts to the Florida panther may occur as a result of the proposed project due to possible reduction in a large mammal prey base. The feral hogs, deer and other mammals that inhabit the citrus grove and the remaining 'natural' areas within the grove serve as a prey source to these large carnivores. However, the project will not preclude these prey items from the reservoir site and the species may continue to utilize the area in the with-project condition.

5.0 CONCLUSIONS

The C-43 West Storage Reservoir project contains approximately 10,360 acres; 267 acres have been previously permitted for the test cell project. The majority of existing land use consists of citrus grove (90.04 percent of the remaining 10,093 acres). Little natural habitat remains on-site and consists only of remnant, isolated shrub and forested wetlands. Wetland and surface water impacts will occur to a total of approximately 895.58 acres of low quality ditches and excavated ponds, and 109.67 acres of wetlands. The existing land use types provide limited wildlife habitat value. Project construction should not adversely affect the floral or faunal species discussed in previous sections. The exception may be the Florida panther, a species that requires large individual territories. Project elements such as berms, sloped cell edges, maintenance roads and canal structures will facilitate panther movement across the reservoir.

6.0 REFERENCES

Auffenberg, W. and R. Franz. 1982. The status and distribution of the gopher tortoise (*Gopherus polyphemus*). Pages 95-126 *in* R. B. Bury, ed. North American tortoises: conservation and ecology. Wildlife Research Report 12. U.S. Fish and Wildlife Service, Washington, D.C.

Bargar, T., R. Frakes, J. Boggs and E. Boughner. 2005. Uptake of Copper by Apple Snails From contaminated Sediments in South Florida. Interim Report. United States Fish and Wildlife Service, Vero Beach, FL.

Barnes, T. 2003. Caloosahatchee Estuary Conceptual Ecological Model. *In:* Draft CERP Monitoring and Assessment Plan. SFWMD.

Diemer, J. E. 1987. The status of the gopher tortoise in Florida. Pages 72-83 *in* R. Odum, K. Riddleberger, and J. Oiser, eds. Proceedings of the third southeastern nongame and endangered wildlife symposium. Georgia Deaprtment of Natural Resources, Game and Fish Division, Atlanta, Georgia.

Fitzpatrick, J.W., G.E. Woolfenden and M.T. Kopeny. 1991. Ecology and development-related habitat requirements of the Florida scrub jay (*Aphelocoma coerulescens coerulescens*). Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program Technical Report No. 8. Tallahassee, FL. 49 pp.

Florida Game and Fresh Water Fish Commission. September 1991. Florida Atlas of Breeding Sites for Herons and their Allies. Non-Game Wildlife Program Technical Report No. 10.

Florida Marine Research Institute. 2002. A Special Study of Manatees in Mullock Creek and the Caloosahatchee River Eastward of the Edison Bridge.

Florida Natural Areas Inventory. Species and Natural Community Summary for Hendry County. Obtained from www.FNAI.org, September 2003.

Humphrey, S. R., (ed.). 1992. Rare and Endangered Biota of Florida. Vol. 1, Mammals. University Presses of Florida. 392 pp.

Gilbert, C. R., (ed.). 1992. Rare and Endangered Biota of Florida. Vol. II, Fishes. University Presses of Florida. 247 pp.

Landers, J.L., and D.W. Speake. 1980. Management needs of sandhill reptiles in southern Georgia. Proceedings of the annual conference of the Southeastern Association of Fish and Wildlife Agencies 34:515-529.

Lawler, H.E. 1977. The status of *Drymarchon corais couperi* (Holbrook), the eastern indigo snake, in the southeastern U.S.A. Herpetological Review 8(3):76-79.

Layne, J.N., and T.M. Steiner. 1996. Eastern indigo snake (*Drymarchon corais couperi*): summary of research conducted on Archbold Biological Station. Report prepared under Order 43910-6-0134 to the U.S. Fish and Wildlife Service, Jackson, Mississippi.

Lellinger, D.B. 1985. A Field Manual of the Ferns and Fern-Allies of the United States and Canada. Smithsonian Institution Press, Washington D.C. 389 pp.

Moler, P.E. 1985. Home range and seasonal activity of the eastern indigo snake, *Drymarchon corais couperi*, in northern Florida. Final performance report, Study E-1-06, III-A-5.

Moler, P.E. 1992. Eastern indigo snake. Pages 181-186 *in* P.E. Moler, ed. Rare and endangered biota of Florida, volume III, Amphibians and Reptiles. University Press of Florida; Gainesville, Florida.

Morrison, J.L. 1996. Distribution and habitat use of Audubon's crested caracara (Caracara plancus audubonii) within the Kissimmee River restoration project area. Final Report to South Florida Water Management District, West Palm Beach, Florida.

Morrison, J.L. 1998. Management guidelines and monitoring protocol for Audubon's crested caracara in Florida, Draft. Prepared for Florida Game and Fresh Water Fish Commission (April 1998).

Morrison, J.L. and S.R. Humphrey. 2001. Conservation value of private lands for crested caracaras in Florida. Conservation Biology 15(3):675-684.

Morrison, J. L. 2001. Recommended management practices and survey protocols for Audubon's crested caracara (*Polyborus plancus audubonii*) in Florida. Technical Report No. 18. Florida Fish and Wildlife Conservation Commission, Tallahasse, FL.

Myers, R. L. and J. J. Ewel (eds.). 1990. Ecosystems of Florida. University of Central Florida Press. 765 pp.

Ogden, J. C. Habitat Management Guidelines for the Wood Stork in the Southeast Region. Southeast Region U.S. Fish and Wildlife Service. pp. 9. January 1990.

Rodgers, J. A., H. W. Kale, and H. T. Smith. 1996. Rare and Endangered Biota of Florida. Vol. V, Birds. University Presses of Florida. 688 pp.

Speake, D.W., J.A. McGlincy, and T.R. Colvin. 1978. Ecology and management of the eastern indigo snake in Georgia: A progress report. Pages 64-73 *in* R.R. Odum and L. Landers, eds. Proceedings of rare and endangered wildlife symposium, Georgia Department of Natural Resources, Game and Fish Division, Technical Bulletin WL 4.

Taylor, W. K. 1992. The Guide to Florida Wildflowers. Taylor Publishing Company. 320 pp.

URS Corporation. 2003. Berry Labelle- Congen Grove Ecological Risk Assessment. Boca Raton, Florida.

U.S. Fish and Wildlife Service. November 30, 2005. Biological Opinion letter for the C-43 West Storage Reservoir Test Cell Project.

U.S. Fish and Wildlife Service. 2005. Manatee Protocols for Existing and New Culverts Located in Manatee-Accessible CERP Projects.

U.S. Fish and Wildlife Service. 2005. Standard Manatee Conditions for In-Water Work.

U.S. Fish and Wildlife Service. 2004. Initial Comprehensive Everglades Restoration Plan Update Planning Aid Report. South Florida Ecological Services Office, Vero Beach, Florida.

U.S. Fish and Wildlife Service, South Florida Ecological Services Office. 2002. Habitat Management Guidelines for Audubon's Crested Caracara in Central and Southern Florida.

U.S. Fish and Wildlife Service. 1999. South Florida Multi-Species Recovery Plan. Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1998. Multi-species recovery plan for the threatened and endangered species of South Florida, Volumes 1 and 2. Technical/Agency draft. Vero Beach (FL): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1995. Florida Manatee Recovery Plan Second Revision. U.S. Fish and Wildlife Service, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1992. Endangered and threatened species of the Southeast United States (The Red Book). Washington: Government Printing Office, USFWS, Ecological Services, Division of Endangered Species, Southeast Region. 1,606 p.

U.S. Fish and Wildlife Service. 1990. The USFWS Habitat Management Guidelines for the Wood Stork in the Southeast Region.

Wunderlin, R. P. 1998. Guide to the Vascular Plants of Florida. University Presses of Florida. 806 pp.

References Specific to the Florida Panther

Beier, P., M.R. Vaughan, M.J. Conroy, H. Quigley. 2003. An analysis of scientific literature related to the Florida panther. Final Report, Project Number NG01-105. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.

Harlow, R. F. 1959. An evaluation of white-tailed deer habitat in Florida. Florida Game and Fresh Water Fish Commission Technical Bulletin 5:1-64. Tallahassee, FL.

Land, E.D., M. Lotz, D. Shindle, and S.K. Taylor. 1999. Florida panther genetic restoration and management. Annual report, Study Number 7508. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.

Land, E.D., M. Lotz, D. Shindle, and S.K. Taylor. 2000. Florida panther genetic restoration and management. Annual report, Study Number 7508. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.

Land, E.D., M. Cunningham, M. Lotz, and D. Shindle. 2003. Florida panther genetic restoration and management. Annual report, 2003. Florida Fish and Wildlife Conservation Commission. Tallahassee, Florida.

Logan, T., A. C. Eller, Jr., R. Morrell, D. Ruffner, and J. Sewell. 1993. Florida Panther Habitat Preservation Plan South Florida Population. U.S. Fish and Wildlife Service. Gainesville, Florida.

Maehr, D.S. 1990a. Florida panther movements, social organization, and habitat utilization. Final Performance Report Study No. 7502. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Maehr, D.S. 1992b. Florida panther distribution and conservation strategy. Final report, study no. 7572. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Maehr, D.S., E.D. Land, and J.C. Roof. 1991. Social ecology of Florida panthers. National Geographic Research and Exploration 7(4): 414-431.

Maehr, D.S., E.D. Land, J.C. Roof, and J.W. McCown. 1989. Early maternal behavior in the Florida panther (*Felis concolor coryi*). American Midland Naturalist 122:34-43.

Maehr, D. S., T. S. Hoctor, L. J. Quinn, and J. S. Smith. 2001. Black Bear Habitat Management Guidelines for Florida. Technical Report No. 17. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

McCown, J.W. 1991. Big Cypress deer/panther relationships: deer herd health and reproduction. Final report, study number 7508. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Shindle, D., et al. 2003. Florida panther genetic restoration and management. Annual Report, Florida Panther Research Project 93112503002. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Simpfendorfer, C. A. 2006. Movement and habitat use of smalltooth sawfish: final report. Mote Marine Laboratory Technical Report 1070.

Steelman, H. G., J. A. Bozzo, and J. L. Schortemeyer. 1999. Big Cypress National Preserve Deer and Hog Annual Report.

Thatcher, C., F.T. van Manen, J.D. Clark. 2003. Habitat assessment to identify potential sites for Florida panther reintroduction in the southeast. Final Report. United States Fish and Wildlife Service. Vero Beach, Florida.

U.S. Army Corps of Engineers. July 28, 2006. Concurrence letter for the Picayune Strand Road Removal project.

U.S. Fish and Wildlife Service. 2000. Technical/Agency Draft Revised Recovery Plan for the Florida panther. U.S. Fish and Wildlife Service Southeast Region. Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1995. Second revision Florida panther recovery Plan, Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1987. Florida panther (*Felis concolor coryi*) recovery plan. Prepared by the Florida panther interagency committee for the U.S. Fish and Wildlife Service, Atlanta, Georgia.

FIGURES

Figure 1 Project Location Map

Figure 2 Existing Land Cover/Use Map

Figure 3 Existing Land Cover/Use within a 25-Mile Radius of the Project

Figure 4 Protected Species Occurrences Within and Around the Project Area

Figure 5 Caracara Occurrences and Protection Zones Within and Around the Project Area

Figure 6 Florida Panther Telemetry Data and MERIT Zones

Figure 7 Florida Panther Telemetry Data and MERIT Zones (25-Mile Project Radius)

Annex A
Fish and Wildlife
Legend
Previously Permitted
Project Boundary
SR 29
Bob Paul Canal
Roberts Canal
Banana Branch
Caloosahatchee River
SR 80
Perimeter Canal
LPDD Canal
Townsend Canal
NE Rim Ditch
13,500
13,500
13,500
Acceler8
South Florida Water Management District
2301 Canter Park West Drive, Suite # 150
West Palm Beach, FL 33401
Tel # (561) 242-5520
FIGURE 1
C-43 WEST STORAGE RESERVOIR
PROJECT LOCATION MAP
Contract # C-C10401P
UPDATED
9/26/06
\\AS_P50\Arcmap_docs\Figure1-project_location_map.mxd
ber 2007

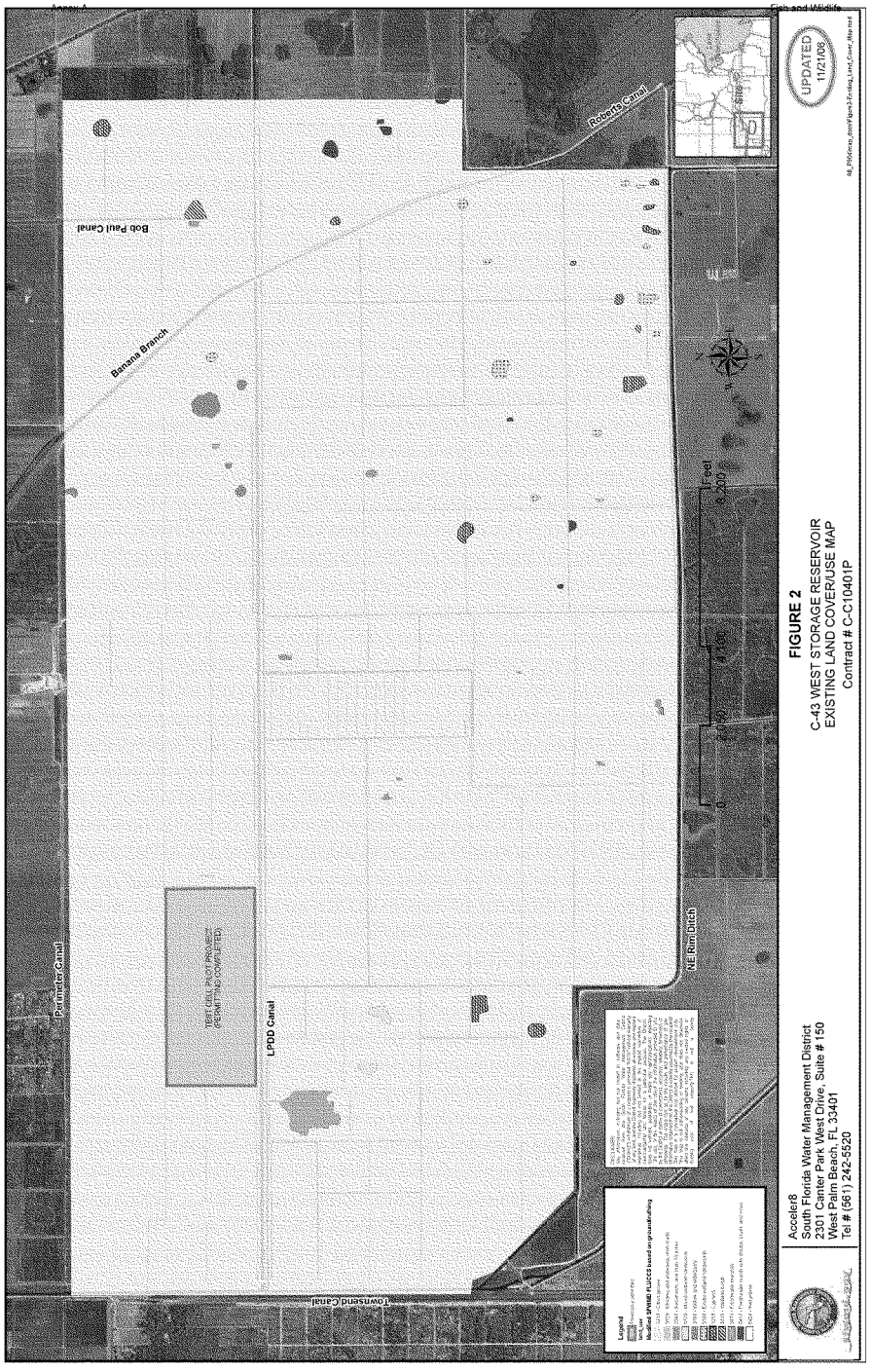
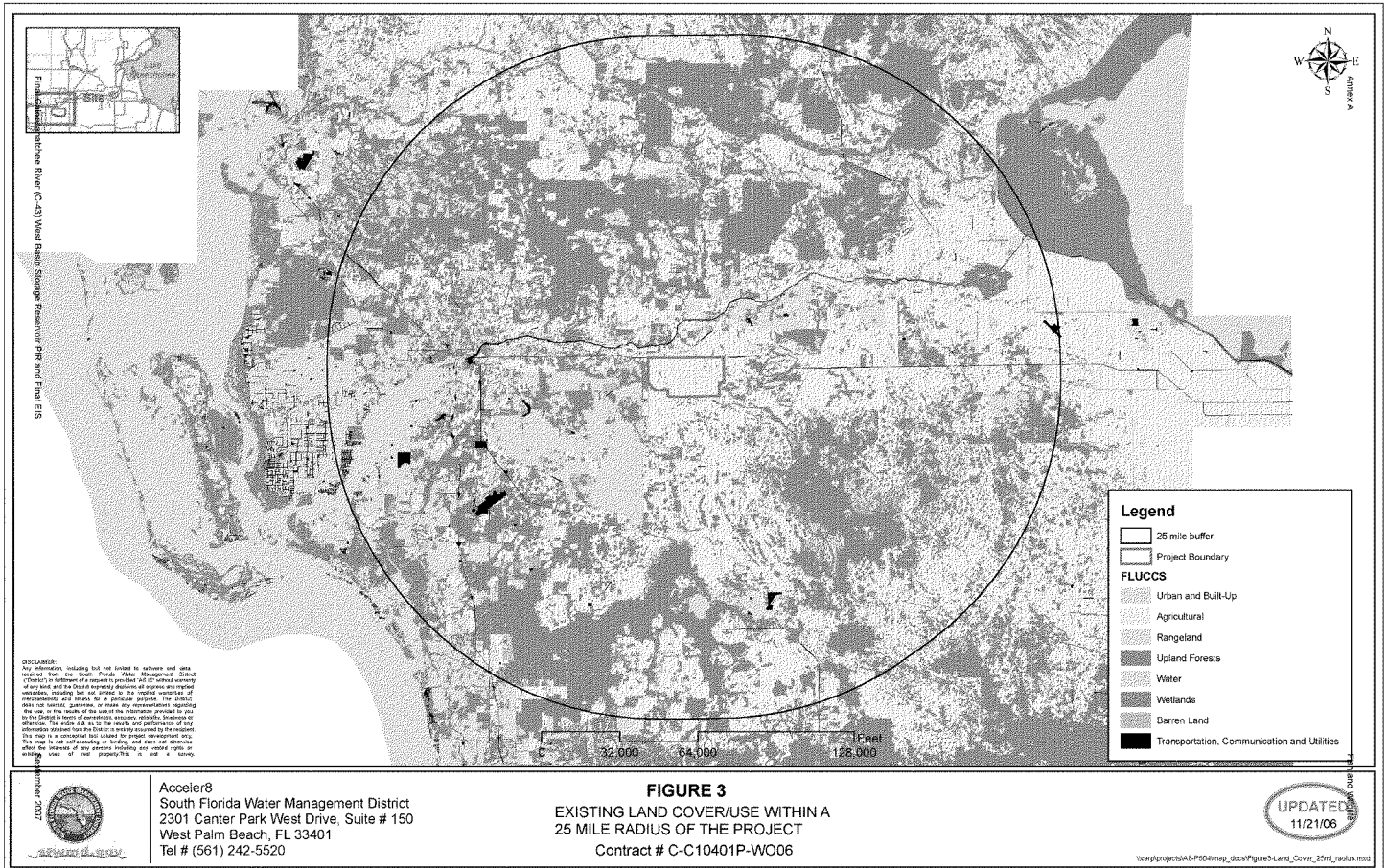
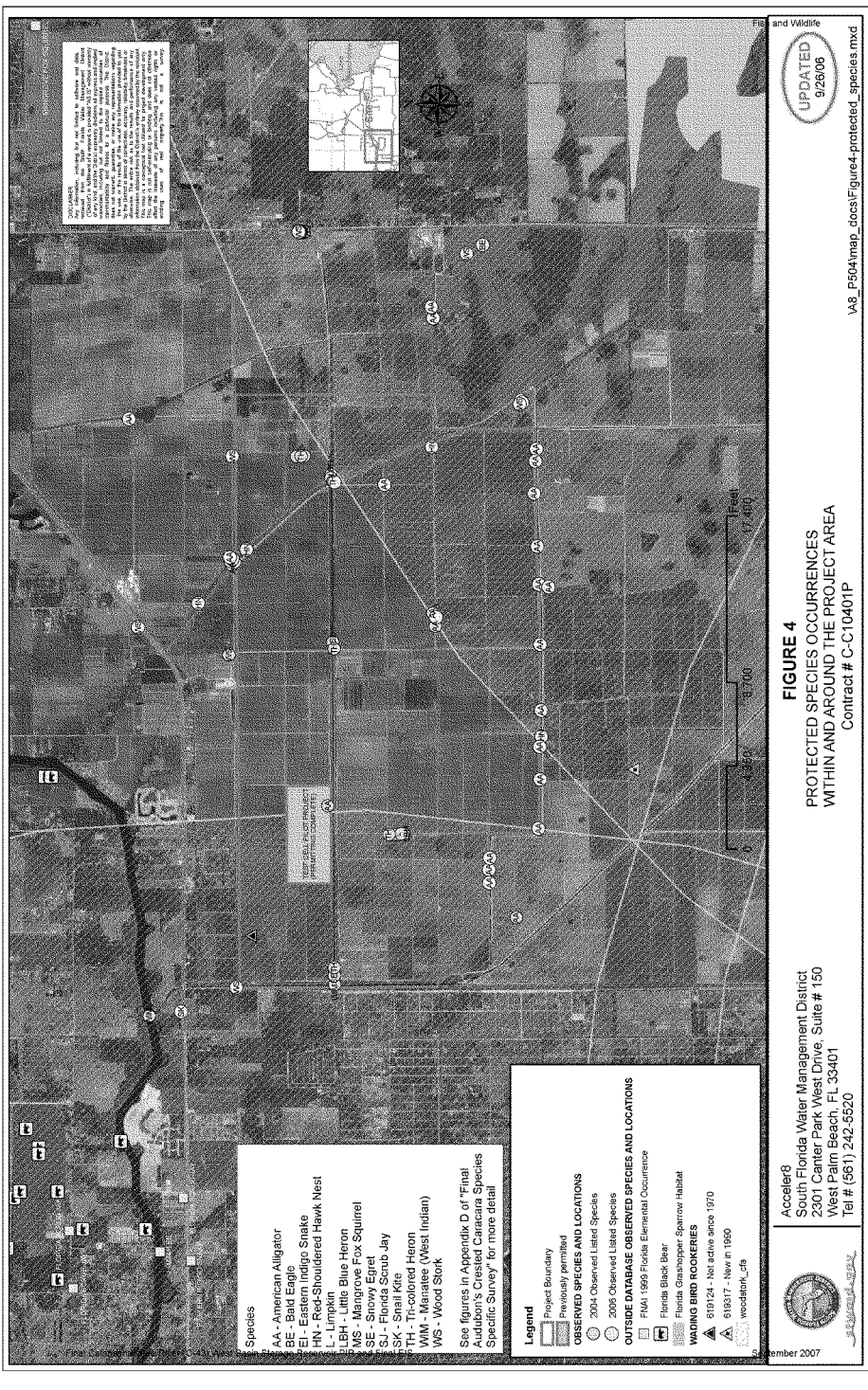
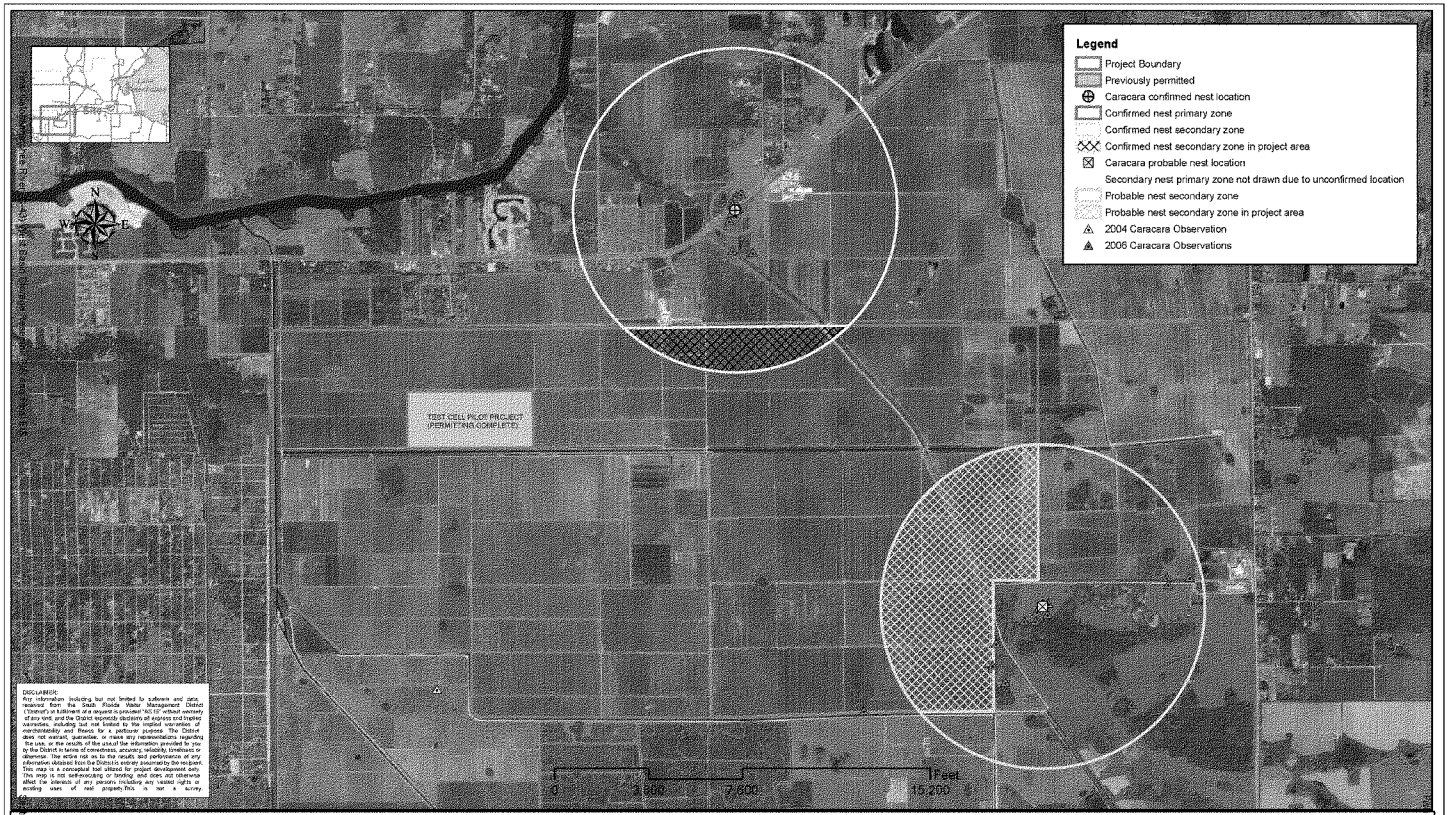


FIGURE 2
C-43 WEST STORAGE RESERVOIR
EXISTING LAND COVER/USE MAP
Contract # C-C10401P


Site
Annex A
Legend
25 mile buffer
Project Boundary
FLUCCS
Urban and Built-Up
Agricultural
Rangeland
Upland Forests
Water
Wetlands
Barren Land
Transportation, Communication and Utilities
0
32,000
64,000
128,000
Feet
DISCLAIMER:
Any information, including but not limited to software and data acquired from the South Florida Water Management District ("District") in fulfillment of a request is provided "AS IS" without warranty of any kind and the District expressly disclaims all express and implied warranties, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. The District does not warrant, guarantee, or make any representations regarding the use, or the results of the use of the information provided to you by the District in terms of correctness, accuracy, reliability, timeliness or otherwise. The entire risk as to the results and performance of any information obtained from the District is entirely assumed by the recipient. This map is a conceptual tool created for project development only. This map is not confounding or binding, and does not otherwise affect the interests of any persons including any vested rights or ownership uses of real property this or any survey.
Acceler8
South Florida Water Management District
2301 Canter Park West Drive, Suite # 150
West Palm Beach, FL 33401
Tel # (561) 242-5520
FIGURE 3
EXISTING LAND COVER/USE WITHIN A
25 MILE RADIUS OF THE PROJECT
Contract # C-C10401P-WO06
UPDATED
11/21/06
\\ewp\projects\AB-P504\map_docs\Figure3-Land_Cover_25mi_radius.mxd


Species
AA - American Alligator
BE - Bald Eagle
EI - Eastern Indigo Snake
HN - Red-Shouldered Hawk Nest
L - Limpkin
LBH - Little Blue Heron
MS - Mangrove Fox Squirrel
SE - Snowy Egret
SJ - Florida Scrub Jay
SK - Snail Kite
TH - Tri-colored Heron
WM - Manatee (West Indian)
WS - Wood Stork
See figures in Appendix D of "Final Audubon's Crested Caracara Species Specific Survey" for more detail
Legend
Project Boundary
Previously permitted
OBSERVED SPECIES AND LOCATIONS
2004 Observed Listed Species
2006 Observed Listed Species
OUTSIDE DATABASE OBSERVED SPECIES AND LOCATIONS
FNAI 1999 Florida Elemental Occurrence
Florida Black Bear
Florida Grasshopper Sparrow Habitat
WADING BIRD ROOKERIES
619124 - Not active since 1970
619317 - New in 1990
woodstork_cfa
September 2007
Acceler8
South Florida Water Management District
2301 Canter Park West Drive, Suite # 150
West Palm Beach, FL 33401
Tel # (561) 242-5520
FIGURE 4
PROTECTED SPECIES OCCURRENCES
WITHIN AND AROUND THE PROJECT AREA
Contract # C-C10401P
UPDATED
9/26/06
\A8_P504\map_docs\Figure4-protected_species.mxd
Feet
0
4,350
8,700
17,400

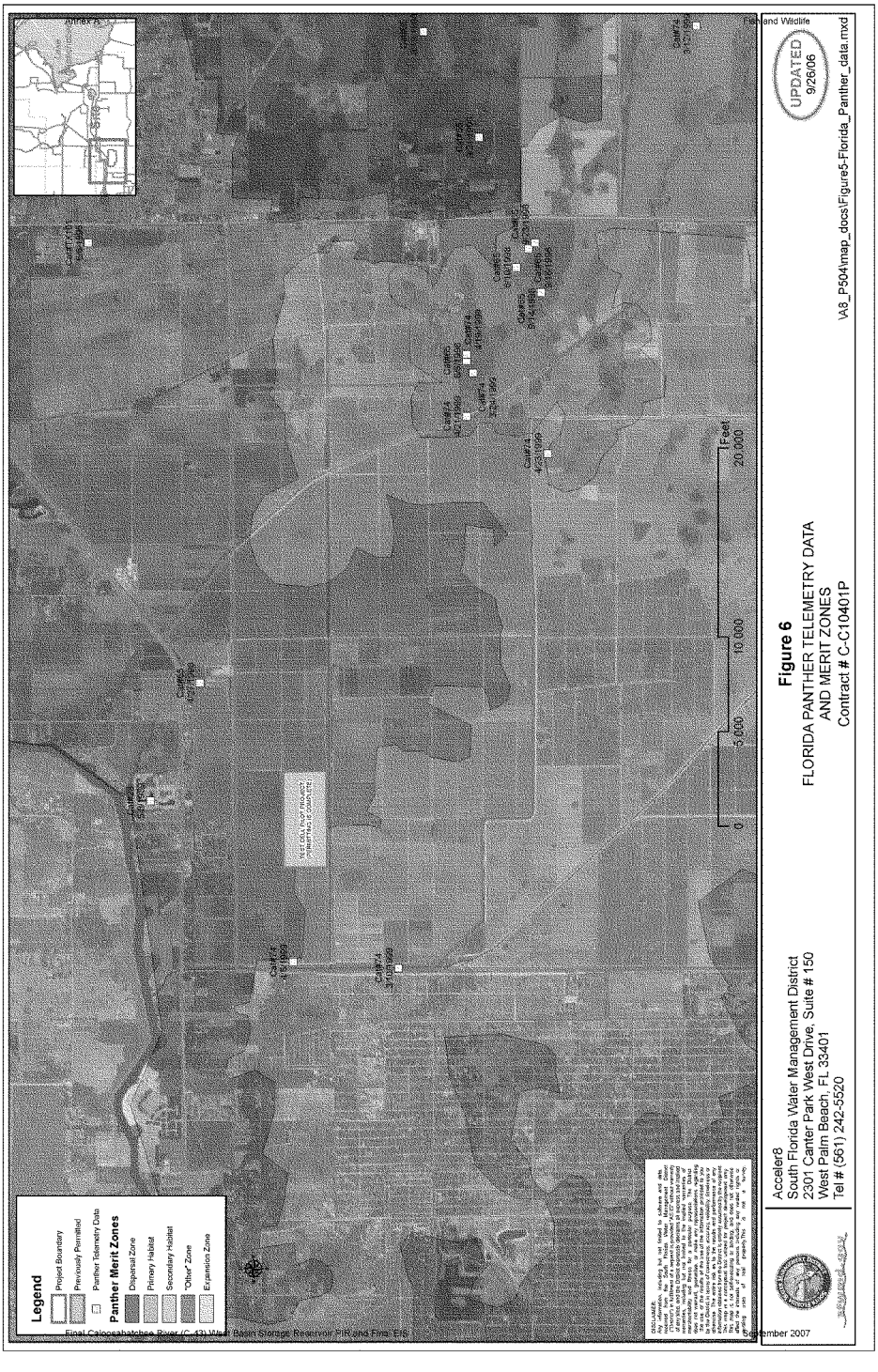


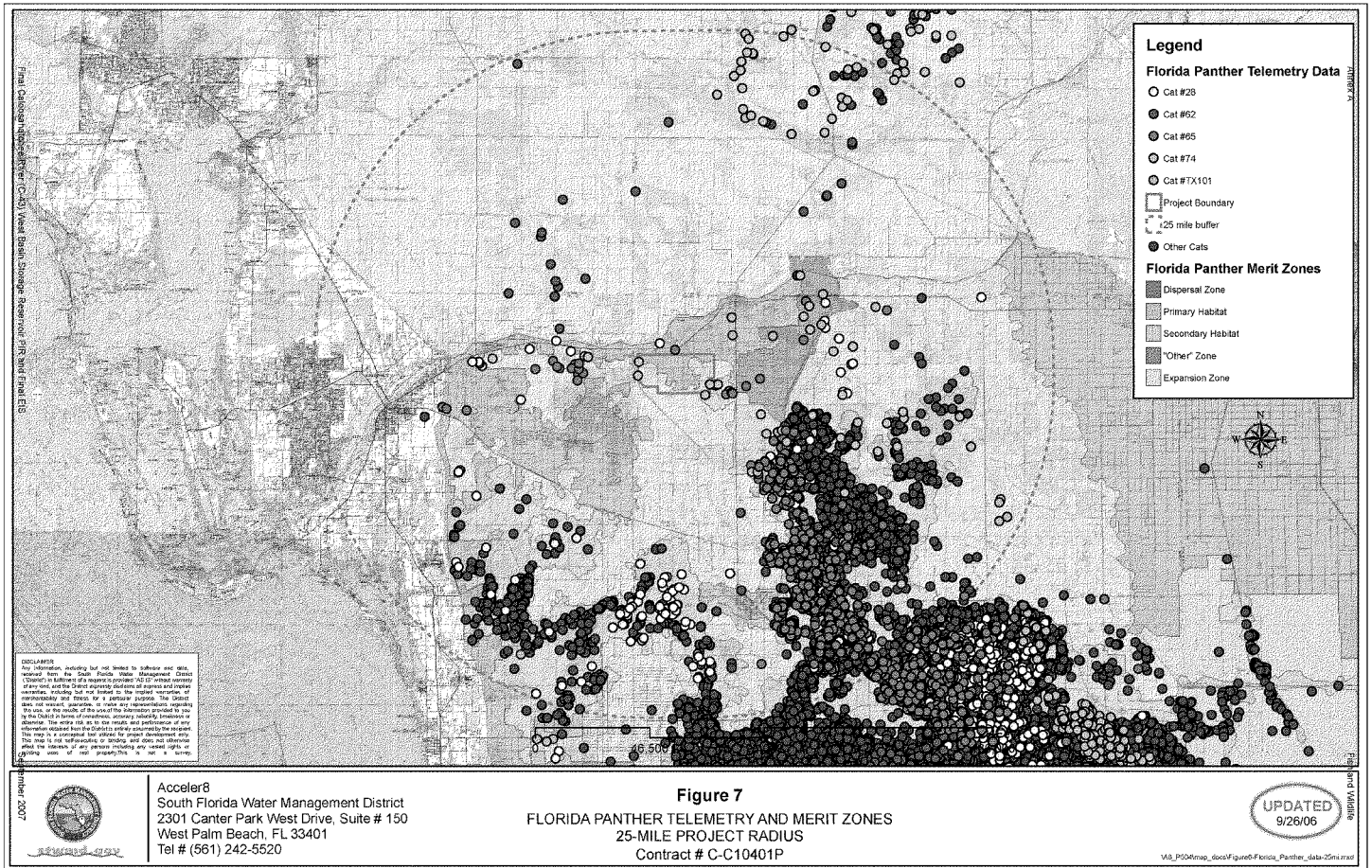
Acceler8
South Florida Water Management District
2301 Canter Park West Drive, Suite # 150
West Palm Beach, FL 33401
Tel # (561) 242-5520

FIGURE 5
CARACARA OCCURRENCES AND PROTECTION ZONES
WITHIN AND AROUND THE PROJECT AREA
Contract # C-C10401P

UPDATED
9/26/06

\A8_P504\map_docs\Figure4-protected_species.mxd


Legend
Project Boundary
Previously Permitted
Panther Telemetry Data
Panther Merit Zones
Dispersal Zone
Primary Habitat
Secondary Habitat
"Other" Zone
Expansion Zone
Annex A
Caloosahatchee River (C-43) West Basin Storage Reservoir EIR and EIS
September 2007
Figure 6
FLORIDA PANTHER TELEMETRY DATA
AND MERIT ZONES
Contract # C-C10401P
Acceler8
South Florida Water Management District
2301 Canter Park West Drive, Suite # 150
West Palm Beach, FL 33401
Tel # (561) 242-5520
UPDATED
9/26/06
\A8_P504\map_docs\Figure5-Florida_Panther_data.mxd
Fish and Wildlife


Legend
Florida Panther Telemetry Data
Cat #28
Cat #62
Cat #65
Cat #74
Cat #TX101
Project Boundary
25 mile buffer
Other Cats
Florida Panther Merit Zones
Dispersal Zone
Primary Habitat
Secondary Habitat
"Other" Zone
Expansion Zone
N
W
E
S
0
6,500
Final Caloosahatchee River (C-43) West Basin Storage Reservoir, PIR, and Final EIS
Florida Panther
Florida Wildlife
DISCLAIMER
Any information, including but not limited to software and data, received from the South Florida Water Management District ("District") in fulfillment of a request is provided "AS IS" without warranty of any kind, and the District expressly disclaims all express and implied warranties, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. The District does not warrant, guarantee, or make any representations regarding the use, or the results of the use of the information provided to you by the District in terms of correctness, accuracy, reliability, timeliness or otherwise. The entire risk as to the results and performance of any information obtained from the District is entirely assumed by the recipient. This map is a conceptual tool utilized for project development only. This map is not authoritative or binding, and does not otherwise affect the interests of any persons including any vested rights or existing uses of real property.This is not a survey.
September 2007
Acceler8
South Florida Water Management District
2301 Canter Park West Drive, Suite # 150
West Palm Beach, FL 33401
Tel # (561) 242-5520
Figure 7
FLORIDA PANTHER TELEMETRY AND MERIT ZONES
25-MILE PROJECT RADIUS
Contract # C-C10401P
UPDATED
9/26/06
\A8_P504\map_docs\Figure6-Florida_Panther_data-25mi.mxd

TABLES

Table 1 Protected Faunal Species Which May Occur Within the Project Study Area

Table 2 Protected Floral Species Which May Occur Within the Project Study Area

Table 3 Potential Habitat Impacts Based Upon Existing Land Cover/Use (FLUCCS) Within the Study Area

Table 4 Florida Panther Habitat Matrix – Panther Habitat Units for C-43 West Storage Reservoir

Table 1. Protected Faunal Species Which May Occur Within or Near the Project Study Area.

COMMON NAME	SCIENTIFIC NAME	OBSERVED IN C-43 PROJECT	OBSERVED ADJACENT TO C-43 PROJECT	USFWS LISTING	FWC LISTING
AMPHIBIANS					
Gopher frog	*Rana capito*				SSC
REPTILES					
American alligator	*Alligator mississippiensis*	Y	Y	T(S/A)	SSC
American crocodile	*Crocodylus acutus*			E	E
Atlantic green turtle	*Chelonia mydas*			E	E
Atlantic loggerhead turtle	*Caretta caretta*			T	T
Eastern indigo snake	*Drymarchon corais couperi*			T	T
Gopher tortoise	*Gopherus polyphemus*				SSC
Hawksbill turtle	*Eretmochelys imbricata*			E	E
Kemp's ridley turtle	*Lepidochelys kempii*			E	E
Leather back turtle	*Dermochelys coriacea*			E	E
AVIFAUNA					
Audubon's crested caracara	*Polyborus plancus audubonii*	Y	Y	T	T
Bald eagle	*Haliaeetus leucocephalus*		Y	T	T
Florida burrowing owl	*Speotyto cunicularia floridana*				SSC
Florida grasshopper sparrow	*Ammodramus savannarum floridanus*			E	E
Florida sandhill crane	*Grus canadensis pratensis*				T
Florida scrub jay	*Aphelocoma coerulescens*			T	T
Least tern	*Sterna antillarum*				T
Limpkin	*Aramus guarana*	Y	Y		SSC
Little blue heron	*Egretta caerulea*	Y	Y		SSC
Peregrine falcon	*Falco perigrinus*				E
Piping plover	*Charadrius melodus*			T	T
Red-cockaded woodpecker	*Picoides borealis*			E	SSC
Roseate spoonbill	*Platalea ajaja*	Y			SSC
Snail kite	*Rostrhamus sociabilis*		Y	E	E
Snowy egret	*Egretta thula*	Y	Y		SSC
Southeastern American kestrel	*Falco sparverius paulus*				T
Tricolored heron	*Egretta tricolor*	Y			SSC
White ibis	*Eudocimus albus*	Y	Y		SSC
Wood stork	*Mycteria americana*	Y	Y	E	E
MAMMALS					
Big Cypress fox squirrel	*Sciurus niger avicennia*				T
Florida black bear	*Ursus americanus floridanus*				T
Florida manatee	*Trichechus manatus latirostris*		Y	E	E
Florida mastiff bat	*Eumops glaucinus floridanus*				E
Florida panther	*Felis concolor coryi*			E	E
Sherman's fox squirrel	*Sciurus niger shermani*				SSC
Sherman's short-tailed shrew	*Blarina carolinensis (brevicauda) shermani*				SSC

Y = Species observed directly (visual) or indirectly (vocalizations, tracks, etc.)

Legend:

USFWS = United States Fish and Wildlife Service

FWC = Florida Fish and Wildlife Conservation Commission

E = Endangered T = Threatened

T (S/A) = Threatened (Similarity of Appearance to American crocodile - *Crocodylus acutus*)

SSC = Species of Special Concern

Sources: Official Lists of Florida's Endangered Species, Threatened Species, and Species of Special Concern. Florida Fish and Wildlife Conservation Commission. January 29, 2004.

Table 2. Protected Floral Species Which May Occur Within the Project Study Area.

COMMON NAME	SCIENTIFIC NAME	OBSERVED IN C-43 PROJECT	USFWS LISTING	FDA LISTING
Meadow Jointvetch	*Aeschynomene pratensis*			E
Toothed Spleenwort	*Asplenium dentatum*			E
American Bird's Nest Fern	*Asplenium serratum*			E
Leafless Bentspur Orchid	*Campylocentrum pachyrrhizum*			E
Narrow Strap Fern	*Campyloneurum angustifolium*			E
Powdery Catopsis	*Catopsis berteroniana*			E
Many-flowered Catopsis	*Catopsis floribunda*			E
Nodding Catopsis	*Catopsis nutans*			E
Cowhorn Orchid	*Crytopodium punctatum*			E
Okeechobee Gourd	*Curcurbita okeechobeensis*		E	E
Beautiful Pawpaw	*Deeringothamnus pulchellus*		E	E
Clamshell Orchid	*Encyclia cochleata*			E
Florida Butterfly Orchid	*Encyclia tampensis*	Y		C
Night-scented Orchid	*Epidendrum nocturnum*			E
Rigid Epidendrum	*Epidendrum rigidum*			E
Fuchs' Bromeliad	*Guzmania monostachia*			E
Edison's Ascyrum	*Hypericum edisonianum*			E
Pineland Clustervine	*Jacquemontia curtisii*			E
Carter's Large-flowered Flax	*Linum carteri* var. *smallii*			E
Florida loosestrife	*Lythrum flagellare*			E
Hidden Orchid	*Maxillaria crassifolia*			E
Mini-max Orchid	*Maxillaria parviflora*			E
Dancing-lady Orchid	*Oncidium bahamensis*			E
Florida Dancing-lady Orchid	*Oncidium floridanum*			E
Hand Fern	*Ophioglossum palmatum*			E
Cinnamon Fern	*Osmunda cinnamomea*	Y		C
Royal Fern	*Osmunda regalis var. spectabilis*	Y		C
Cutthroat Grass	*Panicum abscissum*			E
Pale Passionflower	*Passiflora pallens*			E
Cypress Peperomia	*Peperomia glabella*			E
Low Peperomia	*Peperomia humilis*			E
Spoonleaf Peperomia	*Peperomia magnoliifolia*			E
Florida Peperomia	*Peperomia obtusifolia*			E
Frost-flower Orchid	*Pleurothallis gelida*			E
Ghost Orchid	*Polyrrhiza lindenii*			E
Giant Orchid	*Pteroglossaspis ecristata*	?		T
Small Ladies-tresses	*Spiranthes brevilabris*			E
Lattice-vein Fern	*Thelypteris reticulata*			E
Toothed Lattice-vein Fern	*Thelypteris serrata*			E
Reflexed Wild-pine	*Tillandsia balbisiana*	Y		T
Wild-pine	*Tillandsia fasciculata*	Y		E
Banded Airplant	*Tillandsia flexuosa*			T
Giant Airplant	*Tillandsia utriculata*			E
Soft-leaved Wild-pine	*Tillandsia valenzuelana*			T
Chiggery grapes	*Tournefortia hirsutissima*			E
Wormvine Orchid	*Vanilla barbellata*			E
Coastal vervain	*Verbena maritima*			E
Netted Chain Fern	*Woodwardia areolata*	Y		C
Simpson's Zephyr Lily	*Zephyranthes atamasco*			T
Rain Lily	*Zephyranthes simpsonii*			T

Legend:

USFWS = United States Fish and Wildlife Service

FDA = Florida Department of Agriculture and Consumer Services

E = Endangered T = Threatened

SSC = Species of Special Concern

C = Commercially Exploited

Y = observed; ? = Unconfirmed due lack of inflorescence

Sources: 1. Official Lists of Florida's Endangered Species, Threatened Species, and Species of Special Concern. Florida Fish and Wildlife Conservation Commission. January 29, 2004. 2. Atlas of Florida Vascular Plants. Institute for Systematic Botany. University of South

Table 3. Potential Habitat Impacts Based Upon Existing Land Cover/Use (FLUCFCS) Within the Study Area.

FLUCCS CODE		DESCRIPTION	ACREAGE WITHIN PROJECT BOUNDARY	PERCENT OF TOTAL NATURAL AREAS IMPACT
200: Agriculture	2210	Citrus Groves (includes dirt maintenance roads and berms)	9088.40	90.04%
500: Water	5100	Streams and Waterways	889.73*	8.81%
	5340; 5340/6410; 5340/6417	Reservoirs Less than 10 Acres, some with fringes of Freshwater Marsh or Freshwater Marsh with Shrubs, Brush and Vines	5.85	0.06%
500 Series Subtotal			895.58	8.87%
600: Wetlands	6170/6210; 6170/6210/6417	Mix of Mixed Wetland Hardwoods and Cypress, some with interior components of Freshwater Marsh or Freshwater Marsh with Brush, Shrubs and Vines	6.04	0.06%
	6170/6240	Mix of Mixed Wetland Hardwoods and Cypress-Pine-Cabbage Palm	3.98	0.04%
	6172/6417	Mix of Mixed Wetland Hardwoods with Brush, Shrubs and Vines and Freshwater Marsh with Brush, Shrubs and Vines	1.28	0.01%
	6180	Willow and Elderberry	0.64	< 0.01%
	6190	Exotic Wetland Hardwoods	5.66	0.06%
	6180/6190	Mix of Willow and Elderberry and Exotic Wetland Hardwoods	13.74	0.14%
	6190/6210	Mix of Exotic Wetland Hardwood and Cypress	12.25	0.12%
	6210; 6210/6416	Cypress, some with interior components of Freshwater Marsh with Arrowroot	0.51	< 0.01%
	6310	Wetland Shrub	16.32	0.16%
	6410; 6417	Freshwater Marsh; Freshwater Marsh with Brush, Shrubs and Vines	6.64	0.07%
	6172/6417	Mix of Mixed Wetland Hardwoods with Brush, Shrubs and Vines and Freshwater Marsh with Brush, Shrubs and Vines	41.65	0.41%
	6430	Wet Prairie	0.96	0.01%
600 Series Subtotal			109.67	1.08%
TOTAL			10093.66**	100.00%

* Includes 16.05 acres of the Townsend Canal which will not be altered during project construction

** Does not include the 267-acre previously permitted test cell footprint

Table 4. Florida Panther Habitat Matrix - Panther Habitat Units for C-43 West Storage Resevoir

		Project Development							
		Functional Units Needed							
		Pre				Post			
Land Cover Type	Habitat Value	Primary Acres	Secondary Acres	Other Acres	PHU	Primary Acres	Secondary Acres	Other Acres	PHU
Water	0	3	167	129	0	144	5,291	4,925	0
Reservoir	1.5		2	4	4				
Exotic Plants*	3	3	42	8	101				
Orchards/groves	4	137	5,035	4,776	20,342				
Shrub Swamp	5	0	13	1	47				
Freshwater Marsh	9		9		54				
Hardwood Swamp	9		7		39				
Cypress Swamp	9	1	17	7	132				
Subtotal		**144**	**5,291**	**4,925**	**20,719**	**144**	**5,291**	**4,925**	**0**

*The exotic plants are calculated based on FLUCCS code for exotic hardwoods and percent of exotics within each land cover type. The following is the percent of exotics for each respective category: 70% - freshwater marsh; 60% - shrub marsh; and 10% - cypress swamp.

The current base multiplier for PHUs is 2.5 but is not included in the above table because it is currently under review.

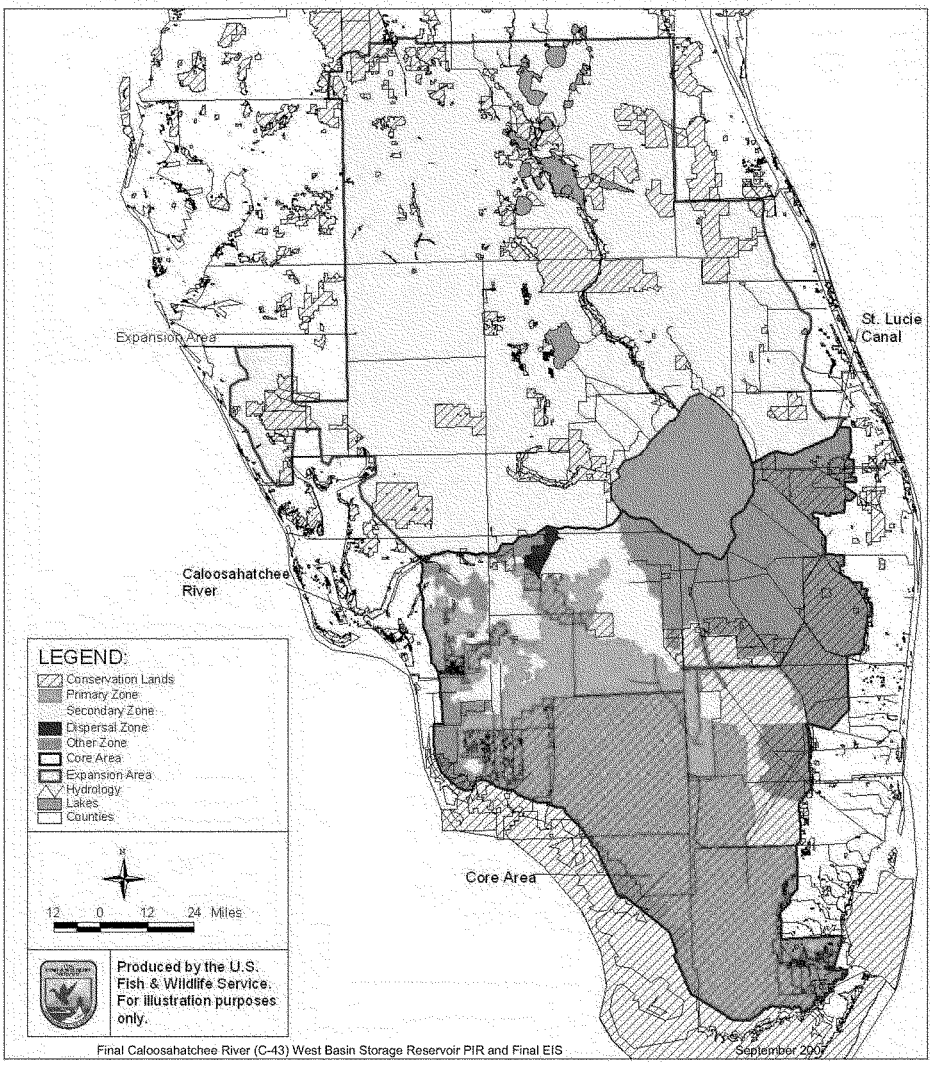
971 PHU's have already been addressed during consultation for the C-43 Test Cell Project. Refer to the November 30, 2005 Biological Opinion.

ATTACHMENTS

CERP LANDSCAPE LEVEL PROJECT PLANNING/SITING MAP FOR PANTHER CONSERVATION

MAP METADATA

Annex Core Area and Expansion Area within Consultation Area.



Map Metadata

All maps appearing in this document meet the standards and guidelines as defined in the CERP GIS Standard Operating Procedures Manual.

Disclaimer: These maps/data are a conceptual tool utilized for project development and implementation only. These maps/data are not self-executing or binding, and do not otherwise affect the interest of any person including any vested rights or existing uses of real property. Any information, including but not limited to maps and data, received from CERP is provided "as is" without any warranty and CERP expressly disclaims all express and implied warranties of merchantability and fitness for a particular purpose. CERP does not make any representations regarding the use, or the results of the use, of the information provided by CERP.

Figure 1: Project Location Map
Map Author: Corey Smolik, Scheda Ecological Associates, GIS Coordinator
Map Created: August 16, 2006
Map Location: \\cerp\projects\GIS\A8_P504\map_docs\Figure1-Project_Location_Map.mxd
Base Imagery: LABINS, 2004 true color DOQQ, 1 meter resolution
Datasets Used:
2006Boundary.shp
testcell_mod.shp

Figure 2: Existing Land Cover/Use Map
Map Author: Corey Smolik, Scheda Ecological Associates, GIS Coordinator
Map Created: August 31, 2006
Map Location: \\cerp\projects\GIS\A8_P504\map_docs\Figure2-Existing land cover_Map.mxd
Base Imagery: LABINS, 2004 true color DOQQ, 1 meter resolution
Datasets Used:
2006Boundary.shp
Testcell_mod.shp
Land_use.shp

Figure 3: Existing Land Cover/Use within a 25 Mile Radius of the Project
Map Author: Corey Smolik, Scheda Ecological Associates, GIS Coordinator
Map Created: August 31, 2006
Map Location: \\cerp\projects\GIS\A8_P504\map_docs\Figure3-Land_Cover_25mi_radius.mxd
Base Imagery: LABINS, 2004 true color DOQQ, 1 meter resolution
Datasets Used:
2006Boundary.shp
25 mile buffer.shp
lscndswf00.shp

Figure 4: Protected Species Occurrences Within and Around the Project Area
Map Author: Corey Smolik, Scheda Ecological Associates, GIS Coordinator
Map Created: August 31, 2006
Map Location: \\cerp\projects\GIS\A8_P504\map_docs\Figure4-protected_species.mxd
Base Imagery: LABINS, 2004 true color DOQQ, 1 meter resolution
Datasets Used:
2006Boundary.shp
C-43_2004_SEA-OBS.shp
bearlocs.shp
fleo99.shp
fgsp_hap.shp
woodstork_cfa.shp
listed_species_obs.shp

Figure 5: Caracara Occurrences and Protection Zones Within and Around the Project Area
Map Author: Corey Smolik, Scheda Ecological Associates, GIS Coordinator
Map Created: August 31, 2006
Map Location: \\cerp\projects\GIS\A8_P504\map_docs\Figure4-caracara.mxd
Base Imagery: LABINS, 2004 true color DOQQ, 1 meter resolution
Datasets Used:
2006Boundary.shp
carasea.shp
caracaraobs.shp
nest_locations.shp
probable nest.shp
300mbuffernest_locations.shp
2000mbuffernest_locations.shp
Potential caracara nest area.shp
Clip_probablenest.shp
SR80 nest_2ndzoneinprj.shp

Figure 6: Florida Panther Telemetry Data and MERIT Zones
Map Author: Corey Smolik, Scheda Ecological Associates, GIS Coordinator
Map Created: August 31, 2006
Map Location: \\cerp\projects\GIS\A8_P504\map_docs\Figure5-Florida_Panther_data.mxd
Base Imagery: LABINS, 2004 true color DOQQ, 1 meter resolution
Datasets Used:
2006Boundary.shp
testcell_mod.shp
panther-dispersal_zone.shp
panther-primary_zone.shp
panther-secondary_zone.shp
panther-expansion_zone.shp

panther-other_zone.shp
panthermerit_final.shp
panthertelem0604.shp

Figure 7: Florida Panther Telemetry and MERIT Zones (25 Mile Radius)
Map Author: Corey Smolik, Scheda Ecological Associates, GIS Coordinator
Map Created: August 31, 2006
Map Location: \\cerp\projects\GIS\A8_P504\map_docs\caracara report\Map Detail_south nest2.mxd
Base Imagery: LABINS, 2004 true color DOQQ, 1 meter resolution
Datasets Used:
2006Boundary.shp
testcell_mod.shp
panther-dispersal_zone.shp
panther-primary_zone.shp
panther-secondary_zone.shp
panther-expansion_zone.shp
panther-other_zone.shp
panthermerit_final.shp
panthertelem0604.shp
25 mile buffer.shp

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

July 23, 2007

Colonel Paul L. Grosskruger
District Commander
U.S. Army Corps of Engineers
701 San Marco Boulevard, Room 372
Jacksonville, Florida 32207-8175

Service Federal Activity Code:	41420-2006-FA-0443
Service Consultation Code:	41420-2007-5-0589
Corps Application No.:	SAJ-2005-5958 (IP-TKW)
Date Received:	January 10, 2007
Formal Consultation Initiation Date:	March 26, 2007
Applicant:	South Florida Water Management District
Project:	Caloosahatchee River (C-43) West Basin Storage Reservoir Project
County:	Hendry

Dear Colonel Grosskruger:

This document transmits the Fish and Wildlife Service's (Service) Biological Opinion for the U.S. Army Corps of Engineers' (Corps) to issue a permit for the construction and operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir project (C-43 West Reservoir project) and its effects on the endangered Florida panther (*Puma concolor coryi*), the threatened Audubon's crested caracara (*Polyborus plancus audubonii*), and the threatened eastern indigo snake (*Drymarchon corais couperi*) in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act) (87 Stat. 884;16 U.S.C. 1531 *et seq.*).

The C-43 West Reservoir project is an Acceler8 component of the Comprehensive Everglades Restoration Plan (CERP), authorized under the Water Resources Development Act of 2000. The purpose of the C-43 West Reservoir project is to restore ecosystem function in the Caloosahatchee Estuary by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee regulatory releases are discharged into the estuarine system via the Caloosahatchee River and to maintain a desirable minimum flow of freshwater to the estuary during dry periods. The C-43 West Reservoir project was designed to capture high freshwater flows from the Caloosahatchee River during the wet season, and store water temporarily in a 10,492-acre (ac) reservoir before discharging it back into the river during the dry season to restore a healthy estuarine salinity balance in the Caloosahatchee River Estuary and Pine Island Sound. The proposed 10,492-ac reservoir footprint and adjacent 110-ac access road parcel are located in portions of Sections 31 through 36, Township 43 South, Range 28

East; Sections 6 and 31, Township 43 South, Range 29 East; and Sections 1 through 12, Township 44 South, Range 28 East, Hendry County, Florida (Figure 1).

Within the C-43 West Storage Reservoir project area, 267 ac were previously impacted during construction of the C-43 West Reservoir Test Cell project (Test Cell project) (Figure 1). The Test Cell project was constructed to evaluate the on-site seepage potential and effectiveness of seepage control measures, the suitability of on-site materials for embankment construction and slope protection, and the effects of water residence time and seepage on water quality. That project included two 500-foot by 500-foot test cells with offset seepage canals, a borrow area, settling ponds, and staging areas and was authorized under Department of Army (DA) Permit number 2005-6598 (IP-TKW) issued December 6, 2005. A total of 29 ac of jurisdictional wetlands and waters of the Unites States (US) were impacted during construction of the Test Cell project and included 1.9 ac of excavated open-water, 4.5 ac of wet prairie, and 26.0 ac of tertiary, agricultural drainage canals.

This Biological Opinion is based on information provided in the November 9, 2006, Department of Army (DA) permit application; the Corps' January 10, 2007, letter to the Service requesting initiation of formal consultation; the December 2006 Biological Assessment (BA) prepared by Scheda Ecological Associates, Inc. (SEA) for the South Florida Water Management District (District); the Corps' March 22, 2007, letter to the Service providing additional information; the Corps' April 2007 *CERP C-43 West Reservoir project, Draft Project Implementation Report* (DPIR); the Corps' April 30, 2007, Public Notice (PN); and maps, meetings, field investigations, telephone conversations, email correspondence, and other sources of information. A complete administrative record is on file at the Service's Ecological Service sub-office co-located at the J.N. "Ding" Darling National Wildlife Refuge in Sanibel, Florida.

The Corps' letters and the BA referenced above describe the potential effects of the proposed C-43 West Reservoir project on federally listed threatened and endangered species. The Corps determined that the C-43 West Reservoir project will have "no effect" on the bald eagle (*Haliaeetus leucocephalus*), Florida scrub jay (*Aphelocoma coerulescens*), Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), red-cockaded woodpecker (*Picoides borealis*), Okeechobee gourd (*Cucurbita okeechobeensis*), and the beautiful pawpaw (*Deeringothamnus pulchellus*); and "may affect, but is not likely to adversely affect" the West Indian manatee (*Trichechus manatus*), Everglade snail kite (*Rostrhamus sociabilis plumbeus*), and the wood stork (*Mycteria americana*). The Corps also provided a "may affect and is likely to adversely affect" determination for the Audubon's crested caracara, eastern indigo snake, and Florida panther.

The following discussion pertains to the nine federally listed threatened or endangered species for which the Corps provided an effect determination of either "may affect, not likely to adversely affect" or "no effect." For these species, consultation was informal.

According to the BA, the Florida scrub jay, Florida grasshopper sparrow, red-cockaded woodpecker, Okeechobee gourd, and the beautiful pawpaw, or suitable habitat for those species, do not occur within or adjacent to the project area. Thus, the Corps has determined that the

proposed C-43 West Reservoir project will have no effect on those federally listed species. The Service concurs with the Corps' effect determinations for those species.

Bald Eagle

Likewise, the bald eagle is unlikely to be present within or adjacent to the project area. The closest documented nest is located 3.4 miles east of the project area and has not been active since 2003. No new nest locations were documented within 3,000 feet (ft) of the reservoir footprint during field surveys conducted during summer 2004 and spring 2006. Additionally, the Service has recently determined that the bald eagle has recovered and published the Final Rule to delist the bald eagle in the Federal Register on July 9, 2007. Removal of the bald eagle from the list of endangered and threatened wildlife will be effective August 8, 2007. Based on this information, the Corps has determined that that the proposed C-43 West Reservoir project will have no effect on the bald eagle. The Service concurs with the Corps' effect determination.

West Indian Manatee

The endangered manatee is known to occur in all coastal waters of south Florida including estuaries, bays, rivers, creeks, and canals (Service 2001). They have been documented within major inland freshwater waterways and canals, including the Caloosahatchee River from Lake Okeechobee to the Gulf of Mexico (*i.e.*, Glades, Hendry, and Lee Counties). Additionally, the Caloosahatchee River is a significant winter aggregation area for manatees. Manatees are highly mobile and may be found in all waters accessible to them. Access to some water bodies may be prevented by weirs, salinity control structures, and locks.

According to the BA and additional information provided, manatees are known to occur in the Townsend Canal which connects the C-43 West Reservoir project area to the Caloosahatchee River through the existing agricultural canal system. Manatees are capable of passing over the weir at the confluence of the Townsend Canal and the river during high water levels and of passing through existing flap gates in the weir into the Townsend Canal during periods of inflow. Manatees are currently prevented from accessing the remaining canals in the project area due to differences in canal elevations at the intersection of the Townsend and Header Canals. The Header Canal is adjacent to and provides water for the project area and is approximately 10 ft above the Townsend Canal at their intersection. The existing pump station located at that intersection takes water in from the Townsend Canal and releases it into the Header Canal at the higher elevation.

The proposed C-43 West Reservoir project includes removal of the weir at the confluence of the Townsend Canal and the Caloosahatchee River. That structure will be replaced with one that serves either as permanent barrier or seasonal barrier which restricts manatee access to the Townsend Canal only during the winter season (November 1 through March 31). Thus, manatees in the river will either have no access if a permanent barrier is erected, or continue to have seasonal access to the Townsend Canal where the two reservoir intake pump stations (*i.e.*, C-43PS-1 and C-43PS-4) will be located. However, both intake pumps will include bar screens and trash rake systems that will prevent manatees from becoming trapped in the intake pipes as

well as from entering the reservoir through C-43PS-1 or the perimeter canal through C-43PS-4, and reduce the likelihood of injury to manatees by the rake systems. The screens consist of vertical bars spaced 6 to 8 inches apart extending from above the water surface to the canal bottom. C43PS-1 includes a monorail picker rake system that extends across and along each intake bay. A Duperon (manatee friendly) trash rake system could not be used at C43PS-1 because Duperon does not manufacture a system that is as wide and deep as the C43PS-1 intake bays. However, through consultation with the Service, the following manatee-friendly components were incorporated into the picker rake system:

1. Slowing the descent speed of the picker rake;
2. Minimizing the width of the automated gripper to 24 inches (unless manually controlled); and,
3. Incorporating a bar across the picker teeth to prevent the tines from crossing.

C43PS-4 includes the Duperon system that extends across and along each intake bay. The Duperon system is considered manatee-friendly because there are no gripper or teeth. The system consists of a rotating cup attached to each bar screen that "scoops" the trash collected against the bar screen up to the trash rack on top of the screen to the trash conveyor.

Likewise, it is unlikely that manatees would be able to access the perimeter canal through any of the discharge structures or gated culverts. The main outfall structure, C-43S-11, is 10 to 12 ft higher in elevation than the Townsend Canal. The double box culverts at the Fort Simmons Branch and the Banana Branch Canals (*i.e.*, C43S-9 and C43S-7, respectively) are each controlled by a slide gate and a weir gate. The slide gates will remain closed except under extreme high flow conditions. The C43S-9 weir gate is supported by a 5-foot high "knee wall" and C43S-7 weir gate is supported by a 3-foot high "knee wall."

As referenced in the BA and discussed during the during the May 15, 2007, interagency meeting between the Corps, District, and Service, and subsequent teleconferences, manatee protection measures will be implemented as part of the proposed project. The Corps and District will follow the CERP Interagency Task Force's October 2006 *Guidelines for Manatee Conservation During Comprehensive Everglades Restoration Plan Implementation* (CERP Manatee Guidelines), particularly those summarized below:

1. Marine Species Observer Experience Requirements, including acceptable level of observer experience corresponding to the expected level of risk to manatees and location for a particular project. As described in the CERP Manatee Guidelines Appendix A-1, Manatee Observers must be approved by the Florida Fish and Wildlife Conservation Commission (FWC) by submitting a resume and a completed form titled Observer Experience and Education Documentation for Marine Species Watch Programs (June 2006). The C-43 West Reservoir project does not include the use of explosives (*i.e.*, blasting) and is not located in an Important Manatee Area. Therefore, observers qualified at Watch Level 2 or higher may fulfill permit requirements. All manatee observations for the C-43 West Reservoir project will be conducted by FWC approved Level 2 Manatee Observers through the Corps' existing volunteer manatee observer program for the Okeechobee Waterway.

2. Standard Manatee Construction Conditions (July 2005) should be followed, including education of construction personnel regarding manatee presence, speed zones, and that civil and criminal penalties exist for harming, harassing, or killing manatees under the Marine Mammal Protection Act, the Endangered Species Act, and the Florida Manatee Sanctuary Act; siltation and turbidity barriers shall not entangle or entrap manatees nor impede their movements; in-water operations and vessels must be shut down if a manatee(s) comes within 50 feet of the operation and will not resume until the manatee(s) has moved beyond the 50-foot radius of the project operation without being herded or harassed into leaving, or until 30 minutes elapses without the manatee(s) reappearing within 50 feet of the operation; any collision with or injury to manatees shall immediately be reported to the FWC Hotline at 1-888-404-FWCC and the Service's Vero Beach Office at 561-562-3909; and finally, temporary manatee signs that have already been approved by the FWC and described in the CERP Manatee Guidelines Appendix A-2 must be posted in prominently visible locations prior to and during all in-water project activities.

3. Minimization and Avoidance of Manatee Entrapment, including pre- and post-construction guidelines should be incorporated to avoid manatee entrapment during installation of the trash rakes on the intake pumps (*i.e.*, C43PS-1 and PS-4). As described in the CERP Manatee Guidelines Appendix A-3, the Corps or District should conduct ground surveys of the waterway prior to installation of the last section of any temporary or permanent barriers so that manatees are not trapped in the waterway between the pump stations and the bar screen and trash rake systems. Surveys should be conducted by qualified observers with conference with the Service and FWC. If no manatees are sighted within the exclusion area, the waterway should be closed off immediately. Otherwise, the manatees should be observed to see if they move beyond the proposed barrier on their own accord. Once the barrier is installed, the barrier and waterway should be monitored by land once daily for a period of one week to check for presence of manatees. The area should also be surveyed for manatee presence prior to initial operation of the pump stations. If manatees are sighted within the exclusion area, the FWC should be contacted at 888-404-FWCC.

4. Thermal Guidelines in Manatee Accessible Waters should be followed during the winter season, typically between November 1 to March 31, and include monitoring reservoir discharge water temperatures at both the reservoir discharge point (*i.e.*, C43S-11) and the receiving waters (*i.e.*, the confluence of the Townsend Canal and Caloosahatchee River) on a daily basis until the effect of the discharge has been determined. Intermittent reservoir discharges shall not increase the ambient temperature of receiving waters above 20° C and create an unreliable warm-water refugia that will not sustain manatees through cold periods (CERP Manatee Guidelines, Appendix A-5).

5. A report summarizing project construction and related manatee observations, including dates, names of qualified observers, and the duration and results of observation will be submitted to the Service annually, until construction is completed.

To achieve Guideline 4 above, the Corps and District agreed during the May 15, 2007, interagency meeting and subsequent teleconferences, to construct at least a seasonal barrier at the confluence of the Townsend Canal and Caloosahatchee River to prevent manatee access to the Townsend during the winter season (November 1 through March 31), and to implement the following monitoring plan during the winter season:

1. During reservoir releases conducted between November 1 to March 31 of each year, continuous recorders will be used to monitor water temperature daily at three locations: 1) the temperature of the reservoir discharge water will be monitored at the discharge point (*i.e.*, C43S-11); 2) ambient water temperature in the Caloosahatchee River will be monitored at the Ortona Lock (*i.e.*, S-78); and 3) the effect of reservoir discharge on the water temperature in the Caloosahatchee River will be monitored at the barrier that will be constructed at the confluence of the Townsend Canal and the Caloosahatchee River. Hourly data points should be downloaded and examined daily to determine the presence and downstream effect of the warm water plume.

2. If the reservoir discharges raise the ambient temperature of the water at the confluence of the Townsend Canal and the Caloosahatchee River greater than or equal to 20° C, or if less than 20° C but increases the water temperature at that location above the ambient water temperature, manatee observations will be conducted daily in the Caloosahatchee River at its confluence with the Townsend Canal to detect any shifts in manatee winter-use patterns and movements to the area. Observations should be conducted in four 10-minute intervals over a 2-hour period every morning. All manatee observations for the C-43 West Reservoir project will be conducted by FWC approved Level 2 Manatee Observers through the Corps' existing volunteer manatee observer program for the Okeechobee Waterway.

3. If manatees move to the area as result of the reservoir discharges and have been observed within the Caloosahatchee River at its confluence with the Townsend Canal during two consecutive observation days or during two of three consecutive observation days, then the Corps should notify the Service and the FWC immediately. The Corps shall continue the manatee observations and the FWC may monitor manatee health as appropriate. If reservoir releases are discontinued based on flows at S-79 during the cold season and the FWC determines that manatees exhibit signs of cold stress following cessation of reservoir discharges, then the Corps and District will reinitiate consultation with the Service.

4. Reports summarizing the water temperature monitoring and manatee observations conducted during the winter period will be submitted to the Service and the FWC, annually. Those reports should include: a) the water temperatures observed at the C-43S-11, S-78, and the barrier constructed at the Townsend and Caloosahatchee River from November 1 through March 31; b) the date, time, and duration of each observation, the name of the approved Level 2 observers, and the results of each observation; and c) if the Service and FWC were notified of manatee presence as outlined above, the date the agencies were contacted as well as the date and results of any additional monitoring of manatee health conducted by FWC.

5. After the reservoir has been in operation a minimum of 5 years, monitoring needs may be re-evaluated. At that time, the range of climatological and hydrological conditions (*i.e.*, occurrence of an extreme cold year, extreme drought year, etc.) under which the reservoir was operated will be considered in the re-evaluation of water temperature monitoring needs and manatee observations.

Based on the above information, the Corps has determined that the proposed C-43 West Reservoir project "may affect, but is not likely to adversely affect" the manatee. The Service concurs with the Corps' effect determination.

No designated manatee critical habitat occurs within the proposed project area. However, the C-43 West Reservoir project will benefit designated critical habitat downstream by improving salinity conditions in the Caloosahatchee Estuary, particularly during the dry season. Therefore, designated West Indian manatee critical habitat will not be adversely affected by the proposed C-43 West Reservoir project.

Everglade Snail Kite

Suitable habitat for the endangered snail kite consists of freshwater marshes, wet prairies, and the shallow vegetated edges of man-made or natural lakes where apple snails (*Pomacea paludosa*) can be found. The closest known nesting concentrations of snail kites and their designated critical habitat occur in the Lake Okeechobee watershed, east of the project area. Snail kites are occasionally known to occur in marshes west of Lake Okeechobee, along the Caloosahatchee River, and west of the project area in Lehigh Acres and borrow canals in Lee County. During February 2006 field surveys, SEA staff observed one snail kite eating a snail while perched on a power transmission line along State Road (SR) 80 approximately 0.75 miles west of the reservoir footprint. However, no snail kites and little suitable foraging habitat (*i.e.*, less than 10 ac) are known to occur within the C-43 West Reservoir project area, including the Test Cell project footprint.

No suitable snail kite habitat would be created within the 110-ac access road parcel. However, the construction and operation of the proposed reservoir may intermittently provide wetland habitats suitable for snail kite use within the 10,492 ac currently under citrus production when the reservoir is drawn down or within the 109 ac of littoral zones that will be constructed as part of the seepage canal. Citrus operations in the project area and elsewhere have routinely applied heavy copper (Cu) treatments as a fungicide for many years, resulting in extensive Cu contamination in the soil. Potential Cu risk to the endangered snail kite may occur due to Cu accumulation in the kite's primary food item, the apple snail (URS 2003). Snail kites have a specific diet comprised almost entirely of apple snails. Apple snails have been found in the larger agricultural canals and in 4.8 ac of retention marsh within the C-43 West Reservoir project area. Thus, wetlands created as a result of the project may occasionally attract foraging snail kites during drawdown conditions.

The Service is conducting an ongoing field study to develop a method to predict Cu concentrations in apple snails based on Cu concentrations in soils and to ultimately predict Cu

concentrations in apple snails in wetlands constructed on former Cu-contaminated citrus properties. Preliminary results of that study indicate a positive relationship between Cu concentrations in soil sediments and Cu concentrations in apple snails (Barger et al. 2005). An interim effects level of 85 milligrams per kilogram (mg/kg) of Cu concentrations in sediments was agreed upon by the Service and the District until that study is completed.

A total of seven grids (*i.e.*, grids 56, 58, 124, 125, 134, 135, and 143) in the Berry Labelle – Congen Groves portion of the project area will require remediation due to Cu contamination (Figure 2). The Service recommended remediation for the entirety of Grids 124, 125, 134, 135, and 143 (250 ac) and for the portions of Grids 56 and 58 that will be within the footprint of the proposed reservoir. The District's remediation plan includes excavation of approximately one foot of soil from those contaminated areas to be remediated and utilizing that soil within the reservoir embankments, burying the soils such that surface water will not contact the Cu-contaminated soil. The Service concurred in a letter dated September 14, 2006, that removing contamination from those seven grids would adequately reduce Cu concentrations in those grids to below the interim screening value for risk to the snail kite and would not likely have direct impacts on other trust resources for which the Service is responsible. However, the Service noted that the remaining Cu concentration in some areas of the property may be high enough to adversely impact benthic organisms. The Service also recommended that no further Cu applications be permitted in Grids 38, 39, and 145 since Cu concentrations in soils from those grids were close to the interim screening value, and that the proposed remediation not commence until project construction is initiated. According to information provided by the Corps in their March 22, 2007, letter, those recommendations have been followed and no additional Cu has been applied within the project area since soil sampling was conducted. Therefore, the Corps has determined that the proposed C-43 West Reservoir project "may affect, but is not likely to adversely affect" the Everglade snail kite. The Service concurs with the Corps' effect determination. No designated critical habitat occurs within or adjacent to the project area and therefore, none will be affected.

Wood Stork

Endangered wood storks utilize wetlands for foraging year-round. Regional declines in wood stork populations can be attributed to the loss and degradation of feeding habitat. Depending on local rainfall and habitat conditions, wood storks may forage in 50 to 200 wetlands within 5 to 40 miles of a rookery site. The Service has identified a Core Foraging Area (CFA) of 18.6 miles around known wood stork rookeries to minimize potential adverse effects to their foraging habitat. Although no wood storks are known to have nested within the project area, approximately 85 percent (*i.e.*, 8,995 ac) of the C-43 West Storage Reservoir project area including the access road parcel (i.e., 10,602 ac), is within 18.6 miles of three wood stork rookeries known to be active (Figure 3). Two rookeries are located to the west in the Caloosahatchee estuary in Lee County, and one rookery is located south of the project area in Collier County just south of Okaloacoochee Slough State Forest (OSSF) and Wildlife Management Area (WMA). Wood storks were observed during listed species surveys and other field inspections of the project area foraging within secondary agricultural canals, loafing along

access roads and borrow ditches, and feeding on prey trapped in vegetation cast aside during mechanical ditch maintenance.

Typical foraging sites for the wood stork include freshwater marshes, stock ponds, shallow and seasonally flooded roadside or agricultural ditches, narrow tidal creeks, shallow tidal pools, managed impoundments, and depressions in cypress heads, swamps, and sloughs. Because of their specialized feeding behavior, wood storks forage most effectively in shallow (*i.e.*, 2 to 15 inches) water areas with highly concentrated prey. Almost any shallow wetland depression where fish become concentrated, either through local reproduction or receding water levels, may be used as feeding habitat during some portion of the year.

The project will result in the loss of approximately 126.7 ac of wetlands and 934.6 ac of other jurisdictional surface waters on the site (Figure 4). The land will be converted primarily to an open-water, above-ground reservoir including associated structures and a seepage canal. However, suitable wood stork foraging habitat is limited within the project area and habitat quality for wood storks is generally poor. On-site freshwater wetlands are primarily impacted wetlands functioning as agricultural retention and detention areas. Secondary and tertiary agricultural canals and ditches may provide shallow-water foraging habitat and concentrate prey during low water periods and their hydrology is dependent on rainfall and irrigation. As a result, agricultural canals and ditches may often receive nutrient and chemical (*i.e.*, fertilizers, pesticides, and fungicides) laden runoff directly from the grove beds. Approximately 6.9 ac of emergent wetlands and depressions in cypress heads were determined to provide suitable wood stork foraging habitat within the C-43 West Reservoir project area and access road parcel during onsite field inspections and examination of aerial photography and photographs of onsite wetlands taken during helicopter surveys. Secondary (191.6 ac) and tertiary (558.5 ac) agricultural canals and ditches within the project area provide an additional 750.1 ac of potential foraging habitat within the CFA of three known rookeries (Figure 5) when hydrological conditions are suitable. The loss of approximately 17.2 ac of tertiary ditches that provide potential wood stork foraging habitat within the Test Cell project boundary was already compensated for under informal consultation for that project as described in our November 22, 2005, letter.

The Uniform Mitigation Assessment Method (UMAM) (Chapter 62-345, F.A.C. [effective date 02-04-2004]) was used to evaluate the current condition (*i.e.*, wetland value) of the existing wetlands (6.9 ac) and drainage canals and ditches (750.1 - 17.2 = 732.9 ac) within the project area that provide potential wood stork foraging habitat and the proposed compensation for the loss of that foraging habitat. During a May 15, 2007, interagency meeting, the Corps, District, Service, and Environmental Protection Agency (EPA) agreed to use the UMAM evaluations of onsite wetlands and agricultural canals and ditches conducted by an interagency team comprised of the Corps, District, and Service, during June and July of 2004. Thus, a total of 96.9 functional wetland units will be lost as a result of the C-43 West Storage Reservoir project (Table 1).

The purpose of the C-43 West Storage Reservoir project is to restore ecosystem function in the Caloosahatchee Estuary by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuarine

system and to maintain a desirable minimum flow of fresh water to the estuary during dry periods. Altered salinity in the estuary has resulted from hydrological modifications that have dramatically changed the natural quantity, quality, timing, and distribution of freshwater flows to the estuary, often without regard to the health of the estuarine community (Haunert et al. 2000). Salinity is a major ecological variable that controls important aspects of the estuarine community structure and food web (Myers and Ewel 1990). Flow alterations have impacted the natural biodiversity of the estuary by affecting food availability, predation pressure, and reproductive success, as well as directly causing chronic and acute stress on biota. Altered freshwater inflow can also influence primary productivity, zooplankton biomass, and nekton abundance by influencing nutrient concentrations and light attenuation.

The excessive variation in discharge and salinity in the Caloosahatchee Estuary (Figure 6) maintains estuarine biota in a constant flux between those favoring higher salinity and those favoring lower salinity (Chamberlain and Doering 1998a; Bulger et al. 1990). Optimal salinity conditions may not last long enough for organisms to complete their life cycle and the estuary can become devoid of some populations, even keystone species that support major ecosystem components along the estuary's salinity gradient such as oysters or submerged aquatic vegetation. The tapegrass (*Valisneria* sp.) beds in the upper estuary provide important breeding, feeding, and escape cover for a variety of estuarine-dependent species, including foraging habitat for two of the rookeries impacted by construction of the reservoir. During the dry season, the combination of limited rainfall, lack of water storage in the basin and withdrawals to meet human demands for irrigation and potable water often results in periods of no freshwater discharge to the estuary. Saltwater can intrude upstream to the Franklin Lock and Dam (S-79), threatening the survival of the tapegrass beds and other species that require low salinity to complete their life cycle (Chamberlain and Doering 1998a; 1998b, Doering et al. 2002; District 2002). For example, tapegrass beds had essentially vanished from the upper estuary as a result of extremely high salinity levels during the 2001 drought. Tapegrass density remained low and started a slight increasing trend during the growing season of 2003. The beds began to recover while salinity conditions were favorable during the spring and summer growing seasons of Water Year (WY) 2004 and WY 2006. However, due to the unusually high salinity associated with the 2007 dry season the tapegrass beds have again almost disappeared.

The optimum S-79 flow ranges and delivery patterns for the estuary were initially designed to protect tapegrass upstream of Fort Myers and formed the basis for development of hydrologic performance measures for CERP, including the C-43 West Storage Reservoir project; the Southwest Florida Feasibility Study; and the Lake Okeechobee Regulation Schedule; as well as meeting legislative mandates for the establishment of the Caloosahatchee River and Estuary Minimum Flow and Level (MFL) (District 2000, 2003). The MFL was based on a flow-salinity relationship that was based on flows at S-79 and downstream salinity levels (Chamberlain and Doering 1998b; Doering et al. 2002).

Although wood storks may be impacted by the loss of foraging habitat within the project footprint, when implemented, the C-43 West Storage Reservoir project has the potential to significantly contribute towards restoration of tapegrass in the upper Caloosahatchee estuary. The C-43 West Reservoir project will improve estuarine health particularly by reducing the

number of damaging low flow events at S-79. Negative project effects to wood stork foraging habitat within the C-43 West Reservoir project area will be offset by the enhancement of about 4,130 ac of submerged tapegrass beds in the upper Caloosahatchee estuary (Figure 3) which will directly benefit two of the three wood stork rookeries in the project vicinity. Restoration and enhancement of the tapegrass beds in the upper estuary will provide approximately 446 wetland mitigation credits and is consistent with the Service's wood stork goal to acquire, enhance, preserve, and recover natural hydropatterns within foraging habitat of the wood stork. We anticipate that the hydrologic improvements would result in significant increases in the cover and density of tapegrass beds in the upper estuary and therefore, result in increases in the spatial extent and productivity of available wood stork foraging habitat. Based on the model results described in the DPIR, the proposed design and operation of the C-43 West Reservoir are effective at augmenting flows below 450 cubic feet per second (cfs) at S-79 to meet MFL criteria than at reducing the extreme high flows (Corps 2007). The MFL salinity criteria are also beneficial for other organisms that utilize this low salinity region of the estuary, including wood stork prey species. The Service, Corps, and EPA used UMAM to evaluate the future condition of the tapegrass beds based on the model results and project benefits analyses described in the DPIR. Restoration and enhancement of the tapegrass beds in the upper estuary will provide approximately 446 wetland mitigation credits and is consistent with the Service's wood stork goal to acquire, enhance, preserve, and recover natural hydropatterns within foraging habitat of the wood stork.

The District has also proposed to construct 109.3 ac of shallow-sloped littoral zones along portions of the C-43 West Storage Reservoir seepage canal. Although this habitat will not be considered as compensation for the loss of wood stork foraging habitat or as mitigation for functional wetland units lost as a result of the proposed project, the littoral zones may provide additional wood stork foraging habitat.

Accordingly, the restoration and enhancement of 4,130 ac of tapegrass beds in the upper Caloosahatchee estuary will compensate for the loss of approximately 749.8 ac primarily consisting of impacted wetlands and agricultural canals and ditches that provide wood stork foraging habitat within the reservoir footprint. Additional wetland habitat will be provided by the construction of 109 ac of littoral zones along C-43 West Storage Reservoir seepage canal. Based on this information, the Corps has determined that the proposed C-43 West Storage Reservoir project "may affect, but is not likely to adversely affect" the wood stork. The Service concurs with the Corps' determination.

This concludes the informal consultation for this project on the species presented above, and these species will not be addressed further in this Biological Opinion.

Audubon's Crested Caracara

Suitable nesting habitat for the threatened Audubon's crested caracara includes wet and dry prairies with scattered saw palmetto, scrub oak, or cypress, and improved or semi-improved pastures and range lands. Two documented caracara nest locations were identified in the project vicinity during species specific surveys conducted February through May of 2006, although none

occur within the proposed reservoir footprint. Project-related activities and resultant land cover changes would occur within the primary (985-foot radius from the nest tree) or secondary (6,600-foot radius from the nest tree) protection zones of one or both caracara nest sites. Therefore, the Corps has determined that the proposed project "may adversely affect" the crested caracara. The Service concurs with the Corps' determination.

Eastern Indigo Snake

The eastern indigo snake is listed by the Service and the FWC as a threatened species. Eastern indigo snakes require a mosaic of habitats. Because eastern indigo snakes are found throughout Florida and use a variety of habitat types, including citrus groves, its presence in the project area is likely. No individuals have been observed during project field surveys, although the Service observed a black snake on the site on February 21, 2007, that may have been an eastern indigo snake. While no gopher tortoise burrows have been observed on the project site, armadillo burrows are frequently observed along canal banks and may provide refuge for indigo snakes.

Following construction, very minimal habitat for the eastern indigo snake will be available in the project area. The interior slopes of the reservoir cells and the interior cell dam embankment will be lined with soil cement, thus making the majority of the reservoir site unsuitable habitat. A perimeter canal will make access to the reservoir difficult. In addition, the access road and other maintenance roads will mainly be all-weather roads consisting of a limerock base with gravel substrate surface. The entrance road and small portions of the perimeter access road and maintenance roads will be paved. The only portions of the C-43 West Reservoir project that may provide limited habitat for the eastern indigo snake are the embankments that will be constructed between the crest of the dam and the project boundary. These embankments will consist of overburden from the project area and maintained sod. Because these embankments will be regularly mowed, they will not provide highly desirable cover or habitat for the species. Therefore, the Corps has determined that the proposed project "may adversely affect" the eastern indigo snake due to the loss of 10,602 ac of potentially suitable habitat. The Service concurs with the Corps' determination.

Florida Panther

The proposed C-43 West Storage Reservoir project is within the Service's Panther Focus Area for the Florida panther (Figure 7) and provides habitat suitable for use for foraging and dispersal. The total construction footprint, including both wetlands and uplands, will be approximately 10,602 ac of which 10,492 ac are within the reservoir and 110 ac are within the access road parcel. In a January 10, 2007, letter, the Corps determined that the C-43 West Storage Reservoir project "may affect" the Florida panther and requested initiation of formal consultation. On January 24, 2007 and March 8, 2007, the Service requested the Corps to provide additional information on manatees, wood storks, snail kites, and panthers. The District provided that information in their March 22, 2007, letter received by the Service on March 26, 2007.

The overall purpose of the CERP is to restore the Everglades ecosystem and species assemblages. Implementation of CERP is expected to provide large-scale, long-term benefits to

the ecosystem and listed species, though individual actions may result in smaller-scale or short-term adverse effects to one or more listed species. Because CERP is a regional ecosystem restoration program with one project sponsor (*i.e.* the District), the Corps and the Service have agreed to evaluate the effects of the complex, long-term, inter-dependent nature of CERP on listed species using a programmatic or regional approach. Thus, the resultant positive (*e.g.*, habitat acquisition and restoration) and negative (*e.g.*, construction-related habitat loss) effects to the panther in south Florida will be evaluated by bands of projects identified in the Master Implementation Sequencing Plan (MISP). Band 1 consists of projects that will be constructed by 2010 including the state-expedited Acceler8 Projects of which the C-43 West Reservoir project is a component. Figure 8 shows the location of these Band 1 projects in relation to the various panther zones in south Florida. In addition to evaluating the effects of the proposed C-43 West Reservoir project in the Biological Opinion, the Service also aggregated the Band1/Acceler8 projects and evaluated them as a group using the method described in Analyses for the Effects of the Action to assess the overall effects of this phase of CERP implementation on Florida panthers and habitat used by the Florida panther. The Service will also assess other Band 1/Acceler8 projects individually in subsequent Biological Opinions as the Corps and District finalize plans for implementation and request consultation on those projects.

The proposed C-43 West Storage Reservoir project is one of several Band1/Acceler8 projects that fall within the Florida Panther Focus Area (Figure 8). The reservoir project will result in the direct loss of 10,602 ac of habitat the panther may use, of which 267 ac were already compensated for under formal consultation for the Test Cell project (DA Permit 2005-6598 [IP-TKW]). The remaining habitat loss (*i.e.*, 10,335 ac) provides approximately 19,438 panther habitat units (PHUs) (see definition in the Effects of the Action) with a recommended compensation of 46,933 PHUs. The Band 1/Acceler8 projects located within the core panther conservation area collectively provide compensation for the loss of 10,602 ac of panther foraging and dispersal habitat on the C-43 West Storage Reservoir project site through the off-site acquisition and restoration of approximately 100,492 ac of habitat used by the panther (Figure 8) (Analyses for Effects of the Action). CERP's ecosystem approach to habitat restoration and preservation will provide long-term net benefits to the Florida panther.

The Use of Best Scientific and Commercial Information by the Service

The Service uses the most current and up-to-date scientific and commercial information available. The nature of the scientific process dictates that information is constantly changing and improving as new studies are completed. The scientific method is an iterative process that builds on previous information. As the Service becomes aware of new information, we will ensure it is fully considered in our decisions, evaluations, reviews, and analyses as it relates to the base of scientific knowledge and any publications cited in our documents.

Specifically, there is one such document cited in this Biological Opinion the Service acknowledges has been affected in its cited form by new scientific information. The Service has taken these new sources of information into account when using this document to help guide our analysis and decisions. This document is the South Florida Multi-Species Recovery Plan (MSRP) of 1999 (Service 1999). In addition, the Service has examined Kautz et al. (2006) for its

scientific validity, specifically with regards to comments and recommendations by other reviewers.

South Florida Multi-Species Recovery Plan

The MSRP was designed to be a living document and it was designed to be flexible to accommodate the change identified through ongoing and planned research and would be compatible with adaptive management strategies. These principals are set forth in both the transmittal letter from the Secretary of the Interior and in the document itself. As predicted, this is what indeed occurred in the intervening years since the MSRP was published. The Service uses the MSRP in the context it still presents useful information when taken in conjunction with all the new scientific information developed subsequent to its publication.

Kautz et al. (2006)

The Florida Panther Subteam was charged with developing a landscape-level strategy for the conservation of the Florida panther population in south Florida. The Subteam produced the draft Landscape Conservation Strategy for the Florida Panther in South Florida in December 2002 and provided it to the Service. Upon receipt, the Service began to use the information in the draft Landscape Conservation Strategy in its decision making processes and documents since it was part of the best scientific information available to the Service at the time. Since then some portions of the science and findings in the draft Landscape Conservation Strategy have been challenged. Many, but not all, of the Subteam members have refined the methodology, further analyzed the data, and better defined the results of the Landscape Conservation Strategy into the publication, referred to here as Kautz et al. (2006). Therefore, Kautz et al. (2006) and the analyses contained therein, along with all other best scientific and commercial data available, is referred to in this document and will be used in our decision making process until or unless new information suggests revisions are necessary.

Consultation History

The Service received a Phase I and II environmental Assessment Report for the Berry Labelle-Congen Grove dated December 6, 1999.

In response to the Corps' February 25, 2002, request, the Service provided information on fish and wildlife resources included federally-listed species that may be within the proposed reservoir locations or affected by the activities of the C-43Basin Storage Reservoir in our April 11, 2002, Planning Aid Letter (PAL). The site-selection sub-team used this information guide the site selection process by focusing on suitable reservoir locations that would minimize impacts to fish and wildlife resources.

On March 20, 2003, site selection sub-team led by the Service, presented new updated preliminary site locations for potential reservoirs in the Caloosahatchee Basin overlayed on various GIS cover type maps.

On March 31, 2003, the Service met with Jim Beever (FWC) and Sandy Scheda (SEA) to review the new reservoir location maps and to apply the matrix to the revised map. Two sites dropped out due to conflicts with panther habitat, specifically, the Caloosahatchee escoscape.

The Service assisted the Corps by providing listed species maps within Caloosahatchee Basin for use in the reservoir siting process and explained these maps at an Environmental Stakeholders meeting on April 30, 2003 and public meeting on May 1, 2003.

In a letter dated May 19, 2003, the Service provided comments on the March 3, 2003, Phase I and II Environmental Site Assessment for the Griffin Brothers property. In that letter, the Service recommended further delineation of pentachlorophenol (PCP) in the canal in the vicinity of the S5 sample location.

The Service provided scoping comments under the National Environmental Policy Act (NEPA) for development of the Draft Environmental Impact Statement for the C-43 Basin Storage Reservoir Project, including information on federally-listed species that may be affected by the proposed project.

The Service provided information on listed species distributions to Alternative Selection sub-team on June 13 and June 26 to refine the list of potential reservoir locations in the Caloosahatchee Basin.

On July 14, 2003, the Service provided comments on the March 25, 2003, Phase I and II Environmental Site Assessment for the Winthrop Citrus Investors property (Winthrop property). In that letter, the Service recommended delineation of aldrin contamination.

The Service provided additional information on direct and indirect impacts to significant fish and wildlife resources in the project area in an August 13, 2003, PAL. That letter addressed wetland and upland habitats of significant importance, federally-listed species, and potential contaminant issues.

On March 31, 2004, the Service received a proposal for the Phase I and II Environmental Site Assessment for the Brian Paul Citrus Grove. The Service requested that zinc be added to list of metals analyzed via an April 8, 2004, email.

Service, Corps, and District staff conducted wetland assessments (Wetland Rapid Assessment Procedure and Uniform Mitigation Assessment Method) of Berry Groves and other potential reservoir sites in the Caloosahatchee River Basin. Ground surveys were conducted on June 8, 9, and 10, 2004, followed by aerial surveys on June 14 and 15, 2004.

Service, Corps, and District staff completed ground and aerial wetland assessment (Wetland Rapid Assessment Procedure and Uniform Mitigation Assessment Method) at Berry Groves July 13, 14, and 15, 2004.

The Service reviewed additional information provided by Environmental Consulting and Technology, Incorporated, (ECT) regarding aldrin contamination on the Winthrop property and agreed in a July 1, 2004, letter, that no further aldrin delineation was necessary.

Service staff met with SFWMD, FWC, and Scheda Ecological Associates on July 20, 2004, to discuss the boundary change for the Berry Groves reservoir. Due to the change in the project boundary, additional consultation on potential project impacts to federally-listed species, including the Florida panther, Audubon's crested caracara, Everglades snail kite, wood stork, and Florida grasshopper sparrow, will be necessary. The southern boundary was expanded to include Duda property in the southwest and southeast corners. The southeast corner contains pine flatwoods, cypress slough, saw palmetto, and lightly wooded pasture that was previously farmed. That area has also been identified as Primary and Secondary Zones for the panther.

Additional information on PCP contamination on the Griffin Brothers property was provided by the District via an August 11, 2004, letter, prepared by ECT. Based on that information, the Service agreed no further delineation of PCP was needed in an October 13, 2004, letter.

On August 17, 2004, the Service received the Phase I and II Environmental Site Assessment report for the Bryan Paul Citrus Grove. In our September 20, 2004, letter, the Service requested further evaluation and remediation for Chlordane. Additional information regarding our letter was provided by Tetra Tech on December 22, 2004.

On December 1, 2004, ECT recommended further delineation of chlordane on the Bryan Paul Citrus Grove in their Screening Level Ecological Risk Assessment for that site.

The Service reviewed and provided comments via a January 25, 2005, email on the November 17, 2004, proposal for the Phase I and II Environmental Site Assessment for the Bob Paul Citrus Grove. The Service requested complete sampling in the former row crop area.

On February 3, 2005, Service staff met with FWC staff to discuss fish and wildlife resource concerns associated with the C-43 West Reservoir location and the remaining potential alternatives.

On March 22, 2005, the Service held an interagency meeting at the District office in Fort Myers to discuss potential project impacts on federally and State-listed species. Representatives from the District, Corps, FWC, and the Service's Vero Beach office were in attendance. The discussion focused primarily on the accelerated C-43 West Reservoir component but also applies to the selected alternative plan that will be addressed in the Corps' Project Implementation Report.

On March 29, 2005, Service staff provided a PAL recommending that the Corps and the District design the C-43 West Reservoir to provide water quality benefits by reducing nutrient loads in accordance with CERP Guidance Memorandum Number-Revision 023.01. That letter also included information regarding federally-listed species in the Caloosahatchee estuary.

On May 5, 2005, the Service received the April 29, 2005, draft scope of work for the C-43 West Storage Reservoir Temporary Test (Embankment) Cells from the District.

On May 26, 2005, Service staff met with the Corps, District, SCI, FWC, and SEA to discuss potential adverse effects to threatened and endangered species that may occur as a result of the C-43 West Reservoir Project or the Test Cell Project. The meeting focused on: 1) the latest method for assessing habitat compensation recommended when adverse project effects to habitat used by the Florida panther cannot be avoided or when adverse effects have been minimized but loss will still occur; and 2) the Test Cell Project design, 404 permit needs, and listed species consultation.

On June 27, 2005, the Corps conducted an interagency site visit to delineate wetland boundaries and assess current conditions within the Test Cell Project footprint. Service, District, SCI, and SEA staff participated in the site visit.

On July 1, 2005, the Service provided comments on the May 27, 2005, Phase I and II Environmental Site Assessment for the Bob Paul Citrus Grove. In that letter, the Service recommended that the District consult with DEP regarding on-site burial of contaminated soil.

On July 25, 2005, the Corps issued a Public Notice for permit application SAJ-2005-5958 (IP-TKW) indicating the District applied for a permit to construct two temporary test cells within the proposed 11,000-acre footprint of the C-43 West Storage Reservoir. The proposed Test Cell Project would dredge, fill, or flood 4.5 acres of jurisdictional wetlands and 24.5 acres of "other surface waters." To mitigate for wetland impacts, the applicant has proposed to include wetland features in the C-43 West Reservoir design and/or other Acceler8 projects. They also requested the Corps to considered downstream environmental benefits that will result from construction and operation of the C-43 West Storage Reservoir during their project evaluation.

On July 28, 2005, Service staff met with the District, Corps, EPA, FDACS, and SEA staff to review and finalize WRAP scores for the wetlands occurring within the Test Cell Project footprint.

On July 29, 2005, the Service received the draft Biological Assessment prepared by SEA for the Test Cell Project via email.

On August 5, 2005, the Service emailed informal comments on the draft Biological Assessment to the District.

On August 19, 2005, the Corps submitted the final Biological Assessment for the Test Cell Project to the Service with a letter of the same date. In the that letter, the Corps determined that the Test Cell Project will have "no effect" on the West Indian manatee, and "may affect, but is not likely to adversely affect" the bald eagle, Audubon's crested caracara, Everglade snail kite, eastern indigo snake, and wood stork. The Corps also provided a "may adversely affect" determination for the endangered Florida panther and requested the Service initiate formal consultation.

On August 29, 2005, the Service telephoned and emailed the Corps requesting additional information necessary to evaluate project effects to the Florida panther.

Service attended a November 9, 2005, interagency meeting to discuss preliminary designs to incorporate littoral zones for fish and wildlife habitat adjacent to the seepage canal bordering the C-43 West Reservoir. Designs will be further developed by SEA and distributed to the group for review. The extent of wetland acreage is much smaller than originally discussed (*i.e.*, total is less than 30 acres) and will be spaced every 500 feet between areas reserved for potential ASR wells. The littoral zones will be used as compensation for the loss of wood stork foraging habitat as result of the Test Cell project.

On November 9, 2005, the District provided the additional information necessary to evaluate project effects to the panther to the Service, including information on living radio-collared panthers with home ranges overlapping the project area, locations of known panther vehicle collisions within the project area, and surrounding land use and permitted projects in the Test Cell Project area.

On November 18, 2005, the Service requested the District to provide information on state and local land acquisitions in the Test Cell project action area from 1999 to present via email.

The District provided the information on state and local land acquisitions in the project area on November 18, 2005, via email.

On November 30, 2005, the Service completed formal and informal consultation on the Test Cell project via a letter and accompanying Biological Opinion addressing project effects on the Florida panther.

The Service received a December 28, 2005, Closure Assessment Report on contaminants for the Griffin Brothers property.

On January 3, 2006, the Service email to Corps and District regarding follow up on the Test Cell project 404 permit and T&E educational materials; caracara and indigo snake surveys for the full reservoir footprint; and the design, location, and acres of littoral zones and other fish and wildlife features.

The Service met with the SFWMD and the Corps on the February 6, 2006, to review the March 28, 2005, draft Fish and Wildlife Recommendations for Comprehensive Everglades Restoration Plan (CERP) Stormwater Treatment Area and Reservoir Operation and Design developed by the Service and the Fish and Wildlife Commission and discuss incorporating those recommendations in the design of the 10,000-acre C-43 West Reservoir. The District will not incorporate any of those recommendations in the reservoir design that might encourage birds to nest in the vicinity. Additionally, the interior slopes of the reservoir levees will be lined with a concrete soil mixture to prevent erosion, reduce seepage, and increase levee stability. The current reservoir design does include construction of 9 to 28 acres of shallow wetland habitat adjacent to the seepage canal that

will be constructed 80 to 100 feet from the outside perimeter of the reservoir. Any existing canals and new borrow pits/canals dredged during levee construction will not be filled to provide deep water habitat for fish during periods of drought or when the reservoir is drawn down.

The Service received an informal summary of the first caracara surveys conducted by SEA in compliance with our survey protocol on March 6, 2006, via email and a formal Memorandum summarizing that first survey on March 22, 2006.

The Service received a formal Memorandum summarizing the second caracara surveys conducted by SEA in compliance with our survey protocol via email on March 24, 2006.

On March 30, 2006, Service staff participated in the third caracara surveys conducted by SEA and received a Memorandum summarizing those surveys via email on April 10, 2006.

The Service received the March 31, 2006, Work Plan for Additional soil Investigations to delineate chlordane contamination on the Bryan Paul Citrus Grove. The Service concurred with the work plan via an April 4, 2006, email.

By letter dated April 18, 2006, the Service provided comments on the October 13, 2003, Ecological Risk Assessment for the Berry Labelle-Congen Grove. In that letter, the Service recommended remediation of areas known to be contaminated with copper and that additional soil sampling for copper be conducted.

On April 24 and 25, 2006, the Service attended the C-43 West Reservoir Critical Criteria Meeting in Labelle, Florida. On April 25, 2006, a breakout session was held to review information needs for upcoming permit applications, including information on federally-listed species. Reservoir fill rates protective of indigo snakes recommended for other CERP projects (*i.e.*, C-44) were discussed. The District indicated that those rates were acceptable and that they probably couldn't fill the reservoir faster anyway.

On April 26, 2006 and May 15, 2005, the Service provided information to the Corps and District via email, on the need for and appropriate methodology to conduct panther prey surveys to adequately address project impacts and associated habitat loss to the Florida panther.

The Service held and internal meeting on May 24, 2006, in Vero Beach, Florida, on Eastern Indigo Snake section 7 consultation issues.

Service staff reviewed and provided comments on Acceler8's preliminary design for the C-43 West Reservoir Design. Comments and recommendations included: development of 3 sets of operating criteria for the reservoir based on current conditions and predicted long-term climatological conditions such as drought, normal, and above average rainfall years; ensure manatee protection measures will be incorporated in design of all water control structures where necessary; ensure inclusion of Indigo snake protection measures in construction contracts; potential decreased surface water elevations in wetlands southwest of the project area in primary panther habitat indicated by preliminary model results need to be evaluated in more detail; and to

ensure that current proposed recreation plans for the project area do not conflict with project goals.

The Service reviewed the July 21, 2006, Additional Soil Assessment Report for the Bryan Paul Citrus Grove. Chlordane contamination was identified to be within a 20-acre area. The Service concurred with the 18ug/kg target clean-up level for chlordane in our August 9, 2006, letter.

The Service provided comments on the Additional Soil Investigations, Berry Labelle-Congen Groves report submitted to the District by URS Corporation by letter dated July 26, 2006. In that letter, the Service recommended that further sampling be conducted to accurately delineate the spatial extent of copper contamination and that soil remediation be considered for grids 56 and 145.

On August 14, 2006, Service staff participated in an interagency (Corps, District, Service, and EPA) helicopter survey of the Caloosahatchee River basin and estuary to assess basin-wide project benefits for the Corps' mitigation ledger.

The Service provided comments on the July 20, 2006, document titled "Additional U.S. Fish and Wildlife Service Soil Investigations, Berry Labelle-Congen Groves" in a September 14, 2006, letter. In that letter, the Service concurred that copper contamination was adequately delineated and that grids 56, 58, 124, 125, 134, 135, and 143 require remediation.

On October 30, 2006, the Service responded to the Response to Corps' October 27, 2006 email regarding section 7 consultation process and keeping the Corps' C-43 West Reservoir Project Implementation Report and the District's Acceler8 C-43 West Storage Reservoir project on the same timeline with one consultation. The Service reiterated that formal consultation would be needed for three species, the caracara, indigo snake, and panther, and requested advanced review of the Biological Assessment before the Corps requested formal consultation.

The Service reviewed and provided comments to the Corps on the Draft Biological Assessment for the C-43 West Storage Reservoir Project, Hendry County, Florida on November 9, 2006.

On November 10, 2006, the Corps submitted the Service's and the Corps' comments submitted to the District.

The Service received combined Department of Army and state of Florida Environmental Resource Permit Application for C-43 project on November 20, 2006.

On December 1 and 7, 2006, the Corps and Service discussed the timing of the initial tree clearing on the project site via email. The District has proposed to clear existing citrus trees onsite after completion of section 7 consultation but prior to 404 permit issuance. They have proposed to avoid wetlands during the initial clearing. We also discussed project effects on snail kites as a result of copper contamination. If no additional copper has been applied to the project area and copper remediation occurs on the grids identified in our September 14, 2006, letter, then the project is probably not likely to adversely affect snail kites.

Via January 10, 2007, email correspondence, the Service reviewed the Corps' preliminary C-43 project effects determinations for listed species and identified information needed to complete consultation on manatees, including effects of reservoir operations.

The Service received a letter and a Biological Assessment from the Corps of Engineers on January 12, 2007, requesting initiation of formal consultation on the C-43 West Reservoir Project.

Service staff reviewed the information provided and requested additional information pertaining to consultation for wood storks and snail kites during a January 24, 2007, telephone conversation and by email on January 30, 2007.

The Service met with the Corps of Engineers and South Florida Water Management District on February 7, 2007, to discuss outstanding threatened and endangered species issues and additional information needed for consultation on wood storks, snail kites, caracara, and manatees; and information regarding potential project impacts to upstream wetlands in the vicinity of the Spirit-or-the-Wild Wildlife Management Area and the Okaloachoochee Slough State Forest and Wildlife Management Area.

Service staff conducted two site visits, February 7 and 8, 2007, to determine if the caracara territory and nest site off State Road 80 is active this year. A pair of caracaras were observed perched near the nest tree used last year. Although the territory is occupied, no nesting activity was observed.

The Service participated in the February 21, 2007, interagency site visit to evaluate wetlands and potential wood stork foraging habitat within the C-43 West Reservoir footprint.

On February 23, 2003, the Corps inquired through email correspondence if changes in the Service's Florida panther consultation area would change consultation needs for the C-43 West Reservoir project. The Service confirmed that compensation for project effects to panther habitat would still be needed.

Information presented during a March 6, 2007, C-43 West Reservoir Project Delivery Team meeting in LaBelle, Florida, included an access road parcel that was not included in the Biological Assessment or consultation initiation package. Through email correspondence on March 8, 2007, the Service requested that more information on that parcel be provided including size, preliminary site plan, and potential habitat alterations. The Service also requested more information on the pump stations and manatee excluders.

The Service received additional information requested from the Corps in a March 26, 2007, letter. The information provided included information on wood stork foraging habitat, copper applications and remediation in the project footprint, wetland impacts, manatees, and additional impacts to panther and caracara habitat associated with the access road parcel. Upon receipt of this information, the Service initiated formal consultation under section 7 of the Act.

Service staff met internally with our caracara species lead on April 14, 2007, to discuss C-43 West Storage Reservoir impacts to caracara habitat, estimating take, potential compensation for habitat loss and monitoring needs.

The Service met with the Corps and District on May 15, 2007, to discuss outstanding threatened and endangered species issues in order to complete informal and formal consultation on the effects of the C-43 project. Outstanding issues included incorporation of CERP Thermal Guidelines in Manatee-Accessible Waters in the project monitoring plan, compensation for impacts to wood stork foraging habitat, and compensation for impacts to crested caracara habitat. The Service attended the May 17, 2007, public meeting in LaBelle, Florida, on the C-43 West Storage reservoir project. The public asked questions regarding the status of endangered species consultation for the project.

The Service received and email on May 18, 2007, from the Corps committing to a monitoring and research project as compensation for impacts to caracara resulting from the proposed reservoir, and committing to using the Corps existing volunteer manatee observer program for the Okeechobee Waterway for manatee observations for the C-43 reservoir project as discussed during the May 15, 2007, meeting.

On May 22, 2007, the Service met with the Superintendent of Duda Farms and their consultant to confirm the location of the caracara nest on Duda property southeast of the reservoir.

In response to an information request made by telephone, the Service received additional information on the trash rake systems that serve as manatee excluders at the pump stations via a May 23, 2007, email. In response to that request, the Service also received information on the elevations of the Townsend Canal and the reservoir intake canal via an email dated May 24, 2007.

The Service sent the draft manatee section of the concurrence letter for the proposed project to the Corps, District, FWC, and other Service staff to review on May 24, 2007.

The Service received information on the construction schedule for the proposed project from the District via email on May 24, 2007.

On May 30, 2007, the Service received comments on the draft manatee section of the concurrence letter for the proposed project from the Corps and District via separate emails. The District did not agree with some of the project modifications to prevent harm to the manatee associated with the CERP Thermal Guidelines in Manatee-Accessible Waters.

The Service provided a map of the confirmed caracara nest location on private property southeast of the project area to the District via email on June 1, 2007.

On June 4, 2007, the Service requested updated habitat acres by Florida Land Use, Cover and Forms Classification System (FLUCCS) within the C-43 reservoir footprint. The Public Notice

identified a total of 10,492 acres within the reservoir footprint and the BA identified 10,361 acres within the reservoir footprint.

The Service held a conference call with the Corps and District on June 5, 2007, to discuss the outstanding issue regarding incorporation of CERP Thermal Guidelines in Manatee-Accessible Waters in the project design and monitoring plan. Both operational and structural modifications to the reservoir project were discussed.

The Service received the Intermediate Design Report (*i.e*, 60 percent design) via overnight mail on June 7, 2007, and the associated design plans on June 8, 2007.

On June 7, 2007, another interagency conference call was held to discus the thermal guidelines for manatees. The District obtained temperature data for the Townsend Canal and the Caloosahatchee River in the vicinity of the Townsend Canal from the Florida Department of Environmental Protection and provided that data as well as temperature data from the Test Cell project to the participants on the conference call.

On June 7, 2007, the Service and FWC further developed monitoring protocol to define what constitutes a shift in manatee distribution as a result of warm-water discharges into the Townsend Canal.

Through email correspondence on June 7, 2007, the Corps and the Service agreed to further discuss ways to prevent potential cold stress to manatees as a result of reservoir releases during the winter including replacing the weir at the Townsend and Caloosahatchee River. Two conference calls were held on June 13 and 14, 2007, to discuss what the potential impacts to manatees are related to thermal stress and potential barriers or other solutions that could prevent the situation from occurring.

On June 8, 2007, the Service received additional temperature data from the District for Test Cell 2 which was not included in the data provided on June 7, 2007, and the raw data provided to the District from DEP. DEP provided shapefiles of the water quality station locations via email.

On June 11, 2007, the Service received updated habitat acreages by FLUCCS code within the reservoir footprint and data on state acquisitions with 25 miles of the project footprint.

On June 11, 2007, the Service received temperature data for the Townsend Canal and Caloosahatchee River from the DEP. They searched the STORET database and the IWR database. The two datasets were essentially the same.

The Corps, EPA and the Service participated in a teleconference on June 12, 2007, to finalize the Uniform Mitigation Assessment Method Scores for the Caloosahatchee River and estuary and the tapegrass beds in the upper Caloosahatchee estuary that will be used for mitigation for on-site wetland impacts and compensation for the loss of on-site wood stork foraging habitat.

The Service provided bar graphs of temperature data and monthly flow comparison data developed by the District, and a spread sheet of temperature data provided by DEP and a map of the station locations to the Corps and FWC for review for the June 13 and 14, 2007, teleconferences referenced above.

The Service confirmed the reservoir fill rate that would reduce take of indigo snakes and reduce negative impacts to other wildlife species via email on June 14 and 15, 2007.

On June 15, 2007, Service contaminants staff reiterated that the copper remediation of all impacted grids in the reservoir footprint to less than 85 ppm will be protective of snail kites and other species, including the indigo snake, via email.

On June 20, 2007, the Service, Corps and District held a conference call to discuss a timeline for resolving the outstanding manatee issues. The Corps and District are researching appropriate weirs or gates that would serve as a barrier to prevent manatee access to the Townsend Canal while still achieving desired flow rates through the canal. The Corps requested more time to research barriers and develop cost estimates for construction and operation and maintenance of a structure. They requested we reach a resolution by August 1, 2007.

On June 20, 2007, the Service requested that the District provide updated habitat acreages by FLUCCS code within the reservoir footprint that was consistent with the jurisdictional wetland data and 10,492-acre reservoir footprint referenced in the Corps' Public Notice. That data was provided via email on June 20, 2007.

On June 21, 2007, the Service requested that the District provide information on cumulative panther habitat impacts (*i.e.,* Developments of Regional Impact, Planned Unit Developments, and South Florida Water Management District Environmental Resource Permits) in a concise manner that could easily be interpreted and used for the analyses in the Biological Opinion and that is consistent with our standard request for additional information for panther consultations.

On June 22, 2007, the Service provided a draft Biological Opinion to the Corps and the District for review.

The district provided information on a potential manatee barrier for the Townsend Canal and the associated cost to the Service and the Corps on June 25, 2007.

On July 3, 2007, the Service received comments from the District on the June 22, 2007, draft Biological Opinion. The District identified concerns regarding the manatee thermal guidelines; the recommended reservoir filling rates for the initial fill and subsequent rehydration events to protect indigo snakes; and the timing, duration, and site access for the caracara research and monitoring plan.

On July 10, 2007, the Service participated in an interagency conference call to discuss construction of a manatee barrier at the confluence of the Townsend canal and the Caloosahatchee River and temperature and manatee monitoring needs.

On July 10, 2007, the Service received information from the District on proposed volumetric reservoir filling rates instead of manually monitoring the depth as the reservoir is filled.

On July 11, 2007, the Service held an internal conference on manatee monitoring needs and the Service and the Corps agreed to a manatee monitoring plan to address the CERP manatee thermal guidelines.

On July 12, 2007, the Service received the revised data for the cumulative effects analyses for the Florida panther.

On July 13, 2007, the Service held an interagency conference call to discuss the District's concerns: the District and Corps agreed to install a barrier to prevent manatee access to the Townsend canal during the winter period; modifications to the temperature monitoring and manatee observation plan were discussed; the volumetric curves and reservoir fill rates were discussed, including the length of time to fill the reservoir at the ½ inch per day rate for the first 6 inches; and the site access, timing, and duration of caracara research and monitoring plan were discussed.

On July 16, 2007, the Service held an internal conference on indigo snakes and the volumetric fill data provided by the District on July 10, 2007.

On July 17, 2007, the Service requested additional information on filling the reservoir at 3 inches and 6 inches per day including the incremental fill times and plots of areas flooded at each interval.

On July 19, 2007, the District provided the incremental fill times and plots of the area flooded at each interval for a fill rate of 1 foot per day. The 1 foot per day was used due to the time needed to generate the plots at the slower pumping rates. Based on this information, the Service recommended an initial fill rate of 6 inches per day and a rehydration rate of 1 foot per day. The Service also recommended inclusion of an indigo snake monitoring plan to determine the effect of rehydration on snakes and the extent of their use of the reservoir during drawdown events.

On July 20, 2007, the service participated in an interagency teleconference to confirm acceptance of the fill rates and monitoring recommendations for indigo snakes.

The Service has reviewed all information received pertinent to the Florida panther, the crested caracara, and the indigo snake for the C-43 West Storage Reservoir project and concurs with the Corps' determination that this proposed project "may affect and is likely to adversely affect" the Florida panther, the crested caracara, and the indigo snake. As of March 26, 2007, the Service received all information necessary for initiation of formal consultation on the Florida panther, the crested caracara, and the indigo snake for this project as required in the regulations governing interagency consultations (50 CFR § 402.14). The Service is providing this Biological Opinion in conclusion of formal consultation.

BIOLOGICAL OPINION

DESCRIPTION OF PROPOSED ACTION

Proposed Action

The C-43 West Storage Reservoir project is a component of CERP and is included in the Band 1/Acceler8 Projects. The overall purpose of the CERP is to restore the Everglades ecosystem and species assemblages. Together, implementation of the CERP and Acceler8 is expected to provide large-scale, long-term benefits to the ecosystem and listed species, though individual actions may result in smaller-scale or short-term adverse effects to one or more listed species. The C-43 West Storage Reservoir project is located in portions of Sections 31 through 36, Township 43 South, Range 28 East; Sections 6 and 31, Township 43 South, Range 29 East; and Sections 1 through 12, Township 44 South, Range 28 East, Hendry County, Florida (Figure 1).

According to the DPIR/EIS and PN, the Corps and District propose to construct an approximately 10,492-ac above-ground reservoir surrounded by a perimeter embankment and canal. Reservoir access and recreational facilities will be located within an adjacent 110-ac access road parcel (Figure 1). The proposed project is designed to pump water from the Caloosahatchee River into the proposed reservoir via the Townsend Canal and capture basin runoff from the Townsend Canal, store water in the reservoir to reduce damaging high freshwater flows to the Caloosahatchee Estuary, and discharge water back to the Caloosahatchee River via the Townsend Canal to augment low flow events during the dry season and maintain a minimum flow of 450 cfs at S-79. The reservoir will consist of two cells capable of storing a total of 170,000 acre-feet of water at an approximate depth of 20 ft. Major features of the proposed project are described in Section 7 and Appendix A of the DPIR and include (Figure 9):

- 16.3 miles of external (dam) embankments varying in height between 27 and 38 ft above the existing grade;
- Soil-Bentonite slurry walls within and beneath the external embankments;
- 2.8 miles of internal (dam) embankment separating the two cells with an approximate height of 31 ft above existing grade;
- An inflow pump station (C43PS-1) consisting of four diesel-powered pumps with a total pumping capacity of 1,500 cfs (i.e., two 500 cfs pumps and two 250 cfs pumps);
- 14.7 miles of perimeter canal;
- A perimeter canal pump station consisting of electric-powered pumps with a total pumping capacity of 195 cfs (i.e., three pumps of 65 cfs);
- Numerous spillways, culverts, and perimeter canal structures; an internal cell balancing structure; and outlet structures; and
- Two discharge structures (C43S-1 and C43S-8) each with a discharge capacity of 500 cfs.

Water control structures C43S-16, C43S-17, C43S-18, and C43S-19 were included in the DPIR but have since been removed from the C-43 West Storage Reservoir project and are not included in the District's Corps permit application.

The C-43 West Storage Reservoir project site contains a total of 10,602 ac, including the reservoir footprint and access road parcel, currently under active citrus production. Land use and cover consists primarily of agricultural land and associated roads and other urban lands (9,540.7 ac). Jurisdictional wetlands and waters of the United States (US) cover 1,061.3 ac of the project site and include 934.6 ac of man-made agricultural ditches and canals used for irrigation and drainage conveyances for the citrus operations and 126.7 ac of jurisdictional wetlands (Figure 4).

Approximately 267 ac within the C-43 West Storage Reservoir project area were previously impacted during construction of the C-43 West Reservoir Test Cell project (Test Cell project), including 29 ac of jurisdictional wetlands and waters of the US (Figure 4). The Test Cell project was constructed to evaluate the on-site seepage potential and effectiveness of seepage control measures, the suitability of on-site materials for embankment construction and slope protection, and the effects of water residence time and seepage on water quality. That project included two 500-foot by 500-foot test cells with offset seepage canals, a borrow area, settling ponds, and staging areas and was authorized under DA Permit number 2005-6598 (IP-TKW) issued December 6, 2005. Impacted jurisdictional areas included 1.9 ac of excavated open-water, 4.5 ac of wet prairie, and 26.0 ac of tertiary, agricultural drainage canals.

The Service understands that the Corps will account for the unavoidable adverse impacts to wetlands and other aquatic resources resulting from both he C-43 West Storage Reservoir project and Test Cell project in an Acceler8 system-wide mitigation ledger. As described in the Corps' PN, that ledger includes accounting for system-wide interdependencies and watershed benefits of the District's Acceler8 projects (*i.e.*, Band 1 projects) in satisfying the regulatory mitigation requirements for wetland and other aquatic resource impacts resulting from construction of individual Acceler8 projects. The Corps is using the UMAM to assess the function and value of aquatic resources adversely impacted by construction of the C-43 West Storage Reservoir and Test Cell projects and to assess the anticipated environmental lift to the Caloosahatchee estuary as a result of implementation of the proposed project and remaining Acceler8 projects.

Although not considered as compensatory mitigation, the proposed C-43 West Storage Reservoir project incorporates features that will enhance fish and wildlife habitat. The existing agricultural canals and interior borrow areas excavated for fill material will provide deep-water refugia for fish and other aquatic organisms within the reservoir during drawdown conditions. The exterior face of the external embankments will be planted and maintained as grass. However, the interior face of the external embankments will be covered in concrete to reduce erosion potential and will not possess a vegetated littoral area. The perimeter canal will include approximately 109 ac of littoral zones to provide foraging and nursery habitat for aquatic fauna (*e.g.*, wading birds, fish, herpetofauna, etc.). Also, portions of the test cell embankments will be left in places to provide roosting habitat for birds, turtles, and other fauna when the reservoir is full.

The C-43 West Storage Reservoir will result in the direct loss of 10,602 ac of habitat suitable for foraging and dispersal by the Florida panther (see discussion under Wildlife Assessment), of which 267 ac were already compensated for under formal consultation for the Test Cell project (DA Permit 2005-6598 [IP-TKW]). The remaining habitat loss (*i.e.*, 10,335 ac) represents

19,438 PHUs with a recommended compensation of 46,933 PHUs (see discussion under Habitat Assessment Methodology). The project overlaps with the Service's Panther Focus Area (Figure 7) for the Florida panther and contains both Florida panther Primary and Secondary habitat (Kautz et al. 2006) (Figure 10).

The District will provide compensation for loss of the remaining 10,335 ac of low quality habitat used by the panther through the acquisition and restoration of approximately 59,294 ac of habitat used by the panther in the Primary Zone and approximately 41,198 ac in the Other Zone through the implementation of Acceler8 Projects under CERP. This gain equates to over 548,000 functional units of habitat used by the panther (see definition in the Effects of the Action). The Acceler8 Projects proposed for compensation will consist of bottomland hardwoods, freshwater marshes, hardwood swamps, cypress swamps, and other wetland habitats. The majority of compensation areas are also surrounded by other Primary Zone habitat used by the panther and protected conservation lands that are used by the Florida panther (Figure 8).

Action Area

The CERP implementation area in South Florida overlaps the Service's Panther Focus Area for the Florida panther (Figure 8). The Panther Focus Area includes lands in Charlotte, Glades, Hendry, Lee, Collier, Palm Beach, Broward, Miami-Dade, and Monroe Counties, as well as the southern portion of Highlands County (Figure 8). Developed urban coastal areas in eastern Palm Beach, Broward, and Miami-Dade Counties, and in western Charlotte, Lee, and Collier Counties were excluded because they contain little or no panther habitat and it is unlikely that panthers would use such areas.

Movements of Florida panthers are much larger than the project site and, therefore, the Service's action area is larger than the proposed action area identified by the Corps' public notice. The action area, which is a subset of the current panther range, includes those lands where the Service believes panthers may experience direct and indirect effects from the proposed development. Maehr et al. (1990a) monitored five solitary panthers continuously for 130-hour periods seasonally from 1986 to 1989, rarely observing measurable shifts in location during the day, but nocturnal shifts in location exceeding 20.0 kilometers (km) (12.4 miles) were not unusual. Maehr et al. (2002a) in a later report documented a "mean maximum dispersal distance" of 68.1 km (42.3 miles) for subadult males and 20.3 km (12.6 miles) for subadult females. In the same report Maehr et al. (2002a) documented a "mean dispersal distance" of 37.3 km (23.1 miles) for subadult males. Comiskey et al. (2002) documented a "mean dispersal distance" for subadult male panthers as an average distance of 40.1 km (24.9 miles) from their natal range, which is similar to the dispersal distance referenced by Maehr et al. (2002a).

Therefore, for both direct and indirect effects, the Service defined the action area (Figure 11) as all lands within a 25-mile radius of the C-43 West Storage Reservoir project, which is slightly greater than the mean dispersal distance for subadult males. This action area does not include urban lands or lands west of I-75. This action area includes areas anticipated to sustain direct and indirect effects, such as roadways experiencing increased traffic, areas with increased human

disturbance (project area and periphery of project), and areas in which habitat fragmentation and intraspecific aggression may be felt.

The CERP planning area overlaps the action area defined above for this consultation, as well as the Service's Panther Focus Area for the Florida panther (Figure 8) and the area currently used by the panther, and therefore, the CERP implementation will affect the Florida panther and habitat used by the panther. Though the overall purpose of the CERP is to restore the Everglades ecosystem and species assemblages, not all projects will benefit Florida panthers or all federally listed species. Implementation of the suite of Band1/Acceler8 projects is, however, likely to provide direct and indirect beneficial effects to the natural ecosystems and native species communities in the Everglades landscape within the area currently used by the Florida panther resulting in a net positive balance for Florida panthers.

STATUS OF THE SPECIES AND CRITICAL HABITAT RANGEWIDE - Florida Panther

Status - Panther Biology and Ecology

The Florida panther is the last subspecies of *Puma* (also known as mountain lion, cougar, painter, or catamount) still surviving in the eastern United States. Historically occurring throughout the southeastern U.S. (Young and Goldman 1946), today the panther is restricted to less than 5 percent of its historic range in one breeding population of less than 100 animals located in south Florida.

When Europeans first came to this country, pumas roamed most all of North, Central, and South America. Early settlers attempted to eradicate pumas by every means possible. By 1899, it was believed that Florida panthers had been restricted to peninsular Florida (Bangs 1899). By the late 1920s to mid 1930s it was thought by many that the Florida panther had been completely eliminated (Tinsley 1970). In 1935, Dave Newell, a Florida sportsman, hired Vince and Ernest Lee, Arizona houndsmen, to hunt for panthers in Florida. They killed eight in the Big Cypress Swamp (Newell 1935). Every survey conducted since then has confirmed that a panther population occurs in southern Florida south of the Caloosahatchee River, and no survey since then has been able to confirm a panther population outside of southern Florida.

Attempts to eradicate panthers and a decline in panther prey, primarily white-tailed deer (*Odocoileus virginianus*), resulted in a panther population threatened with extinction. Prior to 1949, panthers could be killed in Florida at any time of the year. In 1950, the Florida Game and Freshwater Fish Commission (now the Florida Fish and Wildlife Conservation Commission [FWC]) declared the panther a regulated game species due to concerns over declining numbers. The FWC removed panthers from the game animal list in 1958 and gave them complete legal protection. On March 11, 1967, the Service listed the panther as endangered (32 FR 4001) throughout its historic range, and these animals received Federal protection under the passage of the Act in 1973. In addition, the Florida Panther Act (State Statute 372.671), a 1978 Florida State law, made killing a panther a felony. The Florida panther is listed as endangered by the States of Florida, Georgia, Louisiana, and Mississippi.

Since the panther was designated as an endangered species prior to enactment of the Act, there was no formal listing package identifying threats to the species as currently required by section 4(a)(1) of the Act. However, the technical and agency draft of the Florida Panther Recovery Plan, third revision, addressed the five factor threats analysis (Service 2006). No critical habitat has been designated for the panther.

Taxonomy

The Florida panther was first described by Charles B. Cory in 1896 as *Felis concolor floridana* (Cory 1896). The type specimen was collected in Sebastian, Florida. Bangs (1899), however, believed the Florida panther was restricted to peninsular Florida and could not intergrade with other *Felis* spp. Therefore, he assigned it full specific status and named it *Felis coryi* since *Felis floridana* had been used previously for a bobcat (*Lynx rufus*).

The taxonomic classification of the *Felis concolor* group was revised and described by Nelson and Goldman (1929) and Young and Goldman (1946). These authors differentiated 30 subspecies using geographic and morphometric (measurement of forms) criteria and reassigned the Florida panther to subspecific status as *Felis concolor coryi.* This designation also incorporated *F. arundivaga* which had been classified by Hollister (1911) from specimens collected in Louisiana into *F. c. coryi.* Nowell and Jackson (1996) reviewed the genus *Felis* and placed mountain lions, including the Florida panther, in the genus *Puma.*

Culver et al. (2000) examined genetic diversity within and among the described subspecies of *Puma concolor* using three groups of genetic markers and proposed a revision of the genus to include only six subspecies, one of which encompassed all puma in North America including the Florida panther. However, Culver et al. (2000) determined that the Florida panther was one of several smaller populations that had unique features, the number of polymorphic microsatellite loci and amount of variation were lower, and it was highly inbred (eight fixed loci). The degree to which the scientific community has accepted the results of Culver et al. (2000) and the proposed change in taxonomy is not resolved at this time. The Florida panther remains listed as a subspecies and continues to receive protection pursuant to the Act.

Species Description

An adult Florida panther is unspotted and typically rusty reddish-brown on the back, tawny on the sides, and pale gray underneath. There has never been a melanistic (black) puma documented in North America (Tinsley 1970, 1987). Adult males can reach a length of 7 ft (ft) (2.1 meters [m]) from their nose to the tip of their tail and may exceed 161 pounds (lbs) (73 kilograms [kg]) in weight; but, typically adult males average around 116 lbs (52.6 kg) and stand about 24-28 inches (in) (60-70 centimeters [cm]) at the shoulder (Roelke 1990). Female panthers are smaller with an average weight of 75 lbs (34 kg) and length of 6 ft (1.8 m) (Roelke 1990). The skull of the Florida panther is unique in that it has a broad, flat, frontal region, and broad, high-arched or upward-expanded nasal bones (Young and Goldman 1946).

Florida panther kittens are gray with dark brown or blackish spots and five bands around the tail. The spots gradually fade as the kittens grow older and are almost unnoticeable by the time they are 6 months old. At this age, their bright blue eyes slowly turn to the light-brown straw color of the adult (Belden 1988).

Three external characters—a right angle crook at the terminal end of the tail, a whorl of hair or cowlick in the middle of the back, and irregular, white flecking on the head, nape, and shoulders—not found in combination in other subspecies of *Puma* (Belden 1986), were commonly observed in Florida panthers through the mid-1990s. The kinked tail and cowlicks were considered manifestations of inbreeding (Seal 1994); whereas the white flecking was thought to be a result of scarring from tick bites (Maehr 1992, Wilkins et al. 1997). Four other abnormalities prevalent in the panther population prior to the mid-1990s included cryptorchidism (one or two undescended testicles), low sperm quality, atrial septal defects (the opening between two atria in the heart fails to close normally during fetal development), and immune deficiencies and were also suspected to be the result of low genetic variability (Roelke et al. 1993a). A plan for genetic restoration and management of the Florida panther was developed in September 1994 (Seal 1994) and eight non-pregnant adult female Texas panthers (*Puma concolor stanleyana*) were released in five areas of south Florida from March to July 1995. Since this introgression, rates of genetic defects, including crooked tails and cowlicks, have dramatically decreased (Land et al. 2004). In addition, to date neither atrial septal defects nor cryptorchidism have been found in introgressed panthers (M. Cunningham, FWC, pers. comm. 2005). As of January 27, 2003, none of the eight female Texas panthers introduced in 1995 remain in the wild.

Population Trends and Distribution

The Florida panther once ranged throughout the southeastern U.S. from Arkansas and Louisiana eastward across Mississippi, Alabama, Georgia, Florida, and parts of South Carolina and Tennessee (Young and Goldman 1946). Historically, the panther intergraded to the north with *P. c. cougar*, to the west with *P. c. stanleyana*, and to the northwest with *P. c. hippolestes* (Young and Goldman 1946).

Although generally considered unreliable, sightings of panthers regularly occur throughout the southeast. However, no reproducing populations of panthers have been found outside of south Florida for at least 30 years despite intensive searches to document them (Belden et al. 1991, McBride et al. 1993, Clark et al. 2002). Survey reports and more than 70,000 locations of radio-collared panthers recorded between 1981 and 2004 clearly define the panther's current breeding range. Reproduction is known only in the Big Cypress Swamp and Everglades physiographic region in Collier, Lee, Hendry, Miami-Dade, and Monroe Counties south of the Caloosahatchee River (Belden et al. 1991). Although confirmed panther sign, male radiocollared panthers, and uncollared males killed by vehicles have been recorded outside of south Florida in recent years, no female panthers have been documented north of the Caloosahatchee River since 1973 (Nowak and McBride 1974, Belden et al. 1991, Land and Taylor 1998, Land et al. 1999, Shindle et al. 2000, McBride 2002, Belden and McBride 2005).

Puma are wide ranging, secretive, and occur at low densities. However, their tracks, urine markers, and scats are readily found by trained observers, and resident populations are easily located. Van Dyke (1986a) determined that all resident puma, 78 percent of transient puma, and 57 percent of kittens could be detected by track searches in Utah. In south Florida, the Florida panther's limited range and low densities may make the population count derived from track searches more accurate than in Utah. During two month-long investigations – one late in 1972 and early 1973 and another in 1974 – funded by the World Wildlife Fund to determine if panthers still existed in Florida, McBride searched for signs of panthers in portions of south Florida. In 1972, McBride authenticated a road-killed male panther in Glades County and a female captured and released from a bobcat trap in Collier County (R. McBride, Livestock Protection Company, pers. comm. 2005). In 1973, McBride captured one female in Glades County (Nowak and McBride 1974). Based on this preliminary evidence, Nowak and McBride (1974) estimated the "population from the Lake Okeechobee area southward to be about 20 or 30 individuals." In 1974, McBride found evidence of only two additional panthers in the Fakahatchee Strand and suggested that "there could be not more than ten individual panthers in the area around Lake Okeechobee and southward in the state" (Nowak and McBride 1975). This initial survey, while brief in nature, proved that panthers still existed in Florida and delineated areas where a more exhaustive search was warranted. After this initial investigation, more comprehensive surveys on both public and private lands were completed (Reeves 1978; Belden and McBride 1983a, b; Belden et al. 1991). Thirty individual panthers were identified during a wide-ranging survey in 1985 in south Florida (McBride 1985).

Maehr et al. (1991) provides the only published population estimate based on a substantial body of field data (Beier et al. 2003). Maehr et al. (1991) estimated a density of 1 panther per 27,520 ac911,137 hectares [ha]) based on 17 concurrently radiocollared and four uncollared panthers. They extrapolated this density to the area occupied (1,245,435 ac [504,012 ha]) by radio-collared panthers during the period 1985-1990 to achieve a population estimate of 46 adult panthers for southwest Florida (excluding Everglades National Park [ENP], eastern Big Cypress National Preserve [BCNP], and Glades and Highlands Counties). Beier et al. (2003), however, argued that this estimate of density, although "reasonably rigorous," could not be extrapolated to other areas because it was not known whether densities were comparable in those areas.

More recently, McBride (2000, 2001, 2002, 2003) obtained minimum population counts (*i.e.*, number known alive) based on panthers treed with hounds, physical evidence (*e.g.*, tracks where radio-collared panthers were not known to occur), documentation by trail-camera photos, and sightings of uncollared panthers by a biologist or pilot from a monitoring plane or via ground telemetry. He counted adults and subadult panthers but not kittens at the den). The population estimate in 2000 was 62 panthers (McBride 2000), with estimates of 78 in 2001 (McBride 2001), 80 in 2002 (FWC 2002), 87 in 2003 (FWC 2003), 78 in 2004 (R. McBride, Personal Communication, 2006), 82 in 2005 (R. McBride, Personal Communication, 2006), and 96 in 2006 (R. McBride, Personal Communication, 2006).

McBride (2002) documented an increase in the number of uncollared panthers captured each year between 2000 and 2002 relative to 1981 through 1999, while Shindle et al. (2001) reported data showing an apparent increase in the number of panthers killed by vehicles since 1999. In

neither case, however, was supporting evidence provided that would be necessary to conclude that these increases reflected population trends.

Although the breeding segment of the panther population occurs only in south Florida, panthers have been documented north of the Caloosahatchee River over 125 times since February 1972. This has been confirmed through field sign (*e.g.,* tracks, scrapes, scats), camera-trap photographs, seven highway mortalities, four radio-collared animals, two captured animals (one of which was radiocollared), and one skeleton. From 1972 through 2004, panthers have been confirmed in 11 counties (Flagler, Glades, Highlands, Hillsborough, Indian River, Okeechobee, Orange, Osceola, Polk, Sarasota, Volusia) north of the Caloosahatchee River (Belden et al. 1991; Belden and McBride 2005). However, no evidence of a female or reproduction has been documented north of the Caloosahatchee River in over 30 years (Belden and McBride 2005).

Life History

Reproduction: Male Florida panthers are polygynous, maintaining large, overlapping home ranges containing several adult females and their dependent offspring. The first sexual encounters for males normally occur at about three years based on 26 radio-collared panthers of both sexes (Maehr et al. 1991). Based on genetics work, some males may become breeders as early as 17 months (W. Johnson, National Cancer Institute, pers. comm. 2005). Breeding activity peaks from December to March (Shindle et al. 2003). Litters (n = 82) are produced throughout the year, with 56-60 percent of births occurring between March and June (Jansen et al. 2005, Lotz et al. 2005). The greatest number of births occurs in May and June (Jansen et al. 2005, Lotz et al. 2005). Female panthers have bred as young as 18 months (Maehr et al. 1989) and successful reproduction has occurred up to 11 years old. Mean age of denning females is 4.6 ± 2.1 (standard deviation [sd]) years (Lotz et al. 2005). Age at first reproduction for 19 known-aged female panthers averaged 2.2 ± 0.246 (sd) years and ranged from 1.8-3.2 years. Average litter size is 2.4 ± 0.91 (sd) kittens. Seventy percent of litters are comprised of either two or three kittens. Mean birth intervals (elapsed time between successive litters) are 19.8 ± 9.0 (sd) months for female panthers (n = 56) (range 4.1-36.5 months) (Lotz et al. 2005). Females that lose their litters generally produce another more quickly; five of seven females whose kittens were brought into captivity successfully produced another litter an average of 10.4 months after the removal of the initial litter (Land 1994).

Den sites are usually located in dense, understory vegetation, typically saw palmetto (*Serenoa repens*) (Maehr 1990; Shindle et al. 2003). Den sites are used for up to two months by female panthers and their litters from birth to weaning. Independence and dispersal of young typically occurs at 18 months, but may occur as early as one year (Maehr 1992).

Survivorship and Causes of Mortality: Mortality records for uncollared panthers have been kept since February 13, 1972, and for radio-collared panthers since February 10, 1981. One-hundred eighty-nine mortalities have been documented through October 30, 2006, with 86 (46 percent) of known deaths occurring in the past 5 years (FWC 2006a, FWC unpublished data). Overall, documented mortality averaged 3.6 per year through June 2001, and 16.0 per year from July 2001 through June 2006. Of the 189 total mortalities, 100 were radio-collared

panthers that have died since 1981 (FWC 2006a, FWC unpublished data). From 1990-2004, mean annual survivorship of radio-collared adult panthers was greater for females (0.894 ± 0.099 sd) than males (0.779 ± 0.125 sd) (Lotz et al. 2005). Except for intraspecific aggression, the causes of mortality were found to be independent of gender (Lotz et al. 2005).

Intraspecific aggression was the leading cause of death for radio-collared panthers, accounting for 42 percent (Jansen et al. 2005, Lotz et al. 2005). Most intraspecific aggression occurs between male panthers; but, aggressive encounters between males and females, resulting in the death of the female, have occurred. Defense of kittens and\or a kill is suspected in half (5 of 10) of the known instances through 2003 (Shindle et al. 2003).

Unknown causes and collisions with vehicles accounted for 24 and 19 percent of radio-collared panther mortalities, respectively. From February 13, 1972, through June 30, 2006, Florida panther vehicular trauma (n=96), averaged 2.8 per year for radio-collared and uncollared panthers (FWC 2006a). Ten of the collisions were not fatal. Three additional panthers were killed by vehicles from July 1, 2006, through November 30, 2006 (FWC, unpublished data), bringing the total to 99 panthers killed or injured by vehicles.

Female panthers are considered adult residents if they are older than 18 months, have established home ranges and bred (Maehr et al. 1991). Land et al. (2004) reported that 23 of 24 female panthers first captured as kittens survived to become residents and 18 (78.3 percent) produced litters; one female was too young to determine residency. Male panthers are considered adult residents if they are older than three years and have established a home range that overlaps with females. Thirty-one male panthers were captured as kittens and 12 (38.7 percent) of these cats survived to become residents (Jansen et al. 2005, Lotz et al. 2005). "Successful male recruitment appears to depend on the death or home-range shift of a resident adult male" (Maehr et al. 1991). Turnover in the breeding population is low with documented mortality in radio-collared panthers being greatest in subadults and non-resident males (Maehr et al. 1991, Shindle et al. 2003).

Den sites of female panthers have been visited since 1992 and the number of kittens that survived to 6 months for 38 of these litters has been documented. Florida and introgressed panther kitten survival to six months were estimated to be 52 and 72 percent, respectively, but were not significantly different (P = 0.2776) (Lotz et al. 2005). Survival of kittens greater than six months old was determined by following the fates of 55 radio-collared dependent-aged kittens, including 17 introgressed panthers from 1985 - 2004. Only 1 of these 55 kittens died before reaching independence, resulting in a 98.2 percent survival rate (Lotz et al. 2005). The FWC and NPS are continuing to compile and analyze existing reproductive and kitten data.

Dispersal: Panther dispersal begins after a juvenile becomes independent from its mother and continues until it establishes a home range. Dispersal distances are greater for males (n = 18) than females (n = 9) (42.5 mi [68.4 km] vs. 12.6 mi [20.3 km], respectively) and the maximum dispersal distance recorded for a young male was 139.2 mi (224.1 km) over a seven-month period followed by a secondary dispersal of 145 mi (233 km) (Maehr et al. 2002a). Males disperse an average distance of 25 mi (40 km); females typically remain in or disperse short distances from their natal ranges (Comiskey et al. 2002). Female dispersers are considered

philopatric because they usually establish home ranges less than one average home range width from their natal range (Maehr et al. 2002a). Maehr et al. (2002a) reported that all female dispersers (n = 9) were successful at establishing a home range whereas only 63 percent of males (n = 18) were successful. Young panthers become independent at 14 months on average for both sexes, but male dispersals are longer in duration than for females (9.6 months and 7.0 months, respectively) (Maehr et al. 2002a). Dispersing males usually go through a period as transient (non-resident) subadults, moving through the fringes of the resident population and often occupying suboptimal habitat until an established range becomes vacant (Maehr 1997).

Most panther dispersal occurs south of the Caloosahatchee River with only four radio-collared panthers crossing the river and continuing north since 1981 (Land and Taylor 1998, Land et al. 1999, Shindle et al. 2000, Maehr et al. 2002a, Belden and McBride 2005). Western subspecies of *Puma* have been documented crossing wide, swift-flowing rivers up to a mile in width (Seidensticker et al. 1973, Anderson 1983). The Caloosahatchee River, a narrow (295-328 ft [90-100 m]), channelized river, probably is not a significant barrier to panther movements, but the combination of the river, State Route (SR) 80, and land uses along the river seems to have restricted panther dispersal northward (Maehr et al. 2002a). Documented physical evidence of at least 15 other uncollared male panthers have been confirmed north of the river since 1972, but no female panthers nor reproduction have been documented in this area since 1973 (Belden and McBride 2005).

Home Range Dynamics and Movements: Panthers require large areas to meet their needs. Numerous factors influence panther home range size including habitat quality, prey density, and landscape configuration (Belden 1988, Comiskey et al. 2002). Home range sizes of 26 radio-collared panthers monitored between 1985 and 1990 averaged 128,000 ac (51,800 ha) for resident adult males and 48,000 ac (19,425 ha) for resident adult females; transient males had a home range of 153,599 ac (62,160 ha) (Maehr et al. 1991). Comiskey et al. (2002) examined the home range size for 50 adult panthers (residents greater than 1.5 years old) monitored in south Florida from 1981-2000 and found resident males had a mean home range of 160,639 ac (65,009 ha) and females had a mean home range of 97,920 ac (39,627 ha). Beier et al. (2003) found home range size estimates for panthers reported by Maehr et al. (1991) and Comiskey et al. (2002) to be reliable. Annual minimum convex polygon home range sizes of 52 adult radio-collared panthers monitored between 1998 and 2002 ranged from 15,360 – 293,759 ac (6,216 – 118,880 ha), averaging 89,600 ac (36,260 ha) for 20 resident adult males and 44,160 ac (17,871 ha) for 32 resident adult females (Land et al. 1999, Shindle et al. 2000, Shindle et al. 2001, Land et al. 2002). The most current estimate of home-range sizes (minimum convex polygon method) for established, non-dispersing, adult, radio-collared panthers averaged 29,056 ac (11,759 ha) for females (n = 11) and 62,528 ac (25,304 ha) for males (n = 11) (Lotz et al. 2005). The average home range was 35,089 ac (14,200 ha) for resident females (n = 6) and 137,143 ac (55,500 ha) (n = 5) for males located at BCNP (Jansen et al. 2005). Home ranges of resident adults tend to be stable unless influenced by the death of other residents; however, several males have shown significant home range shifts that may be related to aging (D. Jansen, National Park Service [NPS], pers. comm. 2005). Home-range overlap is extensive among resident females and limited among resident males (Maehr et al. 1991).

Activity levels for Florida panthers are greatest at night with peaks around sunrise and after sunset (Maehr et al. 1990a). The lowest activity levels occur during the middle of the day. Female panthers at natal dens follow a similar pattern with less difference between high and low activity periods.

Telemetry data indicate panthers typically do not return to the same resting site day after day, with the exception of females with dens or panthers remaining near kill sites for several days. The presence of physical evidence such as tracks, scats, and urine markers confirm that panthers move extensively within home ranges, visiting all parts of the range regularly in the course of hunting, breeding, and other activities (Maehr 1997, Comiskey et al. 2002). Males travel widely throughout their home ranges to maintain exclusive breeding rights to females. Females without kittens also move extensively within their ranges (Maehr 1997). Panthers are capable of moving large distances in short periods of time. Nightly panther movements of 12 mi (20 km) are not uncommon (Maehr et al. 1990a).

Intraspecific Interactions: Interactions between panthers occur indirectly through urine markers or directly through contact. Urine markers are made by piling ground litter using a backwards-pushing motion with the hind ft. This pile is then scent-marked with urine and occasionally feces. Both sexes make urine markers. Apparently males use them as a way to mark their territory and announce presence while females advertise their reproductive condition.

Adult females and their kittens interact more frequently than any other group of panthers. Interactions between adult male and female panthers last from one to seven days and usually result in pregnancy (Maehr et al. 1991). Aggressive interactions between males often result in serious injury or death. Independent subadult males have been known to associate with each other for several days and these interactions do not appear to be aggressive in nature. Aggression between males is the most common cause of male mortality and an important determinant of male spatial and recruitment patterns based on radio-collared panthers (Maehr et al. 1991, Shindle et al. 2003). Aggressive encounters between radio-collared males and females also have been documented (Shindle et al. 2003, Jansen et al. 2005).

Food Habits: Primary panther preys are white-tailed deer (*Odocoileus virginianus*) and feral hog (*Sus scrofa*) (Maehr et al. 1990b, Dalrymple and Bass 1996). Generally, feral hogs constitute the greatest biomass consumed by panthers north of the Alligator Alley section of I-75, while white-tailed deer are the greatest biomass consumed to the south (Maehr et al. 1990b). Secondary prey includes raccoons (*Procyon lotor*), nine-banded armadillos (*Dasypus novemcinctus*), marsh rabbits (*Sylvilagus palustris*) (Maehr et al. 1990b) and alligators (*Alligator mississippiensis*) (Dalrymple and Bass 1996). No seasonal variation in diet has been detected. A resident adult male puma generally consumes one deer-sized prey every 8-11 days; this frequency would be 14-17 days for a resident female; and 3.3 days for a female with three 13-month-old kittens (Ackerman et al. 1986). Maehr et al. (1990b) documented domestic livestock infrequently in scats or kills, although cattle were readily available on their study area.

Infectious Diseases, Parasites, and Environmental Contaminants: *Viral Diseases*--Feline leukemia virus (FeLV) is common in domestic cats (*Felis catus*), but is quite rare in non-

domestic felids. Routine testing for FeLV antigen (indicating active infection) in captured and necropsied panthers has been negative since testing began in 1978 to the fall of 2002. Between November 2002 and February 2003, however, two panthers tested FeLV antigen positive (Cunningham 2005). The following year, three more cases were diagnosed. All infected panthers had overlapping home ranges in the Okaloacoochee Slough ecosystem. Three panthers died due to suspected FeLV-related diseases (opportunistic bacterial infections and anemia) and the two others died from intraspecific aggression. Testing of serum samples collected from 1990-2005 for antibodies (indicating exposure) to FeLV indicated increasing exposure to FeLV beginning in the late 1990s and concentrated north of I-75. There was apparently minimal exposure to FeLV during this period south of I-75. Positive antibody titers in different areas at different times may indicate that multiple introductions of the virus into the panther population may have occurred. These smaller epizootics were apparently self-limiting and did not result in any known mortalities. Positive antibody titers, in the absence of an active infection (antigen positive), indicate panthers can be exposed and overcome the infection (Cunningham 2005). Management of the disease includes vaccination as well as removal of infected panthers to captivity for quarantine and supportive care. As of June 1, 2005, about one-third of the population had received at least one vaccination against FeLV (FWC and NPS, unpublished data). No new positive cases have been diagnosed since July 2004.

Pseudorabies virus (PRV) (Aujeszky's disease) causes respiratory and reproductive disorders in adult hogs and mortality in neonates, but is a rapidly fatal neurologic disease in carnivores. At least one panther died from PRV infection presumably through consumption of an infected feral hog (Glass et al. 1994). At least one panther has also died of rabies (Taylor et al. 2002). This panther was radiocollared but not vaccinated against the disease.

Feline immunodeficiency virus (FIV) is a retrovirus of felids that is endemic in the panther population. About 28 percent of Florida panthers were positive for antibodies to the puma lentivirus strain of FIV (Olmstead et al. 1992); however, the prevalence may be increasing. Between November 2004 and April 2005, 13 of 17 (76 percent) were positive (M. Cunningham, FWC, unpublished data). The cause of this increase is unknown but warrants continued monitoring and investigation. There is also evidence of exposure to Feline panleukopenia virus (PLV) in adult panthers (Roelke et al. 1993b) although no PLV-related mortalities are known to have occurred.

Serological evidence of other viral diseases in the panther population includes feline calicivirus, feline herpes virus, and West Nile virus (WNV). However these diseases are not believed to cause significant morbidity or mortality in the population. All panthers found dead due to unknown causes are tested for alphaviruses, flaviviruses (including WNV), and canine distemper virus. These viruses have not been detected in panthers by viral culture or polymerase chain reaction (FWC, unpublished data).

Other Infectious Diseases--Bacteria have played a role in free-ranging panther morbidity and mortality as opportunistic pathogens, taking advantage of pre-existing trauma or FeLV infections (FWC, unpublished data). Dermatophytosis (ringworm infection) has been diagnosed in several panthers and resulted in severe generalized infection in at least one (Rotstein et al. 1999). Severe

infections may reflect an underlying immunocompromise, possibly resulting from inbreeding depression or immunosuppressive viral infections.

Parasites--The hookworm, *Ancylostoma pluridentatum,* is found in a high prevalence in the panther population. Other parasites identified from live-captured or necropsied panthers include eight arthropod species, eight nematode species, three cestode species, two trematode species, and three protozoa species (Forrester et al. 1985, Forrester 1992, Wehinger et al. 1995, Rotstein et al. 1999, Land et al. 2002). Of these only an arthropod, *Notoedres felis*, caused significant morbidity in at least one panther (Maehr et al. 1995).

Environmental Contaminants--Overall, mercury in south Florida biota has decreased over the last several years (Frederick et al. 2002). However, high mercury concentrations are still found in some panthers. At least one panther is thought to have died of mercury toxicosis and mercury has been implicated in the death of two other panthers in ENP (Roelke 1991). One individual panther had concentrations of 150 parts per million (ppm) mercury in its hair (Land et al. 2004). Other environmental contaminants found in panthers include polychlorinated biphenyls (Arochlor 1260) and organochlorines (p, p'–DDE) (Dunbar 1995, Land et al. 2004). Elevated levels of p, p'– DDE were also detected in fat from that panther. The role of mercury and p, p'–DDE in this panther's death is unknown and no cause of death was determined despite extensive diagnostic testing. Elevated mercury concentrations have also been found in panthers from Florida Panther National Wildlife Refuge (FPNWR). Two sibling neonatal kittens from this area had hair mercury concentrations of 35 and 40 ppm. Although other factors were believed to have been responsible, these kittens did not survive to leave their natal den. Consistently high hair mercury values in ENP and FPNWR and the finding of elevated values in some portions of BCNP warrant continued monitoring (Land et al. 2004).

Habitat Characteristics and Ecosystem

Landscape Composition: Noss and Cooperrider (1994) considered the landscape implications of maintaining viable panther populations. Assuming a male home range size of 137,599 ac (55,685 ha) (Maehr 1990), an adult sex ratio of 50:50 (Anderson 1983), and some margin of safety, they determined that a reserve network as large as 15,625–23,438 mi^2 (40,469-60,703 km^2) would be needed to support an effective population size of 50 individuals (equating to an actual adult population of 100-200 panthers [Ballou et al. 1989]). However, to provide for long-term persistence based on an effective population size of 500 individuals (equating to 1,000 - 2,000 adult panthers [Ballou et al. 1989]), could require as much as 156,251-234,376 mi^2 (404,687-607,031 km^2). This latter acreage corresponds to roughly 60-70 percent of the Florida panther's historical range. Although it is uncertain whether this much land is needed for panther recovery, it does provide some qualitative insight into the importance of habitat conservation across large landscapes for achieving a viable panther population (Noss and Cooperrider 1994).

Between 1981 and 2003, more than 55,000 locations on more than 100 radio-collared panthers were collected. Belden et al. (1988), Maehr et al. (1991), Maehr (1997), Kerkoff et al. (2000), and Comiskey et al. (2002) provide information on habitat use based on various subsets of these data. Since almost all data from radio-collars have been collected during daytime hours (generally

0700-1100), and because panthers are most active at night (Maehr et al. 1990a), daytime radio locations are insufficient to describe the full range of panther habitat use (Beyer and Haufler 1994, Comiskey et al. 2002, Beier et al. 2003, Dickson et al. 2005, Beier et al. 2006).

The Service created the Multi-species/Ecosystem Recovery Implementation Team (MERIT) to assist with implementation of the MSRP after it was signed in 1999. The Florida Panther Subteam of MERIT developed a landscape-level strategy for the conservation of the panther population in south Florida which was not finalized. Many of the Panther Subteam members refined the methodology, further analyzed the data, and better defined the results of this landscape-level strategy into a spatial model (Kautz et al. 2006). In developing the model, data from radio-collared panthers collected from 1981 through 2000 were used to evaluate the relative importance of various land cover types as panther habitat, thus identifying landscape components important for panther habitat conservation. Those components were then combined with a least cost path analysis to delineate three panther habitat conservation zones for south Florida: (1) Primary Zone – lands essential to the long-term viability and persistence of the panther in the wild; (2) Secondary Zone - lands which few panthers use contiguous with the Primary Zone, but given sufficient habitat restoration could accommodate expansion of the panther population south of the Caloosahatchee River; and (3) Dispersal Zone - the area which may facilitate future panther expansion north of the Caloosahatchee River (Kautz et al. 2006) (Figure 10). The Primary Zone is currently occupied and supports the breeding population of panthers. Although panthers move through the Secondary and Dispersal Zones, they are not permanently occupied. The Secondary Zone could support panthers with sufficient restoration.

These zones vary in size, ownership, and land cover composition. The Primary Zone is 2,270,711 ac (918,928 ha) in size, 73 percent of which is publicly owned (R. Kautz, Dennis, Breedlove, and Associates, pers. comm. 2005), and includes portions of the BCNP, ENP, Fakahatchee Strand Preserve State Park (FSPSP), FPNWR, Okaloacoochee Slough State Forest (OSSF) and Wildlife Management Area (WMA), and Picayune Strand State Forest. This zone's composition is 45 percent forest, 41 percent freshwater marsh, 7.6 percent agriculture lands, 2.6 percent prairie and shrub lands, and 0.52 percent urban lands (Kautz et al. 2006). The Secondary Zone is 812,157 ac (328,670 ha) in size, 38 percent of which is public land (R. Kautz, pers. comm. 2005). This zone's composition is 43 percent freshwater marsh, 36 percent agriculture, 11 percent forest, 6.1 percent prairie and shrub lands, and 2.3 percent low-density residential areas and open urban lands (Kautz et al. 2006). The Dispersal Zone is 28,160 ac (11,396 ha) in size, 12 percent of which is either publicly owned or in conservation easement. This zone's composition is 49 percent agriculture (primarily improved pasture and citrus groves), 29 percent forest (wetland and upland), 8.8 percent prairie and shrub land, 7.5 percent freshwater marsh, and 5.1 percent barren and urban lands (Kautz et al. 2006).

As part of their evaluation of occupied panther habitat, in addition to the average density estimate of one panther per 27,181 ac (11,000 ha) developed by Maehr et al. (1991), Kautz et al. (2006) estimated the present average density during the timeframe of the study, based on telemetry and other occurrence data, to average 1 panther per 31,923 ac (12,919 ha). In the following discussions of the number of panthers that a particular zone may support, the lower

number is based on the 31,923 ac (12,919 ha) value (Kautz et al. 2006) and the higher number is based on the 27,181 ac (11,000 ha) value (Maehr et al. 1991).

Based on these average densities, the Primary Zone could support 71 to 84 panthers; the Secondary Zone 8 to 10 panthers without habitat restoration and 25 to 30 panthers with habitat restoration (existing high quality panther habitat currently present in the Secondary Zone is estimated at 32 percent of the available Secondary Zone lands); and the Dispersal Zone, 0 panthers. Taken together, the three zones in their current condition apparently have the capacity to support about 79 to 94 Florida panthers.

Kautz et al.'s (2006) assessment of available habitat south of the Caloosahatchee River determined non-urban lands in the Primary, Secondary, and Dispersal Zones were not sufficient to sustain a population of 240 individuals south of the Caloosahatchee River. However, Kautz et al. (2006) determined sufficient lands were available south of the Caloosahatchee River to support a population of 79 to 94 individuals (although not all lands are managed and protected).

Even though some suitable panther habitat remains in south-central Florida, it is widely scattered and fragmented (Belden and McBride 2005). Thatcher et al. (2006) used a statistical model in combination with a geographic information system to develop a multivariate landscape-scale habitat model based on the Mahalanobis distance statistic (D^2) to evaluate habitats in south central Florida for potential expansion of the Florida panther population. They identified 4 potential habitat patches: the Avon Park Bombing Range area, Fisheating Creek/Babcock-Webb Wildlife Management Area, eastern Fisheating Creek, and the Duette Park/Manatee County area. These habitat patches are smaller and more isolated compared with the current Florida panther range, and the landscape matrix where these habitat patches exist provides relatively poor habitat connectivity among the patches (Thatcher et al. 2006). Major highways and urban or agricultural development isolate these habitat patches, and they are rapidly being lost to the same development that threatens southern Florida (Belden and McBride 2005).

Diurnal Habitat Use: Diurnal panther locations appear to be within or closer to forested cover types, particularly cypress swamp, pinelands, hardwood swamp, and upland hardwood forests (Belden 1986, Belden et al. 1988, Maehr 1990, Maehr et al. 1991, Maehr 1992, Smith and Bass 1994, Kerkhoff et al. 2000, Comiskey et al. 2002). Dense understory vegetation comprised of saw palmetto provides some of the most important resting and denning cover for panthers (Maehr 1990). Shindle et al. (2003) show that 73 percent of panther dens were in palmetto thickets.

Radio-collar data and ground tracking indicate panthers use the mosaic of habitats available to them as resting and denning sites, hunting grounds, and travel routes. These habitats include cypress swamps, hardwood hammocks, pine flatwoods, seasonally flooded prairies, freshwater marshes, and some agricultural lands. Although radio-collar monitoring indicates forest is a preferred cover type, panthers also utilize non-forest cover types (Belden et al. 1988; Maehr et al. 1991; Comiskey et al. 2002). Compositional analyses by Kautz et al. (2006) confirmed previous findings that forest patches comprise an important component of panther habitat in south Florida, but other natural and disturbed cover types are also present in the large landscapes that support panthers (Belden et al. 1988; Maehr et al. 1991; Comiskey et al. 2002). Kautz et al. (2006)

found the smallest class of forest patches (*i.e.*, 9-26 ac [3.6-10.4 ha]) were the highest ranked forest patch sizes within panther home ranges; this indicates that forest patches of all sizes appear to be important components of the landscapes inhabited by panthers, not just the larger forest patches.

Nocturnal Habitat Use: Maehr et al. (1990a) provide the only descriptions of panther nocturnal activities and represent the available radiocollar data collected during night time hours. However, this paper does not provide analyses of nocturnal habitat use. Dickson et al. (2005) examined the movements of 10 female and 7 male puma at 15-minute intervals during 44 nocturnal periods of hunting or traveling in southern California. They found that traveling puma monitored over nocturnal periods used a broader range of habitats than what they appeared to use based on diurnal locations alone. The use of Global Positioning System (GPS) radiocollars is now being investigated to determine if this technology will be suitable to answer questions regarding Florida panther nocturnal habitat use.

Prey Habitat Use: Panther habitat selection is related to prey availability (Janis and Clark 1999, Dees et al. 2001) and, consequently, prey habitat use. Adequate cover and the size, distribution, and abundance of available prey species are critical factors to the persistence of panthers in south Florida and often determine the extent of panther use of an area. Duever et al. (1986) calculated a deer population of 1,760 in BCNP, based on Harlow (1959) deer density estimates of 1/210 ac (85 ha) in pine forest, 1/299 ac (121 ha) in swamps, 1/1,280 ac (518 ha) in prairie, 1/250 ac (101 ha) in marshes, and 1/111 ac (45 ha) in hammocks. Schortemeyer et al. (1991) estimated deer densities at 1/49-247 ac (20-100 ha) in three management units of BCNP based on track counts and aerial surveys. Labisky et al. (1995) reported 1/49 ac (20 ha) in southeastern BCNP. Using track counts alone, McCown (1994) estimated 1/183-225 ac (74-91 ha) on the FPNWR and 1/133-200 ac (54-81 ha) in the FSPSP.

Hardwood hammocks and other forest cover types are important habitat for white-tailed deer and other panther prey (Harlow and Jones 1965, Belden et al. 1988, Maehr 1990, Maehr et al. 1991, Maehr 1992, Comiskey et al. 1994, Dees et al. 2001). Periodic understory brushfires (Dees et al. 2001) as well as increased amounts of edge (Miller 1993) may enhance deer use of hardwood hammocks, pine, and other forest cover types. However, wetland and other vegetation types can support high deer densities. In the Everglades, for example, deer appear to be adapted to a mosaic of intergrading patches comprised of wet prairie, hardwood tree islands, and peripheral wetland habitat (Fleming et al. 1994, Labisky et al. 2003). High-nutrient deer forage, especially preferred by females, includes hydrophytic marsh plants, white waterlily (*Nymphaea odorata*), and swamp lily (*Crinum americana*) (Loveless 1959, Labisky et al. 2003). Wetland willow (*Salix spp.*) thickets provide nutritious browse for deer (Loveless 1959, Labisky et al. 2003).

Marshes, rangeland, and low-intensity agricultural areas support prey populations of deer and hogs. The importance of these habitat types to panthers cannot be dismissed based solely on use or lack of use when daytime telemetry are the only data available (Comiskey et al. 2002, Beier et al. 2003, Comiskey et al. 2004, Beier et al. 2006).

Travel and Dispersal Corridors: In the absence of direct field observations and measurements, Harrison (1992) suggested that landscape corridors for wide-ranging predators should be half the width of an average home range size. Following Harrison's (1992) suggestion, corridor widths for Florida panthers would range 6.1-10.9 mi (9.8-17.6 km) depending on whether the target animal was an adult female or a transient male. Beier (1995) suggested corridor widths for transient male puma in California could be as small as 30 percent of the average home range size of an adult. For Florida panthers, this would translate to a corridor width of 5.5 mi (8.8 km). Without supporting empirical evidence, Noss (1992) suggests regional corridors connecting larger hubs of habitat should be at least 1.0 mi (1.6 km) wide. Beier (1995) makes specific recommendations for very narrow corridor widths based on short corridor lengths in a California setting of wild lands completely surrounded by urban areas; he recommended corridors with a length less than 0.5 mi (0.8 km) should be more than 328 ft (100 m) wide, and corridors extending 0.6-4 mi (1-7 km) should be more than 1,312 ft (400 m) wide. The Dispersal Zone encompasses 44 mi^2 (113 km^2) with a mean width of 3.4 mi (5.4 km). Although it is not adequate to support even one panther, the Dispersal Zone is strategically located and expected to function as a critical landscape linkage to south-central Florida (Kautz et al. 2006). Transient male panthers currently utilize this Zone as they disperse northward into south-central Florida.

Panther Recovery Objectives

The recovery objectives identified in the draft third revision of the Florida Panther Recovery Plan (Service 2006) are to (1) maintain, restore, and expand the Florida panther population and its habitat in south Florida and, if feasible, expand the known occurrence of Florida panthers north of the Caloosahatchee River to maximize the probability of the long-term persistence of this metapopulation; (2) identify, secure, maintain, and restore habitat in potential reintroduction areas within the panther's historic range, and to establish viable populations of the panther outside south and south-central Florida; and (3) facilitate panther conservation and recovery through public awareness and education.

Panther Management and Conservation

Habitat Conservation and Protection

Panthers, because of their wide-ranging movements and extensive spatial requirements, are particularly sensitive to habitat fragmentation (Harris 1984). Mac et al. (1998) defines habitat fragmentation as: "The breaking up of a habitat into unconnected patches interspersed with other habitat which may not be inhabitable by species occupying the habitat that was broken up. The breaking up is usually by human action, as, for example, the clearing of forest or grassland for agriculture, residential development, or overland electrical lines." The reference to "unconnected patches" is a central underpinning of the definition. For panther conservation, this definition underscores the need to maintain contiguous habitat and protected habitat corridors in key locations in south Florida and throughout the panther's historic range. Habitat fragmentation can result from road construction, urban development, and agricultural land conversions.

Habitat protection has been identified as being one of the most important elements to achieving panther recovery. While efforts have been made to secure habitat (Figure 12 and Table 2), continued action is needed to obtain additions to and inholdings for public lands, assure linkages are maintained, restore degraded and fragmented habitat, and obtain the support of private landowners for maintaining property in a manner that is compatible with panther use. Conservation lands used by panthers are held and managed by a variety of entities including FWS, NPS, Seminole Tribes of Florida, Miccosukee Tribe of Indians of Florida, FWC, Florida Department of Environmental Protection (FDEP), Florida Division of Forestry (FDOF), Water Management Districts (WMD), non-governmental organizations (NGO), counties, and private landowners.

Public Lands: Public lands in south Florida that benefit the panther are listed below and shown in Figure 12:

1. In 1947, ENP was established with 1,507,834 ac (610,201 ha) and in 1989 was expanded with the addition of 104,320 ac (42,217 ha).

2. In 1974, Congress approved the purchase and formation of BCNP, protecting 570,238 ac (230,768 ha), later 145,919 ac (59052 ha) were added.

3. In 1974, the State of Florida began acquiring land for the FSPSP, which encompasses over 80,000 ac (32,375 ha). Efforts are underway to acquire about 16,640 ac (6,734 ha).

4. In 1985, acquisition of Picayune Strand State Forest and Wildlife Management Area (WMA) began with the complex Golden Gate Estates subdivision buyouts and now comprises over 76,160 ac (30,821 ha). The Southern Golden Gate Estates buyout through State and Federal funds is complete. The South Belle Meade portion of Picayune Strand is about 90 percent purchased and although the State is no longer purchasing in South Belle Meade, Collier County's Transfer of Development Rights program is helping to secure the inholdings.

5. In 1989, FPNWR was established and now protects 26,240 ac (10,619 ha).

6. In 1989, the Corkscrew Regional Ecosystem Watershed Land and Water Trust, a public and private partnership, was established and to date has coordinated the purchase of 42 26,880 ac (10,878 ha).

7. In 1996, the South Florida WMD, purchased the 32,000 ac (12,950 ha) OSSF.

8. In 2002 Spirit of the Wild WMA, consisting of over 7,040 ac (2,849 ha), was taken into public ownership by the State of Florida and is managed by FDOF.

9. In 2003, Dinner Island Ranch WMA consisting of 21,760 ac (8,806 ha) in southern Hendry County was taken into public ownership by the State of Florida and is managed by FDOF.

Tribal Lands: Lands of the Seminole Tribes of Florida and Miccosukee Tribe of Indians of Florida encompass over 350,079 ac (141,673 ha) in south Florida. Of these, 115,840 ac (46,879 ha) are used by panthers, and comprise 5 percent of the Primary Zone (R. Kautz, pers. comm. 2005). These lands are not specifically managed for the panther and are largely in cultivation.

Private Lands: A variety of Federal, State, and private incentives programs are available to assist private landowners and other individuals to protect and manage wildlife habitat. Voluntary agreements, estate planning, conservation easements, land exchanges, and mitigation banks are methods that hold untapped potential for conserving private lands. In 1954, the National Audubon Society established the nearly 10,880 ac (4,403 ha) Corkscrew Swamp Sanctuary. However, little additional private land has been protected south of the Caloosahatchee River for panther conservation. A number of properties identified by the State Acquisition and Restoration Council (ARC) for purchase by the Florida Forever Program are used by panthers (*e.g.*, Devil's Garden, Half Circle F Ranch, Pal Mal, Panther Glades). North of the Caloosahatchee River, Fisheating Creek Conservation Easement, 41,600 ac (16,835 ha) in Glades County is a private holding used by dispersing male panthers. Also, 73,235 ac of the 90,845 ac Babcock Ranch were purchased in 2006 by the State of Florida and Lee County for conservation and agriculture. An additional 2,000 ac of this ranch were put into a conservation easement.

Habitat and Prey Management

Land management agencies in south Florida are implementing fire programs that mimic a natural fire regime through the suppression of human-caused wildfires and the application of prescribed natural fires. No studies have been conducted to determine the effects of invasive plant management on panthers. However invasive vegetation may reduce the panther's prey base by disrupting natural processes such as water flow and fire and by significantly reducing available forage for prey (Fleming et al. 1994). All public lands in south Florida have active invasive plant treatment programs. Management for panther prey consists of a variety of approaches such as habitat management and regulation of hunting and off-road vehicle (ORV) use.

Response to Management Activities

Few studies have examined the response of panthers to various land and habitat management activities. Dees et al. (2001) investigated panther habitat use in response to prescribed fire and found that panther use of pine habitats was greatest for the first year after the area had been burned and declined thereafter. Prescribed burning is believed to be important to panthers because prey species (*e.g.*, deer and hogs) are attracted to burned habitats to take advantage of changes in vegetation structure and composition, including exploiting hard mast that is exposed and increased quality or quantity of forage (Dees et al. 2001). Responses of puma to logging activities (Van Dyke et al. 1986b) indicate that they generally avoid areas within their home range with intensification of disturbance.

There is the potential for disturbance to panthers from recreational uses on public lands. Maehr (1990) reported that indirect human disturbance of panthers may include activities associated with hunting and that panther use of Bear Island (part of BCNP) is significantly less during the

hunting season. Schortemeyer et al. (1991) examined the effects of deer hunting on panthers at BCNP between 1983 and 1990. They concluded that, based on telemetry data, panthers may be altering their use patterns as a result of hunting.

Janis and Clark (2002) compared the behavior of panthers before, during, and after the recreational deer and hog hunting season (October through December) on areas open (BCNP) and closed (FPNWR, FSPSP) to hunting. Variables examined were: (1) activity rates, (2) movement rates, (3) predation success, (4) home range size, (5) home range shifts, (6) proximity to ORV trails, (7) use of areas with concentrated human activity, and (8) habitat selection. Responses to hunting for variables most directly related to panther energy intake or expenditure (*i.e.*, activity rates, movement rates, predation success of females) were not detected (Janis and Clark 2002). However, panthers reduced their use of Bear Island, an area of concentrated human activity, and were found farther from ORV trails during the hunting season, indicative of a reaction to human disturbance (Janis and Clark 2002). Whereas the reaction to trails was probably minor and could be related to prey behavior, decreased use of Bear Island most likely reflects a direct reaction to human activity and resulted in increased use of adjacent private lands (Janis and Clark 2002).

Transportation Planning and Improvements

Construction of highways in wildlife habitat typically results in loss and fragmentation of habitat, traffic related mortality, and avoidance of associated human development. Roads can also result in habitat fragmentation, especially for females who are less likely to cross them (Maehr 1990).

There are presently 28 wildlife underpasses with associated fencing suitable for panther use along I-75 (Figure 13). There are four underpasses suitable for panther use currently existing, and two additional underpasses presently proposed by the Florida Department of Transportation (FDOT) along State Road 29 (SR 29) (Department of the Army Public Notice SAJ-2004-778) (Figure 13). Several additional panther and wildlife crossings are proposed along roadways in rural Lee and Collier Counties (Shindle et al. 2001). In addition, Collier County, in cooperation with the National Wildlife Federation and the Florida Wildlife Federation, is coordinating a study of the segment of CR 846 east of Immokalee and the section of Oil Well Road where the road crosses Camp Kies Strand by Dr. Reed Noss and Dr. Daniel Smith to determine the optimum location for wildlife crossing construction (WilsonMiller 2005). An additional crossing of Camp Kies Strand on CR 846 west of Immokalee is also being evaluated. However, vehicular trauma still occurs on outlying rural roads and the FWC is conducting a study to determine the impacts of vehicular collisions to panthers and studying ways to minimize panther vehicle collisions (Swanson et al. 2006).

No panther-vehicle collisions have been recorded in the immediate vicinity of wildlife crossings, with the exception of one collision in December 2005 on SR 29. There have been no collisions on east-west I-75 in the vicinity of crossings since installation in 1991. Prior to 1991, there were five recorded deaths from collisions. FDOT has also identified the location of and constructed wildlife crossings on SR 29. Proposed crossings A and B (Figure 13) will be in an area of 10 documented collisions from 1980 to 2004. Crossings C and D, north of I-75, were installed

in 1995. There were two recorded collisions in the vicinity of crossing D from 1979 to 1990, but none at either C or D since crossing installation. Crossing E was installed in 1997. There has been one collision about 1 mile to the north in 2002. Crossing F was installed in 1999. There was one documented collision in the immediate vicinity in 1981, two collisions about 1.5 miles to the north since crossing installation, and one collision about 0.5 mile to the south in December 2005.

Agriculture, Development, and Mining

The Service developed a draft Panther Habitat Assessment methodology and refugia design in 2003 to help guide the agency in evaluating permit applications for projects that could affect panther habitat (see discussion below). This draft methodology was a way to assess the level of impacts to panthers expected from a given project, and to evaluate the effect of any proposed compensation offered by the project applicant. Prior to development of the methodology, the Service from March 1984 through July 2003 concluded consultation on 42 projects involving the panther and habitat preservation (Table 3). The minimum expected result of these projects is impacts to 76,919 ac and the preservation of 15,479 ac of panther habitat. Of the 76,919 ac of impacts, 38,932 ac are due to agricultural conversion and 37,982 ac to development and mining. Portions (10,370 ac) of the largest agricultural conversion project, the 28,700 ac by U.S. Sugar Corporation, were re-acquired by the Federal Government as a component of the Talisman Land Acquisition (Section 390 of the Federal Agricultural Improvement and Reform Act of 1996 [Public Law 104-127] Farm Bill Cooperative Agreement, FB4) for use in the CERP. The non-agriculture impacts are permanent land losses, whereas the agricultural conversions may continue to provide some habitat functional value to panthers, depending on the type of conversion.

From August 2003 to February, 2007, the Service concluded consultations on 58 projects affecting 17,169 ac with preservation of 18,334 ac (Table 3). Following our refugia design assessment approach, the projects affected 7,287 ac in the Primary Zone, 5,911 ac in the Secondary Zone, and 3,965 ac in the Other Zone. Compensation provided included 15,118 ac in the Primary Zone, 652 ac in the Dispersal Zone, 2 ac in the Secondary Zone, and 1,410 ac in the Other Zone. The project affected lands were primarily agricultural fields consisting of row crops and citrus groves and natural lands with varying degrees of exotic vegetation. Functional habitat value of these lands to the Florida panther, following our Panther Habitat Assessment methodology provided a PHU loss from development of 74,505 PHUs, with a corresponding PHU preservation and enhancement complement of 143,133 PHUs. The preservation lands were generally native habitat lands or disturbed lands that included restoration components. Restoration components included exotic species removal, fire management, wetland hydrology improvement, improved forest management practices, and full habitat restoration from agriculture uses to native habitats.

Similar to residential, commercial, and industrial development projects, individual CERP projects may have an adverse direct effect on the Florida panther through: (1) the permanent loss and fragmentation of habitat used by the panther; (2) the permanent loss and fragmentation of habitat that supports panther prey; (3) the loss of available habitat for foraging, breeding, and dispersing

panthers; and (4) a reduction in the geographic distribution of habitat for the species. Indirect effects may include: (1) an increased risk of roadway mortality to panthers traversing the area due to the increase in vehicular traffic; (2) increased disturbance to panthers in the project vicinity due to human activities; (3) the reduction in panther prey; (4) the reduction in value of habitat used by the panther adjacent to the project due to habitat fragmentation; and (5) a potential increase in intraspecific aggression between panthers (and an increase in mortality of subadult male panthers) due to reduction of the geographic distribution of habitat for the panther.

Panther Habitat Evaluation and Compensation

Population Viability Analysis

Population Viability Analysis (PVA) has emerged as a key component of endangered species conservation. This process is designed to incorporate demographic information into models that predict if a population is likely to persist in the future. PVAs incorporate deterministic and stochastic events including demographic and environmental variation, and natural catastrophes. PVAs have also been criticized as being overly optimistic about future population levels (Brook et al. 1997) and should be viewed with caution; however, they are and have been shown to be surprisingly accurate for managing endangered taxa and evaluating different management practices (Brook 2000). They are also useful in conducting sensitivity analyses to determine where more precise information is needed (Hamilton and Moller 1995, Beissinger and Westphal 1998, Reed et al. 1998, Fieberg and Ellner 2000).

As originally defined by Shaffer (1981), "a minimum viable population for any given species in any given habitat is the smallest isolated population having a 99 percent chance of remaining extant for 1,000 years despite the foreseeable effects of demographic, environmental and genetic stochasticity, and natural catastrophes." However, the goal of 95 percent probability of persistence for 100 years is the standard recommended by population biologists and is used in management strategies and conservation planning, particularly for situations where it is difficult to accurately predict long-term effects (Shaffer 1978, 1981, 1987, Sarkar 2004).

Since 1981, 139 Florida panthers have been radio-collared and monitored on public and private lands throughout south Florida (Lotz et al. 2005). These data were used by researchers to estimate survival rates and fecundity and were incorporated into PVA models previously developed for the Florida panther (Seal et al. 1989, 1992, Cox et al. 1994, Kautz and Cox 2001, Maehr et al. 2002b). These models incorporated a range of different model parameters such as general sex ratios, kitten survival rates, age distributions, and various levels of habitat losses, density dependence, and intermittent catastrophes or epidemics. The outputs of these models predicted a variety of survival scenarios for the Florida panther and predicted population levels needed to ensure the survival of the species.

Root (2004) developed an updated set of PVA models for the Florida panther based on RAMAS GIS software (Akçakaya 2002). These models were used to perform a set of spatially explicit PVAs. Three general single-sex (i.e., females only) models were constructed using demographic variables from Maehr et al. (2002b) and other sources. A conservative model was based on Seal

and Lacy (1989), a moderate model was based on Seal and Lacy (1992), and an optimistic model was based on the 1999 consensus model of Maehr et al. (2002b). In each model, first-year kitten survival was set at 62 percent based on recent information from routine panther population monitoring (Shindle et al. 2001). All models assumed a 1:1 sex ratio, a stable age distribution, 50 percent of females breeding in any year, and an initial population of 41 females (82 individuals including males), the approximate population size in 2001-2002 (McBride 2001, 2002).

Basic Versions: The basic versions of each model incorporated no catastrophes or epidemics, no change in habitat quality or amount, and a ceiling type of density dependence. The basic versions of the models incorporated a carrying capacity of 53 females (106 panthers - 50/50 sex ratio). Variants of the models were run with differing values for density dependence, various levels of habitat loss, and intermittent catastrophes or epidemics. Each simulation was run with 10,000 replications for a 100-year period. The minimum number of panthers needed to ensure a 95 percent probability of persistence for 100 years was estimated in a series of simulations in which initial abundance was increased until probability of extinction at 100 years was no greater than 5 percent. More detailed information concerning the PVA model parameters appears in Root (2004).

The results of these model runs predicted a probability of extinction for the conservative model of 78.5 percent in 100 years with a mean final total abundance of 3.5 females. Also, the probability of a large decline in abundance (50 percent) was 94.1 percent. The moderate model resulted in a 5 percent probability of extinction and mean final abundance of 42.3 females in 100 years. The probability of panther abundance declining by half the initial amount was 20 percent in 100 years under the moderate model. The optimistic model resulted in a 2 percent probability of extinction and mean final abundance of 51.2 females in 100 years. The probability of panther abundance declining by half the initial amount was only 9 percent in 100 years under the optimistic model. These models also provide a probability of persistence (100 percent minus probability of extinction) over a 100-year period of 95 percent for the moderate model and 98 percent for the optimistic model.

One Percent Habitat Loss: Model results were also provided by Root (2004) for probability of extinctions for 1 percent loss of habitat, within the first 25 years of the model run. The 1 percent loss of habitat equates to essentially all remaining non-urban privately owned lands in the Primary Zone and corresponds to the estimated rate of habitat loss (Root 2004) from 1986 to 1996 for the five southwest counties based on land use changes. For the moderate model, the model runs predict a probability of extinction increase of about one percent, from a probability of extinction of about 5 percent with no loss of habitat to 6 percent with 1.0 percent habitat loss per year, for the first 25 years. For the optimistic model, probability of extinction increased from about 2 percent with no loss of habitat to 3 percent with 1.0 percent habitat loss per year, for the first 25 years. These models also predicted the mean final abundance of females would decrease from 41 to 31 females, a 24.3 percent reduction for the moderate model and from 41 to 38 females, a 7.3 percent reduction for the optimistic model.

The model runs also predict a probability of persistence (100 percent minus the probability of extinction) over a 100-year period of about 94 percent for the moderate model and 97 percent

for the optimistic model. The model runs, predict a mean final abundance of 62 individuals (31 females and 31 males) for the moderate model and 76 individuals (38 females and 38 males) for the optimistic model.

Population Guidelines: Kautz et al. (2006), following review of the output of Root's PVA models and those of other previous PVAs for the Florida panther, suggested a set of population guidelines for use in management and recovery of the Florida panther. These guidelines are: (1) populations of less than 50 individuals are likely to become extinct in less than 100 years; (2) populations of 60 to 70 are barely viable and expected to decline by 25 percent over 100 years; (3) populations of 80 to 100 are likely stable but would still be subject to genetic problems (*i.e.,* heterozygosity would slowly decline); and (4) populations greater than 240 have a high probability of persistence for 100 years and are demographically stable and large enough to retain 90 percent of original genetic diversity.

Population guidelines for populations of panthers between 50 and 60 individuals and between 70 and 80 individuals were not specifically provided in Kautz et al. (2006). However, the Service views the guidelines in Kautz et al. (2006) as a continuum. Therefore, we consider populations of 50 to 60 individuals to be less than barely viable or not viable with declines in population and heterozygosity. Similarly, we consider populations of 70 to 80 to be more than barely viable or somewhat viable with some declines in population and heterozygosity. Like other population guidelines presented in Kautz et al. (2006), these assume no habitat loss or catastrophes.

PVA Summaries and Population Guidelines: Root's (2004) moderate model runs, which have a carrying capacity 53 females (106 individuals), show final populations of 42.3 females (84 total) and 31.2 females (62 total) with extinction rates of 5 percent and 6 percent, respectively, for the basic and 1 percent habitat loss scenarios. The predicted final populations in Root (2004) are 84 and 62 panthers for no loss of habitat and 1 percent loss of habitat, respectively, over a 100-year period.

Kautz et al.'s (2006) population guidelines applied to the Root (2004) moderate models for a population of 62 to 84 panthers, with or without habitat loss, respectively, describe the "with habitat loss" population as barely viable and expected to decline by 25 percent over a 100-year period. The "without habitat loss" is likely stable but would still be subject to genetic problems.

In conclusion, the Service believes the model runs show lands in the Primary Zone are important to the survival and recovery of the Florida panther and sufficient lands need to be managed and protected in south Florida to provide for a population of 80 to 100 panthers, the range defined as likely stable over 100 years, but subject to genetic problems. As discussed in the following section, the Service has developed a south Florida panther conservation goal that, through regulatory reviews and coordinated conservation efforts with land owners and resource management partners, provides a mechanism to achieve this goal.

Model Violations: The actual likelihood of population declines and extinctions may be different than the guidelines and models suggest, depending upon the number of and severity of assumptions violated. The Service realizes that habitat loss is occurring at an estimated

0.8 percent loss of habitat per year (R. Kautz, FWC, personal communication, 2003). The Service has accounted for some habitat loss and changes in habitat quality within its regulatory program, and specifically through its habitat assessment methodology (discussed below). For example, we have increased the base ratio used within this methodology to account for unexpected increases in habitat loss. Similarly, we consider changes in habitat quality and encourage habitat restoration wherever possible.

With regard to the assumption of no catastrophes, the Service has considered the recent outbreak of feline leukemia in the panther population at Okaloacoochee Slough as a potential catastrophe. The FWC is carefully monitoring the situation and it appears to be under control at this time due to a successful vaccination program. However, if the outbreak spreads into the population, the Service will consider this as a catastrophe and factor this into our decisions.

We acknowledge uncertainties exist, assumptions can be violated, and catastrophes can occur. The Service and the FWC, along with our partners, will continue to monitor the panther population and the south Florida landscape and incorporate any new information and changes into our decision-making process.

South Florida Panther Population Goal

The Service's goal for Florida panther conservation in south Florida is to locate, preserve, and restore sets of lands containing sufficient area and appropriate land cover types to ensure the long-term survival of a population of 80 to 100 individuals (adults and subadults) south of the Caloosahatchee River. The Service proposes to achieve this goal through land management partnerships with private landowners, through coordination with private landowners during review of development proposals, and through land management and acquisition programs with Federal, State, local, private, and Tribal partners. The acreages of lands necessary to achieve this goal, based on Kautz et al. (2006) average density of 31,923 ac (12,919 ha) per panther is 2,551,851 ac (1,032,720 ha) for 80 panthers or 3,189,813 ac (1,290,900 ha) for 100 panthers.

The principle regulatory mechanism that allows the Service to work directly with private land owners during review of development and land alteration projects is section 10 of the Act. The Service coordinates with Federal agencies pursuant to section 7 of the Act. In August 2000, the Service, to assist the Corps in assessing project effects to the Florida panther, developed the Florida panther final interim Standard Local Operating Procedures for Endangered Species (SLOPES) (Service 2000). The Florida panther SLOPES provide guidance to the Corps for assessing project effects to the Florida panther and recommends actions to minimize these effects. The Florida panther SLOPES also included a consultation area map that identified an action area where the Service believed land alteration projects may affect the Florida panther.

In the original SLOPES the consultation area map (MAP) was generated by the Service by overlaying existing and historical panther telemetry data on a profile of Florida and providing a connecting boundary surrounding most of these points. Since the development of the MAP, we have received more accurate and up-to-date information on Florida panther habitat usage. Specifically we have received two documents the Service believes reflects the most likely

panther habitat usage profiles although documentation clearly shows panther use of areas outside these locations. These documents are the publications by Kautz et al. (2006) and Thatcher et al. (2006). Based on the information in these documents, we have clarified the boundaries of the MAP to better reflect areas where Florida panthers predominate (Figure 7) and refer to these areas cumulatively as the Panther Focus Area.

The Panther Focus Area was determined from the results of recent panther habitat models south of the Caloosahatchee River (Kautz et al. 2006) and north of the Caloosahatchee River (Thatcher et al. 2006). Kautz et al. (2006) model of landscape components important to Florida panther habitat conservation was based on an analysis of panther habitat use and forest patch size. This model was used in combination with radio-telemetry records, home range overlaps, land use and land cover data, and satellite imagery to delineate primary and secondary areas that would be most important and comprise a landscape mosaic of cover types important to help support of the current panther breeding population south of the Caloosahatchee River.

Thatcher et al. (2006) developed a habitat model using Florida panther home ranges in south Florida to identified landscape conditions (land-cover types, habitat patch size and configuration, road density and other human development activities, and other similar metrics) north of the Caloosahatchee River that were similar to those associated with the current panther breeding population.

The Panther Focus Area MAP, south of the Caloosahatchee River is divided into Primary, Secondary, and Dispersal Zones; and north of the Caloosahatchee River into the Primary Dispersal and Expansion Area.

Primary Zone is currently occupied and supports the only known breeding population of Florida panthers in the world. These lands are important to the long-term viability and persistence of the panther in the wild.

Secondary Zone lands are contiguous with the Primary Zone and although these lands are used to a lesser extent by panthers, they are important to the long-term viability and persistence of the panther in the wild. Panthers use these lands in a much lower density than in the Primary Zone.

Dispersal Zone is a known corridor between the Panther Focus Area south of the Caloosahatchee River to the Panther Focus Area north of the Caloosahatchee River. This Zone is necessary to facilitate the dispersal of panthers and future panther population expansion to areas north of the Caloosahatchee River. Marked panthers have been known to use this zone.

Primary Dispersal/Expansion Area is the Fisheating Creek/Babcock-Webb Wildlife Management Area region. These are lands identified by Thatcher et al. (2006) as potential panther habitat with the shortest habitat connection to the Panther Focus Area in south Florida. Several collared and uncollared male panthers have been documented in this area since 1973, and the last female documented north of the Caloosahatchee River was found in this area.

Landscape Preservation Need and Compensation Recommendations

Land Preservation Needs: To further refine the land preservation needs of the Florida panther and to specifically develop a landscape-level program for the conservation of the Florida panther population in south Florida, the Service as previously discussed, in February 2000, appointed a Florida Panther Subteam. The Subteam in addition to the assignments discussed previously, was also charged with developing a landscape-level strategy for the conservation of the Florida panther population in south Florida. The results of this collaborative effort are partially presented in Kautz et al. (2006). One of the primary goals of this effort was to identify a strategically located set of lands containing sufficient area and appropriate land cover types to ensure the long-term survival of the south population of the Florida panther. Kautz et al. (2006) focused their efforts on the area south of the Caloosahatchee River, where the reproducing panther population currently exists.

Kautz et al. (2006) created an updated Florida panther potential habitat model based on the following criteria: (1) forest patches greater than 4.95 ac (2 ha); (2) non-urban cover types within 656 ft (200 m) of forest patches; and (3) exclusion of lands within 984 ft (300 m) of urban areas. The potential habitat map was reviewed in relation to telemetry data, recent satellite imagery (where available), and panther home range polygons. Boundaries were drawn around lands defined as the Primary Zone (Figure 10), defined as the most important area needed to support a self-sustaining panther population. Kautz et al. (2006) referred to these lands as essential; however, as observed in the two previous plans (Logan et al. 1993; Cox et al. 1994), lands within the boundaries of the Primary Zone included some urban areas and other lands not considered to be truly panther habitat (*i.e.*, active rock and sand mines). The landscape context of areas surrounding the Primary Zone was modeled and results were used to draw boundaries of the Secondary Zone (Figure 10), defined as the area capable of supporting the panther population in the Primary Zone, but where habitat restoration may be needed (Kautz et al. 2006).

Kautz et al. (2006) also identified, through a least cost path model, the route most likely to be used by panthers dispersing out of south Florida, crossing the Caloosahatchee River, and dispersing into south-central Florida. Kautz et al. (2006) used ArcView GIS© version 3.3 and ArcView Spatial Analyst© version 2 (Environmental Systems Research, Incorporated, Redlands, California) to construct the least-cost path models and identify optimum panther dispersal corridor(s). The least-cost path models operated on a cost surface that ranked suitability of the landscape for use by dispersing panthers with lower scores indicating higher likelihood of use by dispersing panthers. The lands within the boundaries of the least cost model prediction were defined as the Dispersal Zone (Figure 10). The preservation of lands within this zone is important for the survival and recovery of the Florida panther, as these lands are the dispersal pathways for expansion of the south Florida panther population. The Primary Zone covers 2,270,590 ac (918,895 ha); the Secondary Zone covers 812,104 ac (328,654 ha); and the Dispersal Zone covers 27,883 ac (11,284 ha); providing a total of 3,110,578 ac (1,258,833 ha) (Kautz et al. 2006).

As part of their evaluation of occupied panther habitat, in addition to the average density estimate of one panther per 27,181 ac (11,000 ha) developed by Maehr et al. (1991), Kautz

et al. (2006) estimated the present average density during the timeframe of the study, based on telemetry and other occurrence data, to average 1 panther per 31,923 ac (12,919 ha). In the following discussions of the number of panthers that a particular zone may support, the lower number is based on the 31,923 ac (12,919 ha) value (Kautz et al. 2006) and the higher number is based on the 27,181 ac (11,000 ha) value (Maehr et al. 1991).

Based on these average densities, the Primary Zone could support 71 to 84 panthers; the Secondary Zone 8 to 10 panthers without habitat restoration and 25 to 30 panthers with habitat restoration (existing high quality panther habitat currently present in the Secondary Zone is estimated at 32 percent of the available Secondary Zone lands); and the Dispersal Zone, 0 panthers. Taken together, the three zones in their current condition apparently have the capacity to support approximately 79 to 94 Florida panthers.

Kautz et al.'s (2006) assessment of available habitat south of the Caloosahatchee River determined that non-urban lands in the Primary, Secondary, and Dispersal Zones were not sufficient to sustain a population of 240 individuals south of the Caloosahatchee River. However, Kautz et al. (2006) determined sufficient lands were available south of the Caloosahatchee River to support a population of 79 to 94 individuals (although not all lands are managed and protected).

Compensation Recommendations: To achieve our goal to locate, preserve, and restore sets of lands containing sufficient area and appropriate land cover types to ensure the long-term survival of a population of Florida panthers south of the Caloosahatchee River, the Service chose the mid point (90 panthers) in Kautz et al.'s (2006) population guidelines that a population of 80 to 100 panthers is likely to be stable, although subject to genetic problems, through 100 years. In addition, a population of 90 individuals is eight individuals greater than a population of 82 individuals, which according to the best available PVA (Root 2004) is 95 percent likely to persist over 100 years (assuming a 50:50 male to female ratio). These eight individuals provide a buffer for some of the assumptions in Root's (2004) PVA. Our process to determine compensation recommendations for project affects that cannot be avoided in both our section 7 and section 10 consultations is based on the amount and quality of habitat we believe is necessary to support a population of 90 panthers in south Florida.

The Service, based on Kautz et al.'s (2006) average panther population density of 31,923 ac per panther determined 2,873,070 ac of Primary Zone "equivalent" lands need to be protected and managed. This equivalency factor is needed, since Secondary Zone lands are of less value than Primary Zone lands to the panther, to assure that additional acreage (special consideration) is required in the Secondary Zone to compensate for its lower quality panther habitat. In other words, more than 31,923 ac per panther would be needed, hypothetically, if this acreage were all in the Secondary Zone (see discussion of Primary Zone equivalent lands in the following section). The combined acreage of lands within the Primary, Dispersal, and Secondary Zones is 3,110,577 ac (1,258,833 ha) (Kautz et al. 2006). Currently, 2,073,865 ac of Primary Zone equivalent lands are preserved (Table 4), so 799,205 additional ac need to be preserved to support a population of 90 panthers in south Florida (2,873,070 minus 2,073,865 equals 799,205).

The Service also consults on lands outside of the Primary, Secondary, and Dispersal zones that may effect panthers such as agricultural lands that are adjacent to the Panther Focus Area and proposals in urbanized areas that could generate traffic in or adjacent to the Panther Focus Area or have other identifiable impacts.

Primary Zone Equivalent Lands: Kautz et al. (2006), through their habitat evaluation of lands important to the Florida panther, identified three sets of lands, *i.e.,* Primary Zone, Secondary Zone, and Dispersal Zone, and documented the relative importance of these lands to the Florida panther. These lands generally referred to as the panther core lands (Figure 10), include the majority of the home ranges of the current population of the Florida panther. The Service, in our evaluation of habitat needs for the Florida panther expanded the boundaries of the Kautz et al. (2006) lands to include those lands south of the Caloosahatchee River where additional telemetry points historically were recorded. These additional lands (about 819,995 ac), referred to as the "Other" Zone, are added to the lands in Kautz et al.'s (2006) panther core lands (Figure 10) and represent the lands within the Service's 2000 consultation area boundary south of the Caloosahatchee River as shown in Figure 7. These lands (core lands and other zone lands) together are referred to by the Service as the core area. The "Other" Zone lands, as well as the lands within the Secondary Zone, provide less landscape benefit to the Florida panther than the Primary and Dispersal Zones, but are important as a component of our goal to preserve sufficient lands to support a population of 90 panthers in South Florida.

To account for the lower landscape importance of these lands in our preservation goals and in our habitat assessment methodology, we assigned lands in the Other Zone a value of 0.33 and lands in the Secondary Zone a value of 0.69 to convert these lands to Primary Zone value, *i.e.,* Primary Zone equivalents (Table 5). Kautz et al. (2006) identifies the need for restoration in the Secondary Zone to achieve maximum benefits. To estimate the Primary Zone equivalent of Secondary Zone lands, we derived a relative habitat value (average PHU value) for each by comparing the habitat ranks estimated in Kautz et al. (2006 – Table 1) for each habitat type per zone. The average PHU value for the Primary Zone is 6.94 and for the Secondary Zone 4.79. Based on this analysis, the habitat value of the Secondary Zone is roughly 69 percent of the Primary Zone, and restoration is needed to achieve landscape function (4.79/6.94=0.69). Dispersal Zone lands are considered equivalent to Primary Zones lands with a 1/1 value. At-risk lands in the Other Zone total 819,995 ac. Actions on some of the Other Zone lands such as some actions in areas that have already been urbanized will not have an impact on panthers or their habitat, and these case-specific determinations will be made based on a review of the specific proposals. We estimate 80 percent of these actions will have an impact on achieving the panther population goal, and will monitor this carefully as we review proposed actions (819,995 times 0.8 equals 655,996 ac). Multiply this acreage (655,996 ac) by 0.33 to determine the ac of Primary Zone equivalent lands the Other Zone can provide (655,996 times 0.33 equals 216,479 ac of Primary Zone equivalent lands) (Table 5). Using this assessment, the 503,481 ac of Secondary Zone lands equate to 347,402 ac of Primary Zone equivalent lands. These equivalent values, 0.33 and 0.69, for Other and Secondary Zones, respectively, and 1/1 for Dispersal Zone, are important components in our assessment of compensation needs for a project

in the panther consultation area and are components of our habitat assessment methodology as discussed below.

Habitat Assessment Methodology

To evaluate project effects to the Florida panther, the Service considers the contributions the project lands provide to the Florida panther, recognizing not all habitats provide the same functional value. Kautz et al. (2006) also recognized not all habitats provide the same habitat value to the Florida panther and developed cost surface values for various habitat types, based on use by and presence in home ranges of panthers. The FWC (2006b), using a similar concept, assigned likely use values of habitats to dispersing panthers. The FWC's habitats were assigned habitat suitability rank between 0 and 10, with higher values indicating higher likely use by dispersing panthers.

The Service chose to evaluate project effects to the Florida panther through a similar process. We incorporated many of the same habitat types referenced in Kautz et al. (2006) and FWC (2006b) with several adjustments to the assigned habitat use values reflecting consolidation of similar types of habitats and the inclusion of Everglades Restoration water treatment and retention areas. We used these values as the basis for habitat evaluations and the recommended compensation values to minimize project effects to the Florida panther (Table 6), as discussed below.

Base Ratio: To develop a base ratio that will provide for the protection of sufficient acreage of Primary Zone equivalent lands for a population of 90 panthers from the acreage of Primary Zone equivalent non-urban lands at risk, we developed the following approach.

The available Primary Zone equivalent lands are estimated at 3,276,563 ac (actual acreage is 4,376,444 ac [the "actual acreage" value includes acres of lands in each category in the Secondary and Other Zones as well as the lands in the Primary Zone]) (see Table 5). Currently 2,073,865 ac of Primary Zone equivalent lands (actual acreage is 2,578,152 ac) of non-urban lands are preserved. The remaining non-urban at-risk private lands are estimated at 1,202,698 ac of Primary Zone equivalent lands (actual acreage is 1,798,295 ac). To meet the protected and managed lands goal for a population of 90 panthers, an additional 799,205 ac of Primary Zone equivalent lands are needed. The base ratio is determined by dividing the primary equivalents of at-risk habitat to be secured (799,205 ac) by the result of the acres of at-risk habitat in the Primary Zone (610,935 ac) times the value of the Primary Zone (1); plus the at-risk acres in the Dispersal Zone (27,883 ac) times the value of the Dispersal Zone (1); plus the at-risk acres in the Secondary Zone (503,481 ac) times the value of the Secondary Zone (0.69); plus the at-risk acres in the Other Zone (655,996 ac) times the value of the Other Zone (0.33); minus the at-risk acres of habitat to be protected (799,205 ac). The results of this formula provide a base value of 1.98.

$$799{,}205 / ((610{,}935 \times 1.0) + (27{,}883 \times 1) + (503{,}481 \times 0.69) + (655{,}996 \times 0.33)) - 799{,}205 = 1.98$$

In evaluating habitat losses in the consultation area, we used an estimate of 0.8 percent loss of habitat per year (R. Kautz , FWC, personal communication, 2004) to predict the amount of

habitat loss anticipated in south Florida during the next 5 years (*i.e.,* 6,000 ha per year; 14,820 ac per year). We conservatively assumed that we would be aware of half of these projects. We assumed that half of the projects would occur in the Primary Zone and half would occur in the Secondary Zone. We estimated that over a 5-year period that about 37,000 ac would be developed without Federal review. We adjusted the base value from 1.98 to 2.23.

We also realize that collectively habitat losses from individual single-family residential developments will compromise the Service's goal to secure sufficient lands for a population of 90 panthers. We believe, on an individual basis, single-family residential developments by individual lot owners on lots no larger than 2.0 ha (5.0 ac) will not result in take of panthers on a lot-by-lot basis; however, collectively these losses may impact the panther. Panthers are a wide ranging species, and individually, a 2.0 ha (5.0 acre) habitat change will not have a measurable impact. Compensation for such small-scale losses on a lot-by-lot basis is unlikely to result in meaningful conservation benefits for the panther versus the more holistic landscape level conservation strategy used in our habitat assessment methodology. To account for these losses, we estimated about another 12,950 ac over a 5-year period (2,590 ac per year) would be developed through this avenue. We adjusted the base value from 2.23 to 2.48.

We also realize there is a need for road crossings in strategic locations and we believe there are projects that may not have habitat loss factors but will have traffic generation factors. The Service considers increases in traffic as an indirect effect from a project and can contribute to panther mortality. Therefore, we have added another 0.02 to the base ratio to address traffic impacts, which could provide an incentive to implement crossings in key locations. Following the same approached shown above, we adjusted the base ratio from 2.48 to the 2.5. The Service intends to re-evaluate this base ratio periodically and adjust as needed to make sure all adverse effects are adequately ameliorated and offset as required under section 7 of the Act and to achieve the Service's conservation goal for the Florida panther.

Landscape Multiplier: As discussed previously in the above section on Primary Zone Equivalent Lands, the location of a project in the landscape of the core area of the Florida panther is important. As we have previously discussed, lands in the Primary and Dispersal Zones are of the most importance in a landscape context to the Florida panther, with lands in the Secondary Zone of less importance, and lands in the Other Zone of lower importance. These zones affect the level of compensation the Service believes is necessary to minimize a project's effects to Florida panther habitat. Table 7 provides the landscape compensation multipliers for various compensation scenarios. As an example, if a project is in the Other Zone and compensation is proposed in the Primary Zone, a Primary Zone equivalent multiplier of 0.33 is applied to the PHUs (see discussion below) developed for the project. If the project is in the Secondary Zone and compensation is in the Primary Zone, then a Primary Zone equivalent multiplier of 0.69 is applied to the PHUs developed for the project.

Panther Habitat Units – Habitat Functional Value: Prior to applying the base ratio and landscape multipliers discussed above, we evaluate the project site and assign functional values to the habitats present. This is done by assigning each habitat type on-site a habitat suitability value from the habitats shown in Table 6. The habitat suitability value for each habitat type is

then multiplied by the acreage of that habitat type resulting in a number representing PHUs. These PHUs are summed for a site total, which is used as a measurement of the functional value the habitat provides to the Florida panthers. This process is also followed for the compensation-sites.

Exotic Species Assessment: Since many habitat types in south Florida are infested with exotic plant species, which affects the functional value a habitat type provides to foraging wildlife species (*i.e.,* primarily deer and hog), we believe the presence of these species and the value these species provide to foraging wildlife needs to be considered in the habitat assessment methodology. As shown in Table 6, we have a habitat type and functional value shown for exotic species. This category includes not only the total acres of pure exotic species habitats present but also the percent-value acreages of the exotic species present in other habitat types.

For example, a site with 100 ac of pine flatwoods with 10 percent exotics would be treated in our habitat assessment methodology as 90 ac of pine flatwoods and 10 ac of exotics. Adding another 100 ac of cypress swamp with 10 percent exotics would change our site from 90 ac of pine flatwoods and 10 ac of exotics to 90 ac of pine flatwoods, 90 ac of cypress swamp, and 20 ac of exotics.

Habitat Assessment Methodology Application – Example: To illustrate the use of our habitat assessment methodology, we provide the following example. A 100-acre project site is proposed for a residential development. Plans call for the entire site to be cleared. The project site contains 90 ac of pine flatwoods and 10 ac of exotic vegetation, and is located in the "Secondary Zone." The applicant has offered habitat compensation in the "Primary Zone" to minimize the impacts of the project to the Florida panther. To calculate the PHUs provided by the site, we multiply the habitat acreage by the "habitat suitability value" for each habitat type and add those values to obtain a value of 840 PHUs ((90 ac of pine flatwoods x 9 [the habitat suitability value for pine flatwoods] = 810 PHUs) + (10 ac of exotic vegetation x 3 [the habitat suitability value for exotics] = 30 PHUs) = 840 PHUs). The value of 840 PHUs is then multiplied by the 2.5 (the base ratio) and 0.69 (the landscape multiplier) resulting in a value of 1,149 PHUs for the project site. In this example, the acquisition of lands in the Primary Zone containing at least 1,149 PHUs are recommended to compensate for the loss of habitat to the Florida panther resulting from this project.

Analysis of the species likely to be affected

The Florida panther is an endangered animal restricted to two to three million acres of land (6 to 9 percent of the total land area of Florida) in south Florida. The panther is a wide-ranging species that requires a biotically diverse landscape to survive. Dispersing subadult males wander widely through unforested and disturbed habitat. Human population in south Florida has dramatically increased, from one million in 1950 to six million in 1990, resulting in secondary disturbances such as increased human presence and noise, light, air, and water pollution. Increasing human population has resulted in increasing impacts on native habitat and flora and fauna. Resulting threats to panthers include road mortality, habitat loss, habitat fragmentation, and human disturbance.

STATUS OF THE SPECIES AND CRITICAL HABITAT RANGEWIDE - Audubon's Crested Caracara

The caracara is a member of the Class Aves, Order Falconiformes, Family Falconidae. It was originally described by John James Audubon (1834), who discovered the caracara on November 21, 1831, and published an account under the name *Polyborus vulgaris*. John Cassin renamed it in 1865 to *Polyborus audubonii*. In 1999, Dove and Banks definitively renamed the species *Caracara cheriway* and eliminated all subspecies classifications. Dove and Banks (1999) conducted a taxonomic analysis of museum specimens of caracaras based on plumage and morphological characteristics and concluded that there are three caracara species with no subspecific groupings. They refer to the North American caracara as *Caracara cheriway*, and this name was subsequently accepted by the American Ornithologists' Union. The list of threatened and endangered animals (50 CFR 17.11) continues to refer to the old scientific name *Polyborus plancus audubonii*, but this species is referred to in the remainder of this document as the caracara. It is a resident, diurnal, and non-migratory species that occurs in Florida as well as the southwestern United States and Central America. Florida's population of the caracara is found in the prairie area of the south-central region of the State. Only the Florida population, which is isolated from other populations of the species in the southwestern United States and Central America, is listed under the Act.

Species Description

The caracara is a large raptor with a crest, naked face, heavy bill, elongated neck, and unusually long legs. It is about 50 to 64 centimeters (cm) long and has a wingspan of 120 cm. The adult is dark brownish black on the crown, wings, back, and lower abdomen. The lower part of the head, throat, upper abdomen, and under tail coverts are white, the breast and upper back are whitish, heavily barred with black. The tail is white with narrow, dark crossbars and a broad, dark terminal band. Prominent white patches are visible near the tips of the wings in flight. The large, white patches in the primaries and the white tail, broadly tipped with black, are both very conspicuous in flight and can be recognized at a long distance (Bent 1961).

Juveniles have a similar color pattern but are brownish and buffy, with the breast and upper back streaked instead of barred. Subadults resemble adults but are more brownish in color. Adults have yellow-orange facial skin and yellow legs. Facial skin of juveniles is pinkish in color, and the legs are gray (Layne 1978). Full adult plumage is obtained sometime after 3 years of age (Morrison 1997). There is no evidence of sexual dimorphism, the sexes being similar in color and size; however, gender can be determined surgically or through genetic analysis (Morrison and Maltbie 1999).

A caracara's feet and flight behavior are also notable. Their feet are clearly those of a raptor; however, their talons are flatter, enabling caracaras to run and walk more easily than other raptors. Caracaras are terrestrial and often forage by walking for extended periods on the ground (Morrison and Humphrey 2001). Bent (1938) noted the caracara's flight pattern resembles that of a northern harrier (*Circus cyaneus*), but caracaras fly faster and more gracefully. Caracaras

are strong fliers and may reach speeds of 40 mph. They have also been observed soaring in large circles at great heights (Howell 1932).

Critical Habitat Description

Critical Habitat has not been designated for this species.

Life History

Caracaras are resident, diurnal, and non-migratory. Adult caracaras may be found in their home range year-round. Home ranges average approximately 3,000 ac (approximately 1,200 ha), corresponding to a radius of 1.2 to 1.5 miles (2 to 2.5 kilometers) surrounding the nest site (Morrison and Humphrey 2001). Foraging typically occurs throughout the home range during nesting and non-nesting seasons.

The Florida caracara population historically inhabited native dry or wet prairie areas containing scattered cabbage palms, their preferred nesting tree. Scattered saw palmetto, and low-growing oaks (*Quercus minima, Q. pumila*), and cypress also occur within these native communities. Over the last century, many of the native prairie vegetation communities in central and south Florida have been converted to agricultural land uses, and frequently replaced by improved and unimproved pasture dominated by short-stature, non-native, sod-forming grasses. Morrison and Humphrey (2001) hypothesize that the vegetation structure of open grasslands (short-stature vegetation, scattered shrub cover, and nest trees) may be preferred by the caracara, due to its tendency to walk on the ground during foraging activities. The short vegetation stature and relatively simple vegetation structure may directly facilitate foraging by caracaras and provide less cover for predators. Consequently, caracaras appear to benefit from management actions such as prescribed burning that maintain habitat in a low stature and structurally simple condition. These activities reduce vegetation cover and may facilitate the observation and capture of prey. Within agricultural lands, regular mowing, burning, and high-density grazing may maintain low vegetative structure, an important habitat characteristic of the caracara's nest stand area (Morrison and Humphrey 2001). Regular prescribed burning maintains habitat in a favorable condition in native dry prairies. These field observations are consistent with the home range compositional analyses that indicate non-random selection of improved and semi-improved pasture land use.

Morrison and Humphrey (2001) characterized caracara distribution, reproductive activity, and land use patterns within a 21,000 km^2 area in south-central Florida. Comparisons of caracara home ranges to randomly selected areas and available habitat within the study area revealed caracara home ranges contained higher proportions of improved pasture and lower proportions of forest, woodland, oak scrub, and marsh. Home range size was inversely related to the proportion of improved pasture within the home range. In addition, breeding-area occupancy rate, breeding rates, and nesting success were consistently higher on private ranch lands during the study. Although it is unclear exactly which management activities best promote habitat utilization by caracaras, the mowing, burning, and grazing activities associated with improved pastures serve to maintain the short vegetation structure they appear to favor. The scattered cabbage palms that

are often present within improved pastures to serve as shade for cattle provide nesting substrate for caracaras.

Additional investigations into habitat suitability for caracara (Morrison *et al.* 2006) indicate that maintaining heterogeneity which includes specific land cover types as well as small (less than 1 hectare or 2.47 ac) of freshwater wetlands, is critical in maintaining suitable habitat for the crested caracara in Florida. The proportion of six vegetation and land cover types (*i.e.*, cabbage palm-live oak hammock, grassland, improved pasture, unimproved pasture, hardwood hammocks and forest, and cypress/pine/cabbage palm) and 2 types of water (*i.e.*, lentic and lotic) were determined to be the most important criteria for predicting habitat suitability for caracara. Most known nest locations (72.9 percent) in the study were present on improved pasture although that habitat type only comprised 12.5 percent of the entire study area. Caracara appear to be exploiting pastures, ditches, and impounded wetlands that have replaced the historic land cover as shown by the high occurrence of improved and unimproved pastures and lotic waters in caracara home ranges (Morrison *et al.* 2006).

Caracaras are highly opportunistic in their feeding habits, eating carrion and capturing live prey. Their diets include insects and other invertebrates, fish, snakes, turtles, birds, and mammals (Layne 1978). Live prey also include rabbits, young opossums (*Didelphis marsupialis*), rats (*Rattus* spp.), mice, squirrels, frogs, lizards, young alligators, crabs, crayfish, fish, young birds, cattle egrets (*Bubulcus ibis*), beetles, grasshoppers, maggots, and worms (Bent 1961; Layne et al. 1977; Morrison 2001). Scavenging at urban dumps has also been observed (Morrison 2001). More recent information from Morrison (2005) indicates that wetland-dependent prey items comprise about 64 percent of the total diet. Mammals make up about 31 percent of the diet, with the majority of this being carrion.

The birds also closely follow mowers in pastures and tractors plowing fields, in order to capitalize on prey that may be exposed. Agricultural drainage ditches, cattle ponds, roadside ditches and other shallow water features also provide good foraging conditions for caracaras (Morrison 2001). Within native habitats, caracaras regularly scavenge in recently burned areas, and forage along the margins of wetlands within dry prairie communities.

These raptors hunt on the wing, from perches, and on the ground (Service 1989). They will also regularly patrol sections of highway in search of carrion (Palmer 1988). They may be seen feeding on road kills with vultures. However, caracaras are dominant over vultures and may occasionally chase the larger vultures from the road kill (Howell 1932).

Although adult caracaras are generally territorial and primarily occupy home ranges, large groups of individual caracaras are occasionally encountered (Layne 1978). Oberholser (1974) attributes this to the birds' carrion-feeding habit, although Morrison (2005) has noted that juvenile caracaras are nomadic. Caracaras are capable of moving long distances. Between the time when young birds leave the natal territory, and when subadults establish a territory, each individual may traverse a large portion of the species' range in Florida. Adults will also occasionally leave their territory and travel great distances, primarily outside of the breeding season. The caracara's movement capability and nomadic character during subadult years may

be the cause of occasional observations of caracaras far outside their breeding range. Caracaras have been observed in the Florida Keys and into the panhandle of Florida (Bay County), as well as in other states, though some of these may have been escaped individuals (Layne 1996). There appears to be no migration or genetic exchange between the Florida population and other populations of the northern caracara.

Routine observation and radio-telemetry monitoring suggest there are several "gathering areas" in south-central Florida that may be important to caracaras during the first 3 years after leaving their natal territory, before first breeding (Morrison 2001). Relatively large numbers of caracaras (up to 50) have been observed along the Kissimmee River north of SR 98; south of Old Eagle Island Road in northern Okeechobee County; south of SR 70, west of Fort Pierce; and south of SR 70 in Highlands County, and on the Buck Island Ranch, for example. These gathering areas are regularly but not continually used by subadult and non-breeding caracaras and generally consist of large expanses of improved pasture; however, the particular habitat values of these areas have not yet been evaluated.

Morrison (1999) reported that breeding pairs of caracaras seem to be monogamous, highly territorial, and exhibit fidelity to both their mate and the site. The age at first breeding has been documented as 3 years (Nemeth and Morrison 2002).

Details of breeding behavior in the caracara have been documented by Morrison (1998, 1999). The initiation of breeding is marked by several behavioral changes, including the pair perching together near the nesting site, preening and allopreening, and sharing food. Caracaras are one of the first of Florida's raptors to begin nesting. Although breeding activity can occur from September through June, the primary breeding season is considered to be November through April. Nest initiation and egg-laying peak from December through February.

Caracaras construct new nests each nesting season, often in the same tree as the previous year. Both males and females participate in nest building. Nests are well concealed and most often found in the tops of cabbage palms (Morrison and Humphrey 2001) although nests have been found in live oaks (*Q. virginiana*), cypress (first record, Morrison et al. 1997), Australian pine (*Casuarina* spp.), saw palmetto, and black gum (*Nyssa sylvatica*). Caracaras usually construct their nests 4 to 18 m above the ground; their nests primarily consist of haphazardly woven vines trampled to form a depression (Bent 1938, Sprunt 1954, Humphrey and Morrison 1996). Caracaras vigorously defend their nesting territory during the breeding season (Morrison 2001).

Clutch size is two or three eggs, but most often two. Incubation lasts for about 31 to 33 days (Morrison 1999) and is shared by both sexes. Ordinarily only one brood is raised in a season, but around 10 percent of the population (annually) may raise a second brood. The young fledge at about 7 to 8 weeks of age, and post-fledgling dependency lasts approximately 8 weeks.

Population Dynamics

The great majority of caracara breeding territories occur on private lands in Florida, primarily within the ranchlands of central Florida. This fact makes monitoring the population and

determining territory occupancy and nesting effort or success very difficult. Consequently, estimates of the caracara population in Florida have been based on counts of caracaras along roadsides (Heinzman 1970; Layne 1995). These roadside counts also have the potential be strongly affected by the presence of non-territorial juvenile and sub-adult birds during the period when they are nomadic. Because the occurrence and density of caracaras is not evenly distributed within the region they occupy (due to congregation and nomadic individuals), these roadside surveys are probably unreliable for estimating the overall population.

Status and Distribution

The caracara's perceived decline, as described in historic literature, is attributed primarily to habitat loss (Layne 1996). This perceived decline and the geographic isolation of the Florida population eventually resulted in the caracara's listing as threatened in 1987 (52 FR 25232). In particular, the caracara was listed as threatened because its primary habitat, dry prairie, had been greatly eliminated or modified for agriculture and residential development. It was also listed because existing regulatory mechanisms did not adequately prevent the destruction or modification of the caracara's habitat, which is mainly located on private land.

Morrison and Humphrey (2001) stated that no data are available on historic abundance, habitat use, or nest distribution by caracaras in Florida. The size of Florida's caracara population remains in question. Accurate counts become difficult because of limited access to areas of suitable habitat and because of the bird's behavior and limited detectability (Humphrey and Morrison 1997). Heinzman (1970) published the results of a 4-year road survey (1967-1970), which suggested fewer than 100 individual caracaras at 58 localities remained in Florida. Stevenson (1976) concurred with this estimate in 1974. Layne (1995) monitored caracara distribution and population status in Florida from 1972 to 1989. Based on roadside surveys, he estimated that the adult portion of the population was stable with a minimum of about 300 birds in 150 territories. The immature portion of the population was estimated to be between 100 and 200 individuals, bringing the total statewide population to between 400 and 500 birds. However, given continued landscape change in areas where caracaras have been known to occur, and the fact that not all the probable breeding range has been adequately surveyed for breeding pairs, estimating this population's size remains difficult.

In addition to presumed population declines related to habitat loss, direct human-caused mortality may also be a factor to be considered in the recovery of the species. In the past, large numbers of caracaras were killed in vulture traps (Service 1989). Individuals may also be caught in leg-hold traps used to control mammalian predators (Morrison 1996). Road mortalities are a significant cause of caracara decline. Morrison (2003) identifies highway mortalities as a major cause of juvenile mortalities with young birds especially vulnerable within the first 6 months after fledging.

The Florida population of caracaras is isolated and habitat-specific. Therefore, it may be susceptible to environmental catastrophes and potentially reduced reproductive rates because of demographic accidents such as skewed sex ratios or disproportionate age-related mortality. Low numbers may also reduce the genetic viability through loss of heterozygosity, thereby increasing

vulnerability to environmental stresses. The location of many of the occupied territories on private land, and the inaccessibility of these territories to surveyors, makes it difficult to census the caracara and detect changes in its population size and distribution. This difficulty increases the possibility of not detecting a population decline that could result in extinction.

The major threat to this population remains habitat loss. Large areas of native prairie and pasture lands in south-central Florida have been converted to citrus operations, tree farms, other forms of agriculture, and real estate development and this loss has accelerated in the past few decades (Morrison and Humphrey 2001). However, historical conversion of forested habitats to pasture has not been adequately documented as partially offsetting losses to caracara habitat, so a full accounting of historic habitat changes is lacking. The current threat of habitat loss persists as changes in land use continue. Florida's burgeoning human population has also increased the number of motor vehicles and the need for roads. The increase in traffic as well as the caracara's predisposition for feeding on road-killed animals has probably increased the number of caracaras killed or injured as a result of vehicle strikes.

Cattle ranching and extensive pastures appear to be compatible with caracara survival. Inadequate information is available to assess current caracara use of native wet and dry prairie communities, but these communities are likely the primary communities that caracaras occupied in the historic Florida landscape. The number of territories occurring in improved or unimproved pasture can be expected to increase if sufficiently large overgrown pastures are reclaimed and new pastures or restored native prairies are created from other agricultural land uses. The conversion of pasture to citrus (Cox et al. 1994), sugarcane, and residential development is also cause for concern. Recognizing the conservation value of cattle ranches and enlisting landowner cooperation in the preservation and management of these lands are critical elements in recovery of the caracara.

Lack of habitat management is also a potential threat to caracaras in some areas, and can result in habitat degradation to the point where it is no longer suitable for occupancy. In particular, encroachment of woody shrubs and trees into open dry prairies, pastures and similar habitats will result in some reduction in habitat suitability. Complete clearing of large areas that includes removal of cabbage palms and other trees may also reduce the suitability of habitat, but generally only when very large areas are completely cleared.

While there is inadequate evidence available to conclude that the caracara population in Florida has declined significantly, loss of habitat is threatening remaining caracara territories at an increasing rate. The limited distribution of caracaras and a lack of opportunities for expansion of the distribution make this species vulnerable to reductions in habitat quality and other increasing threats within its range.

STATUS OF THE SPECIES AND CRITICAL HABITAT RANGEWIDE – Eastern Indigo Snake

Species description

The eastern indigo snake is the largest non-venomous snake in North America, obtaining lengths of up to 8.5 ft (2.6 meters) (Moler 1992). Its color is uniformly lustrous-black, dorsally and ventrally, except for a red or cream-colored suffusion of the chin, throat, and sometimes the cheeks. Its scales are large and smooth (the central 3 to 5 scale rows are lightly keeled in adult males) in 17 scale rows at mid-body. Its anal plate is undivided. In the Keys, adult eastern indigo snakes seem to have less red on their faces or throats compared to most mainland specimens (Lazell 1989). Several researchers have informally suggested that Lower Keys eastern indigo snakes may differ from mainland snakes in ways other than color.

Critical habitat description

Critical habitat has not been designated for this species.

Life history

In northern Florida, eastern indigo snakes breed between November and April, with females depositing 4 to 12 eggs during May or June (Moler 1992). Young hatch in approximately 3 months and there is no evidence of parental care. Limited information on the reproductive cycle in south-central Florida suggests that the breeding and egg-laying season may be extended. In this region, breeding extends from June to January; laying occurs from April to July; and hatching occurs during mid-summer to early fall (Layne and Steiner 1996). Eastern indigo snakes in captivity take 3 to 4 years to reach sexual maturity (Speake et al. 1987). Female eastern indigo snakes can store sperm and delay fertilization of eggs. There is a single record of a captive eastern indigo snake laying five eggs (at least one of which was fertile) after being isolated for more than 4 years (Carson 1945). However, there have been several recent reports of parthogenetic reproduction by virginal snakes. Hence, sperm storage may not have been involved in Carson's (1945) example (Moler 1998). There is no information on the eastern indigo snake lifespan in the wild, although one captive individual lived 25 years, 11 months (Shaw 1959).

Eastern indigo snakes are active and spend a great deal of time foraging for food and mates. They are one of the few truly diurnal snake species, meaning that they are active during the day and rest at night. The eastern indigo snake is a generalized predator and will eat any vertebrate small enough to be overpowered. They do not kill their prey by constriction, but swallow their prey alive. Food items include fish, frogs, toads, snakes (venomous, as well as non-venomous), lizards, turtles, turtle eggs, small alligators, birds, and small mammals (Keegan 1944; Babis 1949; Kochman 1978; Steiner et al. 1983).

Population dynamics

Eastern indigo snakes require a mosaic of habitats. A study in southern Georgia found that interspersion of tortoise-inhabited sandhills and wetlands improve habitat quality for the eastern indigo snake (Landers and Speake 1980). Eastern indigo snakes require sheltered retreats from winter cold and desiccating conditions, and often use burrows of the gopher tortoise (*Gopherus polyphemus*) when available (Speake et al. 1978; Layne and Steiner 1996). In habitats lacking gopher tortoises, eastern indigo snakes may take shelter in hollowed root channels, hollow logs, or the burrows of rodents, armadillos, or land crabs (Lawler 1977; Moler 1985a; Layne and Steiner 1996). In the milder climates of central and southern Florida, eastern indigo snakes exist in a more stable thermal environment, where availability of thermal refugia may not be as critical to snake survival. Over most of its range in Florida, the eastern indigo snake frequents diverse habitats such as pine flatwoods, scrubby flatwoods, floodplain edges, sand ridges, dry glades, tropical hammocks, edges of freshwater marshes, muckland fields, coastal dunes, and xeric sandhill communities (Service 1999). Eastern indigos also use agricultural lands and various types of wetlands, with higher population concentrations occurring in the sandhill and pineland regions of northern and central Florida. Observations over the last 50 years made by maintenance workers in citrus groves in east-central Florida indicate that eastern indigo snakes are occasionally observed on the ground in the tree rows and more frequently near the canals, roads, and wet ditches (Zeigler 2006). In extreme south Florida (*i.e.,* the Everglades and Florida Keys), eastern indigo snakes are found in tropical hardwood hammocks, pine rocklands, freshwater marshes, abandoned agricultural land, coastal prairie, mangrove swamps, and human-altered habitats (Steiner et al. 1983). It is thought that they prefer hammocks and pine forests since most observations occur there and use of these areas is disproportionate compared to the relatively small total area of these habitats (Steiner et al. 1983).

Eastern indigo snakes range over large areas and into various habitats throughout the year, with most activity occurring in the summer and fall (Smith 1987; Moler 1985a). In Georgia, the average range of the eastern indigo snake is 12 ac during the winter (December through April), 106 ac during late spring through early summer (May through July), and 241 ac during late summer and fall (August through November) (Speake et al. 1978). Adult males have larger home ranges than adult females and juveniles; their ranges average 554 ac, reducing to 390 ac in the summer (Moler 1985b). In contrast, a gravid female may use from 3.5 to 106 ac (Smith 1987). In Florida, home ranges for females and males range from 5 to 371 ac and 4 to 805 ac, respectively (Smith 2003). At the Archbold Biological Station (ABS), average home range size for females was determined to be 47 ac and overlapping male home ranges to be 185 ac (Layne and Steiner 1996).

Status and distribution

The eastern indigo snake was listed as threatened on January 31, 1978 (43 FR 4028), due to population declines caused by habitat loss, over-collecting for the domestic and international pet trade, and mortality caused by rattlesnake collectors who gas gopher tortoise burrows to collect snakes.

The eastern indigo snake ranges from the southeastern United States to northern Argentina (Conant and Collins 1998). This species has eight recognized subspecies, two of which occur in the United States: the eastern indigo and the Texas indigo (*D. c. erebennus*). In the United States, the eastern indigo snake historically occurred throughout Florida and in the coastal plain of Georgia and has been recorded in Alabama and Mississippi (Diemer and Speake 1983; Moler 1985b). It may have occurred in southern South Carolina, but its occurrence there cannot be confirmed. Georgia and Florida currently support the remaining endemic populations of the eastern indigo snake (Lawler 1977). The eastern indigo occurs throughout most of Florida and is absent only from the Dry Tortugas and Marquesas, Keys and regions of north Florida where cold temperatures and deeper clay soils exist (Cox and Kautz 2000).

Effective law enforcement has reduced pressure on the species from the pet trade. However, because of its relatively large home range, the eastern indigo snake is especially vulnerable to habitat loss, degradation, and fragmentation (Lawler 1977; Moler 1985a). The primary threat to the eastern indigo snake is habitat loss due to development and fragmentation. In the interface areas between urban and native habitats, residential housing is also a threat because it increases the likelihood of snakes being killed by property owners and domestic pets. Extensive tracts of undeveloped land are important for maintaining eastern indigo snakes. In citrus groves, eastern indigo snake mortality occurs from vehicular traffic and management techniques such as pesticide usage, lawn mowers, and heavy equipment usage (Zeigler 2006). Within the last 5 years, since the spread of citrus canker, Zeigler (2006) reported seeing at least 12 dead eastern indigo snakes that were killed by heavy equipment operators in the act of clearing infected trees.

Seven confirmed observations of eastern indigo snakes occurred on the A-1 Reservoir in Palm Beach County, an Acceler8 component of the EAA Storage Reservoir Project (EAA Project) under the CERP. The seven observations included a snake accidentally killed during reservoir construction on October 10, 2006.

Tasks identified in the recovery plan for this species include: habitat management through controlled burning, testing experimental miniature radio transmitters for tracking juveniles, maintenance of a captive breeding colony at Auburn University, recapture of formerly released eastern indigo snakes to confirm survival in the wild, educational lectures and field trips, and efforts to obtain landowner cooperation in conservation efforts (Service 1999).

To protect and manage this species for recovery, large expanses of land must be protected. Management of these lands must be directed towards maintaining and enhancing the diversity of plant and animal assemblages within these properties. Where these goals are achieved, eastern indigo snakes will directly benefit because of improved habitat conditions. Land managers are encouraged to utilize fire as a tool to maintain biodiversity in fire-dependent ecosystems.

ENVIRONMENTAL BASELINE – Florida Panther

The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7

consultation, and the impact of state or private actions, which occur simultaneously with the consultation in progress.

Status of the Species within the Action Area

As stated previously, for the purposes of this consultation, the action area includes the Corps' project area and surrounding lands frequently visited by panthers (Figure 11). The action area is a subset of the current geographic range of the panther and includes those lands that the Service believes may experience direct and indirect effects from the proposed development. Therefore, for both direct and indirect effects, the action area is defined as all lands within a 25-mile radius of the project. This action area does not include urban lands and lands west of I-75. The proposed action may have direct and indirect effects on the ability of panthers to breed, feed, and find shelter, and to disperse within the population.

The Service used current and historical radio-telemetry data, information on habitat quality, prey base, and evidence of uncollared panthers to evaluate panther use in the action area. Panther telemetry data are collected 3 days per-week from fixed-wing aircraft, usually in early to midmorning. However, researchers have shown panthers are most active between dusk and dawn (Maehr et al. 1990a, Beier 1995) and are typically at rest in dense ground cover during daytime monitoring flights (Land 1994). Therefore, telemetry locations may present an incomplete picture of panther activity patterns and habitat use (Comiskey et al. 2002). In addition, telemetry data alone may be misleading since less than half of the panther population is currently collared.

Although telemetry data may not provide a complete picture of panther activity patterns, telemetry locations are a good indicator, due to the extensive data set, of the approximate boundaries of home ranges, panther travel corridors, and the range of Florida panthers south of the Caloosahatchee River. The FWC also uses observational data collected during telemetry flights to assess the yearly breeding activity of radio-collared panthers. Female panthers accompanied by kittens or male panthers within close proximity of an adult female were assumed to have engaged in breeding activity during that year. Documentation by McBride (Shindle et al. 2003) shows that between July 2002 and June 2003, 3-collared panthers, 2-uncollared females, and 2-uncollared males had home ranges in or home ranges that overlapped or were immediately adjacent to the same survey unit as the C-43 West Storage Reservoir project. In addition, 8 other panthers that used this same survey unit previously died during this time period (FWC 2003). This unit, designated as Unit 7, includes the OSSF and WMA and adjacent private lands.

Within the 25-mile radius action area, based on telemetry data as of June 2006, at least 13 living radio-collared panthers have overlapping home ranges. These panthers are FP 48 (female), FP 62 (male), FP 65 (male), FP 66 (female), FP 75 (female), FP 81 (male), FP 83 (female), FP 84 (male), FP 110 (female), FP 131 (male), FP 137 (male), FP 139 (male), and FP 143 (male). In addition, McBride (2003) notes previous use of the action area by other panthers prior to their mortality. The nearest telemetry point to the site of a panther still alive as of this document was FP 65 (male), recorded about 0.04 miles to the north of the access road

parcel. During 1999, FP 74 (male) was documented twice within the reservoir footprint along the Townsend Canal and four times within 0.5 miles of the project footprint on adjacent private property to the southeast (Figure 14); however, he died of a vehicle collision in September of that same year. FP 28 (male) was documented along the perimeter of the reservoir footprint in the southeast corner and died in September 1992 due to intraspecific aggression.

Historically, there have been a total of five radio-collared male and female panthers (FP 28, FP 65, FP 74, FP 137, and TX 101) recorded within 5 miles of the project site on 28 occasions based on telemetry data from May 1989 through June 2006 (Figure 15). This translates to an average of 1.65 occurrences per year or one occurrence every 7 to 8 months. Panther 28 was documented 1 time in 1989 and died in 1992 from intraspecific aggression. Panther 65 was documented 14 times in 1998 and is alive with a home range on private property in Hendry County north of BCNP. Panther 74 was documented 9 times in 1999 and died in September 1999 from a vehicle collision. Panther 137 was documented 1 times in 2005 and is alive with a home range in OWMA. Texas puma 101 was documented 3 times in 1995 and died of unknown causes in 2000. No other radio-collared panthers have been documented within 5 miles of the project site since March 2005, and no radio-collared panthers have been recorded within the project site. The status and activities of uncollared Florida panthers within the action area are unknown. However, the Service believes the project site may occasionally be used by other non-collared panthers because it contains habitat types used by panthers and their prey, and the project vicinity has been used historically by panthers as indicated by telemetry locations.

Past and ongoing Federal and State actions affecting panther habitat in the action area include the issuance of Corps permits and State of Florida Environmental Resource Permits authorizing the filling of wetlands for development projects and other purposes. Since 1982, the Corps and the State have had a joint wetland permit application process, where all permit applications submitted to the State are copied to the Corps and vice versa. Within the 25-mile action area, the Service, since January 14, 1992, has formally consulted on 33 projects and informally consulted on 1 project regarding the panther that were a result of Federal actions (database entries for formal consultations prior to 1992 are incomplete for projects in the action area). These projects have impacted or are expected to impact about 33,062 ac of panther habitat. These projects have also incorporated a total of 22,967 ac of preservation and restoration of panther habitat. The impacted lands generally are: (1) on the western fringe of occupied panther habitat; (2) vegetated with dense stands of exotic species, which may adversely affect the density of the panther prey base; and (3) support agricultural enterprises, *i.e.*, row crops, citrus, etc., which provide a lower quality habitat value to the Florida panther. The preserved lands, which are generally proximate to larger tracts of Federal, State, and other preserves, provide a higher quality habitat value for the Florida panther. The Service determined in the Biological Opinions issued for the 33 Federal actions requiring formal consultation, that individually and cumulatively these projects do not jeopardize the survival and recovery of the Florida panther.

From July 2000 through September 2006, the Service also engaged in informal consultation for projects under 5 ac with the Corps for about 757 projects affecting about 764.1 ac in Collier County (primarily Northern Golden Gate Estates) and about 202.8 ac in Lee County (primarily Lehigh Acres) (database entries for informal consultations prior to 2000 are incomplete for

projects in the consultation area). Almost all of these projects involved the construction of single-family residences in partially developed areas, each in most cases involving less than an acre of direct impact. Although panthers have been known to cross these areas to other parts of their range, prey base and denning utilization of these areas have been affected by the level of development and the additions of these residences is not expected to significantly further impact these habitat functions. For these actions, the Service concurred with the Corps' determination of "may affect, but is not likely to adversely affect" for these individual projects. These projects have been incorporated into the Service's environmental baseline for the Florida panther.

We have received information that within the action area, the Corps has, between March 16, 2004, and August 8, 2005, issued non-jurisdictional wetland determinations (isolated wetlands) for 10 projects totaling 3,779 ac in Collier County and for 10 projects totaling 276 ac in Lee County. These determinations were issued per jurisdictional guidance provided recently in the Supreme Court decision, *Solid Waste Agency of Northern Cook County vs. U.S. Army Corps of Engineers,* 531 U.S. 159 (2001) and, therefore, they will not require a Federal Clean Water Act 404 wetland permit. These projects have been incorporated in the Service's environmental baseline for the Florida panther in this Biological Opinion and the Service has determined, based on the location of these projects (generally in the western fringe of the panther's geographic range), the quality of the habitat present on these project sites, and the overall status of the Florida panther, these projects individually and cumulatively do not jeopardize the survival and recovery of the Florida panther. However, since loss of panther foraging habitat may occur from construction of these projects and no Corps wetland permit is required, the Service is requesting the applicants pursue Habitat Conservation Plans in cooperation with the Service.

There have been 42 documented panther-vehicle collisions within the 25-mile action area (see Table 8 and Figure 16). The panther-vehicle collision closest to the project site (K 128 [male]) occurred in 2004, on CR 832, about 10.6 miles southeast of the site. Three other panthers, UCFP 29 (male), UCFP 90 (female), and UCFP 91 (male) were killed about 0.7, 0.1, and 1.3 miles from the K 128 mortality, respectively, on the same road. UCFP 29 was an adult killed during 1996 and UCFP 90 and UCFP 91 were both kittens (4 to 6 months old) killed during 2007. Two additional panther-vehicle collisions have already occurred in the action area in 2007. One occurred 23.5 miles southwest of the project on Interstate-75 0.5 miles north of Corkscrew Road; and one occurred 19.5 miles southwest of the project on Corkscrew Road near, Alico Road.

Activities within the action area have also benefited panthers. The issuance of Corps and State of Florida Environmental Resource Permits has preserved 22,967 ac of high quality panther habitat for permitted impacts to 33,062 ac of poor quality panther habitat (1992 to present). Installation of wildlife crossings under SR 29 and I-75 within the action area has also benefited the panther by protecting habitat connectivity and eliminating panther-vehicle collision mortalities. Additional benefits have resulted from the acquisition of high quality habitat through acquisition programs by other Federal, State, and County resource agencies. Table 9 provides a summary of State acquisitions within the last 8 years.

Moreover, the management of public lands, including prescribed fire and eradication of exotic vegetation in the Picayune Strand State Forest, Fakahatchee Strand State Preserve, Florida

Panther NWR, ENP, and other conservation areas, is intended to improve habitat for panther prey species, which benefits panthers within these areas.

Factors Affecting Species Environment within the Action Area

Factors that affect the species environment (positively and negatively) within the action area include, but are not limited to, the presence and construction of highways and urban development, agriculture, resource extraction, public lands management (prescribed fire, public use, exotic eradication, etc.), hydrological restoration projects, public and private land protection efforts, effects of genetic inbreeding, and genetic restoration.

Development activities may result in avoidance or limited use of remaining suitable habitat by panthers as well as habitat loss, habitat fragmentation, habitat degradation, and also an increase in risk of vehicular collision (*e.g.*, injury or death).

Public and private land management practices can have a positive, neutral, or negative effect, depending on the management goals. Land protection efforts will help to stabilize the extant population. Hunting of the panther is no longer sanctioned, although there still may be instances of intentional or unintentional shooting of individuals for various reasons.

Wildlife Value and Habitat Quality: As discussed previously in the status of the species, the Service believes the existing habitat conditions present on a site and the foraging value that a site provides to the Florida panther and panther prey species are an important parameter in assessing the importance of the project site to the Florida panther and other wildlife species. In order to assess this importance, the Service requires wildlife surveys and plant species compositions as part of the applicant's biological assessment prepared for the project.

***Wildlife Value*:** A protected species survey of the entire C-43 West Storage Reservoir project was initially conducted by SEA from June 2004 to August 2004 utilizing meandering pedestrian and vehicular (including all-terrain vehicles) transects and stationary observation points. Pre-construction surveys of the Test Cell project site were conducted June 27, 2005, and species specific surveys were conducted for nesting caracara February through May, 2006. Surveys for white-tailed deer and feral hog (*Sus scrofa*) tracks were conducted on seven occasions during September and October 2006 (Table 10). Based on five of the seven the track surveys conducted, SEA calculated a deer density of one deer per 1,093 ac to one deer per 2,623 ac, and a feral hog density of one hog per 54 ac to one hog per 62 ac. If all seven survey events are used, deer density estimates increase to one deer per 165 ac to one deer per 70 ac, and a feral hog density of one hog per 50 ac to one hog per 58 ac. However, two of the surveys conducted in September yielded unusually high deer track counts when compared to the other surveys, possibly due to increased human activity in the groves such as pesticide applicationa, irrigation maintenance, etc. Thus, the latter density estimates may not be realistic. According to the BA, Bobby Murray, the long-term operations manager for one of the onsite citrus operations, *i.e.*, Berry Groves, estimated the deer population to be no more than one deer per 525 ac. Evidence of armadillo, eastern cottontail (*Sylvilagus floridanus*), bobcat and raccoon was observed during the surveys. Other small mammals also constituting panther prey may utilize the site.

Based on the track surveys (Tyson 1952), deer densities on exotic-infested private lands in Lee County have averaged one deer per 591 ac (Turrell 2001) to one deer per 534 ac (Passarella Associates, Incorporated 2004). In comparison, deer densities on wildlife management areas average one deer per 165 ac to one deer per 250 ac (Steelman et al. 1999). Density estimates from deer tracks, however, should be viewed with caution. Track estimates are most appropriately used as long-term indicators (McCown 1991) and several factors can influence counts including weather, food abundance, population density, season, and availability of water (O'Connell et al. 1999).

Deer are known to forage in citrus groves on both the fruit trees and the associated vegetation communities. Citrus groves and other agricultural areas often produce quality bucks. In Hendry, Glades and Collier counties, a relatively high number of fish and wildlife species (*i.e.*, 203 species) were documented utilizing citrus groves and their associated cover types (*i.e.*, grove beds, agricultural reservoirs, impacted wetlands, canals, and ditches) (Mazzotti et al. 1992 and 1993). The majority of those species, however, were observed in natural wetlands now functioning as agricultural reservoirs or wet detention areas (Mazzotti et al. 1992 and 1993). Wildlife use of grove beds as habitat was similar to other disturbed habitats in south Florida in that most species commonly found in grove beds were habitat generalists and able to thrive in human-altered habitats (Mazzotti et al. 1992 and 1993). Nonetheless, mammals that commonly utilized citrus groves included deer, feral hog, raccoon, armadillo, Virginia opossum (*Didelphis virginiana*), marsh rabbit (*Sylvilagus palustris*), eastern cottontail, gray fox (*Urocyon cinereoargenteus*), bobcat, Florida black bear (*Ursus americanus floridanus*), several rodents, and other small mammals (Mazzotti et al. 1992 and 1993).

The Service believes the habitats on the property provide marginal quality foraging for prey species, which directly affects value of the habitat to panthers, and specifically, the frequency and duration of use of the property by panthers. As discussed previously, white-tailed deer densities and other prey species are influenced by the quality of the foraging habitat present in an area. Monotypic stands of poor quality foraging plant species and the invasion of a site by exotic plants provide lower habitat foraging values and affect the utilization by and density of foraging species. The C-43 West Storage Reservoir project area is dominated by citrus trees with an understory of mixed grasses, sedges and forbs. Less than two percent of the site consists of wetland vegetation communities, many of which were dominated by or contained minimal invasive exotic or nuisance vegetation such as Brazilian pepper and primrose willow.

Deer are ruminants with small stomach capacities and are selective for high quality forage to meet their nutritional needs. To meet these high quality forage needs, deer selectively move through the mosaic of habitat types taking advantage of the seasonal forage that provide the most benefit to the deer. The historical vegetation community within the project area was characterized as a mosaic of mesic and wetland habitats that provided seasonal patterns of plant growth. The past conversion of native habitats to citrus groves has resulted in an overall reduction of palatable plant species that provide high quality foraging needs for resident deer populations, hog, and other prey species. Although deer densities at the proposed compensation areas (*i.e.*, Band 1/Acceler8 Project areas) were not determined, they contain diverse habitats

with a variety of plant species that yield quality forage to panther prey species, especially resident deer populations, and many include exotic control, removal, or partial removal as a project feature.

Habitat Quality/Habitat Assessment Methodology Application: The application of the habitat assessment methodology including the base ratio, landscape multiplier, PHU determinations, and compensation recommendations are presented below for the 10,602-acre C-43 West Storage Reservoir project site (minus the 267-acre Test Cell project) and the compensation provided by the Band 1/Acceler8 Projects as a group.

Table 11 illustrates the PHU calculations for the C-43 West Storage Reservoir project with impacts to 144 ac of land in the Primary Zone, 5,236 ac of land in the Secondary Zone, and 4,955 ac in the Other Zone with compensation provided through implementation of the Band 1/Acceler8 Projects combined, including the purchase and restoration of approximately 59,294 ac in the Primary Zone and 41,772 ac in the Other Zone (Figure 17). Table 11 shows the 10,335-acre impact area to presently support 19,438 PHUs with a net loss of 18,773 PHUs. The net loss (*i.e.,* 18,773 PHUs) is multiplied by 2.5 to provide the base ratio compensation need, which is 46,933 PHUs.

Since the overall purpose of the CERP is to restore the Everglades ecosystem and species assemblages, the CERP and Acceler8 implementation is expected to provide large-scale, long-term benefits to the ecosystem and listed species, though individual actions may result in smaller-scale or short-term adverse effects to one or more listed species. Band1/Acceler8 projects which fall within the core panther area (Figure 8) were treated collectively as if they were a single project and the methodology described above was used to assess the effects of these collective District projects on Florida panthers (Table 12 and 13). Calculations for Band1/Acceler8 Projects habitat impacts are estimates based on current project information and will be updated as individual Band 1/Acceler8 Projects plans are further developed. Appendix A includes individual project habitat impacts.

The compensation provided by Band 1/Acceler8 Projects collectively exceeds 548,000 PHUs. Consequently, the Service believes the habitat values lost by the proposed C-43 West Storage Reservoir project will be offset by the resultant preservation and compensation actions from implementation of the Band 1/Acceler8 Projects combined. The lands proposed for development are in the northern fringe of the panther's range and panther habitat value has been diminished by previous conversion to citrus groves. Lands proposed for preservation will be in the core area currently used by the panther, the majority will be within the Primary Zone and adjacent to other natural lands, and will be consistent with the Service's panther goal to strategically locate, preserve, and restore sets of lands containing sufficient area and appropriate land cover types to ensure the long-term survival of the Florida panther population south of the Caloosahatchee River.

Conservation Measures:

Though the C-43 West Storage Reservoir project will result in a net loss in number of acres of habitat available to the panther, the combined beneficial effects of the Band 1/Acceler8 Projects on the habitat quality provided to the Florida panther through restoration and preservation will be superior to that of the areas to be impacted, and the habitat will be protected in perpetuity. The Band 1/Acceler8 Projects will result in a net gain in the number of acres of habitat used by the panther that will be superior in quality to that of the area to be impacted by the C-43 West Storage Reservoir project. The compensation provided by the Band 1/Acceler8 Projects is primarily (*i.e.*, 59 percent) located in the Primary Zone and contains habitat valuable for breeding, foraging, and dispersal by the Florida panther. The restoration and preservation of the habitats as a result of implementation of the combined Band 1/Acceler8 project will increase the overall quality of the habitats to panthers and should result in increased use by panthers.

ENVIRONMENTAL BASELINE – Audubon's Crested Caracara

Status of the Species within the Action Area

As discussed previously, caracaras are nonmigratory with a home range averaging 3,000 ac (1,200 hectare) in size and represented by an area with a radius of approximately 1.2 miles or 2 kms (Morrison 1997a). Adult caracaras typically forage throughout their home range during both the nesting and non-nesting seasons, and have different levels of tolerance and foraging needs that vary considerably throughout the year. Nesting caracaras are susceptible to disturbances that alter the existing levels or patterns of activity present around the nest tree. Observations of nesting caracaras by Morrison (2001) note that the birds will generally flush from the nest during incubation or early nestling stages if the source of the disturbance is within 300 meters (985 ft) from the nest tree.

For purposes of assessing levels of adverse project effects to nesting caracaras, two zones are recognized by the Service as being critical for conservation and recovery of the species. These are the primary zone and the secondary zone. The primary zone radius is the 300 meter (985 ft) flushing distance from the nest. The secondary zone radius is the 2,000-meter foraging territory in which the nest is located. Restrictions in the secondary zone are necessary to minimize disturbances that might compromise the integrity of the primary zone as well as to protect key areas outside of the primary zone. The Service acknowledges that caracara home ranges are not necessarily spherical; however, it demonstrates for the reader the spatial relationship of a typical caracara territory to the project's size and location.

Caracara surveys were conducted in accordance with Service guidelines (Service 2002) during February through May of 2006 by SEA. Suitable caracara habitat within 300 meters and 2,000 meters of the project boundary were identified using 2004 aerial imagery and 2000 Florida Land Use, Cover and Forms Classification System (FLUCCS) Geographic Information System (GIS) data. However, permission to access the private property south and southeast of the C-43 West Reservoir project was not granted until the last survey event and was limited to approximately 1,000 ft of the property line.

Two caracara nest locations (1 confirmed and 1 potential) were identified in the project vicinity during species specific surveys conducted February through May of 2006. One confirmed nest was located in a group of cabbage palms along the southern edge of SR 80, approximately 4,750 ft north of the project boundary (Figure 18). No portion of the C-43 West Reservoir project area falls within the primary protection zone (*i.e.*, 300-meter radius) of that nest tree. However, the 110-acre access road parcel and 264 ac of the reservoir footprint fall within the secondary protection zone (*i.e.* 2,000-meter radius of the nest tree), resulting in a loss of 374 ac of habitat available to those caracaras for foraging.

A potential second nest location was identified during the 2006 surveys in a privately-owned, unimproved pasture property approximately 1,065 ft southeast of the project boundary. Two adults and two juvenile caracaras were observed along the project boundary and within the adjacent property. Activities observed included caracaras flying to and from the project area and adjacent property, and caracaras perching, preening, and foraging along the perimeter of the project and within the adjacent property. One adult was observed carrying prey and feeding juveniles on the ground. SEA was not permitted beyond 1,000 ft of the project boundary to confirm the nest location.

Nestlings fledge the nest at about 7 to 8 weeks although they are incapable of sustained flight and remain dependent on the adults for food. They remain close to the nest site perched in low-lying vegetation or lying on the ground within about 1,600 ft (500 meters) and the adults continue to feed the young for up to 8 weeks or more. Young typically do not venture far away from the nest until about 3 months after fledgling. Therefore, SEA tentatively identified a live oak tree as the potential nest tree based on this information and repeated observations of the adults and young in or near that tree. During a May 15, 2007, site visit, Service staff and the Superintendent for the private property owner and their environmental consultant positively identified the location of the nest tree approximately 80 ft from the potential nest tree identified by SEA. Approximately 1.3 ac of the C-43 West Reservoir project area falls within the primary protection zone and 1,100 ac of the project site falls within the secondary protection zone of this second confirmed nest (Figure 18).

Additionally, District staff observed six caracaras scavenging in the Test Cell Project area during and initial site preparation (*i.e.*, clearing and grubbing) and construction activities. Such activities may provide good foraging conditions for caracaras as they can take advantage of exposed and injured prey.

Factors Affecting Species Environment within the Action Area

Caracara were historically associated with grassland and wetland habitats in Florida. The draining of wetlands and the conversion of prairie habitat to residential and agricultural land uses have negatively impacted the caracara throughout its range. In contrast, the conversion of forested areas to pastureland has seemed to benefit caracaras. According to predevelopment vegetation maps of developed for the Southwest Florida Feasibility Study (Corps 2005), the C-43 West Reservoir project site was historically comprised primarily of mesic and hydric flatwoods,

with lesser amounts of wet prairie and freshwater marsh. While pine flatwoods are valuable ecological communities and are becoming increasingly rare in South Florida, they generally are not suitable for caracaras. Although wet prairie and freshwater marsh may provide a substantial amount of wetland-based forage for caracaras, those habitat types were not historically abundant on the project site. The conversion of the project site to a citrus operation containing citrus groves and impacted wetlands that function as agricultural reservoirs or wet detention areas, may have enhanced the habitat for caracaras. Habitat suitability models developed by Morrison et al. (2006) ranked 13 vegetation cover classes for importance to crested caracaras in south-central Florida, including the C-43 West Reservoir project area, using compositional analysis of 28 caracara home ranges compared to the overall study area. Citrus was ranked 7 on a scale of 0 to 10 and was deemed of medium preference to caracara (Table 14). Only 4 other cover classes ranked higher (*i.e.*, improved pasture, freshwater marsh, grassland, and mixed upland hardwoods). Pinelands or flatwoods were ranked as a 2 and were deemed of low preference to caracara.

This is not to say that the current condition for this species as a whole is better today than it was historically. As a result of ongoing, land use changes, caracaras appear to be exploiting pastures, ditches, and impounded wetlands that have replaced the historic land cover. The level of agricultural development throughout the caracara's range has dramatically impaired or eliminated their native habitat and has substituted it with pastureland that is not self-sustaining. Southwest Florida has had the fastest growing citrus acreage in the state and growth in citrus acreage is usually on land that was formerly converted to pastureland (Corps 2005). Future land use projections for Hendry and Glades counties indicate continued conversion of pasturelands in the project vicinity to citrus operations and an increase in urban and rural development. The recent escalation in residential real estate prices in Florida has resulted in the sale and subdivision of large parcels of pastureland and citrus farms. This is a concern both within the action area and on private lands throughout the species range.

Continued residential development may further impact caracara territories by displacement of caracaras or their prey, or changes in habitat use patterns. Construction of single-family homes on 10 or 20 ac of ranchlands is an increasing threat to caracaras, and many of these will not require a Federal permit. The result is fragmentation of large tracts of pastures that caracaras have occupied. Quantifying the combined effects of these small, incremental reductions in caracara habitat suitability, and the potential effects of these small projects on caracara nesting is difficult, but some impacts have occurred and should be expected in the future. For example, habitat suitability modeling results indicate that some caracaras may nest in less suitable areas that contain suitable nesting trees (*i.e.*, small clumps of or scattered cabbage palms) and that have suitable foraging habitat nearby (Morrison et al. 2006). The two nest locations in the project vicinity may be evidence of this as both nests are located in cabbage palms within or adjacent to small tracts of pasture. The pasture directly north of SR 80 contains 61.7 ac (25.0 hectares) and the fallow agricultural field south of the nest tree contains 83.4 ac (33.7 hectares) and both are completely surrounded by citrus groves or rural development. The nest tree in the southeast corner is located within 67.1 ac (27.3 hectares) of pasture surrounded by citrus, cypress swamp, and pine flatwoods.

Past and ongoing Federal actions affecting the caracara within the action area that may cause additional impacts to the species include the 267-acre Test Cell project previously described and SR80 improvement and widening projects. The Service informally consulted on the Test Cell project in a letter dated November 30, 2005. No crested caracara nests or suitable nesting habitat occurred within the proposed test cell project area, and no construction activities or habitat loss would occur within the primary or secondary protection zones of known caracara nest sites or unknown nest sites in available nesting habitat that had not been surveyed. Based on this information, the Service concurred with the Corps determination that the Test Cell Project "may affect, but is not likely to adversely affect" the crested caracara. During initial site preparation and construction activities, District staff observed six caracaras scavenging in the Test Cell Project area. Such activities may provide good foraging conditions for caracaras as they can take advantage of exposed and injured prey. No birds were injured or killed as a result of project activities.

As noted earlier, one nest is located in the southern right-of-way of SR 80. SR80 is a 132-mile (211 km) route linking United States Highway (US) 1 in West Palm Beach and US 41 in Fort Myers and is an important east-west travel route. Due to high traffic volume, the Florida Department of Transportation has begun construction on a limited-access highway from Interstate 95 to US 441 in Palm Beach County, and a controlled-access highway from US 441 to Interstate 75 east of Fort Myers. Most of the main stretch of controlled-access highway has been completed from Loxahatchee to the northbound US 27 split-off west of Clewiston, as well as the stretch that crosses the action area extending from Interstate 75 to Labelle. Work is currently underway to make drainage improvements to the edge of the roadway from east of the Lee and Hendry County line to west of Grandma's Grove RV Park on SR 80. The Service has already consulted on the effects of those projects on listed species through the DA permitting process.

ENVIRONMENTAL BASELINE – Eastern Indigo Snake

Status of the species within the action area

Although the eastern indigo snake is documented throughout the project area, we have little information on the distribution and abundance of the eastern indigo snake in the action area. Indigo snakes are known to occur in the Caloosahatchee River basin in low densities and are known to occur along the banks of larger ditches and canals in citrus groves, particularly if burrows (*e.g.*, tortoise, armadillo, small mammal, and land crab), debris piles, or other shelter are in close proximity. The most intensive study of wildlife use of citrus groves in the action area was conducted by Mazzotti et al. (1993). That study area included 600,000 ha (1,482,632 ac) in southwest Florida; encompassing the region known as the Immokalee Rise which includes the C-43 West Storage Reservoir project area. Citrus groves, including grove beds, canals, impacted wetlands, and reservoirs, had a relatively high species richness (203 species) however the majority of species (159) were observed in agricultural reservoirs. One hundred six species were observed in grove beds of various ages. Following a scheme developed by Duever et al. (1986), habitat importance values for 380 taxa were assigned to different land cover types in the Immokalee Rise Citrus Development Study. Citrus grove habitat utilization for the indigo snake was assigned an index of 2 (commonly used). Roads and ditches are the most likely places to

observe eastern indigo snakes, but most sitings in natural habitat occur in pine flatwoods, hammocks, and edges of ecotones where prey is abundant. Animal burrows (especially armadillo) in the canal and ditch banks present in this project likely provide refugia for the eastern indigo snake. The Corps and the Service have assumed that eastern indigo snakes occupy the site, and are more prevalent where habitat and prey items are more plentiful.

Past and ongoing Federal actions affecting the eastern indigo snake within the action area include the construction, operation, and monitoring of a 267-acre Test Cell project to evaluate the on-site seepage potential and effectiveness of seepage control measures, the suitability of on-site materials for embankment construction and slope protection, and the effects of water residence time and seepage on water quality. That project included two 500-foot by 500-foot test cells with offset seepage canals, a borrow area, settling ponds, and staging areas and was authorized under DA Permit number 2005-6598 (IP-TKW) issued December 6, 2005. Impacted jurisdictional areas included 1.9 ac of excavated open-water, 2.6 ac of wet prairie, and 24.5 ac of tertiary, agricultural drainage canals. Fifteen armadillo burrows were identified within the 267-acre project area that may provide shelter for indigo snakes. Project-related construction activities were determined to have potential to destroy shelter and refugia sites and cause individuals to leave the area, abandon den sites, and miss foraging and mating opportunities. According to the site plan, the Test Cell Project would primarily impact the smaller, tertiary canals with little or no impact to the larger, secondary and primary canal banks that indigo snakes prefer, so it was deemed unlikely that eastern indigo snakes would occur within the Test Cell project footprint.

The Service informally consulted on the Test Cell project in a letter dated November 30, 2005. The Service's Standard Indigo Snake Protection Conditions were implemented during construction to minimize potential adverse effects to indigo snakes (Service 2002). Those measures include: 1) providing indigo snake educational materials to construction employees prior to project initiation; 2) if a live indigo snake is found, construction activities will cease until the snake has left the project area on its' own accord and the location of sightings will be reported to the Service; and, 3) if a dead indigo snake is found, the snake will be frozen as soon as possible and the Service will be contacted immediately for further instructions. Based on this information, the Service concurred with the Corps determination that the Test Cell Project "may affect, but is not likely to adversely affect" the eastern indigo snake.

Factors affecting species environment within the action area

The project action area is within one of the fastest growing areas in the country (http://www.census.gov/Press-Release/www/releases/archives/population/009865.html; Zwick and Carr 2006). Development includes both residential and agricultural demands that initially targeted coastal and upland areas that include pinelands and coastal hammocks. More recent development has impacted vast areas of wetlands, particularly short-hydroperiod wetlands such as wet prairie, hydric flatwoods, or isolated ponds (Corps 1997, Corps 2005, Service 2000). Degradation and fragmentation of habitat has reduced availability of both refugia and prey for this species. At a landscape level, the C-43 project is surrounded by a matrix of agricultural, forested, and wetland land covers with pockets of urban land use. Citrus groves, row crops and

improved pasture with scattered cypress and mixed wetland hardwoods flank the project to the north, east, and south. The area to the north of the project site also contains some low-density residential areas. Forested uplands (parceled into low-density residential lots in various stages of development) include pine flatwoods, longleaf pine-xeric oak, sand pine, and xeric oak are adjacent and west of the project. Urban areas are present to the southwest and northeast of the project area with small parcels along the Caloosahatchee River. Regions to the northwest and southeast of the project area are generally undeveloped. Intensive agriculture in the study area occurs mainly as citrus, with some row crops, sod farms, plant nurseries, and sugar cane. These non-native areas are generally less desirable habitats for fish and wildlife. They exhibit habitat uniformity and are subject to disturbance from humans, machinery, and pesticide usage. Still, some wildlife is usually present in these areas as either residents or transients from native habitats.

The project footprint is currently an active citrus grove. Natural and biological features and land use within the C-43 West Reservoir project area were initially reviewed using the 2000 FLUCCS GIS data. Citrus grove covers approximately 90 percent of the project site. The citrus grove land use classification includes acreage covered by citrus trees, grove maintenance roads, and small berms, brush piles, and other small features related to citrus grove operations. Water comprises 8.9 percent of the site and includes extensive agricultural canals and ditches, classified as streams and waterways, and excavated ponds, classified as reservoirs less than 10 ac in size. Wetland comprises 1.1 percent of the site and includes mixed wetland hardwoods, willow and elderberry, exotic wetland hardwoods, cypress, wetland shrub, and freshwater marsh.

The 10,602-acre site includes 1,061.3 ac of jurisdictional wetlands and waters of the United States, including 934.6 ac of man-made agricultural ditches and canals used for irrigation and drainage conveyance and 126.7 ac of natural wetlands. Natural wetlands in agricultural areas typically suffer from altered hydrology, typically exhibiting shorter hydroperiods, although some intermittent flooding may occur in areas of low relief. These conditions lead to the loss of habitat for breeding amphibians (Moler and Franz 1987). Agricultural ditches may be permanently flooded, providing habitat for non-native fish. The effect of the availability of non-native prey species, particularly fish and small mammals, is unknown (Mazzotti 1993).

With the exception of the area previously cleared for the Test Cell project, the citrus grove is actively managed. The current irrigation practice in the grove is accomplished through micro irrigation supported by adjacent seepage ditches. Pesticide usage is typical for this type of crop and includes a copper-based fungicidal spray twice a year. However, no copper has been applied to the project area for approximately 3 years. Canal banks and tree rows are regularly mowed. Maintenance vehicles regularly travel on the roads in the grove, providing opportunities for vehicle mortality.

EFFECTS OF THE ACTION – Florida Panther

This section analyzes the direct and indirect effects of the project on the Florida panther and Florida panther habitat.

Factors to be Considered

Residential, commercial, and industrial development projects may have a number of direct and indirect effects on the Florida panther and panther habitat. Direct impacts, which are primarily habitat based, may include: (1) the permanent loss and fragmentation of panther habitat; (2) the permanent loss and fragmentation of habitat that supports panther prey; (3) roadway improvements; (4) the loss of available habitat for foraging, breeding, and dispersing panthers; (5) a reduction in the geographic distribution of habitat for the species; (6) harassment by construction activities; and (7) habitat compensation. Indirect effects may include: (1) an increased risk of roadway mortality to panthers traversing the area due to the increase in vehicular traffic; (2) increased disturbance to panthers and panther prey in the project vicinity due to human activities (human and panther interactions); (3) the reduction in value of panther habitat adjacent to the project due to habitat fragmentation; and (4) a potential increase of intraspecific aggression between panthers due to reduction of the geographic distribution of habitat of the panther. These indirect effects are habitat based, with the exception of vehicular mortality. Intraspecific aggression, though habitat based, could also result in mortality.

This project site contains marginal quality panther habitat (see discussion under Wildlife Assessment) and is located within the northern periphery of the geographic range of the Florida panther's breeding population in south Florida. The timing of construction for this project, relative to sensitive periods of the panther's lifecycle, is unknown. Panthers have the potential to be found on and adjacent to the proposed construction footprint year-round. The project will be constructed in three disruptive events, and result in permanent loss and alteration of the existing ground cover on the project site. Project construction will be undertaken in phases over several years. The initial land clearing will commence July 2007 and proceed through March 2008, the first phase of construction will commence October 2007 and proceed through April 2008, and the final construction phase will commence February 2008 and proceed through December 2011. The disturbance associated with the project will be permanent and result in a loss of habitat currently available to the panther.

Analyses for Effects of the Action

The 10,602-acre C-43 West Storage Reservoir project site is on the extreme northern edge of the Florida panther Primary and Secondary Zones as designated by Kautz et al. (2006), and is located inside the Panther Focus Area as defined by the Service. The site currently provides habitat of mostly low quality for the Florida panther (see discussion under Wildlife Assessment). The project site is located on the northern fringe of occupied habitat, is encompassed by primarily by agricultural development (*i.e.*, citrus groves), and is located near but not within known dispersal corridors (FWC 2006b) between larger publicly owned managed lands. The project will result in the conversion of 10,335 ac of marginal quality panther habitat on-site primarily into open-water reservoir.

Compensation for the loss of 10,335 ac of panther habitat will be through the protection and restoration of 100,492 ac off-site through implementation of Band 1/Acceler8 Projects included in CERP. Fifty-nine percent of the lands preserved are in the Primary Zone (Kautz et al. 2006)

of the panther core lands (Figure 7) and the remaining ac are located in the Other Zone. These "core area" lands include the majority of home ranges of the current population of the Florida panther (see definition of core panther area in Effects of the Action - Primary Equivalent Lands). The total compensation will provide over 548,000 PHUs, primarily in areas with a relatively higher level of documented panther usage (telemetry data) to minimize the impact of the net loss of 18,773 PHUs in an area bordered by agricultural development (*i.e.*, citrus groves) and exhibiting limited documented panther usage (telemetry data).

Direct Effects

Direct effects are those effects that are caused by the proposed action, at the time of construction, are primarily habitat based, are reasonably certain to occur and include: (1) the permanent loss and fragmentation of panther habitat; (2) the permanent loss and fragmentation of habitat that supports panther prey; (3) roadway improvements; (4) the loss of available habitat for foraging, breeding, and dispersing panthers; (5) a reduction in the geographic distribution of habitat for the species; (6) harassment by construction activities; and (7) habitat compensation. The direct effects this project will have on the Florida panther within the action area are discussed below.

Permanent Loss and Fragmentation of Panther Habitat: The project will result in the loss of about 10,335 ac of habitat suitable for foraging and dispersal by the Florida panther. The project lands are located inside and along northern edge of the Florida panther Primary and Secondary Zones. The site offers a limited prey base and is surrounded by existing agricultural development (*i.e.*, citrus groves), or proposed residential development and agricultural activities. The land will be converted to an open-water reservoir. Though the habitat value of the project site to the panther is marginal, the habitat loss may adversely affect the panther by decreasing the spatial extent of lands available to the panther.

Panthers, because of their wide-ranging movements and extensive spatial requirements, are also particularly sensitive to habitat fragmentation (Harris 1984). Mac et al. (1998) defines habitat fragmentation as: "The breaking up of a habitat into unconnected patches interspersed with other habitat, which may not be inhabitable by species occupying the habitat that was broken up. The breaking up is usually by human action, as, for example, the clearing of forest or grassland for agriculture, residential development, or overland electrical lines." The reference to "unconnected patches" is a central underpinning of the definition. For panther conservation, this definition underscores the need to maintain contiguous habitat and protected habitat corridors in key locations in south Florida. Habitat fragmentation can result from road construction, urban development, and agricultural land conversions within migratory habitat use patterns of panther prey species and affect the ability of panthers to move freely throughout their home ranges. Construction of highways in wildlife habitat typically results in loss and fragmentation of habitat, traffic related mortality, and avoidance of associated human development. Roads can also result in habitat fragmentation, especially for females who are less likely to cross them (Maehr 1990).

As described above, the project site is adjacent to existing agricultural and rural development and roadways and is at the extreme north edge of occupied habitat south of the Caloosahatchee River. The property is not located within known dispersal or connection corridors (FWC 2006b) to

larger publicly owned managed lands. As a result of our analysis, we believe that fragmentation of panther habitat is not expected to be appreciable as a result of project implementation.

Permanent Loss and Fragmentation of Habitat that Supports Panther Prey: Prey surveys documented use of the C-43 West Storage Reservoir project site by two primary panther prey species, white-tailed deer and feral hogs. However, the site consists primarily of citrus groves and disturbed wetlands with minimal invasion by exotics, which provide poor foraging value to these and other prey species. The project will result in the loss of about 10,335 ac of habitat available for use by panther prey species. The project site is bounded by SR 80 and existing agricultural and rural development to the north, agricultural activity to the south, the Townsend Canal to the west, and existing agricultural and rural development and SR 29 to the east. Although the native habitats have been degraded through conversion to agriculture and associated hydrological alterations, the loss of habitat may adversely affect the panther by decreasing the spatial extent of lands available for use by panther prey. As described above however, the project site is in an area adjacent to existing agricultural and rural development and roadways and is at the northern edge of the core area of occupied habitat south of the Caloosahatchee River. The property is not located within known dispersal or connection corridors (FWC 2006b) to larger publicly owned managed lands. Therefore, as a result of our analysis, fragmentation of panther prey habitat is not expected to be appreciable.

Road Way Improvements: No expansion of surrounding roads will occur as part of the C-43 West Storage Reservoir project. Some improvements may be necessary to enhance the existing agricultural access roads to meet public health and safety standards for ingress and egress of vehicles to the project site for construction, maintenance, and future recreational access. Therefore, road improvements are not expected to impact the Florida panther.

Loss of Available Habitat for Foraging, Breeding, and Dispersing Panthers: The site is bounded by existing or proposed residential development to the west and south, agricultural activity to the north, and provides limited use potential for the panther due to the conversion to agriculture and the distance from the more commonly used core lands of the panther.
The project site is bounded by SR 80 and existing agricultural and rural development to the north, agricultural activity to the south, the Townsend Canal to the west, and existing agricultural and rural development and SR 29 to the east. Three deceased collared panthers (FP 28, FP 74, and TX 101) have been documented within 5 miles of the project area. One deceased collared male (FP 74) was tracked within the project area along the Townsend canal and four times within 0.5 miles of the southeastern project boundary during 1999. Two living panthers, FP 65 (male) and FP 137 (male) have been documented within 5 miles of the project on numerous occasions in 1998 and 2005, respectively. Since the habitat quality of the site is generally poor, as it is primarily citrus groves with impacted wetlands with limited foraging value for prey species, we believe panther usage of the site is limited; however, habitat loss may adversely affect the panther by decreasing the spatial extent of lands available to the panther for foraging, breeding, and dispersing.

Reduction in the Geographic Distribution of Habitat for the Species: The project will result in the loss of about 10,335 ac of agricultural land along the northern edge of the Panther Focus

Area south of the Caloosahatchee River. This loss represents only 0.53 percent of the 1,962,294 ac of available non-urban private lands in south Florida in the core area of the Florida panther (Table 5). The Service believes the habitat values lost by the project will be minimized by the preservation and restoration actions of the Band 1/Acceler8 projects combined. The project lands proposed are primarily citrus groves and disturbed wetlands with minimal invasion by exotics on the northern fringe of the occupied range of the Florida panther and are encompassed by agriculture, rural development, and existing roads. The lands proposed for compensation through implementation of the Band 1/Acceler8 projects are consistent with the Service's panther conservation strategy to locate, preserve, and restore sets of lands containing sufficient area, access, and appropriate cover types to ensure the long-term survival of the Florida panther south of the Caloosahatchee River.

Harassment by Construction Activities: The timing of construction for this project, relative to sensitive periods of the panther's lifecycle, is unknown. However, it is likely that all land clearing and construction associated with the project will commence during July 2007, and will be completed by December 2011. There are no known den sites within the project boundaries and the quality and quantity of the habitat foraging base for prey species is low. Therefore, we believe panther usage of the property is limited and we do not believe project construction will result in direct panther mortality, but may result in temporary disturbance to resident or dispersing panthers.

Compensation: The impact of the habitat lost as a result of the development will be minimized by the preservation and restoration actions of the Band 1/Acceler8 projects combined. The applicant's proposed preservation acreage is estimated at 100,492 ac. The lands proposed for development are primarily citrus groves and disturbed wetlands at least partially invaded by exotic vegetation, are on the fringe of the currently occupied range of the Florida panther, are adjacent to agricultural and rural development, and are adjacent to SR 80. The lands proposed for preservation are consistent with the Service's panther goal to locate and preserve sets of lands containing sufficient area and appropriate cover types to ensure the long-term survival of the Florida panther south of the Caloosahatchee River.

Interrelated and Interdependent Actions

An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the action under consultation. All access and staging areas are to be located within the project footprint. Future maintenance and monitoring activities are expected to result in minimal impact to the surrounding environment. Therefore, only negligible impacts are expected to result from interrelated or interdependent actions as a result of the project.

Indirect Effects

Indirect effects are those effects that are caused by or will result from the proposed action and are later in time, but are still reasonably certain to occur. The indirect effects this project will

have on the Florida panther within the action area are discussed below and in the assessment of functional habitat values previously discussed. They include: (1) an increased risk of roadway mortality to panthers traversing the area due to the increase in vehicular traffic; (2) increased disturbance to panthers and panther prey in the project vicinity due to human activities (human and panther interactions); (3) the reduction in value of panther habitat adjacent to the project due to habitat fragmentation; and (4) a potential increase of intraspecific aggression between panthers due to reduction of the geographic distribution of habitat for the panther.

Increased Risk of Roadway Mortality: In evaluating a project's potential to increase roadway mortality to the Florida panther, we consider the location of the project in relation to surrounding native habitats, preserved lands, and wildlife corridors that are frequently used by the Florida panther. We also consider the current configuration and traffic patterns of surrounding roadways and the projected increase and traffic patterns expected to result from the proposed action. We evaluate the habitats present on-site, their importance in providing foraging needs for the Florida panther and panther prey species, and if the site development would further restrict access to surrounding lands important to the Florida panther and panther prey species.

The project will result in increased vehicular traffic in the project vicinity during construction and operation. Vehicular mortality and injury data (Table 8, Figure 16) provided by the FWC indicate collisions with motor vehicles have been increasing since 2000 in the 25-mile radius project action area. In 2003 and 2006, there were six documented panther-vehicle collisions per year within the project action area (Table 8). These 2 years represent the most panthers killed by vehicles in single years in the action area. However, this number may be surpassed this year (2007), as 4 panthers have already been killed by vehicle collisions during the first 5 months. Four panthers were killed per year in 2000 and 2002. All of the 42 documented collisions within the action area have occurred more than 10 miles away from the project site, and 37 (88 percent) occurred more than 15 miles from the project site.

Major travel routes in the vicinity of the project site (Figure 1) include SR80 to the north, and SR29 to the east. SR80 is a four-lane divided highway and is already a heavily traveled east-west transportation route. SR29 is a two-lane rural highway. Construction traffic will come from SR80 and then use the existing agricultural roads in the 110-acre access road parcel to travel to and from the project area. Construction is proposed to take place in phases through December 2011. Once construction is completed, additional vehicular traffic will operate in the area as a result of project monitoring, operations, and maintenance. Projected impacts to future traffic are related to maintenance vehicles and possible recreational access to the reservoir site. Considering this information and distances from the project site to documented collisions, it is unlikely the traffic generated by this project will significantly increase the risk of roadway mortality to panthers.

Panther and Prey Disturbance (Panther/Human Interactions): Potential increases in disturbance to the Florida panther and panther prey were evaluated. As discussed previously in our assessment of fragmentation, we considered habitat quality related factors and occurrence data for the Florida panther and panther prey species. This information is also the basis of our evaluation of disturbance to the Florida panther and to panther prey species. As discussed

previously, the habitat on the project site consists primarily of citrus groves and disturbed wetlands with minimal invasion by exotics, which provide low quality habitat to the Florida panther and panther prey species. Though panthers and panther prey may occasionally use the habitats within the project area, we believe panther usage of the property is infrequent and we do not believe project construction will result in a significant increase in panther and human interactions and prey disturbance.

Habitat Fragmentation: Considering our discussion of fragmentation under Direct Effects, the project site is located on the northern fringe of occupied habitat, is adjacent to existing agricultural and rural development, and is not located within known dispersal corridors to larger publicly owned managed lands important to the panther; therefore, fragmentation of panther habitat is not expected to result from project implementation. The project site is located on the northern fringe of the Panther Focus Area south of the Caloosahatchee River. Therefore, fragmentation of panther prey species habitat is not expected.

Intraspecific Aggression: Potential increases in intraspecific aggression and disturbance to the Florida panther were evaluated. As discussed previously in our assessment of fragmentation and habitat for panther and panther prey, we considered habitat quality related factors and occurrence data for the Florida panther and panther prey species as factors affecting intraspecific aggression. As previously discussed, the habitats on the property provide for low quality foraging for prey, which directly affects the frequency and duration of use of the property by panthers. Therefore, we do not believe that panther prey species or Florida panthers utilize the property on a frequent basis. However, the reduction in the geographic range of habitat for dispersal or escape cover may contribute to a potential increased risk of death or injury of panthers in the action area due to intraspecific aggression.

Species Response to the Proposed Action

The proposed action will result in increased human activity and noise in the project area during construction of the project. However, since panthers are not commonly known to use lands within and adjacent to the project site, activities associated with construction of the C-43 West Storage Reservoir project are not anticipated to significantly increase risk of disturbance to panthers, though some temporary disturbance may occur.

The project will result in the loss of 10,335 ac of potential panther habitat according to the most current home range estimates of the Florida panther (Lotz et al. 2005). This represents 35.6 percent of a female panther's average home range (29,059 ac) and 16.5 percent of a male panther's average home range (62,542 ac). The project area provides mostly poor quality panther habitat and panthers are not known to commonly use the project area; however, the loss of habitat may contribute to increases in intraspecific aggression decreasing the spatial extent of lands available to the panther for foraging, breeding, and dispersing. We anticipate any resident panthers with home ranges overlapping or in the vicinity of the project area will adjust the size and location of their ranges to account for this loss and that adjustment is anticipated to occur in concert with project construction.

Panthers are sensitive to habitat fragmentation. However, the project site is located on the northern fringe of occupied habitat, is adjacent to agricultural and rural development, and is not located within known dispersal corridors (FWC 2006b) between larger publicly owned managed lands. Therefore, appreciable fragmentation of panther habitat is not expected to result from project implementation.

EFFECTS OF THE ACTION – Audubon's Crested Caracara

This section includes an analysis of the direct and indirect effects of the proposed action on the caracara, including beneficial effects, interrelated and interdependent actions, and species response to the proposed action. To determine whether the proposed action would likely jeopardize the continued existence of this species, we focused on the expected consequences of the proposed action on the potential for future caracara nesting and habitat use.

Factors to be Considered

Caracaras have been documented to nest immediately adjacent to the C-43 West Reservoir project area and are known to forage within and adjacent to the project area. Thus, the action will take place when this species is likely to be present and nesting in the area. Construction will be conducted in phases commencing during July 2007 and extending through April 2011. The operation and maintenance of the project is anticipated to last at least 40 years. Potential direct and indirect impacts to caracaras may occur as a result of the initial destruction and degradation of existing habitat; dredging, earthmoving, and other activities associated with construction of the reservoir (including associated pump stations and water control structures), seepage canal, access roads, and recreational facilities; modifications to existing canals; and operation and maintenance of the project. Project-related activities may cause caracaras to leave the immediate vicinity, abandon nest sites, abandon territories, abandon active nests during the egg laying or brood-rearing stages, and possibly miss foraging, mating, and brood-rearing opportunities. Displaced adults may incur a higher risk of mortality because of either intraspecific aggression by caracaras defending territories into which displaced caracaras attempt to move, predation, or other sources of mortality such as vehicle collisions or other trauma associated with scouting unfamiliar areas. Potential direct impacts to the caracara or its habitat include direct injury or mortality from (1) all construction-related activities, (2) vehicular traffic, and (3) loss of available habitat for foraging, breeding and dispersing birds. Potential indirect impacts include injury or mortality from future operation and maintenance associated with the reservoir, including (1) vehicular traffic, mowing, and pesticide usage; (2) fluctuations in prey density in the reservoir and associated infrastructure as water levels fluctuate and potentially become dry; and (3) impacts from copper contamination of benthic fauna in the reservoir.

Analyses for Effects of the Action

Direct Effects

Direct effects are those effects that are caused by the proposed action. The direct effects evaluated by the Service include direct injury or mortality and loss or degradation of available

habitat for foraging and breeding. The direct effects that this project may have on caracaras within the action area are discussed below.

Injury and Mortality: Our data indicate that caracaras utilize the area in and around the C-43 West Storage Reservoir project for nesting and foraging. It is difficult to determine the number of caracaras that would be directly injured, disturbed, or killed by the project as it depends on the proximity of project-related activities to the nest trees and the timing of those activities in relation to the occurrence of caracara nesting and fledging. Accidental adult injury or mortality as a direct result of project-related activities would be unlikely since older birds are more wary and likely more experienced than juveniles. However, during winter months when caracara nesting is more prevalent, eggs and small chicks may perish from overexposure if adults are frequently flushed from nest trees or avoid the nest for extended periods (Morrison 1998). Additionally, fledgling and juvenile caracaras spend more time on the ground and do not venture far from the nest tree. Therefore, they are at risk of injury or death from heavy equipment operations, vehicular traffic, and mowers, particularly if such activities occur within the primary and secondary zones during the nesting season. Morrison (2005) identified vehicular traffic as a specific cause of mortality to juvenile caracaras feeding on carrion.

The best way to minimize the risk of this type of injury is to avoid the primary and secondary zones surrounding the nest tree during the nesting season. None of the proposed project activities would occur within the primary zone of the northern nest, and only one acre of the primary zone surrounding the southeastern nest overlaps the project footprint. That one acre is separated from the rest of the primary zone by agricultural roads and a canal that demarcate the boundary between the proposed project and the adjacent private property. Therefore, it is unlikely that recently fledged young incapable of sustained flight would utilize that acre. Juveniles, however, may venture farther from the nest and be present in the project area during construction, particularly in the secondary zones, and therefore may be at risk of direct injury or mortality. Proposed project activities in that area include initial clearing, grubbing and stripping, and construction of a portion of Dam Segment O including the adjacent portion of the seepage canal and associated littoral zones.

Avoidance of the secondary zone surrounding each nest is not entirely possible due to the scale of the proposed project and the methodology required for construction of the reservoir embankments. All or portions of Dam Segments E, F, G, M, N, O, and P, including the adjacent portions of the seepage canal and associated water control structures, will be constructed within the secondary zones of one of the two nests. The full embankment will be best constructed as the project progresses to allow for placement of the upstream soil-cement and establishment of grass on the downstream slope of the embankment. This also includes constructing the internal drain system, borrow, and fill placement as the embankment is built. The embankment construction is a critical element of the project and the quality of this work is key to the District's dam safety program.

Large equipment, such as bulldozers with rakes and pans, will be utilized for embankment construction. This equipment works in a linear fashion around the site borrowing soil and then placing the borrow material on the embankment in six inch lifts. The techniques and sequencing

used are important to insure the necessary quality of the work. The available 6 month work periods outside of the caracara nesting season (*i.e.*, May though October) in the secondary zone represent 1 month of the dry season and 5 months of the rainy season. Thus the majority of the reservoir embankment within the secondary zone can only be constructed during the rainy season which increases the uncertainties of the work. Not only will the construction of the earthen portion of the embankment be impacted by the enforcement of the secondary zone during the Caracara nesting season, the placement of the soil cement, of which the production rate and quality is greatly effected by rainy conditions, will have to also be scheduled for the rainy season. The periods for the construction of all Project elements within the secondary zone is insufficient to meet the requirements of the Project and will require modifying the construction sequence and techniques with an approach that is more difficult and possible raising questions of embankment integrity.

Accordingly, the Service anticipates that disturbance would occur through project activities in the primary or secondary zone that force caracaras to leave foraging or perching sites in the immediate vicinity, to nest in new locations either within or outside the existing territories, abandon active nests during the egg laying or brood-rearing stages, or possibly miss foraging, mating, and brood-rearing opportunities each year over the five-year construction schedule. If breeding or nesting opportunities are missed or abandoned, this could represent a loss of recruitment to the population from two nesting pairs for 5 years. Additionally, displaced adults may incur a higher risk of mortality because of intraspecific aggression by caracaras defending territories into which displaced caracaras attempt to move, predation, or other sources of mortality such as vehicle collisions or other trauma associated with scouting unfamiliar areas.

Loss of Habitat:
Although, no known nest trees or other cabbage palms suitable for nesting will be removed as part of the C-43 West Reservoir project, a total 1,474 ac of potential foraging habitat consisting primarily of citrus groves and impacted wetlands in the secondary zones of two known nest locations, will be converted to reservoir, embankment, or seepage canal. Thus, if we assume a worst-case scenario, the entire 1,474 ac will be habitat lost as a result of the proposed project. This loss of habitat may result in territory shift, intraspecific aggression, or territory abandonment.

It is possible that caracaras may forage in the interior of the reservoir when it is dry, along the exterior reservoir embankments, and along the seepage canal after construction. Caracaras are not expected to forage on the interior of the reservoir embankments as they will be lined with concrete and no vegetation that may support prey is expected to become established. In this scenario, slightly less than 1,474 ac of habitat would be lost. However, we are uncertain how caracaras will react to a change in land use over a substantial percentage of their territory. Morrison (2005) stated that natural wetlands larger than 25 ac (10 hectares) are not as likely to be included in caracara territories as wetlands less than 25 ac. Morrison et al. (2006) found that that 90 percent of 28 caracara home ranges contained 50 to 150 hectares of freshwater marsh (excluding sawgrass- and cattail-dominated marshes). However, 90 percent of those freshwater marshes were less than 1 hectare in size with approximately 50 percent less than or equal to

0.1 hectares in size. Thus, we do not expect caracaras to forage substantially in the reservoir when one or both cells are completely drawn down.

Indirect Effects

Indirect effects are those that are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. The indirect impacts evaluated by the Service include: (1) post-construction maintenance of the roads, embankments, seepage canal, boat ramps, pump stations, and other water control structures; (2) future recreational activities such as picnicking, boating, fishing, hiking, or horseback riding; and (3) chemical contamination. The indirect effects that the proposed action may have on caracaras within the action area are discussed below.

Operation and Maintenance: Routine operation and maintenance may result in temporary and insignificant disturbance to the crested caracara. Once construction is completed, additional vehicular traffic will access and operate in the area as a result of project monitoring, operations, and maintenance which may include mowing of embankments or heavy equipment operation. Adult caracaras nesting in the project vicinity are already acclimated to human presence, and vehicular traffic and heavy equipment operations associated with routine agricultural activities.

Caracara may forage on prey items that could become established on the embankments and littoral zones of the seepage canals. The Service anticipates that vehicular activity or heavy equipment operation associated with maintenance may disturb, injure, or kill individual caracara fledglings or juveniles that may be foraging onsite, since they do not venture far from nest the tree following fledging and are inexperienced.

Recreation: Recreational activities may result in temporary and insignificant disturbance to caracaras. Detailed information on future recreational activities in the project area is not available at this time. However, recreational activities could reasonably include picnicking, boating, fishing, and hiking or horseback riding on the service road along the crown of the reservoir embankments. Future recreational access and facilities (*i.e.*, picnic tables, restrooms, etc.) will most likely be located in the 110-acre access road parcel which occurs within the secondary zone of the nest on SR80. Those adults are already acclimated to routine vehicular traffic along SR80 as well as vehicles traveling to and from the project area as a result of agricultural activities. Additionally, the proposed access route for the reservoir is currently the access route to and from and the location of the existing facilities for the citrus operation (*i.e.*, Berry Groves-LaBelle Congen). The adult caracaras nesting on SR80 are already acclimated to human presence, vehicular traffic, and heavy equipment use associated with routine agricultural activities, including fruit harvesting and ditch maintenance. Likewise, the caracaras nesting to the southeast of the project area are also acclimated to limited human presence, and vehicular traffic and heavy equipment operations associated with routine agricultural activities.

Contaminants:

An environmental site assessment for chemical contamination was performed by the District in 1999 for the entire C-43 West Reservoir project area.

Copper: Soil sampling has identified seven grids (*i.e.*, grids 56, 58, 124, 125, 134, 135, and 143) in the Berry Labelle – Congen Groves (Tracts GX-100-017 & GX-100-018) portion of the site that will require remediation due to copper contamination. The Service recommended remediation for the entirety of Grids 124, 125, 134, 135, and 143 (250 ac) and for the portions of Grids 56 and 58 that will be within the footprint of the proposed reservoir. The Service concurred in a letter dated September 14, 2006, that removing contamination from the seven grids would remove the risk of direct impacts to Service trust resources. Approximately one foot of soil will be excavated from areas to be remediated and the soil will be utilized within the reservoir embankments, burying the soils such that surface water will not contact the copper-contaminated soil. However, the Service noted that the remaining copper concentration in some areas of the property may be high enough to adversely impact benthic organisms.

We anticipate that remediated soils placed in the embankments will not adversely affect caracaras or their prey. The adverse effect of crested caracara consumption of contaminated prey associated with benthic organisms is not known, but is considered to be low given the periodicity and duration of expected draw down events.

Other contaminants: The 600-ac Bryan Paul Citrus Grove (Tract GX-100-009) will be remediated for chlordane contamination by removal of the top two feet of soil in the 20-acre area and utilizing that soil within the reservoir embankments. The 2,025-acre Bob Paul Citrus Grove (Tract GX-100-015) may be remediated for organochlorine pesticides in two 50-acre grids upon further investigation to delineate contamination. The 2,399-acre Winthrop Property (Tract GX-100-005) will be remediated for metals, petroleum hydrocarbons, and pesticides detected around maintenance areas by removal of contaminated soils. The 954-acre Griffin Property (Tract GX-100-001) will be remediated for metals and polycyclic aromatic hydrocarbons in burn areas, chemical barns, and fertilizer mix and load areas by removal of contaminated soils. Given proper remediation, the anticipated risk to crested caracara from other contaminants is considered low.

Beneficial Effects

The loss of caracara foraging habitat when the project is built may be offset, in part, by potential foraging along the external embankments and the seepage canal. The project would have approximately 16.3 miles of external embankments, 2.8 miles of internal embankment, 14.7 miles of perimeter canal, and 109 ac of littoral zones. Interior portions of the reservoir and the interior dam embankments are anticipated to be a harder material (soil cement or concrete) and therefore, would not provide the necessary herbaceous plant cover needed by caracara prey. The width of the side slopes of the external embankments would be 114 ft. The width of the toe between the bottom of the external embankment and the perimeter canal is 90 ft. For the perimeter reservoir embankments and toe, a total of 403.05 ac (204 ft of the perimeter

embankment x 86,064 ft [16.3 miles]) of potential caracara foraging habitat would be created. The top of the embankment was also considered caracara foraging habitat and provides 27.66 ac (14-foot crest of the perimeter embankment x 86,064 ft [16.3 mi]). The total potential caracara habitat created by this project was estimated to be 430.71 ac (403.05 + 27.66) of foraging habitat. The number of birds that may forage on this habitat depends on the number of intersecting territories. Two known territories intersect the C-43 West Reservoir project area. Thus, up to 4 adults and 4 juveniles (two per nest) might forage in the project area. However, these estimates are speculative given that large wetlands (greater than 1 hectare) or large areas of open water are generally not included in caracara territories and large reservoirs have not yet been operated within known territories of the caracara in south Florida. Therefore, we recommend monitoring to determine caracara usage at this site following construction.

Additionally, the proposed project may benefit caracara during the initial stages of construction by exposing prey for foraging birds. However, this benefit may be offset by the increased risk of injury and mortality to young, inexperienced caracara.

Interrelated and Interdependent Actions

An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the action under consultation. All access and staging areas are to be located within the project footprint. Future maintenance and monitoring activities are expected to result in minimal impact to the surrounding environment. Therefore, only negligible impacts are expected to result from interrelated or interdependent actions as a result of the project.

Species' Response to the Proposed Action

Construction, operation, and maintenance of the project can result in actions that may kill or injure individual caracaras, and destroy or degrade occupied and potential nesting and foraging habitat. Due to their large territories (about 3,000 ac) and generally wary reaction to human activity, the risk of direct mortality of adult caracaras is not anticipated. Sub-adult caracaras, especially fledglings, are more at risk since they spend more time on the ground. As a result, the likelihood of mortality or injury increases through predation and vehicular collisions. Any clearing, burning, earthmoving, construction, operation, and maintenance activities may also adversely affect caracaras by disrupting parental care of the nest and chicks, and causing them to leave the area and possibly abandon territories, and miss foraging opportunities. The consequences of disrupting parental care of the nest (*e.g.*, reduced egg incubation or chick protection and feeding) may lead to egg or nestling mortality in a variety of forms, such as exposure, starvation, falling from the nest, or predation. Individual caracaras that leave the area may be more vulnerable to predation and intraspecific aggression.

The Service anticipates that 1,474 ac of caracara foraging habitat consisting primarily of citrus groves and impacted wetlands, would be directly impacted by the proposed project and converted to an above-ground reservoir with an average depth of 20 ft. This habitat conversion

may lead to indirect effects on an unknown amount of additional acreage outside of the project area via caracara territory shifts, shrinkage, or abandonment.

To determine the species' response to the action, we first assumed that the two known nesting pairs would continue to nest either in the same nest tree or one located nearby and may shift their foraging territory as a result of the proposed project and related activities. The pair nesting along SR 80 will likely continue to nest in the same location. The availability of cabbage palms is limited to the highway right-of-way near the current nest tree. The 61.7 ac pasture adjacent to west-bound lane (north) of SR 80 does not contain any cabbage palms which may explain why the pair chose to nest along the south side of the highway. However, if a typical territory is 3,000 ac and is assumed to be circular, the loss of 374 ac (or 12.4 percent of their territory) in the secondary zone consisting primarily of citrus groves and impacted wetlands would not force the pair to abandon their nest tree or territory. They may slightly shift their territory to avoid the project area during and post-construction.

We also do not believe that the pair nesting on private property southeast of the project area will abandon their territory unless the habitat converted to reservoir has critical resources (*e.g.,* better forage) and the remainder of the territory is marginal or sub-marginal habitat. That pair may be able to find another suitable nest tree slightly further away from the reservoir footprint. The current nest tree is located within 67.1 ac of pasture that will not be impacted by the proposed project and that contains several cabbage palms. However, if a typical territory is 3,000 ac and is assumed to be circular, that pair will lose approximately 37 percent (1,101 ac) of its territory. Although this is a significant loss of habitat, aerial photography indicates that additional suitable foraging habitat (i.e., pasture, fallow farm fields, and active citrus groves) is currently available within and adjacent to the remaining portion of their territory (1,899 ac) on privately owned land and the birds would be forced to shift their foraging territory. This prediction is based on limited caracara data and the assumption that this area is not already occupied by other caracaras.

Each nesting pair of caracaras may produce two to three offspring per year. The Service anticipates that the proposed construction activities may cause adults to abandon nest attempts or otherwise disrupt parental care of a nest or chicks, resulting in the loss of two to six juvenile caracaras per year. We also anticipate that the likelihood of reduced reproductive success is greater for the pair nesting on private property southeast of the project area due to greater loss of habitat within their potential territory and the close proximity of construction activities. Increased human presence and noise disturbance from associated equipment operation would occur on the periphery of the primary zone established to protect the nest site from disturbance during the nesting season

If both nesting pairs are successful, there could be up to 10 caracaras (4 adults and 2 to 6 offspring) using the C-43 West Reservoir footprint for at least part of the year. We believe that some caracaras may use the reservoir embankments and the seepage canal following construction if there are sufficient prey items. These individual caracaras may be temporarily displaced while foraging by on-going maintenance, operational, and recreational activities. However, the impact may be beneficial (e.g., mowing may expose prey) or negligible.

EFFECTS OF THE ACTION - Eastern Indigo Snake

Factors to be Considered

Eastern indigo snakes have been documented in the project action area. Because eastern indigo snakes use a variety of habitats, and have very large home ranges, they may occur throughout the project site and adjacent citrus groves and natural areas. This action will take place when this species is likely to be present in the area. The duration of the tree clearing and construction will be from July 12, 2007 to March 30, 2008. Pre-loading of embankments will occur from October 11, 2007 to April 30, 2008. Reservoir and pump station construction will occur from February 14, 2008 to December of 2011. The operation and maintenance of the project is anticipated to last approximately 50 years. Potential impacts to eastern indigo snakes may occur due to citrus tree removal and burning, habitat destruction and degradation, earthmoving, construction of the reservoir and operation and maintenance of the project. The action may also cause eastern indigo snakes to leave the area, abandon den sites, and possibly miss foraging and mating opportunities. Individual eastern indigo snakes fleeing the area may be more vulnerable to road mortality, predation or intraspecific aggression. Potential direct impacts to the eastern indigo snake or its habitat include mortality from (1) all construction activities including tree removal, burning, and contaminant remediation, (2) vehicular traffic, and (3) initial rehydration; and injury or disruption of normal behaviors from the loss of available habitat for foraging, breeding, and dispersing. Potential indirect impacts include mortality from future operation and maintenance associated with the C-43 West Reservoir project that may result in mortality or injury from (1) vehicular traffic, mowing, and pesticide usage; and injury from (2) fluctuations in prey density in the reservoir and associated infrastructure as water levels fluctuate and potentially become dry.

The eastern indigo snake is difficult to detect and quantify for the following reasons: (1) it has a wide-ranging distribution; (2) it has a patchy distribution within suitable habitat; (3) it has limited detectability due to use of burrows or holes for shelter, (4) there is likely unoccupied suitable habitat; (5) juveniles have limited detectability due to their affinity for thick vegetation, and (6) they may use cryptic sheltering areas that may be temporarily established during construction (e.g., brush piles, equipment stockpiles, and dirt mounds). The lack of practical methods to survey, in conjunction with wide-ranging activity and use of a variety of habitat types makes it difficult to determine the exact number of eastern indigo snakes that will be affected.

Analyses for effects of the action

Direct effects

Direct effects are those effects that are caused by the proposed action. The direct impacts evaluated by the Service include direct injury and mortality from construction (including initial hydration) and roadkill, loss of habitat for foraging, breeding, and dispersing, and disturbance related to the initial hydration of the reservoir. The direct effects that this project may have on eastern indigo snakes within the action area are discussed below. For purposes of this analysis,

the 267-acre Test Cell project site has been subtracted from the project effects analysis, and the total impact is estimated to be 10,264 ac.

Injury and mortality: It is difficult to determine the percentage of eastern indigo snakes that would be directly injured or killed by the project. However, due to the nature of the proposed construction (*i.e.*, complete disturbance of the site by tree removal, debris piling and burning, canal plugging or dredging, embankment construction, soil transport for contaminant remediation, and initial hydration), and the known death of an indigo snake on a similar reservoir construction project the Service estimates that the majority of the eastern indigo snakes present at the time of the action could be adversely affected by the project.

On October 10, 2006, an eastern indigo snake was killed while excavation of a sediment mound was occurring in the A-1 Reservoir footprint. The site of mortality was a sediment mound approximately 10-15 ft high and 20-25 ft in diameter along the far side of a canal levee road, adjacent to fallow sugarcane fields. The sediment had been excavated from a canal and deposited along the far side of the levee road approximately one to two weeks earlier, was now dry, and was subsequently being moved to an adjacent area. The equipment operator had been trained to identify eastern indigo snakes and to stop activity if any were observed. The operator did not see the snake on the mound. As the sediment was being deposited, the operator observed an eastern indigo snake falling from the sediment. Similar deaths of snakes have occurred in development of urban sites in Lee (Florida Gulf Coast University) and Collier counties, including the action area. Snakes typically seek refuge in burn or debris pile sites during construction (Dryden personal communication 2007).

It is not easy to estimate the density of eastern indigo snakes at the C-43 West Reservoir using existing data. However, a 26-year study conducted by Layne and Steiner (1996) at Archbold Biological Station (ABS) estimated a population density of 2.6 eastern indigo snakes (1.9 males, 0.7 females) per 247 ac (100 ha). ABS is approximately 30 miles northeast of the project area and contains better snake habitat (*i.e.*, the study area was comprised of 60 percent xeric pine and oak uplands, and 40 percent pine flatwoods, bayheads, swale, and seasonal ponds). Eastern indigo snakes have been observed at ABS in all natural and man-altered habitats with no obvious habitat preferences (Layne and Steiner 1996). The ratio of adult males to adult females at ABS was estimated to be approximately 4:1. The juvenile sex ratio was closer to 1:1. These estimates were consistent with other studies of captive eastern indigo snakes and museum specimens (Moulis 1976, Smith 1941, Duellman and Schwartz 1958).

The C-43 West Reservoir project site likely contains or intersects many eastern indigo snake home ranges. Based on population density estimates at ABS, one could estimate that as many as 108 adult eastern indigo snakes may be present within the C-43 West Reservoir project site (10,264 ac/247 ac x 2.6 snakes = 108 snakes). However, due to the differences in habitat between ABS and the project site, we anticipate that the density of eastern indigo snakes at the C-43 West Reservoir project site would be lower than that at ABS. Regular mowing, vehicular traffic, and pesticide usage on the project site are also likely to have decreased the suitability of the habitat for eastern indigo snakes and their prey. We have made an estimate that the quality

of the eastern indigo snake habitat at the project site is half that of ABS. In that case, then there could be up to 54 adult eastern indigo snakes within the C-43 West Reservoir project site.

Major travel routes in the vicinity of the project site (Figure 1) include SR80 to the north and SR29 to the east. SR80 is a four-lane divided highway and is already a heavily traveled east-west transportation route. SR29 is a two-lane rural highway. Construction traffic will come from SR80 and then use the existing agricultural roads in the 110-acre access road parcel to travel to and from the project area. Construction is proposed to take place in phases through December 2011, exposing eastern indigo snakes to changes or additions in vehicle traffic on the site over a period of approximately four and one-half years.

Loss of habitat: In general, citrus groves are not optimal eastern indigo snake habitat (Bolt 2006, Mazzotti et al. 1993). Some citrus growers maintain a higher herbaceous vegetative structure along canals, roads, and wet ditches as well as in between the rows of trees. Islands of more natural areas (hydric hammocks, cypress, and other wetlands) may also be present, either in or at the periphery of the groves. Groves interspersed or adjacent to natural habitat would have more prey items for eastern indigo snakes and also provide more cover than a grove that is more intensively managed (Zeigler 2006). Factors which influence species richness in citrus groves in the Immokalee Rise region in addition to grove age were size, interspersion of other important habitats, sampling effort, proximity to large natural areas, visibility of wildlife in groves of different ages and effects of workers on wildlife (especially snakes) (Mazzotti et al. 1993). In the Immokalee Rise Citrus Study, grove beds, agricultural reservoirs, impacted wetlands, canals and ditches in citrus groves provided habitat for prey species such as small mammals, birds, toads, frogs, fish, lizards, turtles, alligators, other snakes, and non-native speces such as house mice (*Mus musculus*), black rats (*Rattus rattus*), and Norway rats (*Rattus norvegicus*). For this project, we are assuming that the entire remaining 10,264-acre grove is potential habitat for the eastern indigo snake even though the areas around the wet ditches and canals are likely to have better snake habitat and prey than the interior portions. Therefore, the Service considers the entire 10,264 ac to be habitat lost as a result of construction.

Initial Hydration: The initial flooding of the reservoir has the potential to inundate indigo snakes and their burrows. Indigo snakes may seek temporary refuge in air pockets in burrows. Slow initial flooding may allow some indigo snakes to vacate the reservoir, although some snakes may drown if trapped in air pockets and eggs may be destroyed by water.

Indirect effects

Indirect effects are those that are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. The indirect impacts evaluated by the Service include injury and mortality associated with: 1) post-construction traffic increases from vehicles accessing the area for project monitoring, operations, maintenance or possible recreational access; (2) post-construction maintenance of the roads, levees, pump stations, and reservoir (including vegetation management methods such as mowing, herbicide application, and physical removal; reduced foraging opportunities associated with fluctuations in the prey populations from reservoir, canal or ditch drawdown or flooding; and 3) possible drowning or loss of individuals or nests

associated with rehydration; and harassment associated with rehydration of the reservoir. The indirect effects that the proposed action may have on eastern indigo snakes within the action area are discussed below.

Injury and Mortality: Once construction is completed, additional vehicular traffic will access and operate in the area as a result of project monitoring, operations, maintenance, and recreation. Some portion of the crown of the embankments will also be accessible for recreation access. Considering this information, it is likely that a small amount of mortality will occur as a result of additional vehicles accessing the site.

The Service anticipates that a small number of eastern indigo snakes may occupy the project area during operation and maintenance for the life of the project. Given the elevation of the project site levees and the number of prey items that could become established in and around the reservoir during drydown; these snakes may be at risk from the operation of maintenance vehicles and equipment, although the precise impacts are difficult to measure.

Mowing of embankments, vehicular activity, or heavy equipment operation associated with maintenance has the potential to crush or injure individual eastern indigo snakes and eggs, and destroy or degrade potential habitat. In general, the District uses the following guidelines for mowing levees:

1. Mowing occurs approximately 4 times per year.
2. Mowing occurs when vegetative height reaches 8 to 10 inches.
3. Mowers are set at 6 inches height.
4. Mowing occurs slightly beyond the toe of the slope if water levels allow.
5. No wildlife is to be harmed in the mowing of any levees.

Loss of Prey: Following the establishment of vegetation on the reservoir embankments (within six months after completion), prey items may colonize the reservoir embankments. Additionally, depending on the operation of the project and available water, the reservoir may occasionally dry out in low-precipitation years. It is not clear whether an eastern indigo snake prey base could become established within the reservoir. The interior slopes will be lined with a soil-cement mixture but the floor would remain as a natural substrate. Exposed substrate could attract, expose, or trap prey for the eastern indigo snake. Rehydration of the reservoir could result in loss of prey items. However, due to the large volume of water stored in the reservoir, complete drydown is anticipated to occur infrequently and this potential effect should be re-evaluated as more data becomes available regarding inundation frequency. Pesticide application may occur as part of project maintenance or accommodation of recreational activities. Prey (insects and some amphibians and reptiles) may be vulnerable to pesticide application and may be lost as a result of these activities.

Rehydration of the reservoir: Because the interior of the perimeter emabankment and the sides of the interior dam will be concrete, snake access to a drying reservoir may be limited. If access to the reservoir floor occurs in the event that portions of the reservoir become dry, and in the event a prey base becomes established, eastern indigo snakes may be attracted to the reservoir

floor and cold potentially be vulnerable to inundation upon rehydration. Eastern indigo snakes may drown or have to move off the site to find a suitable substitute. Due to the volume of water stored in the reservoir, complete drydown is anticipated to occur infrequently. However, this effect should be re-evaluated as more data becomes available regarding inundation frequency.

Contaminants:

Copper: Soil sampling has identified seven grids (*i.e.*, grids 56, 58, 124, 125, 134, 135, and 143) in the Berry Labelle – Congen Groves (Tracts GX-100-017 & GX-100-018) portion of the site that will require remediation due to copper contamination. The Service recommended remediation for the entirety of Grids 124, 125, 134, 135, and 143 (250 ac) and for the portions of Grids 56 and 58 that will be within the footprint of the proposed reservoir. The Service concurred in a letter dated September 14, 2006, that removing contamination from the seven grids would remove the risk of direct impacts to Service trust resources. Approximately one foot of soil will be excavated from areas to be remediated and the soil will be utilized within the reservoir embankments, burying the soils such that surface water will not contact the copper-contaminated soil. However, the Service noted that the remaining copper concentration in some areas of the property may be high enough to adversely impact benthic organisms.

We anticipate that remediated soils placed in the embankments will not adversely affect eastern indigo snakes. Copper does not significantly biomagnify in the food chain beyond benthic invertebrates. Since the majority of the potential prey of the indigo snake associated with periodic drawdown of the reservoir is not composed of benthic invertebrates, the Service does not anticipate any effect to the indigo snake (Frakes, personal communication 2007)

Other contaminants: The 600-acre Bryan Paul Citrus Grove (Tract GX-100-009) will be remediated for chlordane contamination by removal of the top two ft of soil in the 20-acre area and utilizing that soil within the reservoir embankments. The 2,025-acre Bob Paul Citrus Grove (Tract GX-100-015) may be remediated for organochlorine pesticides in two 50-acre grids upon further investigation to delineate contamination. The 2,399-acre Winthrop Property (Tract GX-100-005) will be remediated for metals, petroleum hydrocarbons, and pesticides detected around maintenance areas by removal of contaminated soils. The 954-acre Griffin Property (Tract GX-100-001) will be remediated for metals and polycyclic aromatic hydrocarbons in burn areas, chemical barns, and fertilizer mix and load areas by removal of contaminated soils. Given proper remediation, the anticipated risk from other contaminants is probably low.

Beneficial Effects

The management of the C-43 West Reservoir project site may result in minor potential benefits to the eastern indigo snake. The loss of eastern indigo snake habitat when the citrus grove is cleared may be minimally offset after vegetation on the external reservoir embankment has stabilized and prey items for the eastern indigo snake become available at sufficient densities (two to five years following construction). At that time, there should be habitat suitable for the eastern indigo snake on the external portion of the reservoir embankment. Interior portions of the reservoir and the interior dam embankments are anticipated to be a harder material (soil

cement or concrete) and therefore, would not provide the necessary herbaceous plant cover needed by eastern indigo snakes and their prey. The width of the side slopes of the external embankments would be 114 ft. The width of the toe between the bottom of the external embankment and the perimeter canal is 90 ft. For the perimeter reservoir embankments and toe, a total of 403.05 ac (204 ft of the perimeter embankment x 86,064 ft [16.3 mi]) of potential indigo snake habitat would be created. The top of the embankment was not considered eastern indigo snake habitat, even though snakes may be found there, due to the offsetting consequence of potential road mortality and lack of prey. The total potential eastern indigo snake habitat created by this project was estimated to be 403.05. Using the density data for ABS, if this acreage was in one block instead of linear it would support 4.24 eastern indigo snakes. However, since this habitat covers the perimeter of the site, eastern indigo snakes from outside the project area may occasionally use this habitat, assuming prey and cover are suitable and that the perimeter canal can occasionally be crossed. Therefore, it is difficult to estimate how many eastern indigo snakes will actually use the site following construction. Similarly, the extent to which prey items may become available as a result of reservoir drawdown is unknown.

Interrelated and interdependent actions

An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the action under consultation. The management of the C-43 West Reservoir project site is an interdependent action.

Species' response to the proposed action

Construction, operation, and maintenance of the project can result in actions that may kill or injure individual eastern indigo snakes and destroy nests, and destroy or degrade occupied and potential habitat and foraging areas. Due to their large home ranges and relative low density, risk of direct mortality would not normally be considered substantial. However, due to the large size of the project area, the likelihood of mortality or injury increases. Any clearing, burning, earthmoving, construction, operation, and maintenance activities may also adversely affect eastern indigo snakes by causing them to leave the area, and possibly miss foraging and mating opportunities. Individual eastern indigo snakes fleeing the area may be more vulnerable to predation and intraspecific aggression. The Service anticipates that the eastern indigo snake population at the C-43 West Reservoir project will not fully recover from the effects of the proposed action.

It is anticipated that all 10,264 ac of potential eastern indigo snake habitat within the citrus grove portion of the action area would be impacted by the proposed action. The number of individuals present at the time of the action is not known. The Service estimates that as many as 41 adult male and 13 adult female eastern indigo snakes may be present within the site. These estimates are based on population density estimates at ABS (Layne and Steiner 1996) and reduced based on inferior habitat quality in the groves. It is not known how many juvenile eastern indigo snakes may be present at the time of the action. Juvenile indigo snakes are more vulnerable

because they typically do not use underground refugia as adults do, preferring thick vegetation for cover (Speake et al. 1987).

We believe that some eastern indigo snakes may move to the reservoir embankments, interior dam embankments, and toe slopes between the reservoir embankments and the perimeter canal following construction and stabilization of the vegetation and establishment of prey items. Eastern indigo snakes may also access the reservoir if extended periods of drydown occur and prey items establish in the reservoir. Access to these prey items will likely be controlled by the ability of the snake to negotiate the concrete interior surface of the external embankment, water depth, and the extent of available forage habitat in ecotones between dry and wet areas. We cannot estimate the number or age of eastern indigo snakes that may move into either area. Individual eastern indigo snakes may also be affected by on-going maintenance and management activities.

CUMULATIVE EFFECTS – Florida Panther

Cumulative effects include the effects of future State, Tribal, local, or private actions reasonably certain to occur in the action area considered in this Biological Opinion. Future Federal actions unrelated to the proposed action but located in the action area that would affect panthers are not considered in this section because they would require separate consultations pursuant to section 7 of the Act. To identify future private actions that would affect panthers and that may reasonably be certain to occur in the action area, the Service first identified the types of land alteration actions that could occur in the action area, then developed a mechanism to distinguish between those that will require future Federal review and those that are not likely to be a future Federal action, and thus meet the cumulative effects definition. To estimate future non-Federal actions, the Service chose to identify and tabulate recent past non-Federal actions and project this level of development as representative of future non-Federal actions.

Within the action area, past and ongoing state and county actions affecting panther habitat include: (1) State of Florida Developments of Regional Impact (DRI) Orders (2001 to 2006); (2) Collier and Lee County Planned Unit Developments (PUDs) (2001 to 2006); and (5) South Florida Water Management District's Environmental Resource Permits (2001 to 2006) (Figure 19). To evaluate these effects, the Service incorporated the FLUCCS mapping to determine properties that may be exempt from Federal Clean Water Act section 404 wetland regulatory reviews by the Corps. To determine which of these projects would likely be exempt from Federal Clean Water Act section 404 wetland regulatory reviews by the Corps, we identified the percentage of the project site that was classified as wetland habitat, based on the FLUCCS mapping units. The mapping units relied on by the Service included the 600 series (wetland classifications) and the 411 and 419 pine flatwood classifications (hydric pine systems). For listing purposes, properties with less than 5 percent wetlands were considered by the Service to be generally exempt from regulatory review as these quantities of wetlands could be avoided by project design.

Within the action area, based on FLUCCS mapping, about 19,438 acres could be expected to be subject to development without Federal permit involvement through the Clean Water Act section

404 (Table 15). This level of development represents 66.9 percent of a female panther's average home range (29,059 ac) and 31 percent of a male panther's average home range (62,542 ac).

State and county land alteration permits in southwest Florida not part of those actions listed above, generally included single-family residential developments within Northern Golden Gate Estates and Lehigh Acres. Vacant lands within the area of Northern Golden Gate Estates (north of I-75), also within the action area, totaled about 34,028 ac as of September 2004 (Figure 20). To evaluate these effects, the Service overlaid the plat boundaries on 2004 aerials, queried the parcel data from Collier County's Property Appraisers Office, noted lots with developments, compared those to 2003 aerials, and noted the changes. Vacant lands within the area of Northern Golden Gate Estates (north of I-75) totaled about 35,768 ac as of August 2003. The breakdown of acres for August 2003 is: (1) wetlands, about 17,572 ac; (2) uplands, about 17,990 ac; and (3) water, about 210 ac. These changes were overlain on the National Wetlands Inventory (NWI) maps for presence of wetlands. This evaluation was used to estimate the acreage of properties that may be exempt from Federal Clean Water Act section 404 wetland regulatory reviews by the Corps. A comparison of the 2003 and 2004 data for Northern Golden Gate Estates indicates about 1,740 ac of land were converted from vacant to developed with the breakdown as: (1) wetlands, about 696 ac; and (2) uplands, about 1,740 ac.

The evaluation process provided an estimate of 417 lots totaling 1,740 ac for Northern Golden Gate Estates. Therefore, using NWI mapping for the Northern Golden Gate Estates, a total of about 1,740 ac could be expected to be subject to development in a year in these areas without Federal permit involvement. Based on historical records for wetland permits issued by the Corps for these areas, most of these projects will involve the construction of single-family residences in partially developed areas and will involve less than an acre of impact. This level of development represents 3.59 percent of a female panther's average home range (29,059 ac) and 1.67 percent of a male panther's average home range (62,542 ac).

Vacant lands within the area of Lehigh Acres, also within the action area, totaled about 34,852 ac as of April 2003 (Figure 21). The breakdown of acres is: (1) wetlands, about 1,057 ac; (2) uplands, about 33,592 ac; and (3) water, about 202 ac. A review of aerial photography and Lee County building permit data for Lehigh Acres from the 1-year period prior to April 2003 indicates about 441 ac of land was converted from vacant to occupied, during the 1-year period. The breakdown of converted acres is estimated as: (1) wetlands, 66 ac; (2) uplands, 375 ac; and (3) water, 0 ac. Therefore, using NWI mapping, about 375 ac could be expected to be subject to development in a year in this area without Federal permit involvement.

In conclusion, the Service's cumulative effects analysis has identified about 21,553 ac within the action area that could be developed without Federal wetland permit involvement. This level of development, which the Service believes is representative of future non-Federal actions, is reasonably certain to occur and, therefore, meets the definition of cumulative effect. This level of projected future development represents 74.2 percent of a female panther's average home range (29,059 ac) and 34.5 percent of a male panther's average home range (62,542 ac), though the impacts will be scattered and generally located on the fringes of occupied panther habitat, supported primarily with disturbed vegetative communities, in row crops, or in

partially developed areas. These lands represent 1.10 percent of the non-urban private lands at risk in the core area (1,962,294 ac) (Table 5). Based on the above analysis, we believe the loss of the habitat associated with these lands, though insignificant in the short-term, may adversely impact the panther as development continues to occur in the future in the action area. The Service has accounted for some habitat loss and changes in habitat quality through its habitat assessment methodology and is encouraging state and county environmental staff to pursue section 10 (HCP) process to account for and compensate for adverse effects to the Florida panther.

CUMULATIVE EFFECTS – Audubon's Crested Caracara

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Biological Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Conversion of land from pasture to more intensive agricultural or residential uses could be a cumulative effect on the species if no wetlands were impacted (or no Federal permit was required). The most significant threat to the caracara is habitat loss resulting from this type of land use conversion (Layne 1996, Humphrey and Morrison 1997). Our assumed post-construction shifts in caracara territories may ultimately result in nest or territory abandonment if these large tracts of privately owned pastures or other agricultural activities adjacent to the project site are converted to residential or other non-pasture or non-prairie land uses. Based on the information in Table 15, the likelihood of more intensive land use conversions on adjacent land without Federal permit involvement through the Clean Water Act section 404 is high.

As caracara are known to feed on road kills, road improvement and widening projects may benefit caracara by increasing traffic and consequently increasing the number of road kills. However, caracaras are often killed while feeding on carrion within and along roadways. Thus, increased traffic and increased road kills likely lead to increased mortality of caracaras, particularly juveniles.

CUMULATIVE EFFECTS – Eastern Indigo Snake

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Conversion of large tracts of natural and rural habitats to more intensive agricultural or residential uses could be a cumulative effect on the species if no wetlands were impacted (or no federal permit was required). The primary threat to the eastern indigo snake is habitat loss and fragmentation due to development (Lawler 1977; Moler 1985a). Additional habitat may be lost by non-federally reviewed actions such as single-family residential developments. Residential developments also increase risk of harm to indigo snakes in the interface areas between urban and native habitats because it increases the likelihood of snakes being killed by property

owners and domestic pets. Increased traffic associated with development may also lead to increased snake mortality.

SUMMARY OF EFFECTS – Florida Panther

Panther Usage: The timing of construction for this project, relative to sensitive periods of the panther's lifecycle, is unknown. However, all land clearing associated with the development will be completed in phases over several years. There are no known den sites within the project boundaries and the quality and quantity of the foraging prey base is low. Though panthers likely use the habitats within the project's action area, we believe panther usage of the project site is infrequent and we do not believe project construction will result in direct panther mortality, but may result in temporary disturbance to resident or dispersing panthers.

Traffic: There will be traffic increases with project development. As discussed above and in previous sections, the lands on the project site provide limited value to the Florida panther and panther prey species, the site is encompassed by agricultural (*i.e.*, citrus groves) and rural development, and the proposed action will further restrict suitability of the site for use by either resident or dispersing panthers. Panthers, however, are known to use the lands within the action area and collisions with motor vehicles have been increasing since 2000 in the project action area. Although the risk to the panther from collisions with vehicles as a result of the C-43 West Reservoir project is difficult to quantify, the Service believes that the increase in traffic generated by the project is not likely to increase the risk of roadway mortality or injury to panthers in the 25-mile radius action area.

Habitat Loss: The Service, based on the habitat evaluations discussed previously, believes the project will result in the direct and indirect loss of about 10,335 ac of mostly low quality panther habitat within the Primary, Secondary, and Other Zones (see discussion under Wildlife Assessment). Habitat types are primarily citrus groves and disturbed wetlands. Wildlife utilization of the property shows limited foraging values to panther prey species. We believe panther usage of the site is limited; however, the permanent loss is anticipated to adversely affect the panthers in the action area by decreasing the spatial extent of lands available for foraging, breeding, and dispersing. This loss of about 10,335 ac of panther habitat represents 0.53 percent of the 1,962,294 ac of available non-urban private lands in the core area. This small loss (0.53 percent) of non-urban private lands on the northern edge of the panther's occupied range will not negatively impact the Service's land conservation and preservation goals.

Compensation: The Band1/Acceler8 Projects will collectively provide for the preservation and restoration of approximately 100,492 ac in the panther core area, including 59,294 ac in the Primary Zone and 41,198 ac in the Other Zone. Preservation of 41,198 ac in the Other Zone is equivalent to preservation of 13,733 ac (*i.e.*, 41,198 ac times 1/3) in the Primary Zone. Thus, the combined Band1/Acceler8 project lands in the panther core area preserves 73,027 ac (*i.e.*, 59,294 + 13,733) of Primary Zone equivalent lands, which represents 9.4 percent of the 778,082 ac of Primary Zone equivalent lands in private ownership still needed for the panther population goal of 90 individuals. The functional value of the habitats to the panther will be maintained long-term through hydrological restoration and the removal of exotic vegetation.

Therefore, we believe the preservation and restoration of approximately 100,492 actual ac of habitat used by the panther in the panther core area will minimize the impact of the loss of this lower quality habitat and will further the Service's panther conservation goal.

Compensation provided by the combined Band1/Acceler8 projects benefit the survival and recovery of the Florida panther as referenced in the draft Panther Recovery Plan (Service 2006) goal 1.1.1.2.3. This goal recommends that habitat preservation and restoration within the Primary Zone be provided in situations where land use intensification can not be avoided. The applicant has proposed equivalent habitat protection and restoration, to compensate for both the quantity and functional value of the lost habitat.

Fragmentation: The project site is also located on the northern edge of occupied habitat, is encompassed by agricultural (*i.e.*, citrus groves) and rural development, and is not located within known dispersal corridors to larger publicly owned managed lands important to the panther. Therefore, appreciable fragmentation of habitat used by the panther is not expected to result from project implementation.

Intraspecific Aggression: Potential increases in intraspecific aggression and disturbance to the Florida panther were evaluated. The Service believes, as previously discussed, the habitat on the property provides low quality foraging for prey species, which directly affects the frequency and duration of use of the property by panthers. However, the reduction in the geographic range of habitat for dispersal and escape cover may contribute to a potential increased risk of death of injury of panthers in the action area due to intraspecific aggression.

Cumulative Effects Analysis: In the cumulative effects analysis, the Service identified the potential loss of about 4,046 ac within the action area that could be developed without Federal wetland permit involvement and we believe this level of development represents future non-Federal actions expected to occur in the action area. This level of development represents a small percentage (0.22 percent of the 1,962,294 ac) of available non-urban private lands in the core area. In general, these lands are primarily within previously impacted areas or are in the western more urbanized portion of the Florida panther's consultation area. Although this small percentage of lands may be lost from the core area of private lands available for panther conservation, the Service believes the loss of these lands will not negatively impact the Service's land conservation and preservation goals.

Conservation Land Acquisitions: The State and County land acquisition programs acquired about 17,092 ac of lands within the action area from 2000 to 2004 (Table 9), which represents 2.1 percent of the 799,205 ac of private lands still needed for the population of 90 individuals. These lands are generally located within the core lands of the Florida panther and are intended to be actively managed for the benefit of many wildlife species including the Florida panther. The preservation of these lands in the panther core lands will have a beneficial effect on the panther and further the Service's goal in panther conservation.

SUMMARY OF EFFECTS – Audubon's Crested Caracara

The Service anticipates approximately 1,474 ac of caracara habitat will be lost through conversion of citrus groves to an above-ground reservoir. The Service anticipates disturbance of adults would occur that could also result in potential injury or mortality to eggs, chicks, and fledglings over a minimum of 5 years.

The Service anticipates a potential beneficial effect of the project for caracaras. We anticipate that up to 430.71 ac of levee-based foraging habitat could be generated by the project within the existing two caracara territories. Additionally, initial site preparation and construction activities may provide good foraging conditions by exposing prey.

SUMMARY OF EFFECTS – Eastern Indigo Snake

The C-43 West Storage Reservoir project will affect the eastern indigo snake by the loss of habitat associated with conversion of 10,264 ac of primarily upland citrus grove to deep water reservoir, embankments, canals, ditches and roadways. Direct injury or mortality could occur from construction activity and vehicle operation, destruction of temporary refugia (vegetation and debris piles) and the initial hydration. Indigo snakes will lose most of the project prey base to the initial rehydration and will have to move off of the site, risking exposure to predation and intraspecific aggression. Post-construction management and maintenance activities will include mowing, pesticide application, equipment maintenance, and possible recreation opportunities for the public which may result in injury or mortality. Rehydration after drydown may result in mortality, loss of habitat and loss of prey. The potential habitat replacement associated with embankments within 2 to 5 years after construction is estimated to be only 403 ac of habitat.

CONCLUSION

Florida Panther

In conclusion, the Service has determined there will be no direct mortality or injury of the Florida panther resulting from this project. Indirect effects are difficult to quantify due to the wide-ranging habit of the species and the challenge of linking the death or injury of a single panther to increases in panther interactions (intraspecific aggression) or traffic generated as a result of the C-43 West Reservoir project. The adverse affects of project-generated traffic and intraspecific aggression potential, however, is not anticipated to appreciably diminish or preclude the survival and recovery of the panther. The loss of habitat from implementing the project, taking into consideration the status of the species, remaining habitat, and other factors considered by this Biological Opinion, such as the overall recovery objectives and other cumulative effects from actions in the action area, will be minimized by the conservation of other, more functionally valuable habitat. Taking all of the above into consideration, the Service believes the proposed construction and operation of the C-43 West Reservoir project is not likely to jeopardize the continued existence of the Florida panther. Critical habitat has not been designated for this species; therefore, none will be affected.

Audubon's Crested Caracara

After reviewing the current status of the caracara, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the C-43 West Reservoir project, as proposed, is not likely to jeopardize the continued existence of the caracara. The Service reached this conclusion based on the determination that there will be no direct mortality or injury to adult caracara from the proposed project. However, the project-related changes in land cover and use primarily in the secondary zones of active nests as well as the increase in human presence and construction activities may contribute to indirect effects on the nest success of caracaras in the project vicinity. The Florida population of caracara is considered stable (Morrison 1996) and the potential short-term loss of reproductive success of two nesting pairs as a result of the project is not expected to appreciably affect the overall population of caracaras over time as caracaras are long-lived, maintain pair bonds for life, and exhibit strong nest site fidelity.

No critical habitat has been designated for the caracara; therefore, none will be affected.

Eastern Indigo Snake

After reviewing the current status of the eastern indigo snake, the environmental baseline for the action area, the effects of the proposed action and cumulative effects, it is the Service's biological opinion that the C-43 West Storage Reservoir project, as proposed, is not likely to jeopardize the continued existence of the eastern indigo snake. Although we anticipate incidental take of eastern indigo snakes, the Service has determined that the loss of a large area of primarily upland citrus grove under active agricultural production will not reduce the distribution of indigo snakes in the action area or in southern Florida. The indigo snake has a broad distribution in a mosaic of habitats and is a generalist that forages on a variety of available prey. The eastern indigo snake has some ability to move away from situations which may result in direct injury and mortality (construction and hydration) and can access adjacent habitat if escape opportunities are made available. For this project, the presence of on-site observers, pre- and post education, speed restrictions, order of construction, and rate of reservoir fill should reduce the incidence of injury, mortality, and disturbance.

No critical habitat has been designated for the eastern indigo snake; therefore, none will be affected.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. "Take" is defined as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct." "Harm" is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to

listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking, that is incidental to and not intended as part of the agency action, is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The terms and conditions described below are nondiscretionary and must be undertaken by the Corps so they become binding conditions of any grant or permit issued to the District, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the District to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protection coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps or the District, must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR § 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE

Florida Panther

The Service anticipates that incidental take of the Florida panther will be difficult to detect for the following reasons: (1) the Florida panther is wide-ranging; (2) the lands on the project site provide limited value to the Florida panther and panther prey species; and (3) lands adjacent to the project site consist of existing agricultural and rural developments that reduce their suitability for use by either resident or dispersing panthers. However, the Service does not anticipate construction of the project will result in the direct mortality or injury of any Florida panthers. The Service does however, anticipate indirect take of the panther in the form of harm and harassment because of potential increases in interspecific aggression within the 25-mile radius action area. This level of incidental take may is associated with the loss of 10,335 ac of panther habitat within the Primary, Secondary, and Other Zones (*i.e.*, 144, 5,236, and 4,955 ac, respectively).

Audubon's Crested Caracara

The Service anticipates that the proposed action will incidentally take the federally listed caracara, though the level of incidental take may be difficult to detect and quantify for the following reasons: (1) it has a wide-ranging distribution; (2) it has a protracted breeding season; (3) it would be difficult to find or identify dead or impaired individuals; and (4) there is a possibility for double brooding in a season, which may or may not occur in the same nest tree. The incidental take is expected to be in the form of harassment although take may also occur in the form of harm due to tree clearing, burning, construction, and operation and maintenance of the project. Caracaras will be permanently displaced from the project site in the open-water

portion of the reservoir cells. It is possible that these caracaras could utilize the reservoir embankments or seepage canal after construction.

The Service anticipates that up to two adult pairs of caracaras could be taken as a result of this proposed action. This incidental take for adult birds is expected to be in the form of harassment. No direct killing or injuring of adult caracaras is anticipated. Harassment of adults is limited to the flushing of adults off the nest, modification of their foraging and nesting behavior, and the possible displacement from their home territory to adjacent suitable lands due to a net loss of habitat quality for this species as a result of the action. The consequences of disrupted parental care of the nest (*e.g.,* reduced egg incubation, chick protection and feeding, or care of fledglings) may lead to egg, nestling, or fledgling mortality in a variety of forms, such as exposure, starvation, falling from the nest, or predation.

Therefore, the Service also anticipates that disturbance may cause the loss of productivity (eggs or young) associated with up to two caracara nest sites for up to five consecutive breeding seasons. The Service anticipates that up to six caracara eggs or young (a maximum of three per nest) could be incidentally taken per year during the construction of the project. This take would be in the form of harm.

The Service will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703-712), if such take is in compliance with the terms and conditions (including amount or number) specified herein.

Eastern Indigo Snake

Incidental take of the eastern indigo snake is difficult to detect and quantify for the following reasons: (1) it has a wide-ranging distribution; (2) it has a patchy distribution within suitable habitat; (3) it has limited detectability due to use of burrows or holes for shelter, (4) there is likely unoccupied suitable habitat; (5) juveniles have limited detectability due to their affinity for thick vegetation, and (6) they may use cryptic sheltering areas that may be temporarily established during construction (e.g., brush piles, equipment stockpiles, and dirt mounds). The lack of practical methods to survey, in conjunction with wide-ranging activity and use of a variety of habitat types makes it difficult to determine the exact number of eastern indigo snakes that will be incidentally taken.

The Service anticipates that the direct permanent loss of approximately 10,264 ac of eastern indigo snake habitat will occur through conversion of citrus grove to reservoir and associated embankments, canals, and other infrastructure. Based on the reported density of eastern indigo snakes at ABS, and reducing that density by half based on the inferior habitat characteristics of the existing citrus grove, the Service anticipates up to 54 eastern indigo snakes will be taken incidental to the initial project construction and operations. The Service estimates that up to 25 percent of the eastern indigo snakes potentially impacted by the C-43 West Reservoir project site may be killed or injured by the initial construction activities. Above-ground refugia (burn, sediment, or debris piles) may be lost during clearing and construction. Additionally, individual eastern indigo snakes fleeing the area may be more vulnerable to roadkill, predation and

intraspecific aggression. The remaining 75 percent of the snakes would not be directly killed or injured but would be be affected by the loss of habitat. These individuals could leave the area, abandon den sites, miss foraging and mating opportunities and experience lower productivity. The incidental take associated with construction activities and loss of the majority of the habitat on the site is in the form of harm and harassment.

Initial hydration and rehydration may drown indigo snakes or destroy nests. This incidental take is expected to be in the form of harm.

It is not expected that this species will be permanently extirpated from the project site; however, it is not know how many snakes may return to the site, reproduce on the site, or survive from juvenile or adult on the site. Reservoir embankments may provide limited habitat. Maintenance, operations, and recreational activities (including mowing, and vehicle and equipment operation) may kill or injure indigo snakes. This incidental take is primarily in the form of harm. Human disturbance, loss of prey from pesticide application, loss of prey from initial hydration or rehydration, and movement away from habitat as a result of rehydration may be the result of long-term project operation and management. This incidental take, which is difficult to quantify, is expected to be in the form of harassment.

The Service anticipates a potential beneficial but minor indirect effect of the project to be interrelated to the management of the reservoir. We anticipate that up to 403.05 ac of embankment-based eastern indigo snake habitat could be generated by the project within 2-5 years of project completion. Because this potential habitat is linear in shape, we estimated it as if it were all in one evenly-shaped block, providing potential benefits to four eastern indigo snakes.

EFFECT OF THE TAKE

In the accompanying Biological Opinion, the Service determined this level of anticipated take is not likely to result in jeopardy to listed species or adverse modification of their designated critical habitat. No critical habitat has been designated for the Florida panther, Audubon's crested caracara, or the eastern indigo snake; therefore, none will be affected.

REASONABLE AND PRUDENT MEASURES

Florida Panther

The Service believes the Corps and the District have developed a project that has conservation measures necessary and appropriate to minimize the effect of incidental take of the Florida panther. In summary, to compensate for impacts to 10,335 ac of habitat, the Corps and the District propose to enhance and preserve approximately 59,294 ac and 41,772 ac of habitat used by the panther within the Primary and Other Zones, respectively, to benefit the Florida panther and its prey.

Audubon's Crested Caracara

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of the caracara. Disturbance and injury to caracaras should be minimized during construction activities. Education of personnel on the site will facilitate minimization of impacts and conservation of the species. The District staff will coordinate and report on their activities to the greatest extent practical to minimize potential adverse effects on natural resource compliance, management, and monitoring requirements; and post speed limit of 35 mph or slower.

Eastern Indigo Snake

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of the eastern indigo snake. Disturbance and injury to eastern indigo snakes should be minimized during construction activities. Education of personnel on the site will facilitate minimization of impacts and conservation of the species. Initial and rehydration fill rates can be adjusted to minimize mortality of indigo snakes and reduce the loss of prey. The District staff will coordinate and report on their initial construction activities; initial reservoir fill and reservoir rehydration; and long-term maintenance, management, and recreational activities to minimize potential adverse effects on the eastern indigo snake.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the reasonable and prudent measures, described above and outline reporting and monitoring requirements. The terms and conditions described below are non-discretionary, and must be undertaken by the Corps so they become binding conditions of any grant or permit issued to the District, as appropriate, for the exemption in section 7(o)(2) to apply.

The Corps has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the District to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, the protection coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps or the District, must report the progress of the action and its impact on the species to the Service as specified in the Incidental Take Statement (50 CFR § 402.14(i)(3)).

Florida Panther

Although we have not identified any specific Reasonable and Prudent Measures not incorporated in the project for Florida panthers, we are providing the following for clarification:

1. The Corps will include, as special conditions to the permit instrument, the conservation measures listed below and in the description of the proposed action that commits the applicant to purchase, preserve, and manage high quality habitat used by the panther, which is necessary and appropriate to minimize incidental take of panthers by the proposed action. Specifically, to compensate for the loss of 10,335 ac of habitat used by the panther, the District proposes to preserve and enhance 59,294 ac and 41,772 ac of Florida panther habitat in the Primary and Other Zones, respectively;

2. The preservation-sites will be managed in perpetuity for the control of invasive exotic vegetation as defined by the Florida Exotic Pest Plant Council's Pest Plant List Committee's 2001 List of Invasive Species (Category 1)(2005);

3. The Corps will provide a copy of the final permit to the Service upon issuance. The Corps will monitor the permit conditions regarding conservation measures to minimize incidental take of panthers by providing the Service a report on implementation and compliance with the conservation measure within 1 year of the issuance date of the permit;

4. **Annual Report:** An annual report will be presented to the Corps and to the Service in order to comply with 50 CFR part 402.14(i)(3), which states "In order to monitor the impacts of incidental take, the Federal agency or any applicant must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement." The report will contain the following information:

    a. The current status of the construction of the project as well as any construction phases or milestones that have been completed;

5. The Corps will provide a copy of the final as-builts to the Service within 1 year of construction completion. These as-builts will also include habitat types and acreages of all land cover types within the project footprint;

6. The Corps will provide documentation to the Service for completion of any proposed restoration and verification of the execution and terms of the conservation easement or deed, if applicable;

7. Upon locating a dead, injured, or sick threatened or endangered species, initial notification must be made to the nearest Service Law Enforcement Office; Fish and Wildlife Service; 9549 Koger Boulevard, Suite 111; St. Petersburg, Florida 33702; 727-570-5398. Secondary notification should be made to the FWC; South Region; 3900 Drane Field Road; Lakeland, FL; 33811-1299; 1-800-282-8002; and

8. Care should be taken in handling sick or injured specimens to ensure effective treatment and care or in the handling of dead specimens to preserve biological material in the best possible state for later analysis as to the cause of death. In conjunction with the care of sick or injured panthers or preservation of biological materials from a dead animal, the finder has

the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

Audubon's Crested Caracara

In order to be exempt from the prohibitions of section 9 of the Act, the Corps shall ensure that the District complies with the following terms and conditions which implement the reasonable and prudent measures described above and outline reporting and monitoring requirements. These terms and conditions are non-discretionary.

Caracara pairs proximate to the C-43 site will be monitored during land cover conversion and construction of reservoirs associated with this project. The goal of monitoring is to obtain detailed information on how a caracara breeding pair is affected by project-related disturbance and the changes in habitat availability within their territory. This will include the ability to evaluate changes in area use by caracaras, changes in location of nesting, nest success, fledging success, and adult and juvenile survival. The monitoring will be conducted starting as soon as possible before any clearing or grubbing occurs within the primary or secondary zones of a caracara nest and will continue until 1 year post-construction. The approved monitoring plan should include the following specific objectives:

1. Conduct additional annual surveys for caracara nests and territories in the proposed project area and within 1.5 miles of the project area boundary to evaluate effectiveness of surveys and to increase knowledge of caracara nest sites and densities within these areas. This will also provide information to allow evaluation of how any observed changes in habitat use may affect any other caracara territories in the vicinity in conjunction with data collected on radio-tagged birds. Surveys of suitable habitat within 1.5 miles of the project area may be conducted from roads or other public access points.

2. Capture and radio tag caracaras at the nest located on private property southeast of the proposed project footprint. Use satellite or standard VHF telemetry to monitor the adult caracaras' movements, habitat use, and survival over multiple years, both pre- and post-conversion. Monitoring of radio-tagged birds must be sufficient to document movements away from the territory if they occur.

3. Compare documented habitat use before and after project activities using the recently available habitat model and map (Morrison et al. 2006).

4. Monitor reproductive effort, nest success, fledging success, and adult and juvenile survival of all caracara nests within 3,000 meters of the proposed project.

The monitoring must be sufficiently rigorous to determine which of the following hypotheses about caracara responses to habitat conversion are exhibited by each caracara pair whose territory overlaps the project area:

- Caracara pairs may move to the nearest suitable habitat and establish a new nest site and territory. This suitable habitat may already be occupied by other caracaras, but if the habitat is suitable and sufficient in size, territory boundaries may shift and all pairs may be able to coexist and reproduce successfully.
- Caracara pairs may leave the project area and travel some distance to find another area of suitable habitat where they can establish a new nest site and territory. If they can find such new areas, they may be able to survive and reproduce successfully.
- Caracara pairs may attempt to establish new nest sites and territories either near or far from the development area but may be unsuccessful either because of territorial aggressiveness from resident pairs or because no other suitable habitat exists.
- In the absence of being able to establish a new territory and nesting site, the caracaras may become nomadic, traveling around south-central Florida, perhaps joining sub-adult flocks, or if not, simply surviving but being unable to establish anywhere and breed. In this case, these pairs' reproductive contribution to the overall population's persistence is lost.
- Displaced caracaras could die prematurely. As nomads, displaced adults may incur higher risk of mortality because of either a) being killed by caracaras defending territories into which displaced caracaras attempt to move, or b) through collision with vehicles our other trauma associated with scouting unfamiliar areas.
- The effects of the project do not result in any changes to the territory location and habitat use, and do not affect survival or productivity of the caracara pair at the site.

A monitoring proposal that details the methods which address the objectives described above should be submitted to the Service for review and approval at least 30 days prior to initiating caracara monitoring. The agency personnel or contractor who will be conducting the monitoring will also be responsible for obtaining a section 10(a)(1)(A) recovery permit that authorizes affects to caracaras that result from caracara trapping, transmitter attachment, nest monitoring and other associated activities.

Annual reports on the caracara monitoring project which include results form the monitoring to date, preliminary results of analyses, and complete data sets that result from the monitoring efforts shall be submitted to the Service. A final report shall also be prepared that provides results and final analyses after completion of all data collection and analyses.

Eastern Indigo Snake

In order to be exempt from the prohibitions of section 9 of the Act, the Corps shall ensure that the District complies with the following terms and conditions, which implement the reasonable and prudent measures described above and outline reporting and monitoring requirements. These terms and conditions are non-discretionary.

1. Minimize road and construction-related mortality:

a. Precautions for the eastern indigo snake will be required to avoid injury to any individual animal. The Draft Standard Protection Measures for the Eastern Indigo Snake (Service 2002) will be incorporated into special conditions of the permit.

b. The District shall provide at least one qualified observer during ground clearing activities. The observer's qualifications will be provided to and approved by the Service's C-43 Project biologist (Fish and Wildlife Service, South Florida Ecological Services Office; J.N. "Ding" Darling National Wildlife Refuge, 1 Wildlife Drive, Sanibel, Florida 33957, (941) 472-1100 (ext. 231), 2 weeks prior to initiation of construction. The observer's sole function would be to visually evaluate the area to be cleared immediately prior to, and following vegetation removal, stockpiling, and burning and to record any eastern indigo snake activity. Only individuals who have been either authorized by a section 10(a)(1)(A) permit issued by the Service, or by the State of Florida through the FWC for such activities, are permitted to come in contact with an eastern indigo snake.

c. During initial removal of the citrus trees the canal banks will not be altered. The trees will be up-rooted, allowed to dry, and subsequently pushed into piles and burned. Brush piles would be located as far away from the ditches (snake habitat) as possible in order to keep snakes from recolonizing brush piles before they are burned. Removal of trees would proceed at a relatively slow pace, thus allowing eastern indigo snakes the opportunity to move away.

d. During tree clearing, the equipment operators will start work at the farthest point from ditches, canals, or other potential temporary refugia and work towards the ditches or canals so that the eastern indigo snake, if encountered, would be encouraged to move away from the disturbance and towards temporary refugia.

e. The District shall conduct a pre-construction wildlife education meeting with all workers and contractors that will be present on the site, including those conducting the initial remediation activities, using the standard Acceler8 preconstruction package, as well as conditions under which the Service should be notified with regard to eastern indigo snake concerns.

f. For avoidance and safety reasons, a speed limit of 35 mph will be posted for all vehicular traffic. Pre-construction education materials shall specify speed restrictions.

2. Minimize harm (habitat loss, mortality due to drowning) and harassment (disturbance, loss of prey) by:

a. Initial hydration of the reservoir will be at a maximum rate of 6 inches per day until the water depth is 6 inches above the highest surface elevation excluding existing embankments. The highest surface elevation is approximately 26.0 feet; thus the reservoir would be filled at a maximum rate of 6 inches per day until the water elevation

reaches 26.5 feet. Once the 26.5 foot depth is reached, the reservoir fill rate will not be restricted.

b. The subsequent first rehydration of the reservoir after an extended drydown event will be at a rate of 1 foot per day until the water is 1 foot above the highest surface elevation excluding embankments or other man-made structures such as boat ramps. The highest surface elevation is approximately 26.0 feet; thus the reservoir would be filled at a maximum rate of 1 foot per day until the water elevation reaches 27 feet. Once the 27 foot depth is reached, the reservoir fill rate will not be restricted. An extended drydown event will be defined and included as a 404 permit condition.

c. The Corps shall monitor indigo snake response during initial fill to determine the effect of hydration on indigo snakes. If necessary, snakes will be captured and released outside the reservoir. The Corps shall monitor indigo snakes during rehydration following the first extended drydown event to determine reservoir accessibility and use by indigo snakes and their prey during drydown events and the effect of rehydration on snakes if present. An extended drydown event will be defined prior to the 404 permit issuance and a detailed monitoring plan shall be submitted to the Service for review and approval at least 30 days prior to initial filling of the reservoir. The agency personnel or contractor who will be conducting the monitoring will also be responsible for obtaining a section 10(a)(1)(A) recovery permit that authorizes affects to indigo snakes as a result of trapping, transporting, and releasing them. If snake monitoring indicates that snakes are capable of escaping the reservoir without harm or that snakes do not use the reservoir bottom during extended drydown events, then restrictions on rehydration rates will be re-evaluated.

d. The Corps shall conduct a pre-construction wildlife education meeting with all workers and contractors that will be present on the site, including those conducting the initial remediation activities, using the standard Acceler8 preconstruction package; as well as conditions under which the Service should be notified with regard to eastern indigo snake concerns.

e. All vehicle and equipment operators will be notified for the life of the project, including all management and maintenance personnel, to avoid all snakes and burrows if at all possible. All on-site personnel will be educated to recognize the eastern indigo snake for the life of the project. If any snake is encountered, it will be avoided and allowed to leave the area on its own before vehicle or equipment use is resumed.

f. Educational information on the eastern indigo snake will be posted at the educational kiosks on the site.

3. Monitoring and reporting requirements:

a. Results of all observations associated with ground clearing activities (as required in Terms and Conditions 1.a.) shall be provided to the Service's C-43 Project biologist (Fish and Wildlife Service, South Florida Ecological Services Office; J.N. "Ding" Darling National Wildlife Refuge, 1 Wildlife Drive, Sanibel, Florida 33957, (941) 472-1100 (ext. 231), within 30 days following the activity.

b. Initial hydration shall be monitored to assure consistency with the Term and Condition 2 (a) and 2 (c). Results of observations associated with initial hydration including stage gauge levels, observations of indigo snakes or their prey, additional information identified in the monitoring plan, and recommendations to reduce effects to indigo snakes during rehydration shall be provided to the Service's C-43 Project biologist (Fish and Wildlife Service, South Florida Ecological Services Office; J.N. "Ding" Darling National Wildlife Refuge, 1 Wildlife Drive, Sanibel, Florida 33957, (941) 472-1100 (ext. 231) within 10 days following the activity.

c. Levee mower operators will scan the areas where vegetation has been cut immediately afterwards mowing and count and record the number of all species of dead or injured snakes observed with particular attention to identifying and counting any potential eastern indigo snakes.

d. The Corps shall provide the Service C-43 Project biologist (Fish and Wildlife Service, South Florida Ecological Services Office; J.N. Ding Darling National Wildlife Refuge, 1 Wildlife Drive, Sanibel, Florida 33957, (941) 472-1100 (ext. 231), a one-week advance notice on the schedule for ground clearing of citrus trees or other construction phases (pre-loading of embankments, perimeter canal construction, pump and infrastructure construction, and initial hydration) so that we may participate in on-site observational activities.

e. The Corps shall provide the Service C-43 Project biologist (Fish and Wildlife Service, South Florida Ecological Services Office; J.N. Ding Darling National Wildlife Refuge, 1 Wildlife Drive, Sanibel, Florida 33957, (941) 472-1100 (ext. 231), a two-day advance notice on the schedule to rehydrate the reservoir by pumping or weir operation after the first drydown event. This term and condition will be discontinued if rehydration events are determined to have no adverse effect on eastern indigo snakes as determined by monitoring and agreed to by the Service.

4. Disposition of dead or injured animals (salvage):

a. Annually, a report of all snakes killed or injured by operation or maintenance of the C-43 West Reservoir project (as indicated in Terms and Conditions 1.h.) must be submitted to the Service's C-43 project biologist (Fish and Wildlife Service, J.N. "Ding" Darling National Wildlife Refuge, 1 Wildlife Drive, Sanibel, FL 33957, (941) 472-1100. This report should contain the location, dates, and times for any sightings of eastern indigo snakes and the disposition of all eastern indigo snakes found. A site map with

observation locations should also be included in this report. If no snakes are encountered, a report should be submitted indicating that fact.

b. Upon locating a dead, injured, or sick federally listed species, initial notification must be made to referenced project biologist and the nearest Service Law Enforcement Office (Fish and Wildlife Service; Ed Lewis, Fort Myers, Florida (239) 561-8148. Secondary notification should be made to the FWC, South Region; 8535 Northlake Boulevard; West Palm Beach, Florida; 33412-3303; (561) 625-5122; 1-888-404-3922. If not specifically instructed by Service law enforcement to submit dead specimens, all dead specimens and snake sheds should be offered to the Florida Museum of Natural History, Gainesville, FL 32960. The museum should be contacted with regard to details for preservation and transport.

Care should be taken in handling sick or injured specimens to ensure effective treatment and care or in the handling of dead specimens to preserve biological material in the best possible state for later analysis as to the cause of death. Dead eastern indigo snakes should be placed on ice and frozen as soon as possible. In conjunction with the care of sick or injured specimens or preservation of biological materials from a dead animal, the finder has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. We recommend the following:

Audubon's Crested Caracara

1. Support scientific studies to determine the response of breeding caracaras to habitat restoration efforts (*e.g.*, flooding of pasture, general construction activities) within their established territories. This information would be useful in predicting the effects of other restoration efforts in the CERP that are planned within the caracara's existing range, as well as in developing measures to reduce potentially adverse project effects on the caracara and assist in the recovery of this species.

2. Implement the procedures in *Recommended Management Practices and Survey Protocols for Audubon's Crested Caracara in Florida* (Morrison 2001) during project planning and construction, as appropriate. The implementation of these guidelines by land managers and Federal action agencies would help in the recovery of this species.

3. Monitor the long-term responses of caracaras to altered habitat conditions over broad areas. This would provide useful information in determining the potential effects of large-scale

projects, such as the CERP, agricultural conversion, and residential development on this species.

4. The Corps should continue to work with the Corps, Service, public land managers, and private landowners to identify other habitats that have the potential to be improved for caracaras. When potential habitat improvement sites are identified, the agencies will cooperate and jointly coordinate with the respective land management entities and landowners to improve these caracara habitats. Habitat improvement measures may include land management actions such as removal of exotic or nuisance species of vegetation, prescribed burning, and planting of native vegetation. The short-term goal of these habitat restoration measures would be to offset or compensate for any potential losses in caracara breeding pairs resulting from this and anticipated projects. A long-term goal of these measures would address the potential loss of caracara reproduction resulting from implementation of future phases of the CERP.

5. Following construction, maintain an on-site educational kiosk for the public on the listed species and other wildlife that may be observed in the project area.

Eastern Indigo Snake

1. Following construction, maintain an educational kiosk for the public on the listed species and other wildlife that may be observed in the C-43 West Reservoir project.

2. If large snake skins are found, they should be collected, dried, and sent to the Service's C-43 Project biologist (Fish and Wildlife Service, J.N. "Ding" Darling National Wildlife Refuge, 1 Wildlife Drive, Sanibel, Florida 33957, (941) 472-1100 for positive identification and genetic studies. Information on the collection date and location should be included.

3. Cooperate with research-based efforts to provide for long-term ecological monitoring on eastern indigo snake prey densities and habitats in the project area.

REINITIATION NOTICE

This concludes formal consultation on the C-43 West Reservoir project. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; (3) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

Thank you for your cooperation and effort in protecting fish and wildlife resources. If you have any questions regarding this project, please contact Joyce Mazourek at 239-472-1100, extension 231.

Sincerely yours,

Paul Souza
Field Supervisor
South Florida Ecological Services Office

cc:
Corps, Jacksonville, Florida (Beth Marlowe, Susan Conner)
Corps, West Palm Beach, Florida (Tori White)
District, Fort Myers, Florida (Janet Starnes)
District, West Palm Beach (John Mitnik)
EPA, West Palm Beach, Florida (Richard Harvey)
FWC, Punta Gorda, Florida
FWC, Naples, Florida (Darrell Land)
FWC, Tallahassee, Florida (Ron Mezich)
Service, Atlanta, Georgia (Noreen Walsh) (electronic copy only)
Service, J.N. "Ding" Darling NWR, Sanibel, Florida (Robert Jess, Joyce Mazourek)
Service, Vero Beach, Florida (Chris Belden) (electronic copy only)

LITERATURE CITED

Ackerman, B. B., F. G. Lindzey, and T. P. Hemker. 1986. Predictive energetics model for cougars. Pages 333-352 in S. D. Miller and D. D. Everett (eds). Cats of the world: biology, conservation, and management. National Wildlife Federation and Caesar Kleberg Wildlife Research Institute, Washington, D. C. and Kingsville, TX.

Aebischer, N.J., P.A. Robertson, and R.E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology 74:1313-1325.

Akçakaya, H.R. 2002. RAMAS GIS: Linking spatial data with population viability analysis (version 4.0). Applied Biomathetics, Setauket, New York.

Anderson, A.E. 1983. A critical review of literature on puma (Felis concolor). Special report Number 54. Colorado Division of Wildlife, Wildlife Research Section; Denver, Colorado.

Audubon, J.J. 1834. Ornithological biography. Volume I. Adam and Charles Black; Edinburgh, Scotland.

Babis, W.A. 1949. Notes on the food of the indigo snake. Copeia 1949 (2):147.

Ballou, J. D., T. J. Foose, R. C. Lacy, and U. S. Seal. 1989. Florida panther (Felis concolor coryi) population viability analysis and recommendations. Captive Breeding Specialist Group, Species Survival Commission, IUCN, Apple Valley, MN.

Bangs, O. 1899. The Florida Puma. Proceedings of the Biological Society of Washington 13:15-17.

Barone, M.A., M.E. Roelke, J. Howard, J.L. Brown, A.E. Anderson, and D.E. Wildt. 1994. Reproductive characteristics of male Florida panthers: Comparative studies from Florida, Texas, Colorado, Latin America, and North American zoos. Journal of Mammalogy 75(1):150-162.

Bargar, Tim, R. Frakes, J. Boggs, E. Boughner. 2005. Uptake of Copper by Apple Snails from Contaminated Sediments in South Florida, Interim Report. Environmental contaminants Program South Florida Ecological Services Office, U.S. Fish and Wildlife Service,Vero Beach, Florida.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. Journal of Wildlife Management 59(2):228-237.

Beier, P. 2003. Comments on landscape conservation strategy for the Florida panther in south Florida. Unpublished report to the U.S. Fish and Wildlife Service, South Florida Ecological Services Office; Vero Beach, Florida.

Beier, P., M.R. Vaughan, M.J. Conroy, and H. Quigley. 2003. An analysis of scientific literature related to the Florida panther. Final Report. Florida Fish and Wildlife Conservation Commission; Tallahassee, Florida. 203 pages.

Beissinger, S.R. and M.I. Westphal. 1998. On the use of demographic models of population viability in endangered species management. Journal Wildlife Management 62:821-841.

Belden, R. C. 1986. Florida panther recovery plan implementation - a 1983 progress report. Pages 159-172 in S. D. Miller and D. D. Everett (eds). Cats of the world: biology, conservation, and management. National Wildlife Federation and Caesar Kleberg Wildlife Research Institute, Washington, D.C. and Kingsville, TX.

Belden, R. C. 1988. The Florida panther. Pages 515-532 in Audubon Wildlife Report 1988/1989. National Audubon Society, New York, NY.

Belden, R. C., and R. T. McBride. 1983a. Florida panther surveys – Big Cypress National Preserve. Final report to Hughes and Hughes Oil and Gas Company.

Belden, R. C., and R. T. McBride. 1983b. Florida panther surveys – South Florida Indian Reservations. Final report to Natural Resources Management Corporation.

Belden, R. C., and R. T. McBride. 2005. Florida panther peripheral areas survey final report 1998-2004. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Belden, R. C., W. B. Frankenberger, R. T. McBride, and S. T. Schwikert. 1988. Panther habitat use in southern Florida. Journal of Wildlife Management 52:660-663.

Belden, R. C., W. B. Frankenberger, and J. C. Roof. 1991. Florida panther distribution. Final Report 7501, E-1 II-E-1. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Bennetts, R.E. and W.M. Kitchens. 1994. Estimation and environmental correlates of survival and movements of snail kites in Florida. 1994 annual progress report. Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville. 41 pp.

Bennetts, R.E., M.W. Collopy, and J.A. Rodgers, Jr. 1994. The snail kite in the Florida Everglades: a food specialist in a changing environment. Pages 507-532 in S.M. Davis and J.C. Ogden (eds.), Everglades: the ecosystem and its restoration, St. Lucie Press, Delray Beach, Florida.

Bent. A.C. 1938. Life histories of North American birds of prey, part 2. U.S. National Museum Bulletin 170, Government Printing Office: Washington, D.C.

Bent, A.C. 1961. Life histories of North American birds of prey, Volume I. Dover Publishers; New York. New York.

Beyer, Jr., D.E. and J.B. Haufler. 1994. Diurnal versus 24-hour sampling of habitat use. Journal of Wildlife Management 58:178-180.

Bolt, R. 2006. Personal communication. Biologist. Conference call with the U.S. Fish and Wildlife Service, South Florida Water Management District and U.S. Army Corps of Engineers on August 9, 2006. Dynamac; Kennedy Space Center, Florida.

Brook, B. 2000. Pessimistic and optimistic bias in population viability analysis. Biology Conservation 14:564-566.

Brook, B.W., L. Lim, R. Harden, and R. Frankham. 1997. Does population viability analysis software predict the behaviour of real populations? A restrospecitve study of the Lord Howe Island Woodhen Tricholimnas sylvestris (Sclater). Biology Conservation 82:119-128.

Bulger, A.J., B.P. Hayden, M.G. McCormick-Ray, M.E. Monaco, and D.M. Nelson. 1990. A proposed estuarine classification: analysis of species salinity ranges. ELMR Report No. 5, Strategic Assessment Branch, NOS/NOAA, Rockville, Maryland.

Carson, H.L. 1945. Delayed fertilization in a captive indigo snake with note of feeding and shedding. Copeia 1945(4): 222-224.

Chamberlain, R.H. and P.H. Doering. 1998a. Freshwater inflow to the Calooshatchee Estuary and the resource-based method for evaluation. P.81-90 in S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington D.C.

Chamberlain, R.H. and P.H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Calooshatchee Estuary: A resource-based approach. P.121-130 in S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington D.C.

CERP Interagegency Manatee Task Force. 2006. Guidelines for Manatee Conservation During Comprehensive Everglades Restoration Plan Implementation. U.S. Fish and Wildlife Service, South Florida Ecological Services Office, Vero Beach, Florida.

Clark J. D., D. Huber, and C. Servheen. 2002. Bear reintroductions: lessons and challenges. Ursus 13:335-345.

Comiskey, E. J., L. J. Gross, D. M. Fleming, M. A. Huston, O. L. Bass, Jr., H. Luh, and Y. Wu. 1994. A spatially-explicit individual-based simulation model for Florida panther and white-tailed deer in the Everglades and Big Cypress landscapes. Pages 494-503 in D. Jordan (ed). Proceedings of the Florida Panther Conference. U.S. Fish and Wildlife Service, Gainesville, FL.

Comiskey, E. J., O. L. Bass, Jr., L. J. Gross, R. T. McBride, and R. Salinas. 2002. Panthers and forests in south Florida: an ecological perspective. Conservation Ecology 6:18.

Comiskey, E. J., A. C. Eller, Jr., and D. W. Perkins. 2004. Evaluating impacts to Florida panther habitat: how porous is the umbrella? Southeastern Naturalist 3:51-74.

Conant, R. and J.T. Collins. 1998. A field guide to reptiles and amphibians of eastern and central North America. Third Edition, Expanded. Houghton Mifflin Company; New York, New York.

Cory, C.B. 1896. Hunting and fishing in Florida. Estes and Lauriat; Boston, Massachusetts.

Cox, J.A. and R.S. Kautz. 2000. Habitat conservation needs of rare and imperiled wildlife in Florida. Florida Fish and Wildlife Conservation Commission; Tallahassee, Florida.

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida. 239 pages.

Cox, J.R., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the gaps in Florida's wildlife habitat conservation system. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Culver, M., W.E. Johnson, J. Pecon-Slattery, and S.J. O'Brien. 2000. Genomic ancestry of the American puma (Puma concolor). Journal of Heredity 91(3):186-197.

Cunningham, M. W. 2005. Epizootiology of feline leukemia virus in the Florida panther. M.S. Thesis. University of Florida, Gainesville, FL.

Dalrymple, G.H. and O.L. Bass, Jr. 1996. The diet of the Florida panther in Everglades National Park. Bulletin of the Florida Museum of Natural History 39(5):173-194.

Davis, J. H. 1943. Vegetation map of southern Florida. Florida Geological Survey, Bulletin 25 Figure 71.

Dees, C.S., J.D. Clark, and F.T. Van Manen. 1999. Florida panther habitat use in response to prescribed fire at Florida Panther National Wildlife Refuge and Big Cypress National Preserve. Final Report. University of Tennessee; Knoxville, Tennessee.

Dees, C.S., J.D. Clark, and F.T. Van Manen. 2001. Florida panther habitat use in response to prescribed fire. Journal of Wildlife Management 65(1):141-147.

Delany, M.F., C.T. Moore, and D.R. Progulske, Jr. 2005. Territory size and movements of Florida grasshopper sparrows. Journal of Field Ornithology 66(2):305-309.

Dial Cordy and Associates, Inc. 1999. Audubon's crested caracara survey and monitoring plan for the Lake Okeechobee Water Retention and Phosphorus Removal Critical Project. Jacksonville, Florida.

Dial Cordy and Associates, Inc. 2000. Audubon's crested caracara nest tree survey for the Lake Okeechobee Water Retention and Phosphorus Removal Critical Project. Jacksonville, Florida.

Diemer, J.E. and D.W. Speake. 1983. The distribution of the eastern indigo snake, Drymarchon corais couperi, in Georgia. Journal of Herpetology 17(3): 256-264.

Doering, P.H., R.H. Chamberlain, and D.E. Haunert. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. Estuaries 25 (1343-1354).

Dove, C.J. and R.C. Banks. 1999. A taxonomic study of crested caracaras (Falconidae). Wilson Bulletin 111(3):330-339.

Dryden, K.A. 2007. Personal communication. Biologist. U.S. Fish and Wildlife Service, Naples, Florida Suboffice.

Duellman, W.E. and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. Bulletin of the Florida State Museum, Biological Science 3:180-325.

Duever, M.J., J.E. Carlson, J.F. Meeder, L.C. Duever, L. H. Gunderson, L.A. Riopelle, T.R. Alexander, R.L Myers, and D. P. Spangler. 1986. The Big Cypress National Preserve. Research Report No. 8 of the National Audubon Society. National Audubon Society. New York. 444 p.

Dunbar, M.R. 1993. Florida panther biomedical investigation. Annual performance report, July 1, 1992, to June 30, 1993. Study Number 7506, Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Dynamac Corporation. 2006. Final report: threatened and endangered species survey and general fish and wildlife inventory for Indian River Lagoon-South Project C23/C24. Cape Canaveral, Florida. 58 pp. September 28.

F.A.C., Chapter 62-345.900(3) [effective date 02-04-2004]

Federico, A.C., K.G. Dickson, C.R. Kratzer, and F.E. Davis. 1981. Lake Okeechobee water quality studies and eutrophication assessment. Technical publication 81-2, South Florida Water Management District; West Palm Beach, Florida.

Fieberg, J. and S.P. Ellner. 2000. When it is meaningful to estimate and extinction probability? Ecology 81:2040-2047.

Fleming, D.M., J. Schortemeyer, and J. Ault. 1993. Distribution, abundance, and demography of white-tailed deer in the Everglades. National Park Service, Everglades National Park, Homestead, Florida.

Florida Exotic Pest Plant Council's Pest Plant List Committee. 2005. List of Invasive Species. Florida Exotic Pest Plant Council. April 2005. Gainesville, Florida. [online] URL: http://www.fleppc.org/Plantlist/list.htm.

Florida Fish and Wildlife Conservation Commission (FWC). 1999. Land, E.D., M. Lotz, D. Shindle, and S.K. Taylor. Florida panther genetic restoration and management. Annual report, Study Number 7508; Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission (FWC). 2001. Land, E.D., M. Cunningham, M. Lotz, and D. Shindle. Florida panther genetic restoration and management. Annual report, Study Number 7500; Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission (FWC). 2002. Land, E.D., M. Cunningham, M. Lotz, and D. Shindle. Florida panther genetic restoration and management. Annual report, Florida Panther Research Number 93112503002; Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission (FWC). 2003. Land, E.D., M. Cunningham, M. Lotz, and D. Shindle. Florida panther genetic restoration and management. Annual report, Florida Panther Research Number 93112503002; Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission (FWC). 2004. Land, E.D., M. Cunningham, M. Lotz, and D. Shindle. Florida panther genetic restoration and management. Annual report, Florida Panther Research Number 93112503002; Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission. 2005. Eagle Nest Locator [Internet]. Available from: http://wildflorida.org/eagle/eaglenests/Default.asp#latlonlocator (Date accessed 7/22/2005).

Florida Fish and Wildlife Conservation Commission (FWC). 2006a. Annual report on the research and management of Florida panthers: 2005-2006. Fish and Wildlife Research Institute and Division of Habitat and Species Conservation. Naples, FL.

Florida Fish and Wildlife Conservation Commission (FWC). 2006b. Use of least cost pathways to identify key highway segments for panther conservation. Tallahassee, Florida.

Florida Fish and Wildlife Conservation Commission and U.S. Fish and Wildlife Service. 2005. Draft Central and South Florida Project Manatee Accessibility Map. Gainesville, Florida.

Frederick, P. C., M. G. Spalding, and R. Dusek. 2002. Wading birds as bioindicators of mercury contamination in Florida, USA; annual and geographic variation. Environmental Toxicology and Chemistry 21:163-167.

Glass, C. M., R. G. McLean, J. B. Katz, D. S. Maehr, C. B. Cropp, L. J. Kirk, A. J. McKeirnan, and J. F. Evermann. 1994. Isolation of pseudorabies (Aujeszky's disease) virus from a Florida panther. Journal of Wildlife Diseases 30:180-184.

Hall, E.R. 1981. The mammals of North America Volume II. The Ronald Press Company; New York, New York.

Hall, E.R. and K.R. Kelson. 1959. The mammals of North America. Volume II. The Ronald Press Company; New York, New York.

Halls, L.K., ed. 1984. White-tailed deer, ecology and management. The Wildlife Management Institute; Washington, D.C.

Hamilton, S. and H. Moller. 1995. Can Population Viability Analysis models using computer packages offer useful conservation advice? Sooty shearwaters Puffinus griseus in New Zealand as a case study. Biology Conservation 73:107-117.

Harlow, R.F. 1959. An evaluation of white-tailed deer habitat in Florida. Florida Game and Fresh Water Fish Commission Technical Bulletin 5:1-64; Tallahassee, Florida.

Harris, L.D. 1985. The fragmented forest. University of Chicago Press; Chicago, Illinois.

Haunert, D., B. Chamberlain, P. Doering, and K. Konyha. 2000. Draft Technical criteria to guide an adaptive management strategy for minimum flows to the Caloosahatchee Estuary, Florida. South Florida Water Management District. West Palm Beach, Florida.

Heinzman, G. 1970. The caracara survey: A 4-year report. Florida Naturalist 43(4):149.

Hollister, N. 1911. The Louisiana puma. Proceedings of the Biological Society of Washington 24:175-178.

Howell, A.H. 1932. Florida bird life. Florida Department of Game and Fresh Water Fish; Tallahassee, Florida.

Humphrey, S.R. and J.L. Morrison. 1997. Habitat associations, reproduction, and foraging ecology of Audubon's crested caracara in south-central Florida. Final Report. Florida Game and Fresh Water Fish Commission Nongame Program Project No. NG91-007, August 8, 1997.

Janis, M.W. and J.D. Clark. 1999. The effects of public use on the behavior of Florida panthers at Big Cypress National Preserve. University of Tennessee; Knoxville, Tennessee.

Janis, M. W., and J. D. Clark. 2002. Responses of Florida panthers to recreational deer and hog hunting. Journal of Wildlife Management 66:839-848.

Jansen, D. K., S. R. Schulze, and A. T. Johnson. 2005. Florida panther (Puma concolor coryi) research and monitoring in Big Cypress National Preserve. Annual report 2004-2005. National Park Service, Ochopee, FL.

Kautz, R.S. and J.A. Cox. 2001. Strategic habitats for biodiversity conservation in Florida. Conservation Biology 15:55-77.

Kautz, R., R. Kawula, T. Hoctor, J. Comiskey, D. Jansen, D. Jennings, J. Kasbohm, F. Mazzotti, R. McBride, L. Richardson, and K. Root. 2006. How Much Is Enough? Landscape-scale Conservation for the Florida Panther. Biological Conservation.

Keegan, H.L. 1944. Indigo snakes feeding upon poisonous snakes. Copeia 1944 (1):59.

Kochman, H.I. 1978. Eastern indigo snake, Drymarchon corais couperi. Pages 68-69 in R.W. McDiarmid, ed. Rare and endangered biota of Florida. University Presses of Florida; Gainesville, Florida.

Labisky, R. F., M. C. Boulay, K. E. Miller, R. A. Sargent, Jr., and J. M. Zultowskil. 1995. Population ecology of white-tailed deer in Big Cypress National Preserve and Everglades National Park. Final report to National Park Service, Ochopee, FL.

Labisky, R. F., C. C. Hurd, M. K. Oli, and R. S. Barwick. 2003. Foods of white-tailed deer in the Florida Everglades: the significance of Crinum. Southeastern Naturalist 2:261-270.

Land, E. D. 1994. Response of the wild Florida panther population to removals for captive breeding. Final Report 7571. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Land, D., and S. K. Taylor. 1998. Florida panther genetic restoration and management annual report 1997-98. Florida Game and Fresh Water Fish Commission, Tallahassee, FL.

Land, D., B. Shindle, D. Singler, and S. K. Taylor. 1999. Florida panther genetic restoration annual report 1998-99. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Land, D., M. Cunningham, R. McBride, D. Shindle, and M. Lotz. 2002. Florida panther genetic restoration and management annual report 2001-02. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Land, D., D. Shindle, M. Cunningham, M. Lotz, and B. Ferree. 2004. Florida panther genetic restoration and management annual report 2003-04. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Lasley, M.F.W. 1978. Genetics of livestock improvement. Third Edition, Prentice-Hall; Englewood Cliffs, New Jersey.

Lawler, H.E. 1977. The status of Drymarchon corais couperi (Holbrook), the eastern indigo snake, in the southeastern USA. Herpetological Review 8(3): 76-79.

Layne, J.N. 1978. Threatened, Audubon's crested caracara. Pages 34-36 in H.W. Kale II, ed., Rare and endangered biota of Florida. Volume II: Birds. University Press of Florida; Gainesville, Florida.

Layne, J.N. 1995. Audubon's crested caracara in Florida. Pages 82-83 in E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, eds. Our living resources: A report to the nation on the distribution, abundance, and health of United States plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service; Washington, D.C.

Layne, J. N. 1996. Crested caracara. Pp. 197-210 in: J. A. Rodgers, Jr., H. W. Kale II, and H.T. Smith (eds.). Rare and Endangered Biota of Florida. Volume V. Birds. University Press of Florida; Gainesville, Florida.

Layne, J.N., F.E. Lohrer, and C.E. Winegarner. 1977. Bird and mammal predators on the cattle egret in Florida. Florida Field Naturalist (5): 1.1-4.

Layne, J.N. and T.M. Steiner. 1996. Eastern indigo snake (Drymarchon corais couperi): summary of research conducted on Archbold Biological Station. Report prepared under Order 43910-6-0134 to the U.S. Fish and Wildlife Service; Jackson, Mississippi.

Lazell, Jr. J.D., Jr. 1989. Wildlife of the Florida Keys: a natural history. Island Press; Washington, D.C.

Logan, T.J., A.C. Eller, Jr., R. Morrell, D. Ruffner, and J. Sewell. 1993. Florida panther habitat preservation plan - south Florida population. Prepared for the Florida Panther Interagency Committee.

Lotz, M., D. Land, M. Cunningham, and B. Ferree. 2005. Florida panther annual report 2004-05. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Loveless, C. M. 1959. The Everglades deer herd life history and management. Florida Game and Fresh Water Fish Commission Technical Bulletin 6, Tallahassee, FL.

Mac, M.J., P.A. Opler, C.E. Puckett Haecker, and P.D. Doran. 1998. Status and trends of the nation's biological resources. 2 vols. U.S. Department of the Interior, U.S. Geological Survey, Reston, Va.

Maehr, D.S. 1989. Florida panther road mortality prevention. Final Performance Report, Study Number 7502. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Maehr, D.S. 1990a. Florida panther movements, social organization, and habitat utilization. Final Performance Report, Study Number 7502. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Maehr, D.S. 1990b. The Florida panther and private lands. Conservation Biology 4(2):167-170.

Maehr, D.S. 1992a. Florida panther. In Rare and Endangered Biota of Florida. Volume I: Mammals. S.R. Humphrey, (ed.). University Press of Florida; Gainesville, Florida.

Maehr, D.S. 1992b. Florida panther distribution and conservation strategy. Final Report, Study Number 7572. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Maehr, D.S. 1997. The Florida panther: life and death of a vanishing carnivore. Island Press, Washington D.C. 259 pages.

Maehr, D.S. and G.B. Caddick. 1995. Demographics and Genetic Introgression in the Florida Panther. Conservation Biology 9:1295-1298.

Maehr, D.S. and J.A. Cox. 1995. Landscape features and panthers in Florida. Conservation Biology: 9(5):1008-1019.

Maehr, D.S. and R.C. Lacy. 2002. Avoiding the lurking pitfalls in Florida panther recovery. Wildlife Society Bulletin 30:971-978.

Maehr, D.S., E.D. Land, J.C. Roof, and J.W. McCown. 1989. Early maternal behavior in the Florida panther (Felis concolor coryi). America Midlands Naturalist 122:34-43.

Maehr, D.S., R.C. Belden, E.D. Land, and L. Wilkins. 1990a. Food habits of panthers in southwest Florida. Journal of Wildlife Management 54:420-423.

Maehr, D.S., E.D. Land, J.C. Roof, and J.W. McCown. 1990b. Day beds, natal dens, and activity of Florida panthers. Proceedings of the Annual Conference of Southeast Fish and Wildlife Agencies 44:310-318.

Maehr, D.S., E.D. Land, and J.C. Roof. 1991a. Social ecology of Florida panthers. National Geographic Research and Exploration 7(4):414-431.

Maehr, D.S., E.D. Land, and M.E. Roelke. 1991b. Mortality patterns of panthers in southwest Florida. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 45:201-207.

Maehr, D.S., R.C. Lacey, E.D. Land, O.L. Bass, and T.S. Hoctor. 1999. A reassessment of Florida panther population viability analysis and recovery efforts from multiple perspectives. Paper presented at Population Viability Analysis: Assessing Models for Recovering Endangered Species. University of California, Berkeley and The Wildlife Society; San Diego, California. March 15-16, 1999.

Maehr, D.S., E.D. Land, D.B. Shindle, O.L. Bass, and T.S. Hoctor. 2002. Florida panther dispersal and conservation. Biological Conservation 106:187-197.

Maehr, D.S., J.L. Larkin, and J.J. Cox. 2004. Shopping centers as panther habitat: inferring animal locations from models. Ecology and Society 9(2): 9. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art9.

Mazzotti, F.J., L.A. Brandt, L.G. Pearlstine, W.M. Kitchens, T.A. Obreza, F.C. Depkin, N.E. Morris, and C.E. Arnold. 1993. An evaluation of the regional affects of new citrus development on the ecological integrity of wildlife resources in southwest Florida. Volume I. South Florida Water Management District. West Palm Beach, Florida.

Mazzotti, F.J., L.A. Brandt, L.G. Pearlstine, W.M. Kitchens, T.A. Obreza, F.C. Depkin, N.E. Morris, and C.E. Arnold. 1992. An evaluation of the regional affects of new citrus development on the ecological integrity of wildlife resources in southwest Florida. Volume II. South Florida Water Management District. West Palm Beach, Florida.

McBride, R. T. 1985. Population status of the Florida panther in Everglades National Park and Big Cypress National Preserve. Report to National Park Service in fulfillment of Contract #RFP 5280-84 04, Homestead, FL.

McBride, R.T. 2000. Current panther distribution and habitat use. A review of field notes: fall 1999 – winter 2000. Livestock Protection Company; Alpine, Texas.

McBride, R.T. 2001. Current panther distribution, population trends, and habitat use. Report of field work: fall 2000 – winter 2001. Livestock Protection Company; Alpine, Texas.

McBride, R.T. 2002. Current verified population, distribution and highlights of field work. Report of field work: fall 2001 – winter 2002. Livestock Protection Company; Alpine, Texas.

McBride, R.T. 2003. Documented panther population and its current distribution. Appendix IV, Annual Report: Florida Panther Genetic Restoration and Management. Florida Fish and Wildlife Conservation Commission; Tallahassee, Florida.

McBride, R. T., R. M. McBride, J. L. Cashman, and D. S. Maehr. 1993. Do mountain lions exist in Arkansas? Proceedings Annual Conference Southeastern Fish and Wildlife Agencies 47:394-402.

McCown, J.W. 1991. Big Cypress Deer/Panther Relationships: Deer Herd Health and Reproduction. Final Report. Study Number: 7508. Bureau of Wildlife Research, Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Myers, R. and Ewel, J. 1990. Ecosystems of Florida. University of Florida Press. Orlando, Florida.

Miller, R.E., Jr., and B. Gunsalus. 1997. Wetland Rapid Assessment Procedure (WRAP). South Florida Water Management District Technical Publication REG-001.

Moler, P.E. 1985a. Distribution of the eastern indigo snake, Drymarchon corais couperi, in Florida. Herpetological Review 16(2):37-38.

Moler, P.E. 1985b. Home range and seasonal activity of the eastern indigo snake, Drymarchon corais couperi, in northern Florida. Final Performance Report, Study E-1-06, III-A-5. Florida Game and Freshwater Fish Commission; Tallahassee, Florida.

Moler, P.E. and R. Franz. 1987. Wildlife values of small isolated wetlands in the southeastern coastal plain. Proc. Of the Third SE Nongame and Endangered Wildlife Symp. GA Dept. of Natural Resources. pp. 234-238.

Moler, P.E. 1992. Rare and endangered biota of Florida. Volume III. Amphibians and reptiles. University presses of Florida; Gainesville, Florida.

Moler, P.E. 1998. Personal communication. Biologist. Comments dated January 9, 2006, to the U.S. Fish and Wildlife Service on the technical/agency draft Multi-Species Recovery Plan for South Florida. Florida Fish and Wildlife Conservation Commission; Tallahassee, Florida.

Morrison, J.L. 1996. Crested caracara (Caracara plancus). In: A. Poole and F. Gill (eds.). The Birds of North America, No. 249. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, D.C.

Morrison, J.L. 1997. Reproductive ecology and habitat associations of Florida's crested caracara (Caracara plancus audubonii). Ph.D. dissertation. University of Florida; Gainesville, Florida.

Morrison, J.L. 1998. Management guidelines and monitoring protocol for Audubon's crested caracara in Florida, Draft. Prepared for Florida Game and Fresh Water Fish Commission, April 1998.

Morrison, J.L. 1999. Breeding biology and productivity of Florida's Crested Caracaras. Condor 101(3):505-517.

Morrison, J.L. 2001. Recommended management practices and survey protocols for Audubon's crested caracaras (Caracara cheriway audubonii) in Florida. Technical Report Number 18. Florida Fish and Wildlife Conservation Commission; Tallahassee, Florida.

Morrison, J.L. 2003. Semi-annual monitoring report of Audubon's crested caracara within the Kissimmee River Restoration Project area – January-June 2003. Prepared for the South Florida Water Management District. Johnson Engineering, Fort Myers, Florida 33901.

Morrison, J.L. 2005. Personal communication. Associate professor of biology. Caracara workshop in Vero Beach, Florida on October 31, 2005. Trinity College, Hartford Connecticut.

Morrison, J.L. and S.R. Humphrey. 2001. Conservation value of private lands for crested caracara in Florida. Conservation Biology 15(3): 675-684.

Morrison, J.L. and M. Maltbie. 1999. Methods for gender determination of Crested Caracaras. Journal of Raptor Research 33(2):128-133. Morrison, J.L. K.V. Root, and J. Barnes. 2006. Habitat suitability and demographic population viability models for Florida's crested caracaras. Final Report to the Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Morrison, J.L. K.V. Root, and J. Barnes. 2006. Habitat suitability and demographic population viability models for Florida's crested caracaras. Final Report to the Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.

Morrison, J.L., M.A. McMillian, S.M. McGehee, and L.D. Todd. 1997. First record of crested caracara nesting in cypress. Florida Field Naturalist 25(2):51-53.

Moulis, R. 1976. Autecology of the eastern indigo snake, Drymarchon corais couperi. Bulletin of the New York Herpetological Society 12:14-23.

Nelson, E.W. and E.A. Goldman. 1929. List of the pumas with three described as new. Journal of Mammalogy 10:345-350.

Nemeth, N.M. and J.L. Morrison. 2002. Natal dispersal of the crested caracara in Florida. Journal of Raptor Research 36(3):203-206.

Newell, David. 1935. Panther. The Saturday Evening Post. July 13:10-11, 70-72

Noss, R. F. 1992. The wildlands project land conservation strategy. Wild Earth (Special Issue):10-25.

Noss, R. F., and A.Y. Cooperrider. 1994. Saving Nature's Legacy: Protecting and Restoring Biodiversity. Island Press, Washington, D.C.

Nowak, R. M., and R. T. McBride. 1974. Status survey of the Florida panther. Project 973. World Wildlife Fund Yearbook 1973-74:237-242.

Nowak, R. M., and R. T. McBride. 1975. Status of the Florida panther. Project 973. World Wildlife Fund Yearbook 1974-75:245-46.

Nowell, K., and P. Jackson. 1996. Status survey and conservation action plan: Wild cats. International Union for Conservation of Nature and Natural Resources. Burlington Press, Cambridge, U.K.

Oberholser, H.C. 1974. The bird life of Texas (Volume I). University of Texas Press; Austin, Texas.

O'Brien, S.J., M.E. Roelke, L. Marker, A. Newman, C.A. Winkler, D. Meltzer, L. Colly, J.F. Evermann, M. Bush, and D.E. Wildt. 1985. Genetic basis for species vulnerability in the cheetah. Science 227:1428-1434.

O'Connell, A.F. Jr., L. Ilse, and J. Zimmer. 1999. Annotated bibliography of methodologies to census, estimate, and monitor the size of white-tailed deer Odocoileus virginianus populations. Department of the Interior, National Park Service, Boston Support Office. Technical Report NPS/BSO-RNR/NRTR/00-2. 67 pages.

Palmer, R.S. 1988. Crested caracara. Pp. 235-249 in: R.S. Palmer (ed.). Handbook of North American birds, Volume 5. Yale University Press; New Haven, Connecticut.

Passarella and Associates, Incorporated (Passarella). 2004. White-Tailed Deer Census Report. Terafina Development. Passarella and Associates, Incorporated; Fort Myers, Florida.

Ralls, K. and J. Ballou. 1982. Effects of inbreeding on infant mortality in captive primates. International Journal of Primatology 3:491-505.

Reed, J.M., D.D. Murphy, and P.F. Brussard. 1998. Efficacy of population viability analysis. Wildlife Social Bulletin 26:244-251.

Reeves, K. A. 1978. Preliminary investigation of the Florida panther in Big Cypress Swamp. Unpublished report. Everglades National Park, Homestead, FL.

Rettie, J.W. and P.D. McLoughlin. 1999. Overcoming radio-telemetry bias in habitat-selection studies. Canadian Journal of Zoology 77:1175-1184.

Roelke, M.E. 1990. Florida panther biomedical investigations. Final Performance Report, July 1, 1986 - June 30, 1990. Study Number 7506. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Roelke, M.E. 1991. Florida panther biomedical investigation. Annual performance report, July 1, 1990 to June 30, 1991, Study Number 7506. Florida Game and Fresh Water Fish Commission; Tallahassee, Florida.

Roelke, M.E., J.S. Martenson, and S.J. O'Brien. 1993. The consequences of demographic reduction and genetic depletion in the endangered Florida panther. Current Biology 3:340-350.

Root, K.V. 2004. Using models to guide recovery efforts for the Florida Panther. In H.R. Akçakaya, M. Burgman, O. Kindvall, C. C. Wood, P. Sjogren-Gulve, J. Hatfield, and M. McCarthy (eds.), Species Conservation and Management: Case Studies, Oxford University Press; New York, NY.

Sarkar, S. 2004. Conservation Biology: The Stanford Encyclopedia of Philosophy (Winter 2004 Edition), Edward N. Zalta (ed.). [online] URL: http://plato.stanford.edu/archives/win2004/entries/conservation-biology.

Seal, U.S., R.C. Lacy, and Workshop Participants. 1989. Florida panther viability analysis and species survival plan. Report to the U.S. Fish and Wildlife Service, by the Conservation Breeding Specialist Group, Species Survival Commission, IUCN; Apple Valley, Minnesota.

Seal, U.S. and R.C. Lacy. 1992. Genetic management strategies and population viability of the Florida panther (Felis concolor coryi). Report to the U.S. Fish and Wildlife Service. Captive Breeding Specialist Group, IUCN; Apple Valley, Minnesota.

Seal, U.S. and Workshop Participants. 1994. A plan for genetic restoration and management of the Florida panther (Felis concolor coryi). Report to the Florida Game and Fresh Water Fish Commission, by the Conservation Breeding Specialist Group, Species Survival Commission, IUCN; Apple Valley, Minnesota.

Shaffer, M.L. 1978. Determining Minimum Viable Population Sizes: A Case Study of the Grizzly Bear. Ph.D. Dissertation, Duke University; Durham, NC.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.

Shaffer, M.L. 1987. "Minimum viable populations: Coping with uncertainty," Viable populations for conservation, M>E., Soule, ed., Cambridge University Press, Cambridge, MA, 69-85.

Shaw, C.E. 1959. Longevity of snakes in the United States as of January 1, 1959. Copeia 1959(4):336-337.

Shindle, D., D. Land, K. Charlton, and R. McBride. 2000. Florida panther genetic restoration and management. Annual Report 7500. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Shindle, D., D. Land, M. Cunningham, and M. Lotz. 2001. Florida panther genetic restoration and management. Annual Report 7500. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Shindle D., M. Cunningham, D. Land, R. McBride, M. Lotz, and B. Ferree. 2003. Florida panther genetic restoration and management. Annual Report 93112503002. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Small, J.K. 1922. Wild pumpkins. Journal New York Botanical Garden 23: 19-23.

Smith, C.R. 1987. Ecology of juvenile and gravid eastern indigo snakes in north Florida. M.S. thesis, Auburn University; Auburn, Alabama.

Smith, H.M. 1941. A review of the subspecies of the indigo snake (Drymarchon corais). Journal of the Washington Academy of Science 31:466-481.

Smith, R. 2003. Personal communication. Biologist. Presentation to the U.S. Fish and Wildlife Service on February 24, 2003. Dynamac; Kennedy Space Center, Florida.

South Florida Water Management District (District). 2000. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary. South Florida Water Management District, Florida.

South Florida Water Management District (District). 2002. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary: Draft Status Update Report. South Florida Water Management District, Florida.

South Florida Water Management District (District). 2003. Existing legal Sources for the Caloosahatchee Estuary at the Franklin Lock and Dam (S-79). Coastal Ecosystems Division, Southern Restoration Department, South Florida Water Management District, Florida.

Speake, D.W., J.A. McGlincy, and T.R. Colvin. 1978. Ecology and management of the eastern indigo snake in Georgia: A progress report. Pages 64-73 in R.R. Odum and L. Landers,

editors. Proceedings of rare and endangered wildlife symposium, Georgia Department of Natural Resources, Game and Fish Division; Technical Bulletin WL 4.

Speake, D.W., D. McGlincy, and C. Smith. 1987. Captive breeding and experimental reintroduction of the eastern indigo snake. Pages 84-90 in Proceedings of the 3rd Southeastern Nongame and Endangered Wildlife Symposium; Athens, Georgia.

Sprunt, A., Jr. 1954. Florida bird life. Coward-McCann, Incorporated, and National Audubon Society, New York, New York.

Steelman, H.G., J.A. Bozzo, and J.L. Schortemeyer. 1999. Big Cypress National Preserve Deer and Hog Annual Report.

Steiner, T.M., O.L. Bass, Jr., and J.A. Kushlan. 1983. Status of the eastern indigo snake in Southern Florida National Parks and vicinity. South Florida Research Center Report SFRC-83-01, Everglades National Park; Homestead, Florida.

Stevenson, H.M. 1976. Vertebrates in Florida. University Presses of Florida. Gainesville, Florida.

Swanson, K., D. Land, R. Kautz, and R. Kawula. 2006. Use of least cost pathways to identify key highway segments for panther conservation. Unpublished report. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

Swayze, L.J. and B.F. McPherson. 1977. The effects of the Faka Union Canal System on water levels in the Fakahatchee Strand, Collier County, Florida. United States Geological Survey Water Resources Investigations 77-61.

Taylor, S. K., C. D. Buergelt, M. E. Roelke-Parker, B. L. Homer, and D. S. Rotstein. 2002. Causes of mortality of free-ranging Florida panthers. Journal of Wildlife Diseases 38:107-114.

Thatcher, C., F.T. van Manen, and J.D. Clark. 2003. Habitat assessment to identify potential sites for Florida panther reintroduction in the southeast. Final Report to U.S. Fish and Wildlife Service. University of Tennessee; Knoxville, Tennessee.

Thatcher, C., F. T. van Manen, and J. D. Clark. 2006. Identifying suitable sites for Florida panther reintroduction. Journal of Wildlife Management.

Tinsley, J.B. 1970. The Florida panther. Great Outdoors Publishing Company, St. Petersburg, FL.

Tinsley, J. B. 1987. The puma: legendary lion of the Americas. Texas Western Press, University of Texas, El Paso, TX.

Turrell and Associates, Incorporated (Turrell). 2001. White-Tailed Deer Census Report. Collier Regional Medical Center Development. Turrell and Associates, Incorporated; Naples, Florida.

Tyson, E.L. 1952. Estimating deer populations from tracks. Annual Conference of Southeastern Association of Fish and Wildlife Agencies 6:3-15.

URS Corporation. 2003. Berry Labelle- Congen Grove Ecological Risk Assessment. Boca Raton, Florida.

U.S. Army Corps of Engineers. 2005. Southwest Florida Feasibility Study. Feasibility Scoping Meeting Documentation. U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL.

U.S. Army Corps of Engineers. 1997. Environmental Impact Statement (EIS) on Improving the Regulatory Process in Southwest Florida in Lee and Collier Counties, FL. U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL.

U.S. Fish and Wildlife Service. 1987. Florida panther recovery plan. June 1987. Prepared by the Technical Subcommittee of the Florida Panther Interagency Committee. Fish and Wildlife Service; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1989. Recovery plan for the Florida population of Audubon's crested caracara. Southeast Region; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1990. Habitat Management Guidelines for the Wood Stork in the Southeast Region. Southeast Region; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1995. Florida panther recovery plan: second revision. March 1995. Prepared by the Florida Panther Recovery Team. Fish and Wildlife Service; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1999. Multi-species recovery plan (MSRP) for south Florida. Fish and Wildlife Service; Vero Beach, Florida.

U.S Fish and Wildlife Service. 1999. South Florida Multi-Species Recovery Plan. Southeast Region; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 2000. Florida panther final interim standard local operating procedures (SLOPES) for endangered species. Fish and Wildlife Service; Vero Beach, Florida.

U.S. Fish and Wildlife Service. 2000. Planning Aid Report. Southwest Florida Feasibility Study. Fish and Wildlife Service, Vero Beach, Florida.

U.S. Fish and Wildlife Service. 2001. Florida Manatee Recovery Plan (Trichechus manatus latirostris), Third Revision. Atlanta, Georgia.

U. S. Fish and Wildlife Service. 2002. Standard protection measures for the eastern indigo snake. South Florida Ecological Services Office; Vero Beach, Florida.

U. S. Fish and Wildlife Service. 2006. The National Bald Eagle Management.

U.S. Fish and Wildlife Service. 2006. Florida panther recovery plan: third revision. January 2006. Prepared by the Florida Panther Recovery Team and the South Florida Ecological Services Office. Fish and Wildlife Service; Atlanta, Georgia.

van der Leek, M. L., H. N. Becker, E. C. Pirtle, P. Humphrey, C. L. Adams, B. P. All, G. A. Erickson, R. C. Belden, W. B. Frankenberger, and E. P. J. Gibbs. 1993. Prevalence of pseudorabies (Aujeszky's disease) virus antibodies in feral swine in Florida. Journal Wildlife Diseases 29:403-409.

Van Dyke, F. G., R. H. Brocke, and H. G. Shaw. 1986a. Use of road track counts as indices of mountain lion presence. Journal Wildlife Management 50:102-109.

Van Dyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. 1986b. Reactions of mountain lions to logging and human activity. Journal of Wildlife Management 50:95-102.

Wehinger, K. A., M. E. Roelke, and E. C. Greiner. 1995. Ixodid ticks from Florida panthers and bobcats in Florida. Journal of Wildlife Diseases 31:480-485.

Wildt, D.E. 1994. Endangered species spermatozoa: Diversity, research and conservation. Pages 1-24 in: A. Bartke, edition, Function of somatic cells in the testes. Springer-Verlag; New York.

Wildt, D.E., E.J. Baas, P.K. Chakraborty, T.L. Wolfle, and A.P. Stewart. 1982. Influence of inbreeding on reproductive performance, ejaculate quality and testicular volume in the dog. Theriogenology 17:445-452.

Wilkins, L. 1994. Practical cats: Comparing coryi to other cougars: An analysis of variation in the Florida panther, Felis concolor coryi. Pages 14-41 in: D.B Jordan, (ed.). Proceedings of the Florida panther conference. U.S. Fish and Wildlife Service; Atlanta, Georgia.

Wilkins, L., J. M. Arias-Reveron, B. Stith, M. E. Roelke, and R. C. Belden. 1997. The Florida panther (Puma concolor coryi): a morphological investigation of the subspecies with a comparison to other North and South American cougars. Bulletin of the Florida Museum of Natural History 40:221-269.

Williams, M. 1990. Americans and their forests, a historical geography. Cambridge University Press; New York, New York.

WilsonMiller. 2005. Email message to the Fish and Wildlife Service, South Florida Ecological Services Office, dated February 11, 2005.

Young, S.P. and E.A. Goldman. 1946. The Puma - Mysterious American Cat. Dover Publications, Incorporated; New York, New York.

Zeigler, M. 2006. Personal communication. Citrus grove operations manager. Meeting with the U.S. Fish and Wildlife Service on August 1, 2006. Agricultural Resource Management; Vero Beach, Florida.

Table 1. Wood Stork Foraging Habitat Assessment.

		Uniform Mitigation Assessment Method		
Cover Type	**Acres**	**Existing**	**With Project**	**Functional Value (+ or -)**
Freshwater Marsh	6.9	0.5	0.27	(-) 1.6
Secondary	191.6	0.4	0.27	(-) 24.9
Tertiary	541.3	0.4	0.27	(-) 70.4
Tapegrass	4,130	0.33	0.60	(+) 446

Table 2. *Targeted and Acquired Acreage Totals of Conservation Lands in South Florida Directly Affecting the Panther within the Consultation Area.

Name	Targeted[1] Acreage	Acquired Acreage	Indian Reservation
Federal Conservation Lands			
Everglades National Park	1,508,537	1,508,537	--
Big Cypress National Preserve	720,000	720,000	--
Florida Panther National Wildlife Refuge	26,400	26,400	--
Subtotal	**2,254,937**	**2,254,937**	--
State of Florida: Florida Forever Program			
Belle Meade	28,505	19,107	--
Corkscrew Regional Ecosystem Watershed	69,500	24,028	--
Twelvemile Slough	15,653	7,530	--
Panther Glades	57,604	22,536	--
Devil's Garden	82,508	0	--
Caloosahatchee Ecoscape	18,497	2,994	--
Babcock Ranch	91,361	0	--
Fisheating Creek	176,760	59,910	--
Subtotal	**540,388**	**136,105**	--
State of Florida: Other State Acquisitions			
Water Conservation Area Number 3	491,506	491,506	--
Holey Land Wildlife Management Area	33,350	33,350	--
Rotenberger Wildlife Management Area	25,019	20,659	--
Fakahatchee Strand State Preserve	74,374	58,373	--
Picayune Strand State Forest	55,200	55,200	--
Okaloacoochee Slough State Forest and WMA	34,962	34,962	--
Babcock-Webb Wildlife Management Area	79,013	79,013	--
Subtotal	**793,424**	**773,063**	--
Indian Reservations[2]			
Miccosukee Indian Reservation	--	--	81,874
Big Cypress Seminole Indian Reservation	--	--	68,205
Brighton Seminole Indian Reservation	--	--	37,447
Subtotal	**--**	**--**	**187,526**
GRAND TOTALS	**3,588,749**	**3,164,105**	**187,526**

[1] Targeted acres not available for all lands. In Such cases, targeted equals acquired acreage.
[2] Indian lands are included due to their mention in the MSRP. Acreages taken from GIS data.
* Table 2 was excerpted from the Brief of Amicus (2003). However, the lands shown as acquired in this table may include some private in-holdings and may include lands currently under sales negotiations or condemnation actions.

Table 3. Habitat preservation efforts resulting from formal and informal consultations with the Service for projects affecting Florida panther habitat from March 1984 to May 2007.

Date	Service Log Number	Corps Application Number	Project Name	County	Habitat Impacts (Acres)	Habitat Preserved On-site (Acres)	Habitat Preserved Off-site (Acres)	Total Habitat Preserved (Acres)
03/29/84	4-1-83-195	83M-1317	Ford Test Track	Collier	530	0	0	0
02/21/85	4-1-85-018	unknown	I-75	Broward Collier	1,517	0	0	0
10/17/86	4-1-87-016 4-1-87-017	unknown	Exxon Master Plan	Collier	9	0	0	0
01/07/87	4-1-86-303	86IPM-20130	Citrus Grove	Collier	11,178	0	0	0
01/11/88	4-1-88-029	unknown	NERCO - Clements Energy	Collier	3	0	0	0
02/23/88	4-1-88-055	unknown	Shell Western E&P	Collier Dade Monroe	0	0	0	0
02/10/89	4-1-89-001	FAP IR-75-4(88)81	SR 29/I-75 Interchange	Collier	350	0	0	0
08/15/90	4-1-90-289	unknown	I-75 Recreational Access	Collier	150	0	0	0
09/24/90	4-1-90-212	89IPD-20207	U.S. Sugar Corporation	Hendry	28,740	700	0	700
03/12/91	4-1-91-229	90IPO-02507	Lourdes Cereceda	Dade	97	0	0	0
01/14/92	4-1-91-325	199101279	Dooner Gulf Coast Citrus	Collier	40	40	0	40
09/25/92	4-1-92-340	unknown	STOF, BCSIR Citrus Grove	Hendry	1,995	0	0	0
06/18/93	4-1-93-217	199200393	Corkscrew Road	Lee	107	0	0	0
02/25/94	4-1-94-209	199301131	Daniels Road Extension	Lee	65	0	0	0
05/09/94	4-1-93-251	199202019	Corkscrew Enterprises	Lee	900	100	100	200
10/27/94	4-1-94-430	199302371 199400807 199400808	Florida Gulf Coast University Treeline Boulevard	Lee	1,088	526	0	526
05/24/95	4-1-95-230	199302130	Turner River Access	Collier	1,936	0	0	0
08/07/95	4-1-95-274	199405501	Bonita Bay Properties	Collier	509	491	0	491
08/15/95	4-1-94-214	199301495	SW Florida Airport Access Road	Lee	14	0	0	0
09/19/96	4-1-95-F-230	199302052 199301404	I-75 Access Points	Broward	116	0	0	0
03/10/98	4-1-98-F-3	L30 (BICY)	Calumet Florida	Collier Broward Dade	0	0	0	0
03/27/98	4-1-97-F-635	199604158	Willow Run Quarry	Collier	359	190	0	190
06/11/99	4-1-98-F-	199800622	STOF Water	Hendry	1,091	0	0	0

Date	Service Log Number	Corps Application Number	Project Name	County	Habitat Impacts (Acres)	Habitat Preserved On-site (Acres)	Habitat Preserved Off-site (Acres)	Total Habitat Preserved (Acres)
	398		Conservation Plan					
09/27/99	4-1-98-F-310	199130802	Daniels Parkway	Lee	2,093	0	94	94
12/08/99	4-1-98-F-517	199607574	Cypress Creek Farms	Collier	239	0	24	24
04/17/00	4-1-98-F-428	199507483	Miromar	Lee	1,323	0	194	194
06/09/00	4-1-99-F-553	199900619	Naples Reserve	Collier	833	0	320	320
02/21/01	4-1-00-F-135	199803037	Corkscrew Ranch	Lee	106	0	0	0
04/17/01	4-1-00-F-584	200001436	Sun City	Lee	1,183	0	408	408
07/30/01	4-1-94-357	199003460	Naples Golf Estates	Collier	439	175	0	175
08/31/01	4-1-00-F-183	199900411	Colonial Golf Club	Lee	1,083	0	640	640
12/14/01	4-1-00-F-585	199301156	SW Florida Airport	Lee	8,058	0	6,986	6,986
01/30/02	4-1-98-F-372	199402492	Florida Rock	Lee	5,269	802	0	802
03/07/02	4-1-00-F-178	199901251	Southern Marsh Golf	Collier	121	75	80	155
04/24/02	4-1-01-F-148	199901378	Hawk's Haven	Lee	1,531	267	0	267
09/24/02	4-1-01-F-135	200001574	Verandah	Lee	1,456	0	320	320
10/08/02	4-1-02-F-014	199602945	Winding Cypress	Collier	1,088	840	1,030	1,870
05/19/03	4-1-02-F-1741	200200970	Apex Center	Lee	95	10	18	28
06/10/03	4-1-01-F-1955	200003795	Walnut Lakes	Collier	157	21	145	166
06/18/03	4-1-01-F-136	199701947	Twin Eagles Phase II	Collier	593	57	98	155
06/23/03	4-1-01-F-143	199905571	Airport Technology	Lee	116	55	175	230
07/02/03	4-1-98-F-428	199507483	Miromar	Lee	342	158	340	498
09/04/03	4-1-02-F-1486	200206725	State Road 80	Lee	33	2	12	14
10/06/03	4-1-02-F-0027	200102043	Bonita Beach Road	Lee	1,117	145	640	785
12/29/03	4-1-02-F-1743	200202926	The Forum	Lee	650	0	310	310
01/18/05	4-1-04-F-4259	199702228	Bonita Springs Utilities	Lee	79	0	108	108
02/21/03 03/09/05	4-1-01-F-607	200001926	Mirasol	Collier	800	914	145	1,059
03/31/05	4-1-04-F-5656	200306759	Gateway Shoppes II	Collier	82	0	122	122
04/08/05	4-1-04-F-8176	2004-5312	Seminole Mine	Broward	110	0	220	220
04/29/05	4-1-04-F-5780 4-	2003-5331 2003-6965	Arborwood and Treeline Avenue	Lee	2,329	0	1,700	1,700

Date	Service Log Number	Corps Application Number	Project Name	County	Habitat Impacts (Acres)	Habitat Preserved On-site (Acres)	Habitat Preserved Off-site (Acres)	Total Habitat Preserved (Acres)
	1-04-F-5982							
06/06/05	4-1-03-F-7855	2003-11156	Collier Regional Medical	Collier	44	0	64	64
06/14/04 03/21/05	4-1-04-F-5744	199603501	Terafina	Collier	437	210	261	471
02/22/05 03/16/05 06/29/05 04/04/06	4-1-04-F-6866	200309416	Ava Maria DRI	Collier	5,027	0	6,114	6,114
06/29/05	4-1-03-F-3915	199806220	Wenthworth Estates	Collier	917	0	458	458
07/15/05	4-1-04-F-5786	199405829	Land's End Preserve	Collier	231	0	61	61
09/08/05	4-1-04-F-5260	200106580	Parklands Collier	Collier	489	157	434	591
09/23/05 10/26/05	4-1-04-F-9348	200101122	Super Target-Tarpon Bay Plaza	Collier	34	0	20	20
11/23/05	4-1-04-F-6043	20034914	Summit Place	Collier	108	0	61	61
11/29/05	4-1-04-F-8847	20048995	STOF Administrative Complex	Collier	6	0	8	8
12/06/05	4-1-03-F-3483	200302409	SW Florida Commerce Center	Lee	207	0	305	305
12/06/05	4-1-04-F-6691	200310689	Rattlesnake Hammock Road Widening	Collier	23	0	23	23
01/04/06	4-1-04-F-8388	2004554	Immokalee Regional Airport - Phase I	Collier	67	0	43	43
01/04/06	4-1-04-F-9777	20048577	Logan Boulevard Extension	Collier	30	0	10	10
1/13/06	4-1-04-F-6707	20042404	Journey's End	Collier	66	0	34	34
01/26/06	4-1-04-F-8940	20047053	The Orchard	Lee	93	0	81	81
02/19/06	4-1-05-F-11724	2005834	Firano at Naples	Collier	24	0	19	19
02/22/06	4-1-04-F-6504	200491	Corkscrew Road	Lee	20	0	47	47
02/23/06	4-1-04-F-5244	200312276	Summit Church	Lee	10	0	13	13
03/31/06	4-1-05-F-11343	20051909	Coral Keys Homes	Miami-Dade	41	0	61	61
05/05/06	41420-2006-I-0274	2005-6176	Santa Barbara , Davis to Radio Road, Widening	Collier	6	0	3	3
05/9/06	41420-2006-I-0263	20056298	Santa Barbara and Radio Road Widening	Collier	29	0	20	20
05/9/06	41420-2006-F-0089	20043248	Collier Boulevard, Immokalee Rd. to Goldengate Blvd.	Collier	14	0	16	16
05/16/06	4-1-05-F-10309	19971924	Sabal Bay	Collier	1,017	1,313	223	1,536

Date	Service Log Number	Corps Application Number	Project Name	County	Habitat Impacts (Acres)	Habitat Preserved On-site (Acres)	Habitat Preserved Off-site (Acres)	Total Habitat Preserved (Acres)
06/05/06	4-1-05-I-8486	20041688	Seacrest School	Collier	31	0	16	16
06/09/06	4-1-05-I-10965	200303733	HHJ Development	Dade	3	0	4	4
06/14/06	4-1-05-F-11855	200411010	Keysgate School	Dade	39	0	62	62
06/15/06	41420-2006-FA-0811 and I-0362	20056149	Collier County Wellfield	Collier	29	0	36	36
07/12/06	41420-2006-F-0282	200311150	Cypress Shadows	Lee	244	0	326	326
07/28/06	4-1-04-F-12330	20047920	Hamilton Place	Dade	10	0	50	50
07/28/06	4-1-04-F-7279	20041695	Raffia Preserve	Collier	131	0	119	119
08/15/06	41420-2006-I-0151	20031963	Naples Custom Homes	Collier	10	0	9	9
08/21/06	4-1-03-F-3127	19956797	Atlantic Civil Agriculture Expansion	Dade	981	0	1553	1553
08/21/06	4-1-03-I-0540	20041813	ASGM Business Park	Collier	41	0	25	25
9/12/06	41420-2006-FA-0589 and F-0554	20037414	Miccosukee Government Complex	Dade	17	0	37	37
9/22/06	41420-2006-I-0355	20040047	Immokalee Seminole Reservation Road Improvements	Collier	17	0	35	35
10/16/06	41420-2006-FA-1488 and F-0442	199507483	Miromar Lakes Addition	Lee	366	0	390	390
10/05/06	41420-2006-I-0616	20065295	New Curve on Corkscrew Road	Lee	12	0	18	18
10/18/06	41420-2007-FA-0029 and F-0787	2004777	Treeline Preserve	Lee	97	0	95	95
10/25/06	41420-2006-FA-1129 and F-0442	20047046	Koreshan Boulevard Extension	Lee	14	0	31	31
10/26/06	41420-2006-FA-1636 and F-0787	200306755	Jetway Tradeport	Lee	38	0	51.5	52
10/26/06	41420-2006-I-0849	20055702	Marina Del Lago	Lee	49	0	36	36
10/27/06	41420-	20057180	Living Word Family	Collier	18	0	35	35

Date	Service Log Number	Corps Application Number	Project Name	County	Habitat Impacts (Acres)	Habitat Preserved On-site (Acres)	Habitat Preserved Off-site (Acres)	Total Habitat Preserved (Acres)
	2006-I-0203		Church					
10/30/06	41420-2006-I-0607	200604878	Seminole Tribe Access Road	Hendry	2	0	5	5
11/15/06	41420-2006-TA-0727	N/A	Liberty Landing	Collier	27	0	19	19
pending	41420-2006-F-0850	200312445	Airport Interstate Commerce Park	Lee	323	0	371	371
02/21/03 03/09/05 05/03/07	4-1-01-F-607	200001926	Mirasol	Collier	773	941	182	1,117
pending	4-1-04-F-6112	20021683	Alico Airpark (Haul Ventures)	Collier	241	75	414	489
				Totals	94,088	7,349	26,464	33,814

Table 4. Land Held for Conservation within the Florida Panther Core Area.

	Acres	Primary Equivalent Factor	Primary Equivalent Acres
Primary	1,659,657	1.00	1,659,657
Dispersal	0	1.00	0
Secondary	308,623	0.69	212,950
Other	609,872	0.33	201,258

Table 5. Undeveloped Privately Owned Land within Florida Panther Core Area.

	Acres	Primary Equivalent Factor	Primary Equivalent Acres
Primary	610,935	1.00	610,935
Dispersal	27,883	1.00	27,883
Secondary	503,481	0.69	347,402
Other	655,996*	0.33	216,479

*** About 819,995 ac are at risk in the other zone with about 80 percent with resource value**

Table 6. Habitat suitability values for use in assessing habitat value to the Florida panther.

Land Cover Type	Value	Land Cover Type	Value	Land Cover Type	Value
Water	0	STA	4.5	Cypress swamp	9
Urban	0	Shrub swamp	5	Sand pine scrub	9
Coastal strand	1	Shrub and brush	5	Sandhill	9
Reservoir	1.5	Dry prairie	6	Hardwood-Pine forest	9
Mangrove swamp	2	Grassland/pasture	7	Pine forest	9
Salt marsh	2	Freshwater marsh	9	Xeric oak scrub	10
Exotic plants	3	Bottomland hardwood	9	Hardwood forest	10
Cropland	4	Bay swamp	9		
Orchards/groves	4	Hardwood swamp	9		

Table 7. Landscape Compensation Multipliers

Zone of Impacted Lands	Zone of Compensation Lands	Multiplier
Primary	**Secondary**	**1.45**
Secondary	**Primary**	**0.69**
Other	**Secondary**	**0.48**
Other	**Primary**	**0.33**

Table 8. Panther-Vehicle Collisions within the C-43 West Reservoir project Action Area as of June 2007.

YEAR	Distance From Project Center	Roadway	Sex	Panther	Result
1972	27.3	SR 25	M	UCFP28	Death
1983	21.2	US 27	M	UCFP09-(G83-22)	Death
1988	18.9	Near Daniels Road	M	FP28	Injury
1989	13.2	CR 850	M	UCFP18-(RK-850)	Death
1992	21.6	Alico Road	M	NONE	Injury
1993	18.9	Daniels Road	M	UCFP22	Death
1993	21.6	CR 846	M	FP50	Death
1994	26.2	County Line Road	M	UCFP23-(FP52'S)	Death
1995	20.7	CR 846	F	FP52	Death
1996	11.3	CR 832	M	UCFP29	Death
1997	21.7	CR 846	U	UCFP31	Death
1998	26.2	CR 846	F	UCFP25	Death
2000	25.4	CR 846	M	UCFP34	Death
2000	19.8	CR 846	M	UCFP35	Death
2000	24.6	CR 846	F	UCFP36	Death
2000	21.1	CR 846	F	UCFP37	Death
2001	25.7	CR 846	F	UCFP42	Death
2001	25.8	CR 846	M	UCFP43	Death
2002	24.7	3.4 miles North of Palmdale, Glades County	M	UCFP45	Death
2002	21.7	CR 846	F	UCFP48	Death
2002	20.2	CR 846	F	UCFP49 (K98)	Death
2002	24.7	CR 846	M	FP99	Death
2003	21.8	CR 846	M	UCFP50 (K33)	Death
2003	24.8 miles east	CR 833	M	UCFP52	Death
2003	26.7 miles southeast	SR 29	F	UCFP53	Death
2003	26.2 miles southeast	SR 29	M	UCFP54	Death
2003	21.8 miles south	CR 846	F	UCFP58	Death
2003	27.3 miles southeast	CR 833	F	UCFP61	Death
2004	25.6 miles southeast	SR 29	F	UCFP69	Death
2004	24.3 miles southeast	SR 29	F	UCFP70	Death
2004	10.6 miles southeast	CR 832	M	K128	Death
2005	24.4 miles southeast	SR 29	M	UCFP75	Death
2006	22.5 miles southeast	CR846	M	UCFP78	Death
2006	23.8 miles south	CR846	F	UCFP79	Death
2006	18.1 miles west	I-75 Lee County	M	UCFP81	Death
2006	18.2 miles east	CR 832	M	UCFP85	Death
2006	19.5 miles southwest	Corkscrew Road	M	UCFP87	Death
2006	24.6 miles southeast	County Line Road	M	UCFP89	Death
2007	10.7 miles southeast	CR 832	F	UCFP90	Death
2007	11.9 miles southeast	CR 832	M	UCFP91	Death
2007	23.5 miles southwest	I-75 Lee County	M	UCFP93	Death
2007	19.5 miles southwest	Corkscrew Road	F	UCFP97	Death

Table 9. County and State Acquisitions within the Action Area (Acres).

	State Acquisition
Year	**Acres**
1999	71297
2000	49086
2001	34774
2002	56324
2003	56110
Totals	17,092.43

Table 10. Results of Panther Prey Abundance Surveys Conducted Within the C-43 West Reservoir Project Area. Table excerpted from Appendix I, Final Biological Assessment for the C-43 West Storage Reservoir Project, Hendry County, Florida.

Table 1. Number of tracks per survey date for white-tailed deer and feral hog.

		Number of Tracks per Survey Date							
Transect	Species	9/15/2006	9/26/2006*	9/27/2006*	9/28/2006	9/29/2006	10/12/2006	10/13/2006	Total (for the 5 analyzed days)
1	White-tailed Deer	1	1	5	0	0	1	0	2
	Feral Hog	7	10	1	7	9	0	4	27
2	White-tailed Deer	0	0	2	0	0	0	1	1
	Feral Hog	26	0	14	4	7	2	23	62
3	White-tailed Deer	0	0	0	0	0	0	0	0
	Feral Hog	15	0	23	4	1	0	2	22
4	White-tailed Deer	0	7	7	0	0	0	0	0
	Feral Hog	0	2	0	5	1	1	0	7
5	White-tailed Deer	0	1	0	0	0	0	0	0
	Feral Hog	5	2	6	0	4	1	2	12
Total	White-tailed Deer	1	25	35	0	0	1	1	3
	Feral Hog	53	14	44	20	22	4	31	130
t_i (average # of tracks/mile)	White-tailed Deer	0.4	10.4	14	0	0	0.4	0.4	0.24
	Feral Hog	21.2	5.6	17.6	8	8.8	1.6	12.4	10.4

Notes:

1. Data from these two days were considered outliers and were not used in the population density estimate.
2. All transects are 0.5 miles in length, and consist of grove access/maintenance roads (dirt surface).
3. t_i is derived from Tyson (1952) formula for population estimates $X_1 = 11 / D$ where X_1 is the population density per square mile, t_i is the number of tracks per mile, and D is the average daily range of deer.
4. sample calculation for deer using D=1 mile (as per Tyson, 1952): $X_1 = 0.24$ tracks per mile / 1 mile = 0.24 deer/mi^2. Then 0.24 deer per mi2 x 16.19 mi2 = 3.9 deer in the project site.

Table 11a. Florida Panther Habitat Matrix – Primary Equivalent Panther Habitat Units for C-43 Test Cell Project

Test Cell Project Only		**Test Cell Project Development** 267 acres					
		Functional Units Needed 388					
		Pre			**Post**		
Land Cover Type	**Habitat Values**	Secondary Acres	Other Acres	Primary Equivalent PHUs	Secondary Acres	Other Acres	Primary Equivalent PHUs
Freshwater Marsh	9	0	2.6	8			0
Citrus Groves	4	47.5	190.5	381			0
Water	0	6.1	20.3	0	53.6	213.4	0
Subtotal		**53.6**	**213.4**	**388**	**53.6**	**213.4**	**0**

Table 11b. Florida Panther Habitat Matrix – Primary Equivalent Panther Habitat Units for C-43 West Reservoir Project.

C-43 West Storage Reservoir Project and Access Road Parcel (without Test Cell Project)		C-43 West Storage Reservoir Project and Access Road Parcel (without Test Cell Project) Development 10,335 acres Functional Units Needed 46,933							
		Pre				Post			
Land Cover Type	Habitat value	Primary Acres	Secondary Acres	Other Acres	Primary Equivalent PHUs	Primary Acres	Secondary Acres	Other Acres	Primary Equivalent PHUs
Freshwater marsh	9	0	9	5	69	--	--	--	--
Cypress swamp	9	1	24	8	177	--	--	--	--
Grassland/pasture	7	1	0	0	7	15	89	62	665
Shrub swamp	5	3	57	10	222	--	--	--	--
Shrub and brush	5	0	4	3	18	--	--	--	--
Orchards/groves	4	128	4,702	4421	18,945	--	--	--	--
Water	0	11	440	456	0	129	5147	4783	0
Urban	0	0	0	52	0	0	0	110	0
Subtotal		**144**	**5236**	**4955**	**19438**	**144**	**5236**	**4955**	**665**

803

Table 12. Florida Panther Habitat Matrix –Primary Equivalent Panther Habitat Units by individual Band 1/Acceler8 Project –Development.

Band 1/ Acceler8 Project Name[1]	Land Cover Type	Habitat value	Project Development Functional Units Needed 172,473							
			Pre				Post			
			Primary Acres	Secondary Acres	Other Acres	PHU	Primary Acres	Secondary Acres	Other Acres	PHU
C-43 West Storage Reservoir (*Includes Test Cell Project and Access Road Parcel)	Freshwater marsh	9	0	9	8	77	--	--	--	--
	Cypress swamp	9	1	24	8	177	--	--	--	--
	Grassland/pasture	7	1	0	0	7	15	89	62	665
	Shrub swamp	5	3	57	10	222	--	--	--	--
	Shrub and brush	5	0	4	3	18	--	--	--	--
	Orchards/groves	4	128	4,750	4612	19326	--	--	--	--
	Water	0	11	446	476	0	129	5201	4996	0
	Urban	0	0	0	52	0	0	0	110	0
	Subtotal		**144**	**5290**	**5168**	**19826**	**144**	**5290**	**5168**	**665**
EAA Reservoir	Hardwood forest	10	--	--	--	--	--	--	95	317
	Freshwater marsh	9	--	--	59.5	179	--	--	308	924
	Grassland/pasture	7	--	--	242.8	567	--	--	445	1,038
	Shrub swamp	5	--	--	165.44	276	--	--	--	--
	Shrub and brush	5	--	--	8.47	14	--	--	--	--
	STA	4.5	--	--	--	--	--	--	1,500	2,250
	Crop land	4	--	--	32,668	43,557	--	--	--	--
	Reservoir	1.5	--	--	11.51	6	--	--	--	--
	Water	0	--	--	468.83	0	--	--	31,392	0
	Urban	0	--	--	115.45	0	--	--	--	--
	Subtotal		**0**	**0**	**33,740**	**44,598**	**0**	**0**	**33,740**	**4,529**
C-111 Spreader	Freshwater marsh	9	2348	--	--	21132	225	--	--	2025
	Shrub swamp	5	1088	--	--	5440	--	--	--	0
	STA	4.5	--	--	--	0	3436	--	--	15462
	Water	0	225	--	--	0	--	--	--	0
	Subtotal		**3,661**	**0**	**0**	**26,572**	**3,661**	**0**	**0**	**17,487**
Projects Combined	**Total**		**3,805**	**5,290**	**33,740**	**90,996**	**3,805**	**5,290**	**33,740**	**22,681**

[1] All values are estimates and habitat impacts will be updated as individual Band 1/Acceler8 Projects plans are developed.

804

Table 13. Florida Panther Habitat Matrix Panther Habitat Units by Individual Band 1/Acceler8 Project – Compensation.

Band 1/ Acceler8 Project Name	Land Cover Type	Habitat Value	Band 1/Acceler8 Compensation							
			59,294 ac Primary Zone							
			Pre				Post			
			Primary Acres	Secondary Acres	Other Acres	PHU	Primary Acres	Secondary Acres	Other Acres	PHU
Picayune Strand Restoration Project	Freshwater marsh	9	702			6,318	14,720			132,480
	Bottomland hardwood	9	44,046			396,414	18,388			165,492
	Hardwood swamp	9	1,818			16,362	10,433			93,897
	Cypress swamp	9	744			6,696	13,739			123,651
	Exotic plants	3	11,829			35,487	0			0
	Water	0	155			0	2,014			0
	Total		**59,294**	**0**	**0**	**461,277**	**59,294**	**0**	**0**	**515,520**

All values are estimates and habitat impacts will be updated as individual Band 1/Acceler8 Project plans are developed.

Table 14*. Thirteen vegetation cover classes ranked for importance to crested caracaras in south-central Florida. Ranks were obtained using compositional analysis of 28 caracara home ranges compared to the overall study area. Cover classes were derived from the original 43 classes in the Florida Vegetation and Land Cover layer (FWC 2003). General preference ranks were assigned subjectively, based on field observations of caracaras in the region.

Vegetation cover class	More detailed preference rank[1]	General Preference Rank
Improved pasture	10	High
Freshwater marsh	9	High
Grassland	9	High
Mixed upland hardwoods	8	High
Citrus	7	Medium
Agriculture	6	Medium
Shrub swamp	5	Medium
Bare soil	3	Low
Shrub and brushland	3	Low
Pinelands	2	Low
Urban	1	Low
Scrub	1	Low
Wetland forest	0	Not used
All other habitats	0	Not used

* Table adapted from Morrison et al. 2006
[1] From results of compositional analysis

Table 15. C-43 West Reservoir Project Panther Consultation Area Project List.

Less than 5 percent Wetland Acres					
Project Name	Total Acres	Wetland Acres	Percent Wetland Acres	District ERP	PUD
FPL CORKSCREW ROAD SUBSTATION	0.12	0.00	0.00	2001	
HICKEY CREEK MITIGATION PARK	0.23	0.00	0.00	2001	
JOHNSON PROPERTY L308A DT	0.25	0.00	0.00	2001	
EL RIO GRANDE MOBILE HOME PARK	18.12	0.00	0.00	2002	
PALMETTO RIDGE HIGH SCHOOL	151.16	0.00	0.00	2002	
SR-78 ROADSIDE DITCH RELOCATION	5.82	0.00	0.00	2002	
STONEYBROOK AT GATEWAY	25.04	0.00	0.00	2002	
GATEWAY BOULEVARD EXTENSION AT STONEYBROOK OF GATEWAY	0.23	0.00	0.00	2003	
HARRIS MORAN RESEARCH FACILITY	7.63	0.00	0.00	2003	
HEACOCK	6.09	0.00	0.00	2003	
LEE COUNTY GUN RANGE	9.59	0.00	0.00	2003	
VILLAGE WALK - BONITA SPRINGS	631.33	0.00	0.00	2003	
AIRPORT TERMINAL AND AUTO TRANSPORT SERVICES	1.39	0.00	0.00	2004	
CAMP JERNEE	14.24	0.00	0.00	2004	
CYPRESS LEGENDS NO DEWATERING CONDITION REMOVAL	21.45	0.00	0.00	2004	
GUNNERY ROAD FROM SR 82 TO LEE BOULEVARD	32.01	0.00	0.00	2004	
SR 78 S OF NICODEMOUS SLOUGH TO BRIDGE NUMBER 050056	82.46	0.00	0.00	2004	
THE SHOPS AT VERANDAH	0.23	0.00	0.00	2004	
TRANSPORTATION EAST FACILITY - PARKING LOT AND BLDG ADDITION	20.69	0.00	0.00	2004	
ALICO LAKES VILLAGE	31.71	0.00	0.00	2005	
CORKSCREW ROAD CURVES IMPROVEMENTS	0.29	0.00	0.00	2005	
DOGWOOD COMMERCIAL PLAZA	2.85	0.00	0.00	2005	
DQ GRILL AND CHILL AT SHERWOOD	1.20	0.00	0.00	2005	
E.M.S. COMPOUND	9.44	0.00	0.00	2005	
FIFTH THIRD BANK - FT MYERS	1.19	0.00	0.00	2005	
GOFF COMMUNICATIONS TELECOMMUNICATION TOWER/THORP RD	0.23	0.00	0.00	2005	
MOBIL SERVICE STATION RAS NO 81285	1.39	0.00	0.00	2005	
OAKS AND HAMMOCK AT VERANDAH	13.43	0.00	0.00	2005	
ORANGE BLOSSOM RANCH	522.43	0.00	0.00	2005	
ORANGE BLOSSOM RANCH PHASE A	428.13	0.00	0.00	2005	
OWENS PARKING LOT	1.03	0.00	0.00	2005	
BIGGERSTAFF 2	1.29	0.00	0.00	2006	
FAIRWAY COVE AT VERANDAH	20.63	0.00	0.00	2006	
WORTHINGTON WAREHOUSE CONDOMINIUMS	14.25	0.00	0.00	2006	
AIRPORT CROSSINGS	80.85	0.00	0.00		2002
AIRPORT TECHNOLOGY CENTER IPD	94.00	0.00	0.00		2002
JETWAY TRADEPORT MPD	37.14	0.00	0.00		2002
JETWAY TRADEPORT MPD	0.92	0.00	0.00		2002
JETWAY TRADEPORT MPD	0.99	0.00	0.00		2002
SOUTHWEST FLORIDA ROCK	177.54	0.00	0.00		2002
WORTHINGTON VILLAGE @ SR82 RPD/CPD	338.13	0.00	0.00		2002
AIRPORT SOUTH INTERCHANGE CPD	31.65	0.02	0.00		2002
IMMOKALEE ROAD 6-LANE WIDENING	85.26	0.00	0.00	2004	
BAYSHORE FARMS 1	113.32	0.02	0.01	2004	
QUAIL CREEK DRAINAGE IMPROVEMENTS	2.39	0.01	0.44	2001	
COTTONWOOD BEND AT VERANDAH	20.52	0.11	0.52	2004	
SR 82 GROVES LLP PKA (IMMOKALEE FARM)	917.33	8.39	0.91	2002	
NICK SINGLETARY FARMS INC	234.88	4.77	2.03	2002	
GLADES RESORT	85.79	1.79	2.08	2005	
COLONIAL BLVD BICYCLE PATHS	30.41	0.64	2.10	2001	
HOME DEPOT - FORT MYERS	15.12	0.36	2.39	2004	
CROOKS RANCH	2748.49	76.64	2.79	2004	
EVERGLADES ECOTOUR LODGE	68.45	2.04	2.98	2005	
HILL GRADE FARM CENTER PIVOTS	9948.07	314.30	3.16	2002	
APEX CENTER	95.35	3.10	3.25	2004	
TALAVERA ESTATES	34.48	1.19	3.46	2005	
AVE MARIA PHASE 2	965.58	34.96	3.62	2006	

Less than 5 percent Wetland Acres					
Project Name	**Total Acres**	**Wetland Acres**	**Percent Wetland Acres**	**District ERP**	**PUD**
DOUBLE BOTTOM CENTER (C.C.E. DISTRIBUTION CENTER)	20.22	0.78	3.88	2003	
GATEWAY UTILITY SITE - MAINTENANCE BUILDING	46.24	1.84	3.97	2005	
AIRPORT SEWER DISTRICT GATEWAY WWTP EXPANSION - 2 MGD	44.31	1.84	4.15	2006	
SCHOENBRUN FARMS GROVE 2	537.12	23.34	4.35	2001	
PORTICO	585.82	26.03	4.44	2005	
	19,437.94				

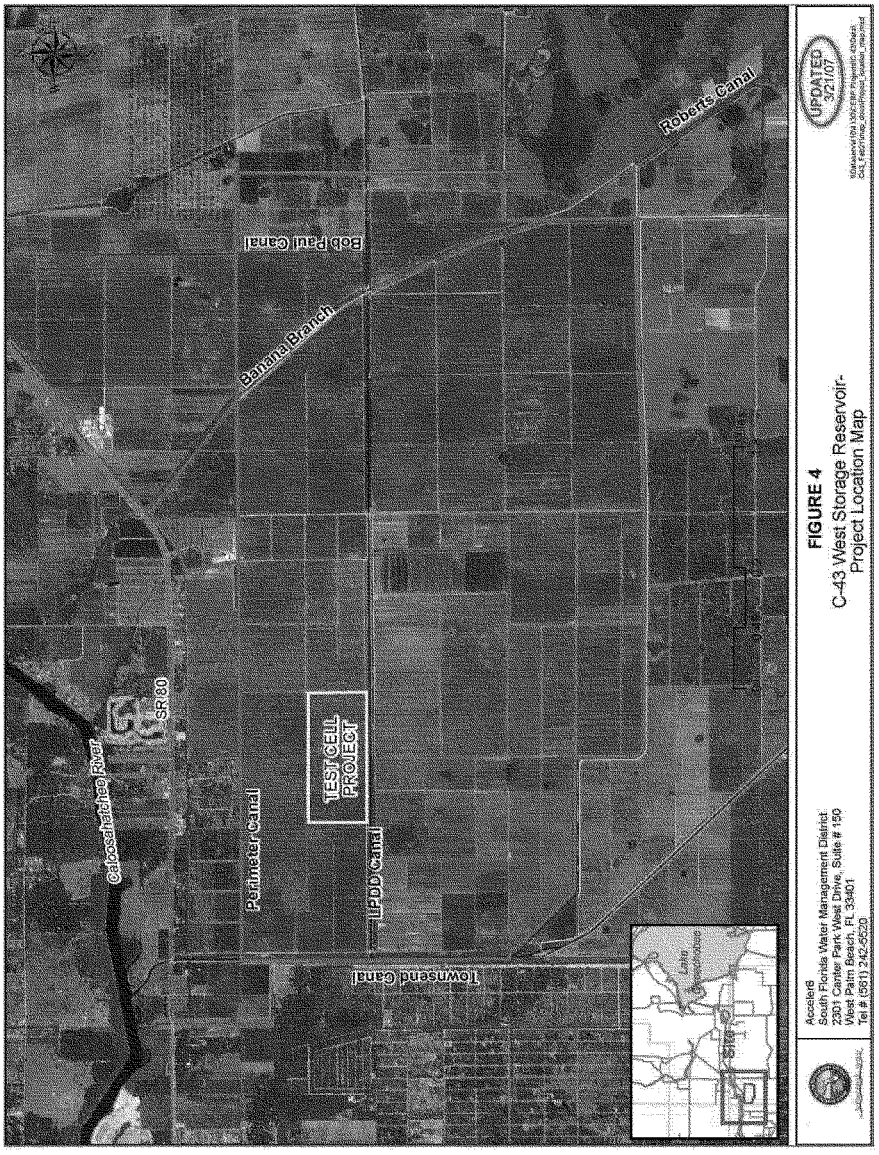


Figure 1. C-43 West Storage Reservoir Project, Access Road Parcel, and Test Cell Project location.

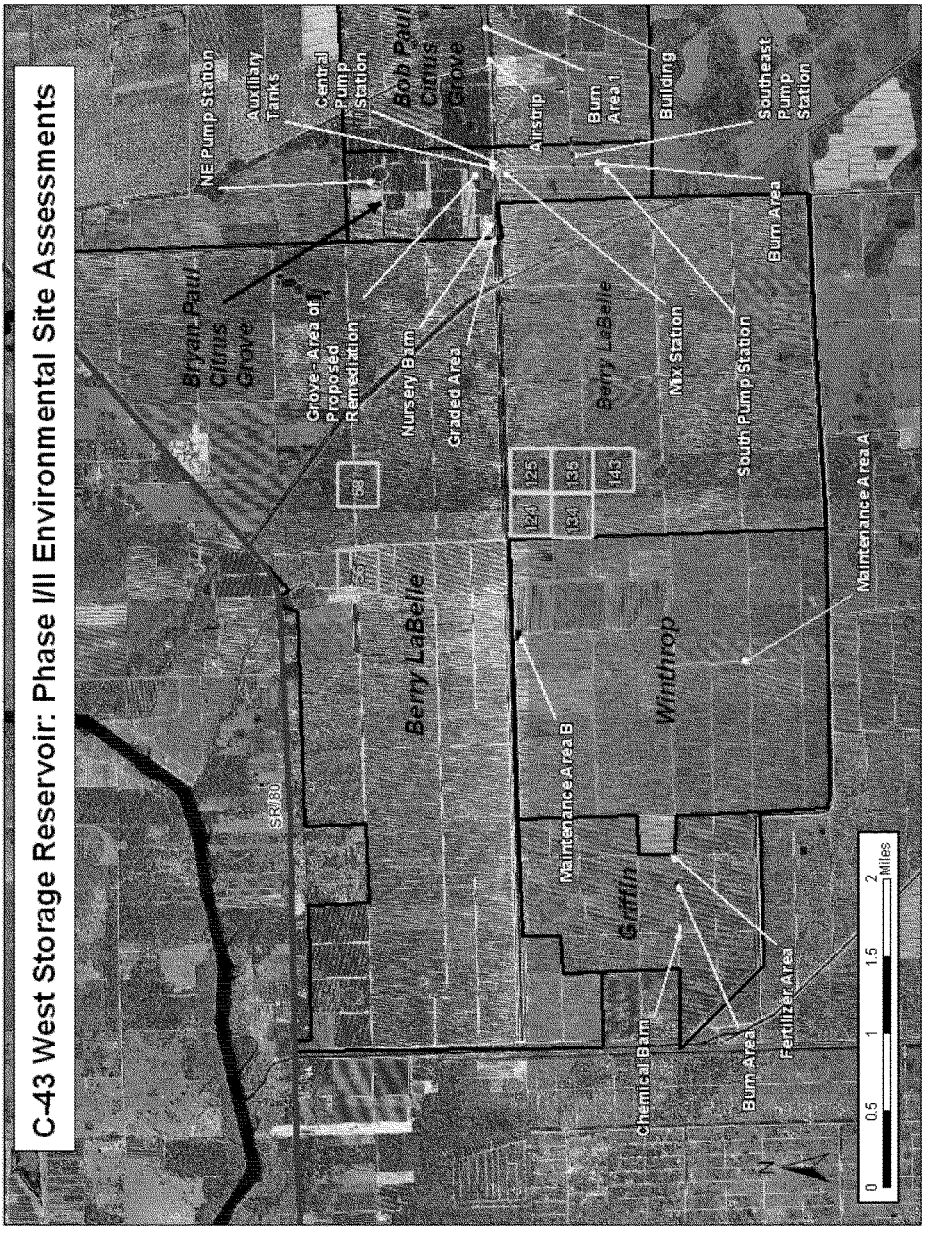


Figure 2. C-43 Basin Storage Reservoir: Phase I and II Environmental Assessments.

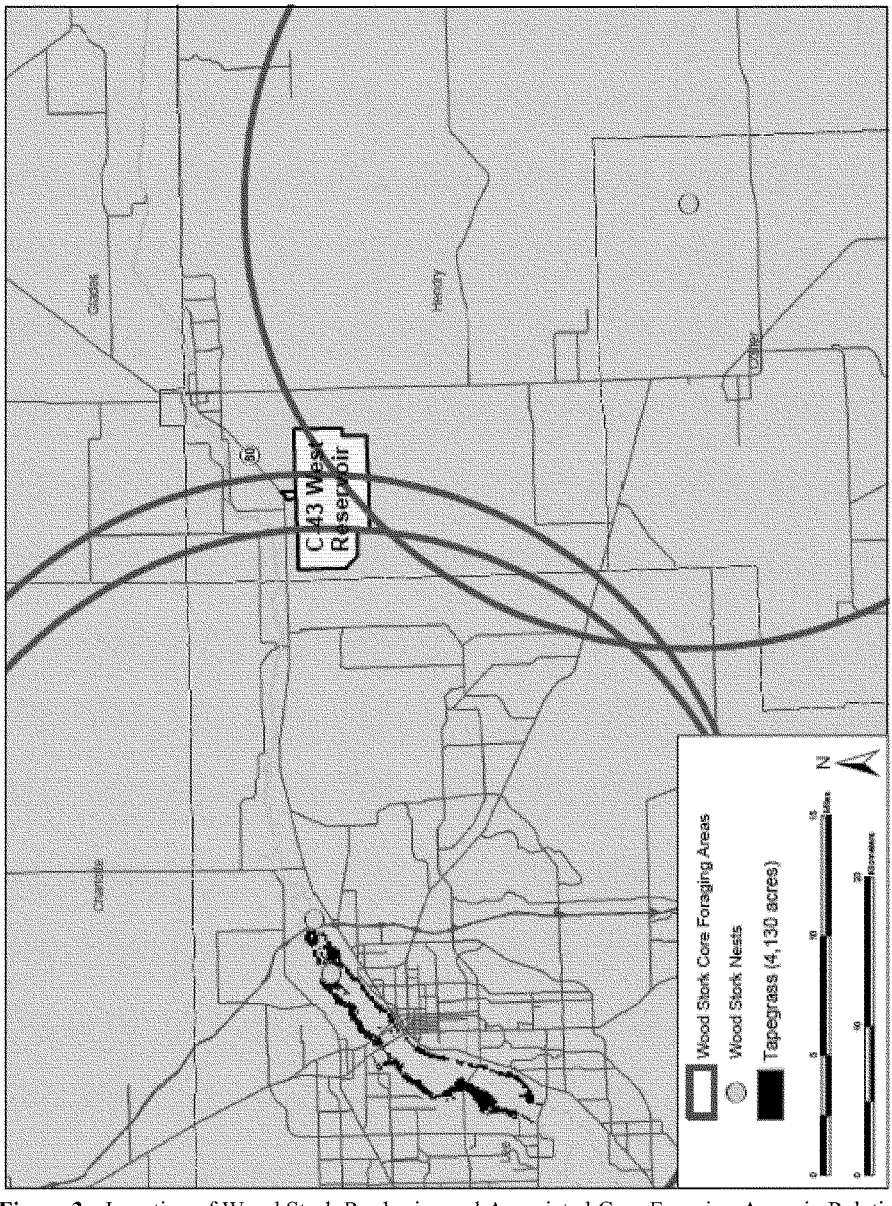


Figure 3. Location of Wood Stork Rookeries and Associated Core Foraging Areas in Relation to the C-43 Basin Storage Reservoir Project Area and Tapegrass Beds in the Upper Caloosahatchee Estuary.

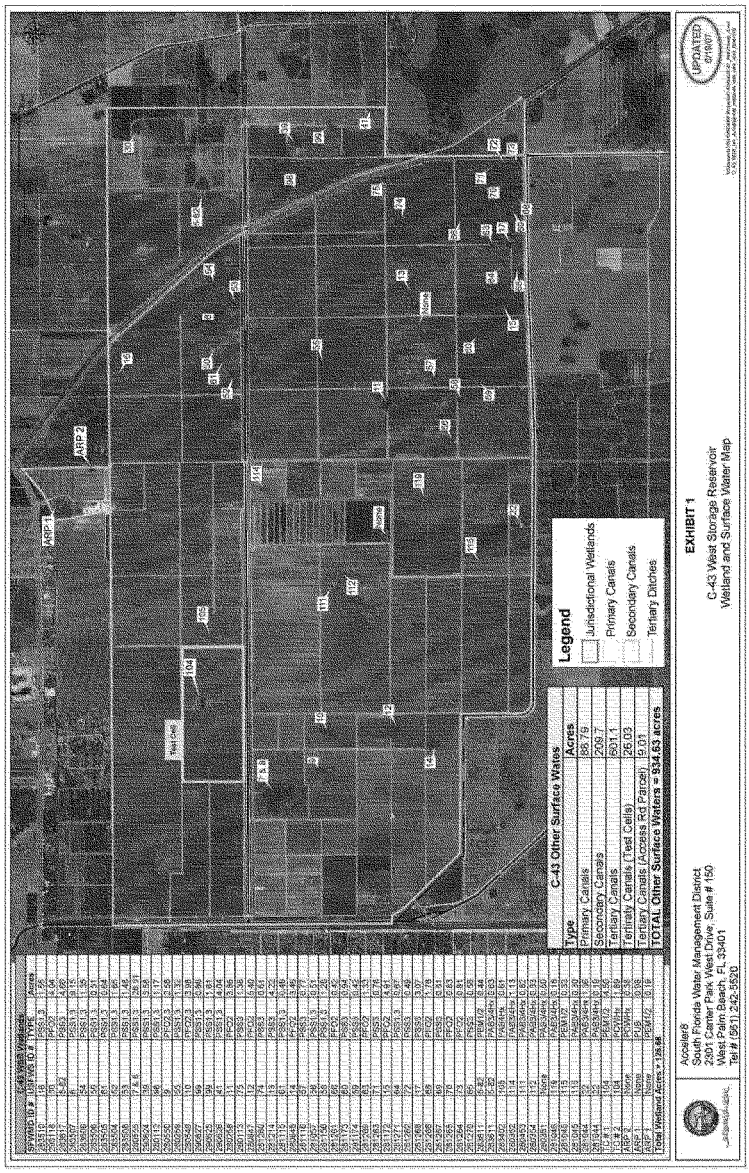
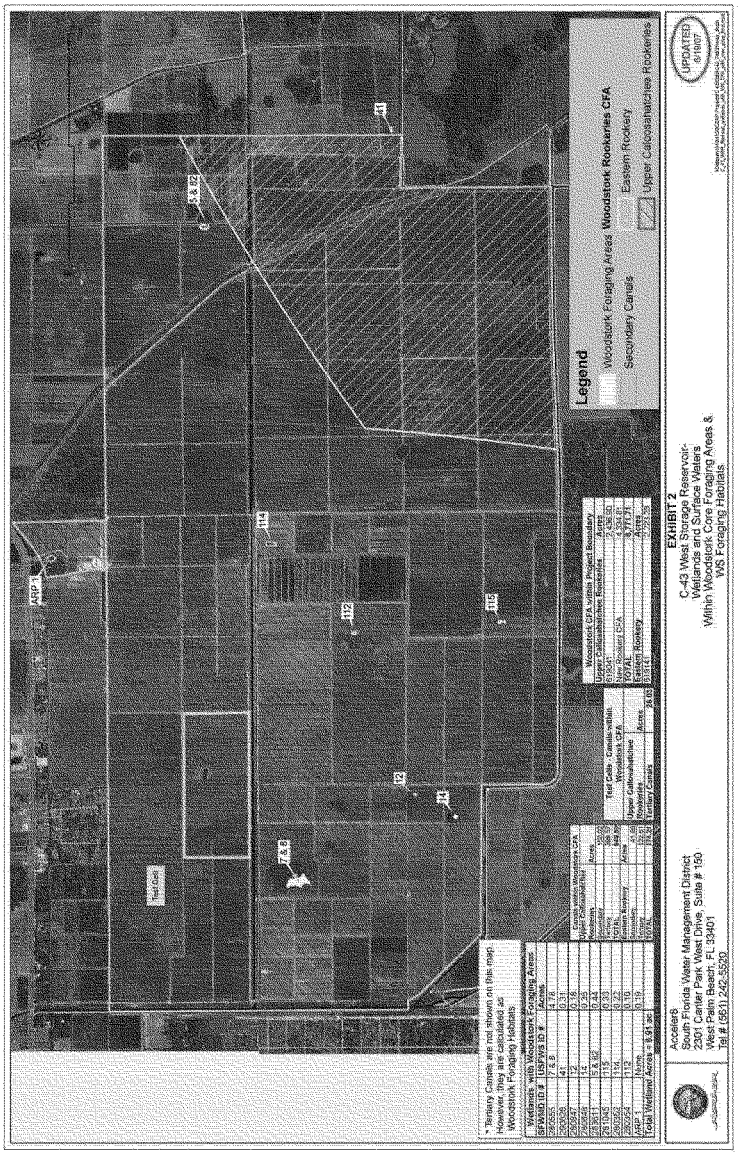
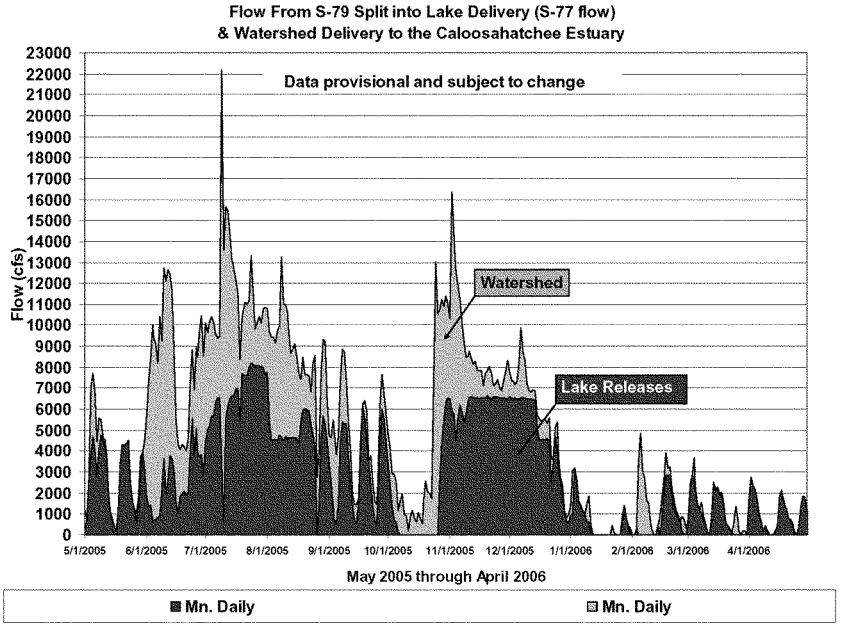


Figure 4. C-43 Basin Storage Reservoir: Jurisdictional Wetlands and Surface Waters of the United States.


Legend
Woodstork Foraging Areas
Woodstork Rookeries CFA
Secondary Canals
Eastern Rookery
Upper Caloosahatchee Rookeries
EXHIBIT 2
C-43 West Storage Reservoir-
Wetlands and Surface Waters
Within Woodstock Core Foraging Areas &
WS Foraging Habitats
Acceler8
South Florida Water Management District
2301 Cantar Park West Drive, Suite # 150
West Palm Beach, FL 33401
Tel # (561) 242-5580
UPDATED
8/16/07
* Tertiary Canals are not shown on this map;
However, they are calculated as
Woodstork Foraging Habitats
Wetlands with Woodstork Foraging Areas
SFWMD ID # | USFWS ID # | Acres
Canals within Woodstork CFA
Upper Caloosahatchee | Acres
Secondary
Tertiary
TOTAL
Eastern Rookery
Upper Caloosahatchee Rookeries
Woodstork CFA within Project Boundary
Upper Caloosahatchee Rookeries | Acres
Secondary Canals
New Woodstork CFA
TOTAL
Eastern Rookery
Upper Caloosahatchee Rookeries
Tot Calo - Eastern within Woodstork CFA
Woodstork CFA
Upper Caloosahatchee
Rookeries
Secondary Canals
Acres
Total Wetland Acres = 8,61 ac.
Tertiary Canals
Total Acres
Tert Calo
Tert Canals
Tert Canals
Tert Canals



Note: The portion of the discharge accounted for by Lake Okeechobee releases is shown in blue.

Figure 6. Total discharge into the Caloosahatchee Estuary from Lake Okeechobee and the Caloosahatchee Watershed at S-79.

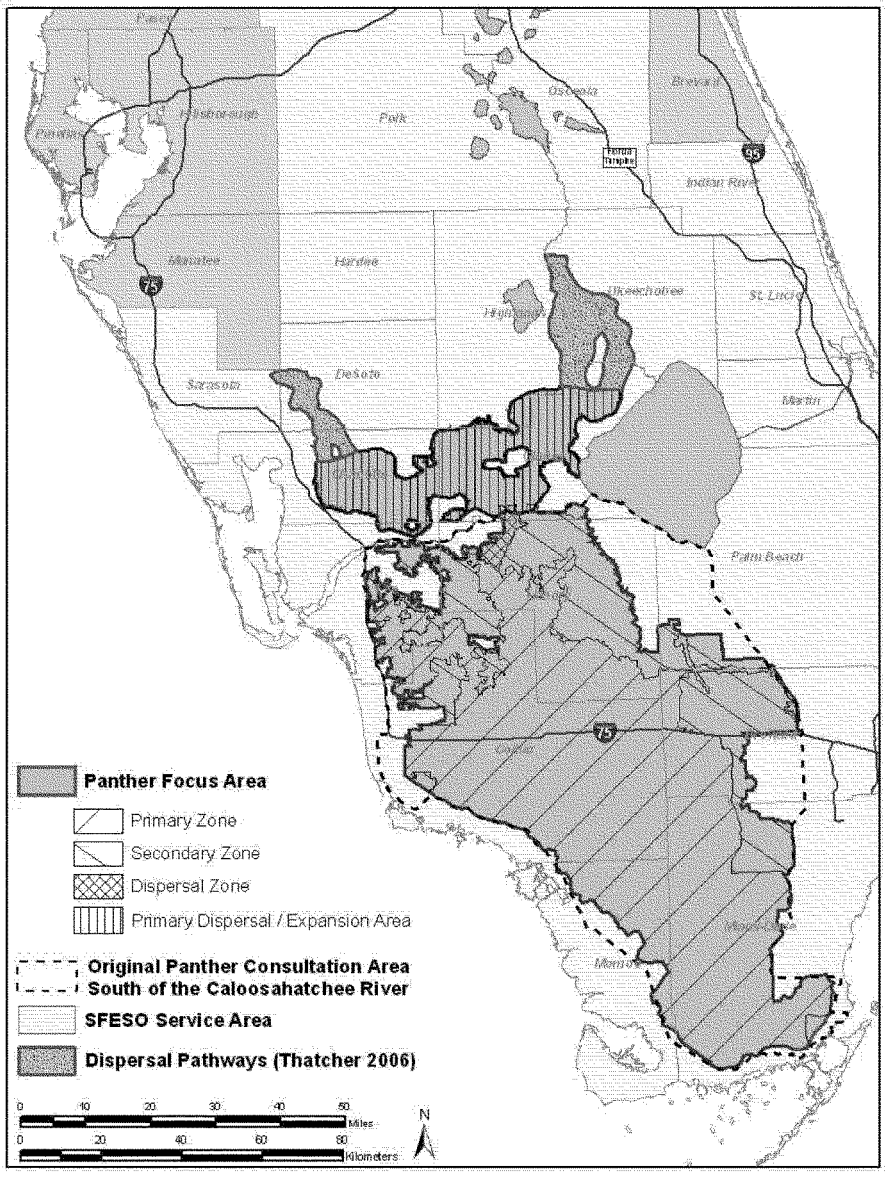


Figure 7. Florida Panther Focus Area.

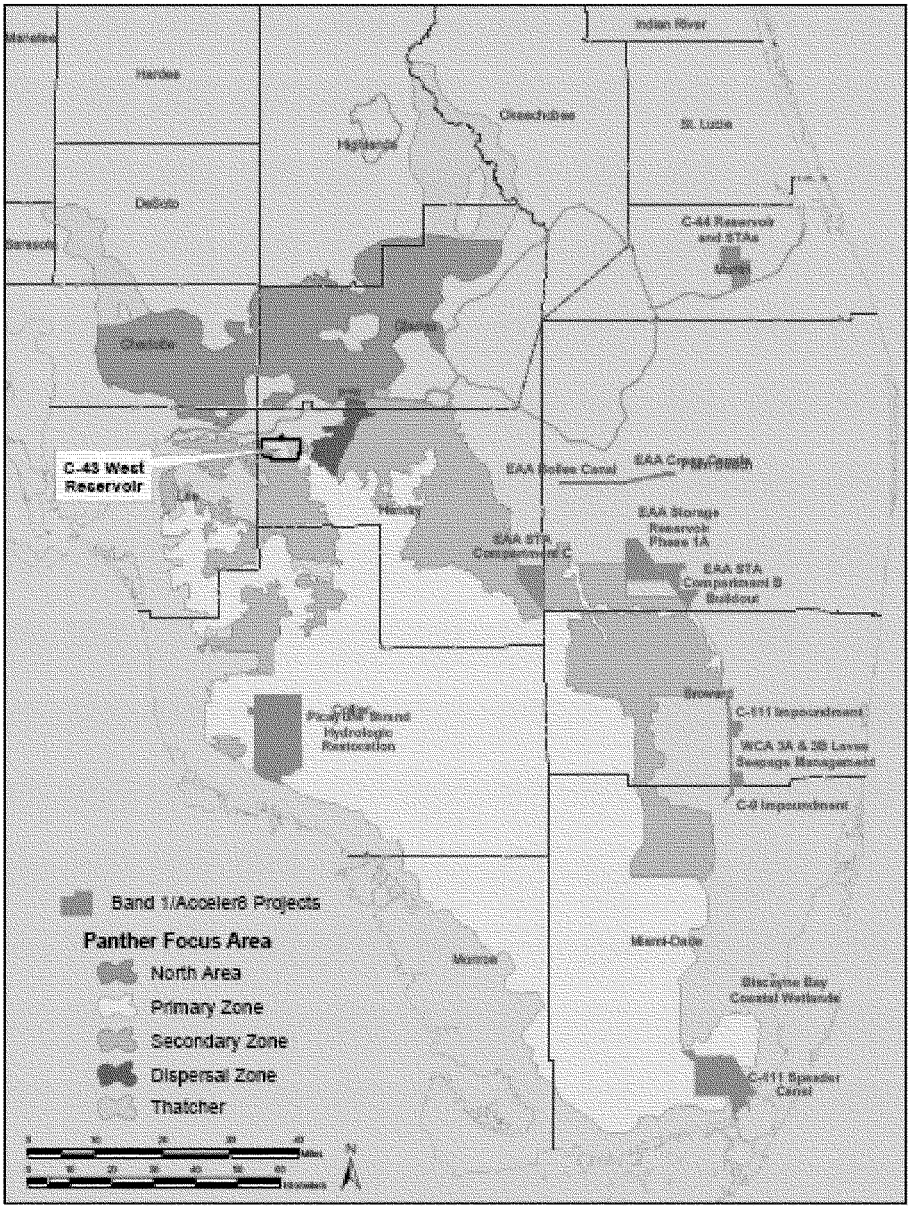


Figure 8. C-43 West Reservoir Project and other Acceler8 Projects in Relation to Florida Panther Focus Area and Primary, Secondary, and other Panther Zones.

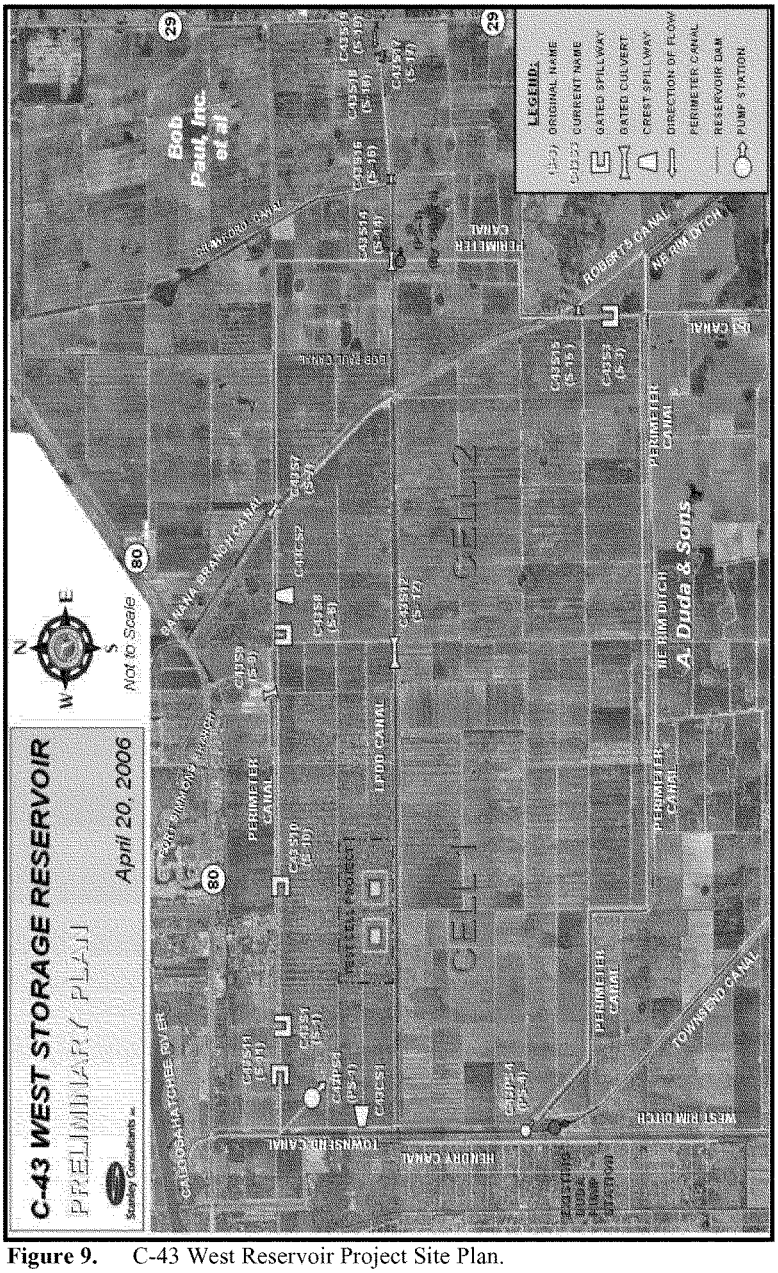


Figure 9. C-43 West Reservoir Project Site Plan.

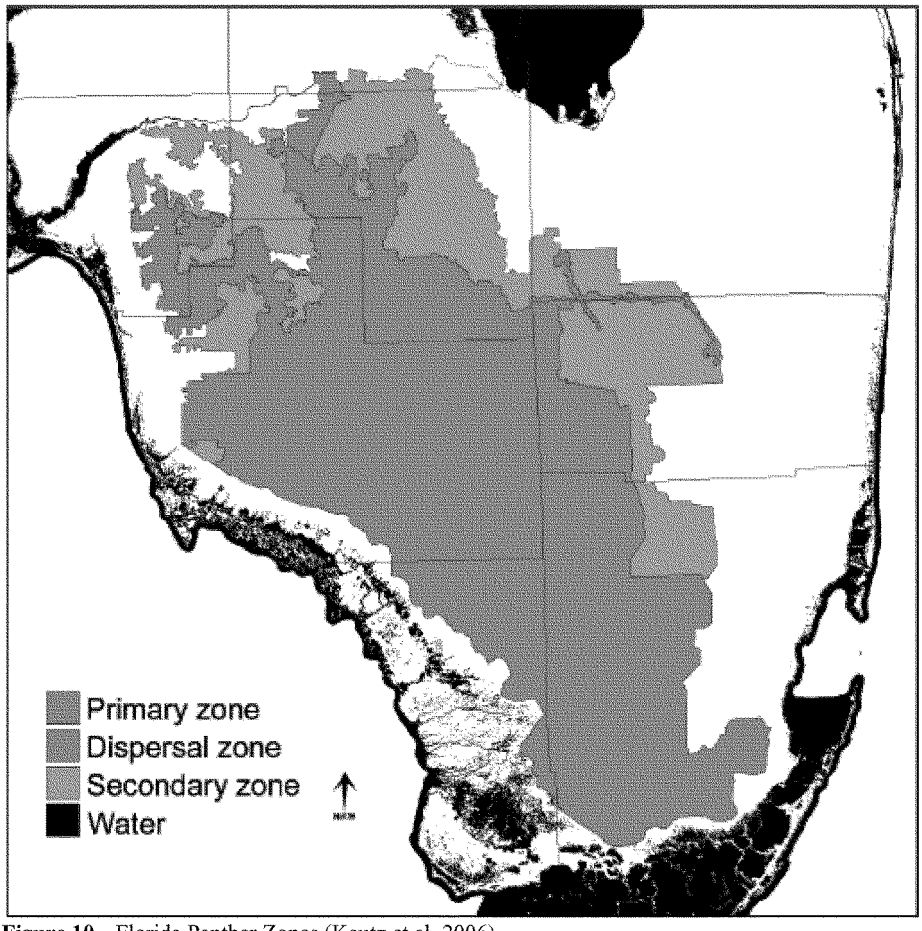


Figure 10. Florida Panther Zones (Kautz et al. 2006).

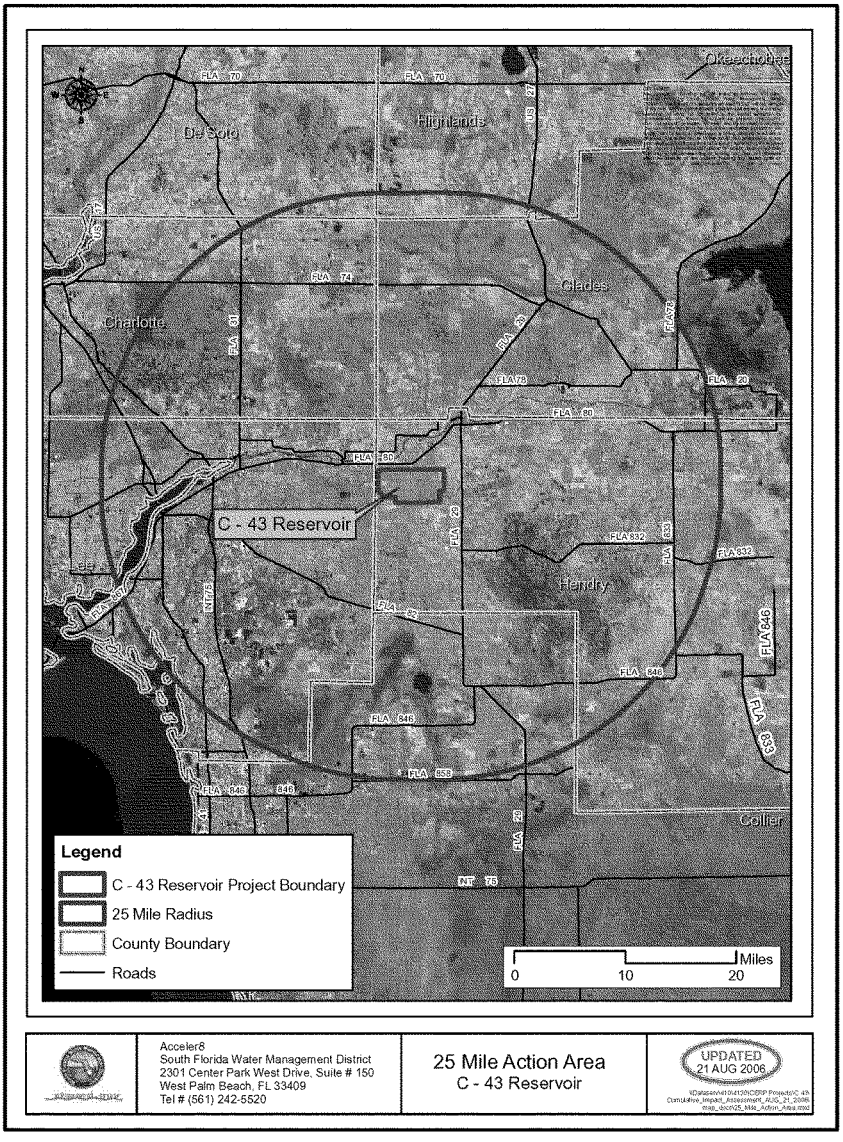


Figure 11. The 25-Mile Florida panther Action area for C-43 West Reservoir Project Area.

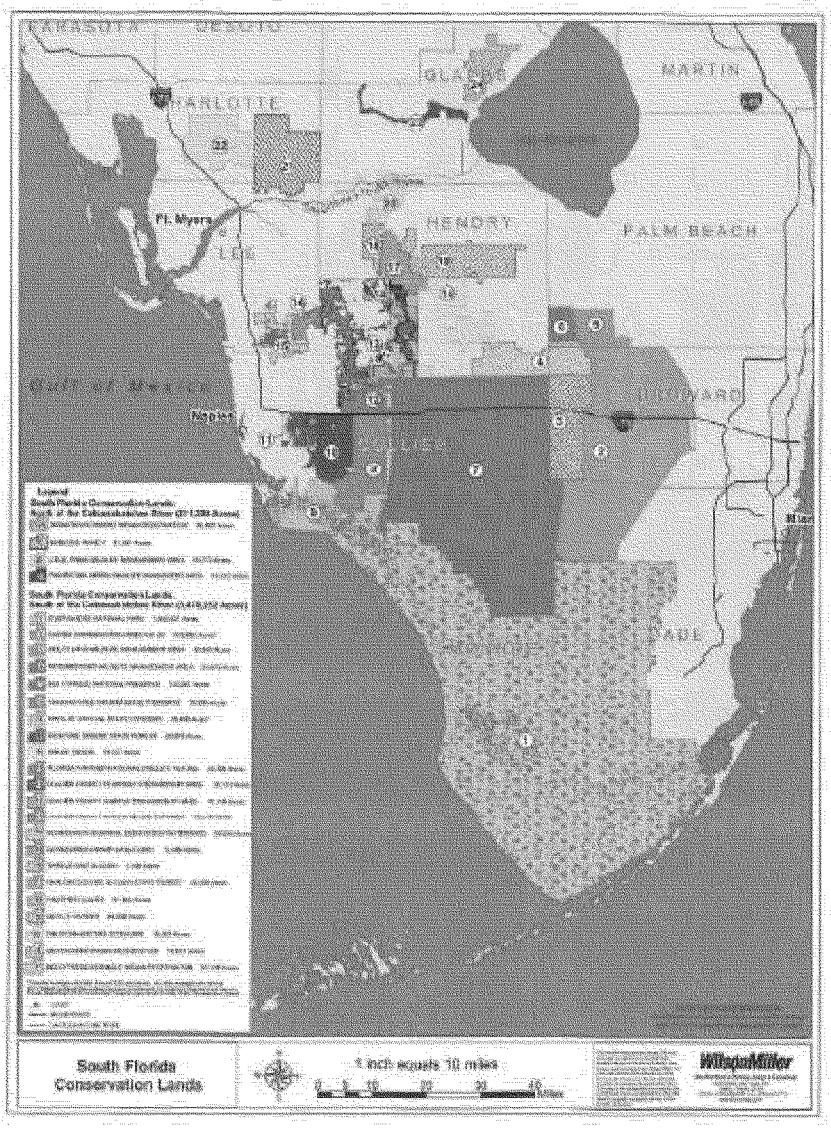


Figure 12. South Florida Conservation Lands.

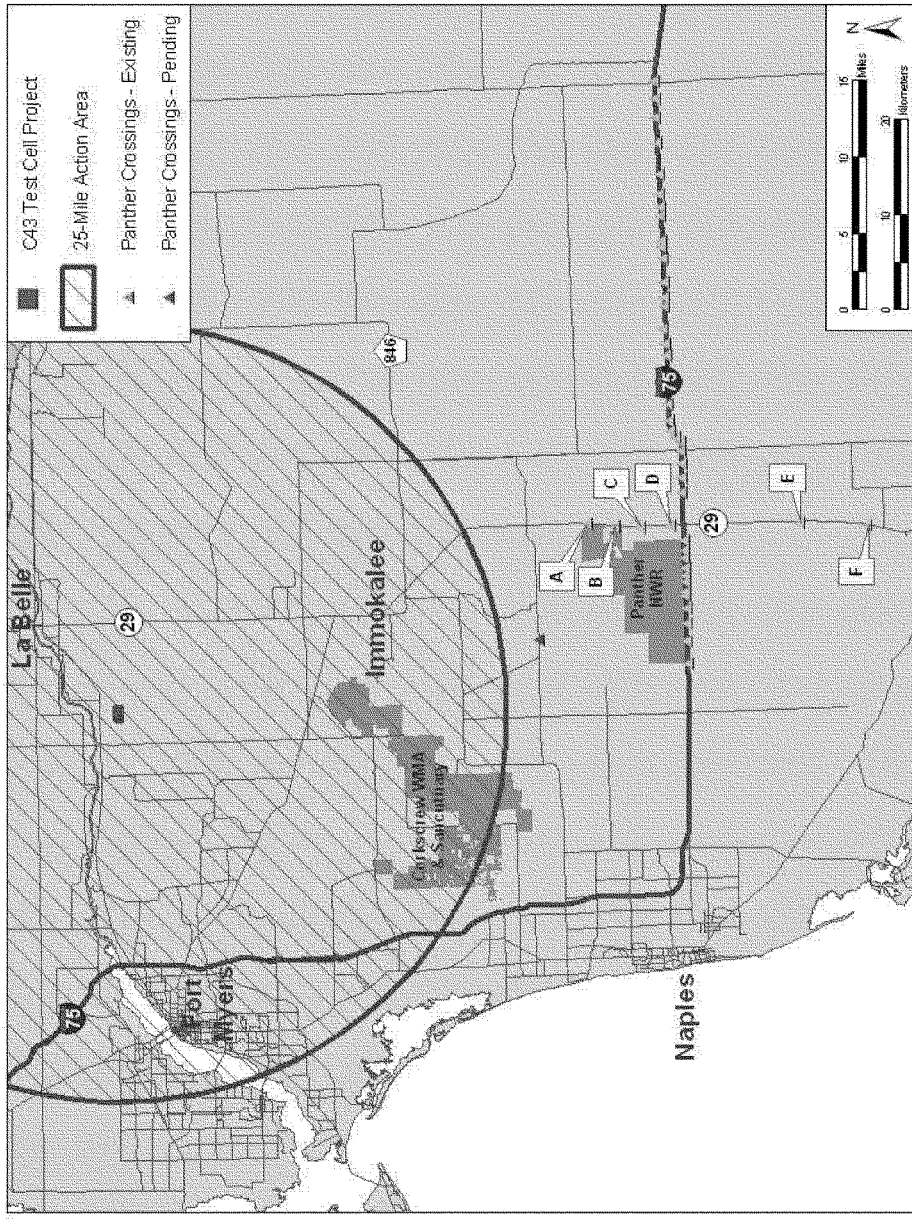


Figure 13. Location of Wildlife Crossings.

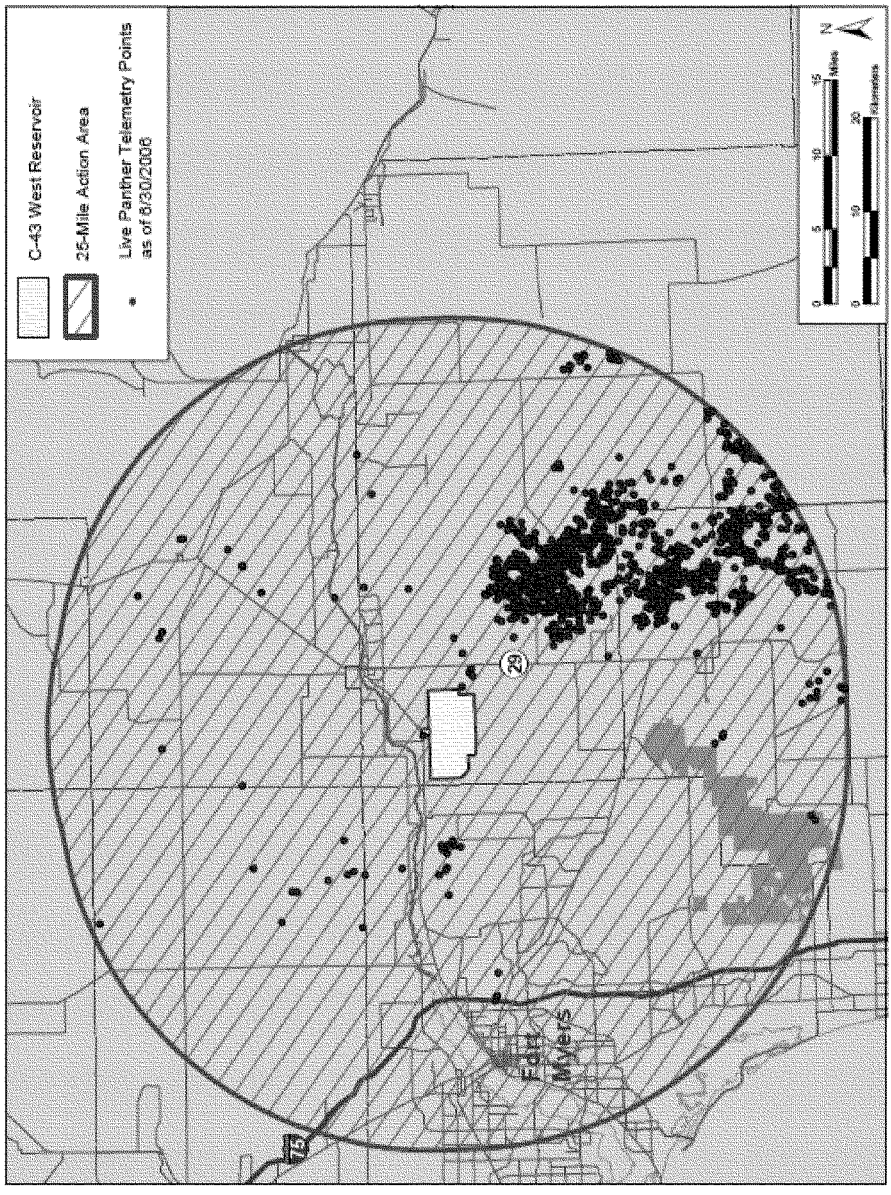


Figure 14. Telemetry Showing Live Panther Activity within the Action Area for the C-43 West Reservoir Project.

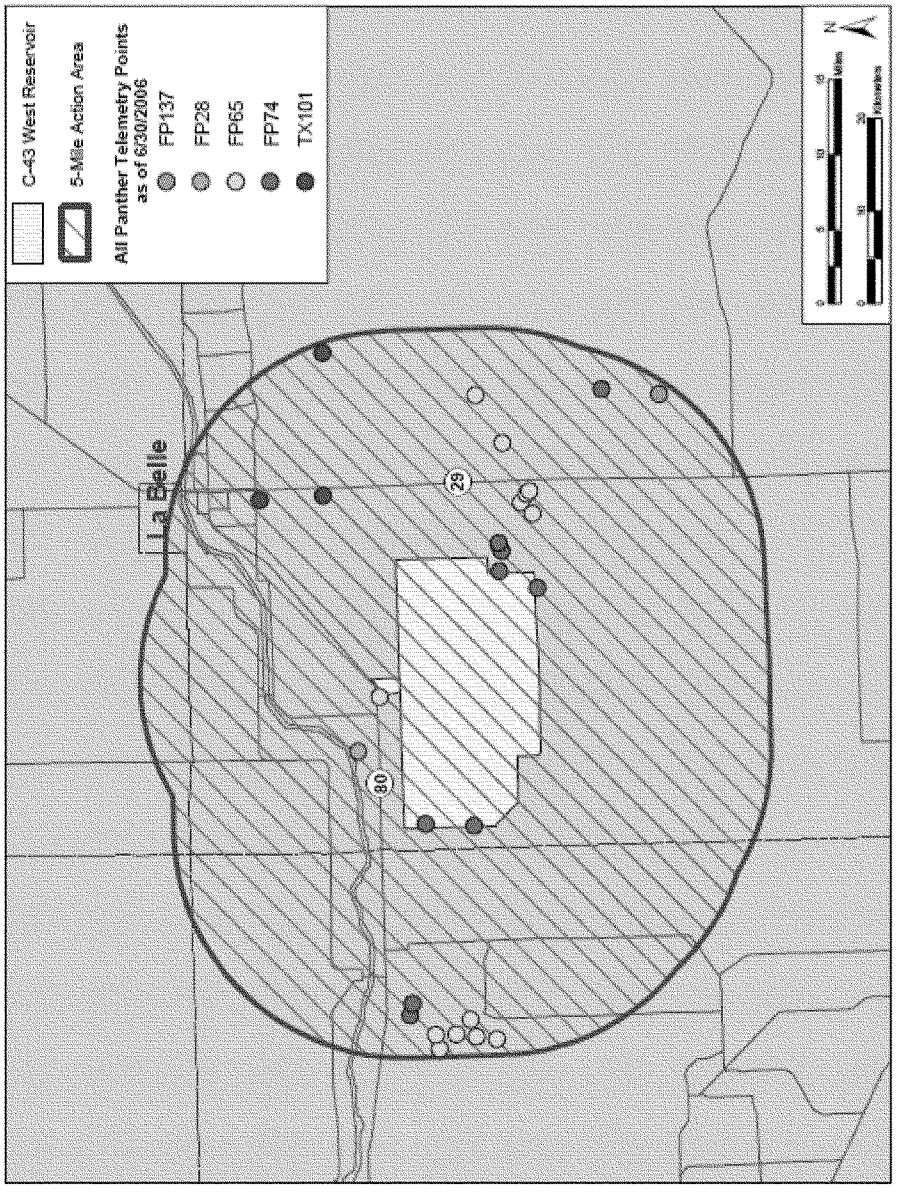


Figure 15. Telemetry Showing Panther Activity within 5 miles of the C-43 West Reservoir Project.

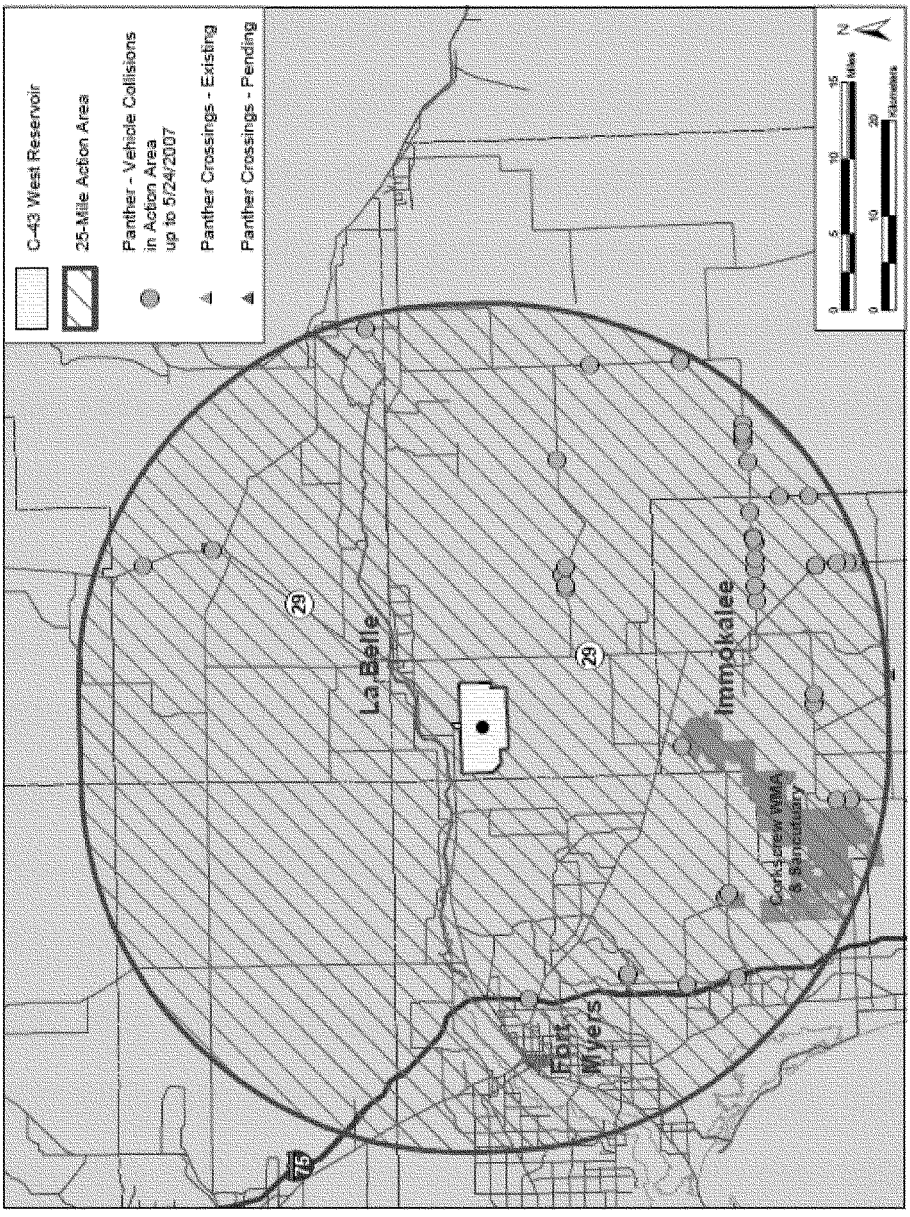


Figure 16. Panther-Vehicle Collisions Within the Action Area

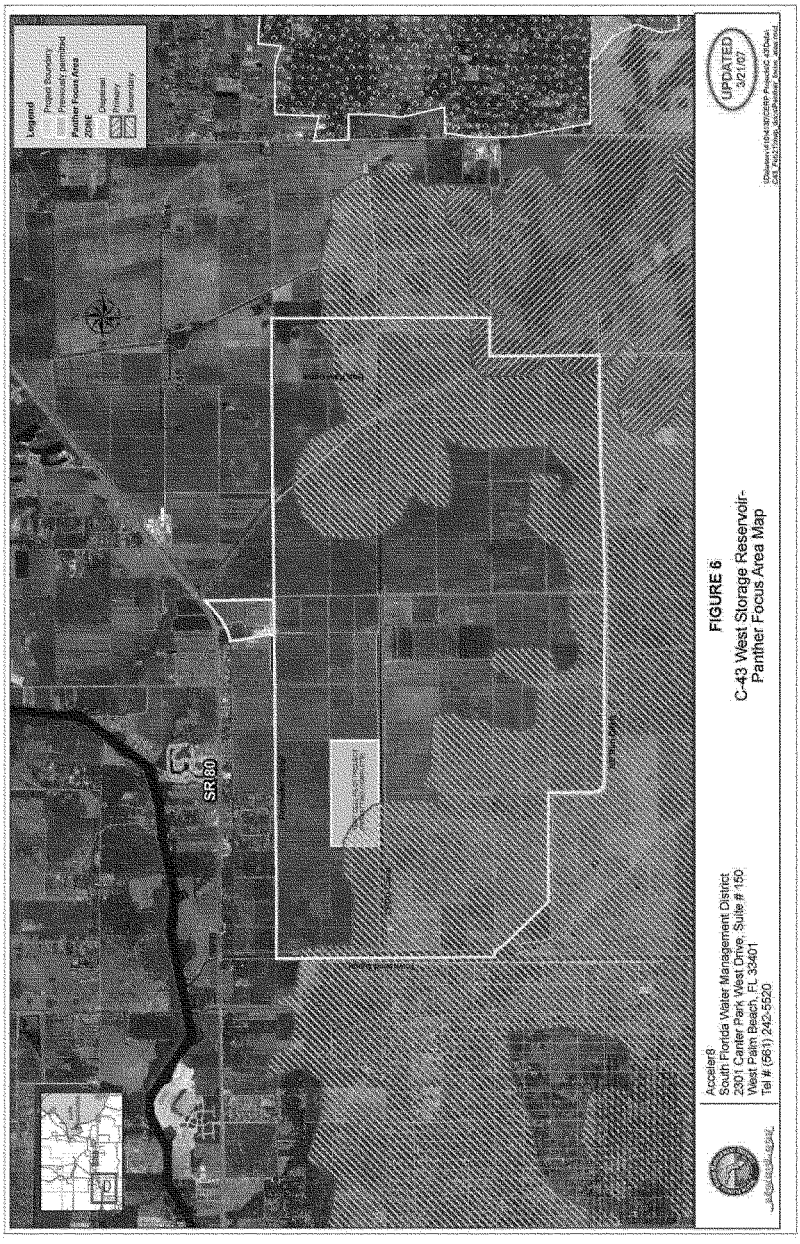


Figure 17. C-43 West Reservoir Project Area and FloridaPanther Habitat Zones.

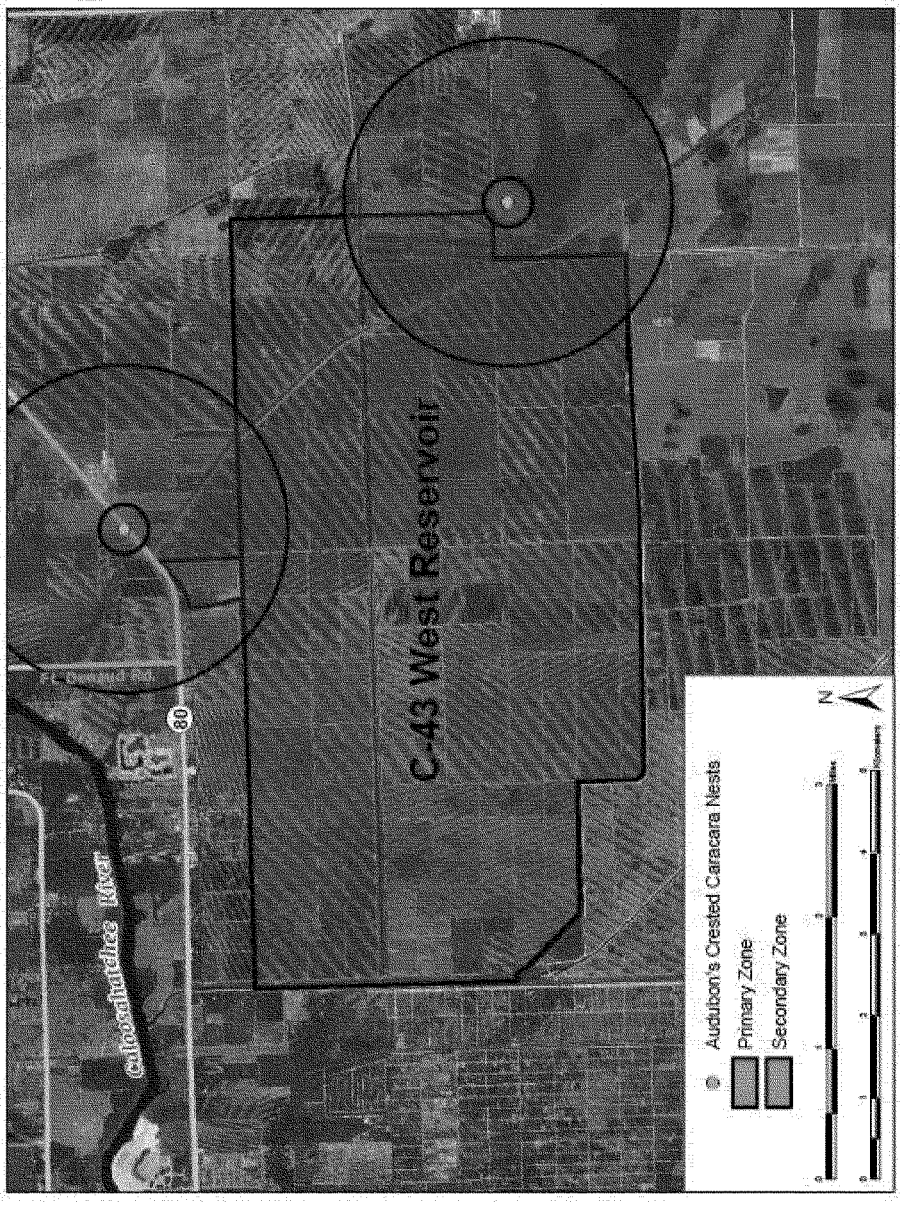


Figure 18. Audubon's Crested Caracara Nest Locations within the C-43 West Reservoir Project Area.

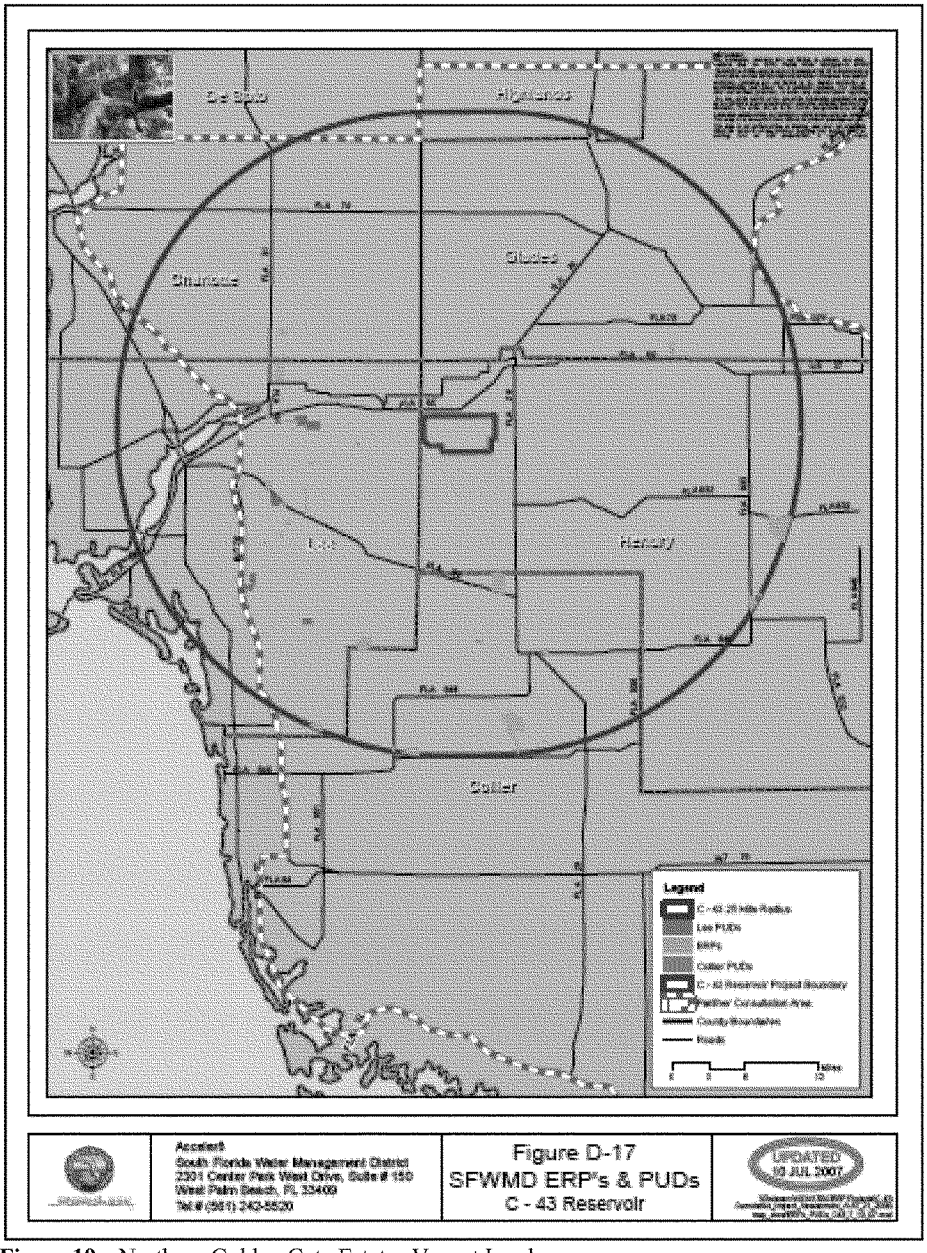


Figure 19. Northern Golden Gate Estates Vacant Lands.

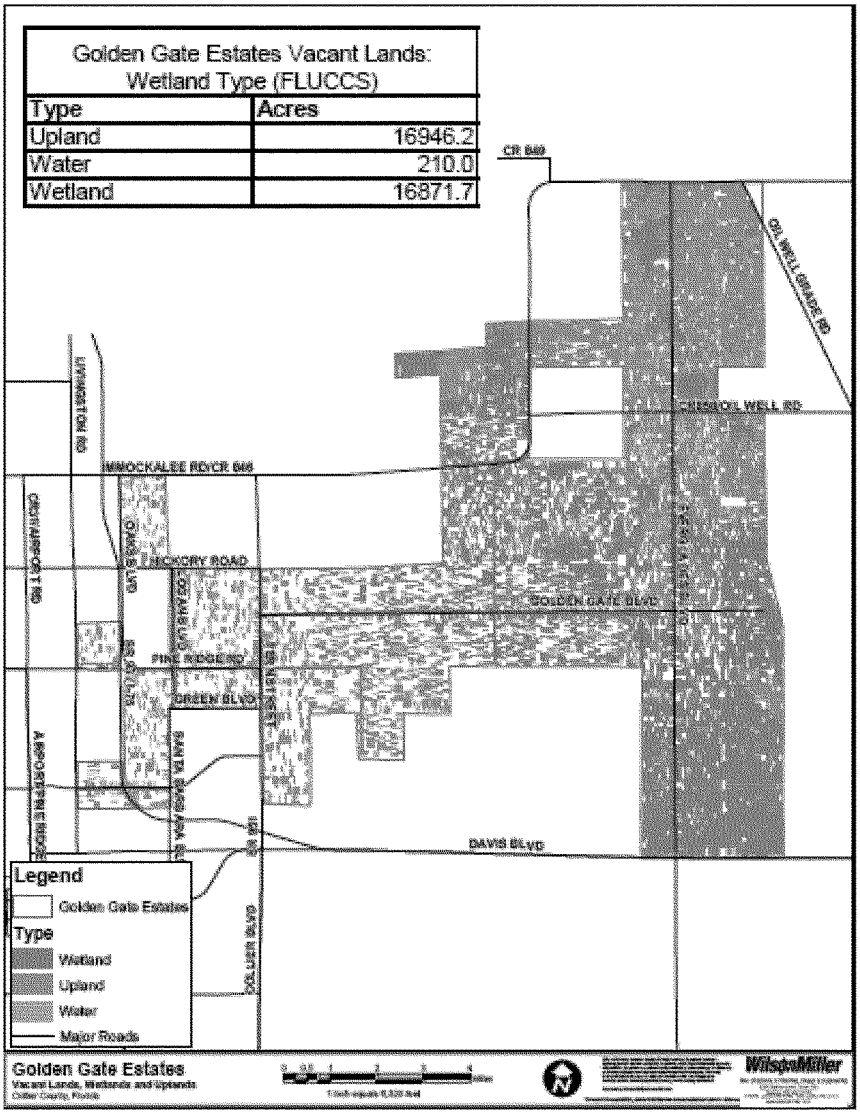


Figure 20. Northern Golden Gate Estates Vacant Lands.

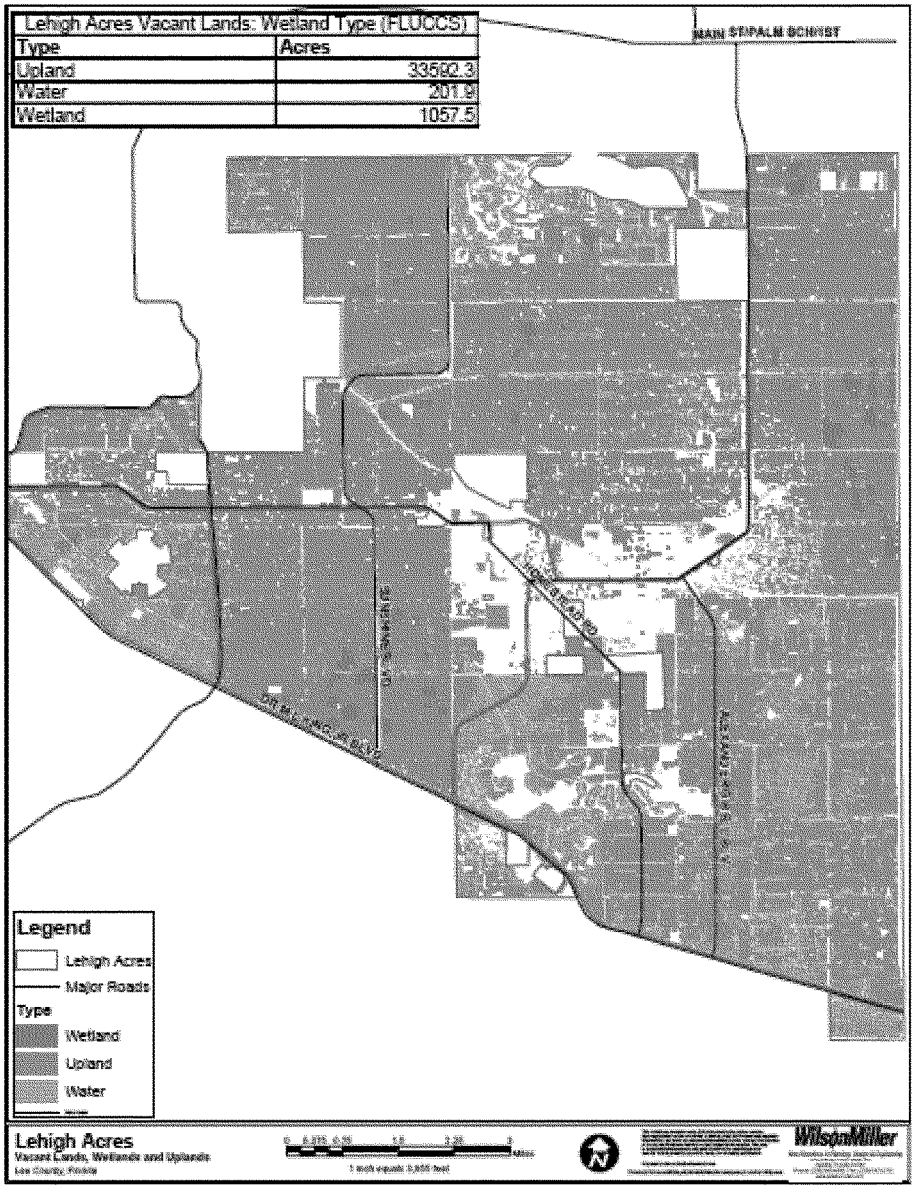


Figure 21. Lehigh Acres Vacant Lands.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

July 17, 2007

Colonel Paul L. Grosskruger
District Commander
U.S. Army Corps of Engineers
701 San Marco Boulevard, Room 372
Jacksonville, Florida 32207-8175

Service Federal Activity Code: 41420-2006-FA-0443
Project: C-43 Basin Storage Reservoir

Dear Colonel Grosskruger:

The enclosed document is the final Fish and Wildlife Coordination Act (FWCA) report for the Caloosahatchee River (C-43) West Basin Storage Reservoir (C-43 West Storage Reservoir) Project for your review. This report is provided by the Fish and Wildlife Service (Service) in accordance with the FWCA of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq.*) and the Endangered Species Act of 1973, as amended (Act) (87 Stat. 884; 16 U.S.C. 1531 *et seq.*).

The Service and the U.S. Army Corps of Engineers (Corps) have been actively engaged over several years to plan this project. The Service supports the Corps' preferred alternative identified in the draft Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS) (Corps and South Florida Water Management District 2007).

This report does not constitute a biological opinion as described under section 7 of the Act. The Service is currently in the process of preparing a biological opinion for this project, which will address the project impacts on the Florida panther (*Puma concolor coryi*), Audubon's crested caracara (*Polyborus plancus audobonii*), eastern indigo snake (*Drymarchon corais couperi*), and other listed species. After consultation is concluded, if modifications are made to the selected plan or if additional information involving potential impacts to listed species becomes available, reinitiation of consultation may be necessary.

On June 27, 2007, the Florida Fish and Wildlife Conservation Commission concurred with the findings and recommendations contained within the draft FWCA report. A copy of those comments are included as an appendix to this report. This final FWCA report constitutes the Secretary of the Interior's recommendations for the C-43 West Storage Reservoir project, in accordance with section 2(b) of the FWCA, and will be incorporated into the Corps' final PIR and EIS for public review and comment in accordance with the provisions of the National Environmental Policy Act.

Colonel Paul L. Grosskruger Page 2

If you or your staff has any questions regarding the findings and recommendations contained in this final FWCA report, please contact Joyce Mazourek at 239-472-1100, extension 231. The cooperation of your staff and the staff of the South Florida Water Management District is greatly appreciated.

Sincerely yours,

Paul Souza
Field Supervisor
South Florida Ecological Services Office

Enclosure

cc: w/enclosure
Corps, Jacksonville, Florida (Beth Marlowe)
Corps, West Palm Beach, Florida (Tori White)
District, Fort Myers, Florida (Janet Starnes)
DOI, Miami, Florida (Terrence Salt)
EPA, Jacksonville, Florida (Eric Hughes)
FWC, Okeechobee, Florida (Don Fox)
FWC, Tallahassee, Florida (MaryAnne Poole)
NOAA Fisheries, West Palm Beach, Florida (Audra Livergood)
Service, Atlanta, Georgia (Fernando Nunez)
Service, Jacksonville, Florida (Miles Meyer)
Service, J.N. "Ding" Darling NWR, Sanibel, Florida (Rob Jess)

Fish and Wildlife Coordination Act Report

CALOOSAHATCHEE RIVER (C-43)
WEST BASIN STORAGE RESERVOIR PROJECT

Submitted to:
Jacksonville District
U.S. Army Corps of Engineers
Jacksonville, Florida

Prepared by: Joyce Mazourek
Reviewed by: Todd E. Hopkins and Pam Repp
Approved by: Paul Souza

Fish and Wildlife Service
South Florida Ecological Services Office
Vero Beach, Florida

July 16, 2007

EXECUTIVE SUMMARY

The Central and Southern Florida Comprehensive Review Study, Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (Restudy) established the need for and the beneficial effects of an above-ground reservoir in the Caloosahatchee River (*i.e.,* Canal-43 or C-43) basin as part of a comprehensive plan to achieve restoration objectives for the Caloosahatchee Estuary. The Restudy included two primary structural components focused on improving environmental conditions in the Caloosahatchee River and Estuary: 1) a 160,000 acre-foot reservoir with associated aquifer storage and recovery (ASR) wells; and 2) basin runoff backpumping and stormwater treatment. Due to technical uncertainty and implementation issues, the ASR features originally associated with a storage reservoir in the Caloosahatchee Basin will be evaluated and implemented separately. The availability and effectiveness of storing basin runoff for backpumping to the C-43 Canal and Lake Okeechobee has been called into question since completion of the Restudy and will be re-evaluated as part of future Comprehensive Everglades Restoration Plan (CERP) updates. As such, this document discusses only the Caloosahatchee River West Basin Storage Reservoir (C-43 West Storage Reservoir) project, one of 68 components identified for Everglades restoration located in the Caloosahatchee River Basin in the Lower West Coast Region of Florida.

The purpose and scope of the C-43 West Storage Reservoir project is to restore the ecosystem function in the Caloosahatchee Estuary by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuary system and to maintain a desirable minimum flow of fresh water to the estuary during dry periods. The project may also achieve water supply benefits, some flood attenuation, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The proposed reservoir footprint is located in Hendry County west of LaBelle, Florida, on approximately 10,492 acres south of State Road 80 and approximately two miles west of State Road 29. The majority of the property is owned by the South Florida Water Management District (District) and is under a lease agreement with Jack M. Berry, Inc. for continued citrus grove operations.

The Caloosahatchee River and Estuary is at the head of a vast estuarine and marine ecosystem that includes aquatic preserves (AP) managed by the State of Florida (*e.g.,* Matlacha Pass AP, Estero Bay AP, Pine Island Sound AP), as well as the federally designated Charlotte Harbor National Estuary Program, the J.N. "Ding" Darling National Wildlife Refuge Complex, and numerous other state and local parks and recreation areas. In 2006 the American Rivers organization listed the Caloosahatchee River as one of the top ten endangered rivers in the United States. Restoration of healthy, productive aquatic ecosystems in the Caloosahatchee River and estuary is essential to maintaining the ecological integrity and associated economic activity in these publicly owned and managed areas. The major environmental concerns for the estuary and adjacent waters are altered freshwater inflows and extreme variation in salinity levels, eutrophication, and habitat loss. Altered salinity in the estuary has resulted from hydrological modifications that have dramatically changed the natural quantity, quality, timing, and distribution of freshwater flows to the estuary. Salinity is a major ecological variable that controls important aspects of the estuarine community structure and food web. Flow alterations

impact the natural biodiversity of the estuary by affecting food availability, predation pressure, and reproductive success, as well as directly causing chronic and acute stress on biota.

Seventeen federally listed threatened or endangered animal species, two listed plant species, and one endangered fish species are present or potentially present in the study area or proposed project footprint, and may be impacted by the construction and operations of the project. Although some of these species may be impacted by the loss of habitat within the project footprint, when implemented, the project has the potential to significantly contribute towards environmental restoration beyond the project footprint.

The Service notes differences in methods and models used for plan formulation, alternative selection, and alternative analyses which add complexity to comparisons. Plan formulation and selection for the C-43 project was based on MIKE SHE hydrologic model output containing a significant error in the water budget. A separate spreadsheet analysis, based on output from the South Florida Water Management Model was used to evaluate the next added increment analysis for the preferred alternative (3B). Compliance with Saving Clause requirements were modeled using a spreadsheet analysis for system-wide effects and a localized reservoir model for project level impacts. Model assumptions, boundary conditions, and level of risk and uncertainty varied among modeling efforts.

The Service recognizes the importance of this project as an initial step to improve the timing and quantity of freshwater flows to the Caloosahatchee Estuary and adjacent waters and to enhance or conserve aquatic and estuarine habitats. In support of those objectives, we provide the following recommendations:

1. The Corps and District should consult with natural resource agencies in developing a detailed project operating manual for the reservoir to ensure restoration objectives are met. The operational plan should include the regulation schedules, operating criteria, and additional provisions as may be required to collect, analyze, and disseminate basic data. Detailed operating instructions to ensure that the project meets the restoration goals and targets should also be included in the form of a draft, interim, preliminary, and final operational plan. The water resource allocation for the natural system as described in the Project Implementation Report (PIR) should be utilized and described in both documents as the project progresses. An adaptive assessment team should meet when operations begin, during interim construction operations, and after construction to review the operational plan in concert with the information obtained from the Water Quality and Ecological Monitoring Plans to assure that restoration benefits are being met and that operations are optimized for restoration (Annex D in the Draft PIR).

2. The Service recommends that the hydrologic monitoring plan in Section D.2 of Annex D in the PIR be expanded beyond the immediate footprint of the reservoir to include both existing canals and adjacent and upstream wetlands to ensure operation of the reservoir will not result in adverse impacts to the Spirit-of-the Wild (SOW) Wildlife Management Area (WMA) and the Okaloacoochee Slough State Forest (OSSF) WMA, and that the Corps formulate and incorporate related ecological hypotheses to be tested in the adaptive management protocol in

Section D.4 of Annex D in the PIR. Emphasis should be placed on acquiring pre-project baseline data for existing canals (*i.e.,* Roberts Canal) that can either provide direct or indirect drainage of areas of concern such as the SOW and the OSSF WMAs.

3. The Corps should evaluate results of the Test Cell Water Quality Monitoring Plan and incorporate that information in the reservoir design and water management operation and maintenance plan to maximize the reduction of nutrient loads from C-43 West Reservoir outflows.

4. The Service recommends that the Corps use the results from the Test Cell Water Quality Monitoring Plan to further evaluate: the quality of water while it is retained within the reservoir; the quality of water released from the reservoir and its potential effects on water quality of flows discharged at S-79; and, the effects of the quality and volume of water released at S-79 on the estuary.

5. The Service recommends that the Corps monitor the water quality effects of the project consistent with the Water Quality portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR).

6. The Service recommends that the Corps monitor the surface water and groundwater effects of the project consistent with the Water Quality portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR) and recommendation number 2 above.

7. The Service recommends that the Corps monitor effects of the project on estuarine resources consistent with the estuarine portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR).

8. The Service recommends that the Corps implement the adaptive management protocols consistent with the Draft Project Operating Manual and Monitoring Plan.

9. If ASR wells are not constructed around the reservoir perimeter, the Service recommends that the Corps and the District expand the littoral zones created along the seepage canals.

10. The Service recommends that compatible public recreational opportunities which do not conflict with the primary function of the reservoir be provided in accordance with State Rule 40E-7.

11. The Service recommends that the Corps or District pursuit funding for oyster reef restoration by placement of hard substrate in the estuary through other programs to increase the likelihood of oyster reef expansion to 30 acres over a 10- to 15-year period and 100 acres over the project life. Although the proposed project will improve salinity conditions for oysters and associated flora and fauna in the middle estuary, oyster expansion is directly tied to the availability of hard substrate for colonization.

The Service has participated in the development and review of alternatives for the C-43 West Storage Reservoir project since it was initiated. Throughout the evaluation process we have provided recommendations involving the location, refinement, and selection of project alternatives based on ecological considerations onsite and within the Caloosahatchee Estuary. The Service believes that the selected plan could provide meaningful hydrologic, economic, and ecological improvements to the Caloosahatchee Estuary. Project operations will benefit the upper Caloosahatchee Estuary by augmenting low flows during dry periods and reduce the number of times the estuary suffers from high salinity, and to a lesser extent, will benefit the lower estuary by reducing the number of high flow events during the wet season.

ACKNOWLEDGEMENTS

The Service acknowledges Emily Boughner, Kim Dryden, John Galvez, Steve Glass, Todd Hopkins, LeeAnn Kelso, Freddie James, Anne Philip, Brad Rieck, Pamela Repp, and Art Roybal for their assistance in writing, reviewing, and preparing the Draft and Final Fish and Wildlife Coordination Act Reports.

The Service appreciates the cooperation of the C-43 West Basin Storage Reservoir project team for responding to our recommendations throughout the planning process, and we remain committed to assist in addressing our remaining recommendations to further enhance fish and wildlife resources as detailed project plans are reviewed and the project is constructed.

TABLE OF CONTENTS

EXECUTIVE SUMMARY i
ACKNOWLEDGEMENTS iv
LIST OF ACRONYMS AND ABBREVIATIONS USED IN THE TEXT viii
I. PURPOSE, SCOPE, AND AUTHORITY 1
A. Introduction 1
B. Purpose and Scope of Project 2
C. Authority 3
II. PREVIOUS SERVICE INVOLVEMENT IN THE C-43 WEST STORAGE RESERVOIR PROJECT 4
III. AREA SETTING 19
A. Project Location 19
B. Description of Study Area 20
1. Hydrological Description 20
a. Primary Drainage Basins 21
b. Surface and Ground Water 22
2. Geology and Soils 23
3. Land Use 24
4. Water Quality 24
5. Ecological Description 26
a. Upland and Freshwater Habitats 26
b. Coastal and Estuarine Habitats 32
6. Fish and Wildlife Resources 35
a. Federally Listed and Candidate Species 35
b. State-listed Species 43
c. Other Fish and Wildlife Resources 44
C. Description of Proposed C-43 West Storage Reservoir Site 46
IV. FISH AND WILDLIFE RESOURCE CONCERNS 47
A. Introduction 47
B. Resource Concerns 47
1. Protection of Estuarine and Marine Resources 47
a. Management of freshwater flows and salinity conditions 48
b. Water Quality Improvement 52
c. Preservation of Habitat Quality 53
2. Hydrologic Modeling Issues 53
a. Errors in MIKE SHE Irrigation Module 53
b. Modeling Uncertainty 54
c. Analyses Required by WRDA 2000 54
3. Adverse Effects of Reservoir Construction 56
a. C-43 Basin Storage Reservoir and the STAR Recommendations 56
b. Reservoir Water Quality 58
c. Loss of On-site Wetland Habitats 60
4. Contaminants 61
5. Recreational Opportunities 63

6. Integrating the Project with Comprehensive Restoration Efforts 64
V. EVALUATION METHODOLOGY 64
A. Evaluation of Estuarine Habitat Benefits for System Formulation 64
B. Evaluation of Hydrologic Performance 68
C. Next-added Increment Analysis 68
VI. FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT 69
VII. DESCRIPTION OF SELECTED PLAN AND OTHER ALTERNATIVES 71
A. Background 71
B. Alternatives Considered 72
C. Selected Plan: Alternative 3B 77
VIII. POTENTIAL ADVERSE AND BENEFICIAL EFFECTS OF THE PROJECT 78
A. Construction-Related Effects 78
1. Existing Vegetation/Habitat 78
2. Fish and Wildlife Disturbance 78
3. Fish and Wildlife Benefits 78
4. Contaminants and Disposal/Use of Soils 79
5. Exotic Vegetation 79
B. Operational Effects 79
C. Oyster Reef Restoration 79
D. Summary of Consultation under the Endangered Species Act 80
IX. EVALUATION OF THE PROJECT 83
A. Evaluation of Estuarine Habitat Benefits 83
B. Evaluation of Hydrologic Performance 83
C. Next Added Increment and Plan Selection 84
X. RECOMMENDATIONS/CONSERVATION MEASURES 84
XI. SUMMARY OF POSITION 86
XII. LITERATURE CITED 86
APPENDIX A Fish and Wildlife Recommendations for Comprehensive Everglades Restoration Plan Stormwater Treatment Area and Reservoir Operation and Design A-1
APPENDIX B Wetland Classification, Wetland Rapid Assessment Procedure Data Sheets and Uniform Mitigation Assessment Method Data Sheets for the C-43 West Reservoir Project B-1
APPENDIX C Comment Letter from the Florida Fish and Wildlife Commission on the Draft Fish and Wildlife Coordination Act Report C-1

LIST OF TABLES

Table 1. Federally Listed Threatened (T) and Endangered (E) Species known or expected to occur within C-43 Basin Storage Reservoir Study Project Area....36
Table 2. Species listed by the Florida Fish and Wildlife Conservation Commission as threatened (T), endangered (E), or of special concern (SSC) that potentially occur within the Caloosahatchee River Basin (Charlotte, Lee, Collier, Hendry, and Glades Counties) or the Proposed C-43 West Reservoir footprint excluding federally listed species (Florida Natural Areas Inventory 2001). 43
Table 3. Quality Index Calculations by Environmental Attribute.... 91
Table 4. Average Annual Habit Units by Alternative. 91
Table 5. Functional Assessment of Jurisdictional Wetlands and Waters of the United States Affected by the C-43 West Reservoir 92
Table 6. EST05 Target Flow Distribution at S-79.... 93
Table 7. Comparison and Summary of Alternatives. 93
Table 8. Summary of Mean Monthly Flow Events AT S-79 within Different Flow Ranges. 94
Table 9. Comparison of the Next-added Increment (NAI) Analysis to the System Formulation or Last-Added Increment (LAI) Analysis.... 94

LIST OF FIGURES

Figure 1. C-43 Basin Storage Reservoir Project Study Area (Figure adapted from Conservancy of Southwest Florida 2005).....95
Figure 2. Proposed C-43 Basin Storage Reservoir Location.....96
Figure 3. Primary Drainage Basins of the Caloosahatchee River Basin.....97
Figure 4. Florida Department of Environmental Protection Impaired Waters Rule Assessment (Figure adapted from CHNEP 2006).....98
Figure 5. Florida Land Use Cover and Classification in the Caloosahatchee River Basin.....99
Figure 6. Current Distribution of Subermerged Aquatic Vegetation in the Caloosahatchee Estuary.....100
Figure 7. Caloosahatchee Estuary and Salinity Stations.....101
Figure 8. Daily Average Salinity Collected by Continuous Sensors at Two Downstream Locations (Cape Coral Bridge and Shell Point at the river mouth) in the Caloosahatchee Estuary.....102
Figure 9. Total discharge into the Caloosahatchee Estuary from Lake Okeechobee and the Caloosahatchee Watershed at S-79.....103
Figure 10. C-43 Basin Storage Reservoir: Jurisdictional Wetlands and Surface Waters of the United States.....104
Figure 11. C-43 Basin Storage Reservoir: Phase I and II Environmental Assessments.....105
Figure 12. Area of Caloosahatachee Modeled for Habitat Benefits Calculations by Species. ...106
Figure 13. Habitat Unit Combination Methodology.....107
Figure 14. Typical Site Plan for Alternatives.....108
Figure 15. Distribution of Mean Monthly Flows Less than 450 cfs at S-79.....109

LIST OF ACRONYMS AND ABBREVIATIONS USED IN THE TEXT

Acceler8	A State program of accelerated action on eight projects
ac-ft	Acre-feet
AFB	Alternatives Formulation Briefing
AID	Acme Improvement District
AIW	Atlantic Intracoastal Waterway
AP	Aquatic Preserve
ASR	Aquifer Storage and Recovery
BA	Biological Assessment
CA	Consultation Area
C-43 or Canal-43	Caloosahatchee River
C&SF	Central and Southern Florida Project
CERP	Comprehensive Everglades Restoration Plan
CFA	Core Foraging Area
cfs	Cubic feet per second
CHE	Charlotte Harbor Estuary
CHNEP	Charlotte Harbor National Estuary Program
Corps	U.S. Army Corps of Engineers
CWMP	Caloosahatchee Water Management Plan
DEP	Florida Department of Environmental Protection
District	South Florida Water Management District
DO	dissolved oxygen
DOI	Department of Interior
PIR/EIS	Project Implementation Report/Environmental Impact Statement
EIS	Environmental Impact Statement
ESA	Endangered Species Act
EST05	An average monthly flow distribution between 450 and 2,800 cfs at S-79
FAS	Floridan aquifer system
FLUCCS	Florida Land Use Cover and Classification System
FSM	Feasibility Scoping Meeting
Ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
FWCA	Fish and Wildlife Coordination Act
FWRI	Florida Wildlife Research Institute
GIS	Geographic Information System
HTRW	Hazardous, Toxic, and Radioactive Waste
IAS	Intermediate Aquifer System
IWR	Impaired Waters Report
kg	kilogram
LEC	Lower East Coast
LNWR	Arthur R. Marshall Loxahatchee National Wildlife Refuge
MFL	Minimum Flow and Level
mg/L	milligram per liter
MPMP	Master Program Management Plan

NEPA	National Environmental Policy Act
NGVD	National Vertical Geodetic Datum
NOAA Fisheries	National Marine Fisheries Service
NSID	North Springs Improvement District
NWR	National Wildlife Refuge
PA	Preferred Alternative
PAL	Planning Aid Letter
PDT	Project Delivery Team
PIR	Project Implementation Report
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
Restudy	Southern Florida Comprehensive Review Study
RBHS	Regional Biodiversity Hot Spots
RCRA	Resource Conservation Recovery Act
RECOVER	Restoration Coordination and Verification
ROW	right-of-way
S-79	W.P. Franklin Lock and Dam
SAP	Selected Alterative Plan
SAS	Surficial Aquifer System
SAV	Submerged Aquatic Vegetation
SSC	Species of Special Concern
Service	Fish and Wildlife Service
SFWMM	South Florida Water Management Model
SHCA	Strategic Habitat Conservation Areas
STA	Storm water Treatment Area
STORET	STOrage and RETrieval database
SWFFS	Southwest Florida Feasibility Study
TMDL	Total Daily Maximum Load
TN	Total nitrogen
USGS	United States Geological Survey
UMAM	Uniform Mitigation Assessment Method
ug/kg	microgram per kilogram
ug/l	micrograms per liter
VEC	Values ecosystem component
WCA	Water Conservation Area
WPA	Water Preserve Area
WQ	Water Quality Monitoring Plan
WRAP	Wetland Rapid Assessment Procedure
WRDA	Water Resources Development Act
WY	Water year

I. PURPOSE, SCOPE, AND AUTHORITY

A. Introduction

The Comprehensive Everglades Restoration Plan (CERP) was approved as a framework for the restoration of the natural system under Section 601 of the Water Resources Development Act of 2000 (WRDA 2000). The CERP consists of 68 components to restore, preserve, and protect the South Florida Ecosystem while providing for other water-related needs of the region. CERP's components will be implemented over an approximately 40-year period. Together, these components will benefit the ecological functioning of more than 2.4 million acres of the south Florida ecosystem by improving and restoring the proper quantity, quality, timing and distribution of water made available for the natural system while also addressing urban and agricultural water supply concerns and maintaining existing levels of flood protection.

Previous ecosystem restoration and water supply planning efforts, including the Central and Southern Florida Comprehensive Review Study, Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (Restudy) (U.S. Army Corps of Engineers [Corps] and South Florida Water Management District [District] 1999) have established the need for and the beneficial effects of an above-ground reservoir in the Caloosahatchee River (*i.e.*, Canal-43 or C-43) basin as part of a comprehensive plan to achieve restoration objectives for the Caloosahatchee Estuary. The Restudy included two primary structural components focused on improving environmental conditions in the Caloosahatchee River and Estuary: (1) a 160,000 acre-foot (ac-ft) reservoir with associated aquifer storage and recovery (ASR) wells; and (2) basin runoff backpumping and stormwater treatment. Due to technical uncertainty and implementation issues, the ASR features originally associated with a storage reservoir in the Caloosahatchee Basin will be evaluated and implemented separately. The availability and effectiveness of storing basin runoff for backpumping to the C-43 Canal and Lake Okeechobee has been called into question since completion of the Restudy and will be re-evaluated as part of future CERP updates. The C-43 Basin Storage Reservoir (BSR) Project is one of 68 components identified for Everglades restoration and is located in the Caloosahatchee River Basin in the Lower West Coast Region of Florida. The C-43 West Storage Reservoir project is one of several projects authorized for implementation in Section 601(b)(2)(C)(ii) of WRDA 2000, and has been identified as the C-43 West Storage Reservoir "Acceler8" project.

The State of Florida has developed a plan called "Acceler8" for the purpose of accelerating design and construction of a number of critical restoration projects consistent with the CERP prior to one or more of the following: administration approval, congressional committee resolution, congressional authorization, or Federal construction funding. The State anticipates the Acceler8 program will provide immediate environmental, social, and economic benefits in the south Florida region. All Acceler8 projects must be specifically authorized by Congress before becoming a part of the Federal CERP. The District is the state agency responsible for water resources management in south Florida and acts as the non-federal sponsor for Federal water resources projects, including the CERP and is responsible for implementing the Acceler8 plan.

The District proposes to initiate construction of the C-43 West Reservoir Acceler8 project prior to implementation of the Federal C-43 Basin Storage Reservoir Project, Part 1. The Corps is proceeding with two separate and independent but related actions, the feasibility-level evaluation of the Federal project and the regulatory evaluation of the District's proposed Acceler8 project, both of which are described in the Draft Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS). The District's C-43 West Reservoir Acceler8 project is the same as the National Environmental Policy Act (NEPA) preferred alternative or Federal Recommended Plan, described in the Draft PIR and EIS (Corps and District 2006). The purposes of the Federal Recommended Plan identified in this Draft PIR and the District's Acceler8 project are consistent. Therefore, it is anticipated that this Draft PIR and EIS will also serve as the basis for the Regulatory Division's NEPA evaluation of the District's proposed Acceler8 project.

The information provided in this Fish and Wildlife Service (Service) Fish and Wildlife Coordination Act (FWCA) report for the C-43 West Storage Reservoir project is based on information contained in the PIR and EIS, and other communication with the Corps and District. This report discusses the ecological effects of the project for all alternatives and the preferred alternative (PA). The PA is referred to as the selected alternative plan (SAP) in the Draft PIR and EIS.

B. Purpose and Scope of Project

The purpose and scope of the C-43 BSR and ASR Project as defined by CERP is to capture C-43 Basin runoff and releases from Lake Okeechobee to provide environmental water supply deliveries to the Caloosahatchee Estuary and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. Facilities could be designed to provide water supply benefits and some flood attenuation.

The Restudy project features included:

- An above-ground reservoir with total storage capacity of approximately 160,000 acre-feet, and
- Aquifer storage and recovery wells with a capacity of approximately 220 million gallons per day and associated pre and post-water quality treatment.

The storage amount for the above-ground reservoir was established through various previously completed modeling efforts. In the Restudy analysis of the C-43 Basin, an acceptable salinity range for the estuarine ecosystem was established which translated into monthly freshwater inflows of 300 cubic feet per second (cfs) to 2,800 cfs at the W.P. Franklin Lock and Dam (S-79) which is the most downstream structure and marks the upstream extent of the Caloosahatchee Estuary. This flow target included the need for low flow augmentation and minimizing high flow discharge events to improve estuarine water quality and to protect and restore estuarine habitat and biota. This flow target at S-79 helped produce modeling results indicating the most efficient size for determining the storage capacity of reservoirs to capture local basin and Lake Okeechobee inflows.

In order to address these changing conditions and other issues and concerns that have arisen since the Restudy analysis of the project, it was decided that the Part I C-43 Basin Storage Reservoir project would be separated into two phases:

- Phase I – will address the most immediate needs of the estuary
- Phase II – will provide a comprehensive solution for the needs of the entire basin

Part I, Phase I of the C-43 West Storage Reservoir project will focus on restoration of the western Caloosahatchee River Basin and Estuary through hydrologic modification. Phase I seeks to reduce excessive high flows to the estuary during the wet season, while increasing availability of water for the estuarine system during the dry season. This improved hydrologic regime would establish a downstream salinity range suitable for a healthy estuarine ecosystem thereby promoting increased fish and wildlife abundance, and increased biological richness. Phase I is a separable element from Phase II and therefore will be evaluated and justified as an independent project.

The focus of the PIR/EIS was to optimize the C-43 West Reservoir as part of the first phase of the C-43 West Storage Reservoir project. The PIR/EIS for Phase I of the C-43 West Storage Reservoir project provides a solution for the immediate needs of the estuary, while anticipating that there will be unmet demands and needs (potentially both environmental and water supply needs) to be met in a future phase. Water quality features, if necessary to achieve the restoration objectives for the basin and to meet regulatory requirements, will also be addressed in a future phase.

The Part I, Phase II PIR will have two points of focus: (1) addressing those additional needs not met in the Western C-43 Basin that are identified in this PIR, and (2) identifying and addressing the need of the Eastern C-43 Basin which may include agricultural and urban water supply demands and needs. Water quality features, if necessary to achieve the restoration objectives for the basin and to meet regulatory requirements, will be addressed in the Part I, Phase II PIR. Cost-sharing will be in accordance with Federal cost-sharing policy requirements. Although this phased approach defers solving the problems of the upper basin to another PIR, it provides a mechanism for addressing the immediate problems and needs of the Caloosahatchee Estuary.

C. Authority

This Final FWCA report constitutes the report of the Secretary of the Interior as required by section 2(b) of the FWCA of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq.*), which establishes fish and wildlife conservation as a co-equal purpose or objective of federally funded or permitted water resource development projects. The FWCA allows for reports and recommendations from the Service and the State agency exercising administration over wildlife resources (in this case, the Florida Fish and Wildlife Conservation Commission [FWC]) to be integrated into Corps reports seeking authorization for the Federal action. The FWCA also grants authority to the Corps to include fish and wildlife conservation measures within these projects. Other authorities relevant to Service participation in the planning process for this

project include the Endangered Species Act of 1973, as amended (Act) (87 Stat. 884; 16 U.S.C. 1531 *et seq.*), the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 *et seq.*), the Bald and Golden Eagle Protection Act (16 U.S.C. §668 *et seq.*), and the Migratory Bird Treaty Act (16 U.S.C. § 703 *et seq.*).

The WRDA 2000 provides authority for the CERP and section 601(b)(2)(C)(ii) of the WRDA 2000 provides specific authority for implementing the C-43 Basin Storage Reservoir and ASR Project. The Corps and the District have executed a Design Agreement for the Design of Elements of the Comprehensive Plan for the Everglades and South Florida Ecosystem Restoration Project (Design Agreement) May 2000. The direction and guidance for the development of this project are contained within the CERP Master Program Management Plan (MPMP) developed and approved by the Corps and the District for the purposes of describing the framework and processes to be used by the Corps and District for managing and monitoring implementation of CERP. During completion of the MPMP in August of 2000, (Corps and District 2000) the project was divided into two parts, Part 1: The C-43 Basin Storage Reservoir Project (C-43 BSR)(D-Part 1), and Part 2: The C-43 Basin ASR Project (D-Part 2). The projects were separated to accommodate the inclusion of the findings of the Caloosahatchee ASR Pilot Project without delaying the implementation of the reservoir aspect of the project.

II. PREVIOUS SERVICE INVOLVEMENT IN THE C-43 WEST STORAGE RESERVOIR PROJECT

The Service participated in all project-related public workshops and NEPA hearings, PDT meetings and working subgroup meetings, field site inspections, and conference calls from 2002 to present. The following chronology includes most of the major milestones since. Additional meetings, conference calls, and correspondence are not included in this list.

The Service received a Phase I and II environmental Assessment Report for the Berry Labelle-Congen Grove dated December 6, 1999.

In response to the Corps' February 25, 2002, request, the Service provided information on fish and wildlife resources included federally-listed species that may be within the proposed reservoir locations or affected by the activities of the C-43 Basin Storage Reservoir in our April 11, 2002, Planning Aid Letter (PAL). The site-selection sub-team used this information guide the site selection process by focusing on suitable reservoir locations that would minimize impacts to fish and wildlife resources.

On March 18, 2003, the Service provided the C-43 Corps project planning leader with a boat tour of the J.N. "Ding" Darling refuge, as well as the Caloosahatchee Estuary.

On March 20, 2003, site selection sub-team led by the Service, presented new updated preliminary site locations for potential reservoirs in the Caloosahatchee Basin overlayed on various GIS cover type maps.

On March 31, 2003, the Service met with Jim Beever (FWC) and Sandy Scheda (SEA) to review the new reservoir location maps and to apply the matrix to the revised map. Two sites dropped out due to conflicts with panther habitat, specifically, the Caloosahatchee ecoscape.

On April 30, and May 1, 2003, the Service assisted the Corps by providing listed species maps within Caloosahatchee Basin for use in the reservoir siting process and explained these maps at an Environmental Stakeholders meeting (April 30) and public meeting on (May 1).

In a letter dated May 19, 2003, the Service provided comments on the March 3, 2003, Phase I and II Environmental Site Assessment for the Griffin Brothers property. In that letter, the Service recommended further delineation of pentachlorophenol (PCP) in the canal in the vicinity of the S5 sample location.

On June 10, 2003, the Service provided scoping comments under the National Environmental Policy Act for development of the Draft Environmental Impact Statement for the C-43 Basin Storage Reservoir Project, including information on federally-listed species that may be affected by the proposed project.

The Service provided information on listed species distributions to Alternative Selection sub-team on June 13 and June 26 to refine the list of potential reservoir locations in the Caloosahatchee Basin.

On June 25, 2003 Service biologists met to begin developing an ecological model for the C-43 project to assist the C-43 Basin Storage Reservoir Project Delivery Team (PDT) in determining appropriate locations for reservoirs within the Caloosahatchee Basin.

On July 14, 2003, the Service provided comments on the March 25, 2003, Phase I and II Environmental Site Assessment for the Winthrop Citrus Investors property (Winthrop property). In that letter, the Service recommended delineation of aldrin contamination.

The Service provided additional information on direct and indirect impacts to significant fish and wildlife resources in the project area in an August 13, 2003, PAL. That letter addressed wetland and upland habitats of significant importance, federally-listed species, and potential contaminant issues.

Service staff participated in the October 23, 2003, PDT meeting, where the Corps officially announced that the District was pursuing the Berry Groves Reservoir as an "Early Start" project on their own and the Corps' PIR process would continue concurrently.

On October 30, 2003, Service and District staff met to discuss the development and application of a completed ecological model of the Caloosahatchee Basin to assist in reservoir site selection within the Basin.

From December 1 to December 5, 2003, the Service participated in a video teleconference In-Progress Review, which included the C-43 project, and was held in Fort Myers. A major point

of discussion revolved around whether or not to expand the water quality objectives such as nutrient levels of the C-43 project within the context of the Southwest Florida Feasibility Study (SWFFS).

On March 31, 2004, the PDT met at the District's Lower West Coast Regional Service Center.

On March 31, 2004, the Service received a proposal for the Phase I and II Environmental Site Assessment for the Brian Paul Citrus Grove. The Service requested that zinc be added to list of metals analyzed via an April 8, 2004, email.

On April 19 and 20, 2004, the environmental sub-team discussed a plan to conduct a Wetland Rapid Assessment Procedure (WRAP) to assess wetland values and functions at the Berry Grove and Lake Hicpochee proposed reservoir sites.

On May 14, 2004 the Service met with the Corps and District in Clewiston to prepare and coordinate logistics for the WRAP of Berry Groves and other potential sites for the C-43.

Service, Corps, and District staff conducted wetland assessments using WRAP and the Uniform Mitigation Assessment Method (UMAM) of Berry Groves. Ground surveys were conducted on June 8, 9, and 10, 2004, followed by aerial surveys on June 14 and 15, 2004.

Service, Corps, and District staff completed ground and aerial wetland assessments using WRAP and UMAM at Berry Groves on July 13, 14, and 15, 2004.

The Service reviewed additional information provided by Environmental Consulting and Technology, Incorporated, (ECT) regarding aldrin contamination on the Winthrop property and agreed in a July 1, 2004, letter, that no further aldrin delineation was necessary.

On July 20, 2004, Service staff met with the District, FWC, and Scheda Ecological Associates, to discuss the boundary change for the Berry Groves reservoir. Due to the change in the project boundary, additional consultation on potential project impacts to federally listed species, including the Florida panther, Audubon's crested caracara, Everglades snail kite, wood stork, and Florida grasshopper sparrow, will be necessary. The southern boundary was expanded to include the Duda property in the southwest and southeast corners. The southeast corner contains pine flatwoods, cypress slough, saw palmetto, and lightly wooded pasture that was previously farmed. The latter area has also been identified as Primary and Secondary Zones for the panther.

Additional information on PCP contamination on the Griffin Brothers property was provided by the District via an August 11, 2004, letter, prepared by ECT. Based on that information, the Service agreed no further delineation of PCP was needed in an October 13, 2004, letter.

On August 17, 2004, the Service received the Phase I and II Environmental Site Assessment report for the Bryan Paul Citrus Grove. In our September 20, 2004, letter, the Service requested further evaluation and remediation for Chlordane. Additional information regarding our letter was provided by Tetra Tech on December 22, 2004.

During August 2004, Service staff reviewed and provided informal comments on the draft Existing Conditions chapter prepared by the Corps for the C-43 BSR EIS.

On August 24, 2004, Service staff attended the Regional PDT meeting. The agenda included a review of the C-43 BSR project status.

In September 2004, Service staff reviewed and provided informal comments on the draft Problems and Opportunities chapter prepared by the Corps for the C-43 BSR Environmental Impact Statement (EIS).

In our October 6, 2004, letter, Service staff provided comments to FDEP on the Draft Verified List of Impaired Waters for the Caloosahatchee Basin and the Total Maximum Daily Load program and the potential benefits or impacts to the J.N. "Ding" Darling NWR.

In October and November, 2004, Service staff assisted the Corps in preparing the draft Future Without Conditions chapter for the C-43 BSR EIS.

On December 1, 2004, Service staff participated in a telephone conference with the Corps and the District regarding C-43 Plan Formulation and Evaluation. Topics discussed included two strategies for performance measures and evaluation of alternatives and needs for the Feasibility Scoping Meeting (FSM) and the FWCA Report.

On December 1, 2004, ECT recommended further delineation of chlordane on the Bryan Paul Citrus Grove in their Screening Level Ecological Risk Assessment for that site.

On December 15, 2004 Service biologists and hydrologist met to review preliminary documentation regarding the hydrologic model to be used for evaluation of the C-43 alternatives and to discuss pros and cons of use of that model.

On December 20, 2004, Service staff provided comments to the Corps on the FSM materials for this project.

The Service reviewed and provided comments via a January 25, 2005, email on the November 17, 2004, proposal for the Phase I and II Environmental Site Assessment for the Bob Paul Citrus Grove. The Service requested complete sampling in the former row crop area.

In early January 2005 Service staff prepared for and conducted wetland assessments using both the WRAP and the UMAM, on five potential secondary reservoir sites in the Lake Hicpochee area, including the lake itself. Data were collected by helicopter on January 10 and 11, 2005, in cooperation with the District and Corps.

On January 12, 2005, Service biologists and hydrologist met with the District, Corps, and Joint Venture staff to review the preliminary design, hydrologic models, and fish and wildlife resource issues for the C-43 project.

On January 11, 2005, staff reviewed and provided comments on the Executive Summary for the FSM document.

On January 18, 2005, Service staff participated in a teleconference with the Corps and the District regarding their Internal Technical Review of the draft FSM document.

On January 20, 2005, staff met with the Corps and the District in Ft. Myers to prepare for the FSM presentation. Talking points, slides, and visual aids were determined and prepared.

On January 21, 2005, the Service attended the C-43 working group meeting in Fort Myers.

On January 28, 2005, Service staff reviewed and provided informal comments on the draft FSM Document.

January 31, 2005, and February 11, 2005, Service staff conducted helicopter surveys to classify wetland habitats within potential reservoir sites in the Lake Hicpochee vicinity. Land ownership and accessibility for ground surveys was also determined.

On February 3, 2005, Service staff met with FWC staff to discuss fish and wildlife resource concerns associated with the C-43 reservoir and the remaining potential alternatives.

On February 4, 2005, staff participated in an interagency teleconference to discuss nitrogen loading in the Caloosahatchee river and estuary. Most of the nitrogen entering the Caloosahatchee is organic, and at this time, it is unknown if the C-43 West reservoir would reduce nitrogen input to the estuary.

On February 4, 2005, Service staff reviewed and prepared slides for the FSM presentation. Staff also prepared poster-sized site screening maps for display during the FSM. The maps showed potential reservoir sites considered in relation to known threatened and endangered species distributions and habitats.

On February 10, 2005, Service staff traveled to Jacksonville to meet with the Corps and District staff to prepare for the FSM.

On February 11, 2005, staff participated in the presentation of the C-43 FSM package to the Corps vertical team. A description of the problems and opportunities in the Caloosahatchee Basin, project planning objectives and constraints, existing conditions in the basin, future without project conditions, preliminary plan formulation and evaluation, and unresolved issues were presented.

On February 18, 2005, Service staff attended the C-43 West Reservoir Stakeholders Meeting in Fort Myers.

On February 23, 2005, staff participated in a teleconference to discuss nitrogen loading in the Caloosahatchee river and estuary. The water quality objectives of the C-43 West reservoir, the reservoir's potential impacts on nitrogen as currently designed, and the potential need for a stormwater treatment area were also discussed.

On February 25, 2005, Service staff reviewed and provided comments on the Basis of Design Report for the C-43 BSR project.

On March 2, 2005, Service staff participated in the Restoration Verification and Coordination (RECOVER) review of the C-43 performance measures via teleconference.

On March 3, 2005, Service staff participated in a teleconference to discuss the C-43 West reservoir Acceler8 schedule and modeling needs.

On March 7, 2005, Service staff attended the Water Resources Advisory Committee (WRAC) Issues Workshop on the C-43 West Reservoir Project in LaBelle.

On March 10, 2005, Service staff participated in the first weekly interagency teleconference to discuss project status and issues, including opportunities to formulate for water quality improvements.

On March 15, 2005, Service staff participated in a teleconference to discuss the current status of the C-43 performance measures (PMs). The project team decided to request that RECOVER postpone their review until the PMs are updated. Specific issues that are currently unresolved are: 1) How do we estimate historic variability and apply to flows under current conditions? 2) Are we looking at the appropriate time scale?

On March 17 and 24, and April 7, 2005, Service staff participated in weekly interagency teleconferences to discuss project status and needs.

On March 21, March 23, and April 4, 2005, Service staff provided comments and guidance on potential methods to rank proposed project alternatives based on degree of match to preferred flow distributions at S-79.

On March 22, 2005, the Service held and interagency meeting at the District office in Fort Myers to discuss potential project impacts on federally and state listed species. Representatives from the District, Corps, FWC, and the Service were in attendance. The discussion focused primarily on the accelerated C-43 West Reservoir component but also applies to the selected alternative plan that will be addressed in the Corps' PIR.

On March 29, 2005, Service staff provided a PAL recommending that the Corps and the District design the C-43 West Reservoir to provide water quality benefits to the estuary by reducing nutrient loads in accordance with CERP Guidance Memorandum Number-Revision 023.01. We also recommended that the Corps and the District conduct further modeling to quantify those benefits.

On March, 30, 2005, Service staff participated in a meeting at the District office in Fort Myers to develop potential alternatives for water storage and restoration of Lake Hicpochee and to estimate hydrologic and biotic quality values for the natural system, existing, and future without project conditions similar to the South Florida Assessment Method. The team evaluated aerial photos taken by Service staff during a January 31, 2005, helicopter flight and a habitat type cover map developed during that flight.

On April 5, 2005, Service staff attended the Lee County Board of County Commissioners meeting in Fort Myers. The District presented the current design of the C-43 West Reservoir to the Board of Commissioners. Water quality issues were discussed, including the need for quantifying reservoir impacts on water quality and the potential need for a test cell. The test cell project would also address seepage concerns raised by local landowners during the March 7, 2005, WRAC public meeting in LaBelle.

On April 28 and May 5, 2005, Service staff participated in weekly interagency teleconferences to discuss project status and needs, specifically use of an existing WAM-View model to provide nutrient concentrations that would then be fed into Ecolab and MIKE SHE models. The nutrient loads could then be used as an evaluation criteria for screening potential alternatives. The existing WAM-View is poorly calibrated and was not created using the 2000 land use or updated rainfall data that the Ecolab and MIKE SHE models are based on. The Service recommended updating and recalibrating the WAM-View using existing and available data for improved confidence in model results.

On May 5, 2005, the Service received the April 29, 2005, draft scope of work for the C-43 West Storage Reservoir Temporary Test (Embankment) Cells from the District.

On May 26, 2005, Service staff met with the Corps, District, SCI, FWC, and SEA to discuss potential adverse effects to threatened and endangered species that may occur as a result of the C-43 West Reservoir Project or the Test Cell Project. The meeting focused on: 1) the latest method for assessing habitat compensation recommended when adverse project effects to habitat used by the Florida panther cannot be avoided or when adverse effects have been minimized but loss will still occur; and 2) the Test Cell Project design, 404 permit needs, and listed species consultation.

During June 2005, the District proposed a land swap with the Department of Interior (DOI) to swap land purchased within the reservoir footprint for land purchased with DOI funds north of the reservoir footprint but adjacent to and south of Highway 80.

On July 11, 2005, Service staff participated in a Natural Systems Group meeting to develop a restoration alternative for Lake Hicpochee. Service staff presented slides of field work conducted in June 2005 to persuade the group that the existing wetlands (short-hydroperiod to permanently flooded) are far more valuable to fish and wildlife than converting the area to an open-water and cattail marsh. The alternative agreed upon will focus on habitat improvements of existing wetlands, including exotic removal, muck removal, reintroduction of fire, etc.

On June 27, 2005, the Corps conducted an interagency site visit to delineate wetland boundaries and assess current conditions within the Test Cell Project footprint. Service, District, SCI, and SEA staff participated in the site visit.

On July 1, 2005, the Service provided comments on the May 27, 2005, Phase I and II Environmental Site Assessment for the Bob Paul Citrus Grove. In that letter, the Service recommended that the District consult with DEP regarding on-site burial of contaminated soil.

On July 18, 2005, Service staff completed the last helicopter surveys of wetlands within the proposed secondary reservoir locations in Glades and Hendry Counties.

On July 19, 2005, Service staff participated in an interagency teleconference on the status of the 404 permit for the C-43 pilot test cells. Service staff informed the Corps and District that no tree clearing or any other ground disturbing activities should be conducted in the test cell site until formal consultation on federally listed species has been completed.

On July 28, 2005, Service staff met with the District, Corps, EPA, FDACS, and SEA staff to review and finalize WRAP scores for the wetlands occurring within the Test Cell Project footprint.

On August 5, 2005, Service staff reviewed and provided comments on the draft Biological Assessment, C-43 West Storage Reservoir Test Cell Pilot Project, Hendry County, Florida to the District's Acceler8 permitting and NEPA staff.

On August 11, 2005, Service staff participated in the re-instated, weekly interagency teleconference to discuss project status and needs.

On August 18 and 25, 2005, Service staff participated in the weekly interagency teleconference to discuss project status and needs. Current issues discussed include hydrologic model status and timelines and savings clause issues.

On August 24, 2005, Service staff participated in a C-43 Natural Systems Group teleconference on the proposed alternative for Lake Hicpochee restoration. Water storage at Lake Hicpochee would only be possible with impoundments that would not achieve restoration goals and would compromise existing wetland values and functions. Lake Hicpochee is very unique and provides a mosaic of wetlands habitats in close proximity, including a range of short-hydroperiod wetlands. Short-hydroperiod wetlands are being lost across the state, and the country, to development which increases the importance and inherent value of wetlands at Lake Hicpochee. Due to Service staff recommendations, an alternative focusing on habitat improvement was developed for this site that includes exotic removal, muck removal, reintroduction of fire, etc. However, this alternative may be dropped from the C-43 project due to the minimal storage capacity and little to no benefits provided to the estuary and will be included in the SWFFS instead.

On September 8, 2005, Service staff participated in a C-43 Natural Systems Group meeting to develop a method to estimate benefits for the Lake Hicpochee restoration alternative and quantify costs.

On September 15, 2005, Service staff participated in an interagency teleconference to discuss project status and needs. Current issues discussed include hydrologic model status and current changes in the project timeline to reach the Alternatives Formulation Briefing (AFB).

On September 29, 2005, Service staff participated in two interagency teleconferences, one to discuss the overall project status and needs and the second to discuss the hydrologic model and 2050 conditions. A decision needs to be made on whether or not to use all projected 2050 demands on the Caloosahatchee River or only the Savings Clause demands when selecting alternatives. The Service recommended that the Corps use all projected 2050 demands to develop alternatives as this will more accurately reflect the conditions under which the reservoir will operate. Using only the Savings Clause demands is unrealistic because upstream water use cannot be controlled or limited to the Savings Clause levels without legislation. The Service believes that this conservative approach is necessary to provide water to the estuary to protect fish and wildlife resources for the life of the project.

On October 11, 2005, Service staff participated in an interagency teleconference to discuss the C-43 hydrologic model and 2050 conditions. A decision needs to be made on whether or not to use all projected 2050 demands on the Caloosahatchee River or only the Savings Clause demands when selecting alternatives. The agencies have not come to a consensus and will most likely elevate the issue to the Quarterly Review Board (QRB).

On October 12, 2005, the Service reviewed and provided comments on the Water Quality Monitoring Plan for the C-43 Test Cell Project.

On October 13, 2005, Service staff attended the C-43 stakeholders meeting.

On November 3, 2005, Service staff participated in an interagency teleconference to discuss project status and needs. A decision still needs to be made on whether or not to use all projected 2050 demands on the Caloosahatchee River or only the Savings Clause demands when selecting alternatives.

On November 9, 2005, Service staff attended an interagency meeting to discuss preliminary designs to incorporate littoral zones for fish and wildlife habitat adjacent to the seepage canal bordering the C-43 West Reservoir. Designs will be further developed by SEA and distributed to the group for review. The extent of wetland acreage is much smaller than originally discussed (*i.e.*, total is less than 30 acres) and will be spaced every 500 feet between areas reserved for potential ASR wells.

On November 10 and 17, 2005, Service staff participated in the weekly interagency teleconferences to discuss project status and needs. The revised project schedule and milestones

were discussed. The AFB was pushed back to May 11, 2005, and the AFB package submittal to headquarters was planned for April 11, 2005.

Service staff attended the November 14, 2005, scoping meeting for the Corps' upcoming Supplemental EIS on the Lake Okeechobee Regulation Schedule held in Fort Myers.

Service staff attended the November 18, 2005, Southwest Florida Water Resources Conference on Water Quality in the Caloosahatchee Basin.

On November 30, 2005, the Service completed formal and informal consultation on the Test Cell project via a letter and accompanying Biological Opinion addressing project effects on the Florida panther.

Service staff participated in a three day interagency meeting held December 6 through 8, 2005, in Fort Lauderdale to review the formulas and results generated by the Habitat Suitability Index (HSI) models that will be used to evaluate the ecological performance of the proposed project alternatives. Recommendations included changes in the spatial extent of model boundaries for oysters, sea grasses, and *Vallisneria;* and changes in model computations when variables have zero values.

On December 21, 2005, Service staff reviewed responses to our comments on the water quality monitoring plan for C-43 test cells. The District has satisfactorily addressed or incorporated the Service's concerns and recommendations.

On January 3, 2006, the Service email to Corps and District regarding follow up on the Test Cell project 404 permit and threatened and endangered educational materials; caracara and indigo snake surveys for the full reservoir footprint; and the design, location, and acres of littoral zones and other fish and wildlife features.

Service staff participated in the January 6, 2006, conference call on the C-43 Reservoir project status.

Service staff participated in the February 2, 2006, conference call on outstanding project issues. Discussions focused upon: 1) Use of a regression model or the recently available hydrodynamic model to model salinity conditions in the estuary. The regression model still needs refinement, does not incorporate tidal fluctuations, and the Interagency Modeling Center review resulted in 69 comments that need to be addressed. 2) If the proposed monthly output of the HSI models is appropriate or sensitive enough for the species being modeled. For example, juvenile oysters cannot tolerate salinities below 5 parts per thousand for more than 14 days and the monthly out put would not detect this occurrence.

The Service met with the District and the Corps on the February 6, 2006, to review the March 28, 2005, draft Fish and Wildlife Recommendations for Comprehensive Everglades Restoration Plan (CERP) Stormwater Treatment Area and Reservoir Operation and Design developed by the Service and the FWC and discussed incorporating those recommendations in

the design of the C-43 West Reservoir. The District will not incorporate any of the recommendations in the reservoir design that might encourage birds to nest in the vicinity. Additionally, the interior slopes of the reservoir levees will be lined with a concrete soil mixture to prevent erosion, reduce seepage, and increase levee stability. The current reservoir design does include construction of 9 to 28 acres of shallow wetland habitat adjacent to the seepage canal that will be constructed 80 to 100 feet from the outside perimeter of the reservoir. Any existing canals and new borrow pits or canals dredged during levee construction will not be filled to provide deep water habitat for fish during periods of drought or when the reservoir is drawn down.

Service staff participated in the February 7, 2006, interagency review of the HSI models for spotted seatrout, blue crabs, and oysters.

Service staff participated in a February 15, 2006, field investigation of seagrass conditions in San Carlos Bay and Pine Island Sound. Density and biomass observations suggest that seagrass health declines as distance from the mouth of the Caloosahatchee River decreases.

Service staff participated in a February 21, 2006, teleconference regarding the current project status and projected timeline for completion of the Interim PIR.

On February 22, 2006, the Service received a Freedom of Information Act request from People United to Restore Our Rivers and Estuaries (PURRE). PURRE's request includes all documents related to water management of Lake Okeechobee and discharges from the lake into the Caloosahatchee estuary and related to federally listed species in the Caloosahatchee estuary.

The Service received an informal summary of the first caracara surveys conducted by SEA in compliance with our survey protocol on March 6, 2006, via email and a formal Memorandum summarizing that first survey on March 22, 2006.

The Service received a formal Memorandum summarizing the second caracara surveys conducted by SEA in compliance with our survey protocol via email on March 24, 2006.

On March 30, 2006, Service staff participated in the third caracara surveys conducted by SEA and received a Memorandum summarizing those surveys via email on April 10, 2006.

The Service received the March 31, 2006, Work Plan for Additional soil Investigations to delineate chlordane contamination on the Bryan Paul Citrus Grove. The Service concurred with the work plan via an April 4, 2006, email.

By letter dated April 18, 2006, the Service provided comments on the October 13, 2003, Ecological Risk Assessment for the Berry Labelle-Congen Grove. In that letter, the Service recommended remediation of areas known to be contaminated with copper and that additional soil sampling for copper be conducted.

On April 24 and 25, 2006, the Service attended the C-43 West Reservoir Critical Criteria Meeting in Labelle, Florida. On April 25, 2006, a breakout session was held to review information needs for upcoming permit applications, including information on federally-listed species. Reservoir fill rates protective of indigo snakes recommended for other CERP projects (*i.e.*, C-44) were discussed. The District indicated that those rates were acceptable and that they probably couldn't fill the reservoir faster anyway.

On April 26, 2006, and May 15, 2005, the Service provided information to the Corps and District via email, on the need for and appropriate methodology to conduct panther prey surveys to adequately address project impacts and associated habitat loss to the Florida panther.

The Service held an internal meeting on May 24, 2006, in Vero Beach, Florida, on Eastern Indigo Snake section 7 consultation issues.

On June 19, 2006, Service staff participated in the review of the output from the HSI models for the benefits analysis and comparison of the preliminary project alternatives. Once the benefits analysis is complete, the Tentatively Selected Plan will be determined.

Service staff attended a briefing on July 21, 2006 on the Acceler8 preliminary design for the C-43 West Reservoir Design. Service staff provided comments and recommendations including: development of 3 sets of operating criteria for the reservoir based on current conditions and predicted long-term climatological conditions such as drought, normal, and above average rainfall years; ensure manatee protection measures will be incorporated in design of all water control structures where necessary; ensure inclusion of Indigo snake protection measures in construction contracts; potential decreased surface water elevations in wetlands southwest of the project area in primary panther habitat indicated by preliminary model results need to be evaluated in more detail; and to ensure that current proposed recreation plans for the project area do not conflict with project goals. Storage in the reservoir is not sufficient to meet the restoration target of 450 cfs flows at the S-79 structure for all years modeled nor the state-mandated Minimum Flow and Level of 300 cfs at S-79.

The Service reviewed the July 21, 2006, Additional Soil Assessment Report for the Bryan Paul Citrus Grove. Chlordane contamination was identified to be within a 20-acre area. The Service concurred with the 18micrograms per kilogram (ug/kg) target clean-up level for chlordane in our August 9, 2006, letter.

The Service provided comments on the Additional Soil Investigations, Berry Labelle-Congen Groves report submitted to the District by URS Corporation by letter dated July 26, 2006. In that letter, the Service recommended that further sampling be conducted to accurately delineate the spatial extent of copper contamination and that soil remediation be considered for grids 56 and 145.

The Service attended a tour of the test cell project on July 28, 2006. Construction of the C-43 test cells was completed in June and monitoring of seepage and water quality has been initiated.

On June 30, 2006, the Service received a Freedom of Information Act request on the C-43 BSR project and provided the records requested on August 14, 2006, and September 18, 2006.

On July 13, 2006, the C-43 BSR Project Implementation Report team has identified the Tentatively Selected Plan (TSP) which mirrors the Acceler8 project design. However, the TSP includes greater pumping capacity (*i.e.,* 1500 cfs versus 3800 cfs) and improved operations that more closely achieve the hydrologic target of flow distribution at S-79 (*i.e.,* the EST05 flow distribution). The Corps has recently determined that the Townsend canal and the State Road 80 bridge that crosses the canal can only handle a maximum flow of 2500 cfs. Structural changes to the canal and bridge to accommodate 3800 cfs flows will be needed to implement the TSP and will increase project costs.

The Service provided comments on the 30 percent design review of the Acceler8 design on July 18, 2006.

The Service biologist attended the August 10, 2006 public meeting on the C-43 West Reservoir preliminary design.

On August 14, 2006, Service staff participated in an interagency (Corps, District, Service, and EPA) helicopter survey of the Caloosahatchee River basin and estuary to assess basin-wide project benefits for the Corps' mitigation ledger.

Service staff participated in a September 6, 2006, interagency conference call regarding the Environmental Assessment for the C-43 land swap.

The Service provided comments on the July 20, 2006, document titled "Additional U.S. Fish and Wildlife Service Soil Investigations, Berry Labelle-Congen Groves" in a September 14, 2006, letter. In that letter, the Service concurred that copper contamination was adequately delineated and that grids 56, 58, 124, 125, 134, 135, and 143 require remediation.

The Service attended the October 5, 2006, team meeting to discuss current project status. Issues discussed include: 1) optimizing reservoir operations to bring the TSP and the Acceler8 design closer together; 2) additional project costs include modifications to the Townsend canal to accommodate greater flows associated with the greater pumping capacity, removal of the weir at the river, and reinforcement of the highway 80 bridge; 3) The Corps and District make project decisions based on the long-term benefits and cost analyses with CERP in place. However, this does not reflect the need for and importance of the estuarine benefits from the reservoir that are provided before the rest of CERP is in place. It is this interim period from 2010 to 2025 when Lake Okeechobee releases will be highest that the greater pumping capacity will be needed and the project benefits would be greatest. Using 2050 conditions with CERP to calculate benefits and justify project costs masks the "real" benefits to the estuary during the short-term when the need is most critical. Larger pumps are needed to make a difference during the damaging high flows; 4) The project team was instructed to abide by the new GMs 3 and 4 which require an Interim Operation Run for the year the project will be operational. This will take additional time and money not originally in the schedule; 5) The Corps' schedule has changed due to the

additional modeling; 6) Phase II of the project has been funded for Fiscal Year (FY) 07. Phase II will focus on water quality and water supply needs, as well as additional storage needs, and will be built in the eastern Caloosahatchee Basin (*i.e.,* between S-77 and S-78). The project team has already identified potential locations and gone through the screening process for those sites.

Service staff participated in an October 11, 2006, interagency meeting to recalculate project benefits based on the new optimized model runs and to select a new, "optimized" TSP.

On October 30, 2006, the Service responded to the Response to Corps' October 27, 2006, email regarding section 7 consultation process and keeping the Corps' C-43 West Reservoir Project Implementation Report and the District's Acceler8 C-43 West Storage Reservoir project on the same timeline with one consultation. The Service reiterated that formal consultation would be needed for three species, the caracara, indigo snake, and panther, and requested advanced review of the Biological Assessment before the Corps requested formal consultation.

Service biologist participated in the Corps' CERP vertical team AFB on November 3, 2006.

The Service reviewed and provided comments to the Corps on the Draft Biological Assessment for the C-43 West Storage Reservoir Project, Hendry County, Florida on November 9, 2006.

The Service received combined Department of Army and state of Florida Environmental Resource Permit Application for C-43 project on November 20, 2006.

The Service received a letter and a Biological Assessment (BA) from the Corps on January 12, 2007, requesting initiation of formal consultation on the C-43 West Reservoir Project. Service staff reviewed the information provided and requested additional information pertaining to consultation for wood storks and snail kites.

Two project status teleconferences were held January 23, and January 30, 2007, to discuss changes in the project schedule to accommodate modeling needs. The proposed alternatives will be evaluated with the updated MIKE SHE model by March 19, 2007. The Benefits Analysis will be completed by May 7, and the Tentatively Selected Plan will be identified by May 21. The Draft FWCA Report will be due May 19, and the Draft PIR will be completed by June 28.

Service staff participated in the February 1, 2007, interagency meeting to develop and review the Monitoring and Assessment Plan for the C-43 project; and in the February 2, 2007, Natural Systems Group meeting.

Service staff participated in two interagency project status teleconferences held February 6, 2007, and February 13, 2007. The project schedule has now been revised again to have a Final PIR by July 2007. A spreadsheet model will be used instead of MIKE SHE for Assurances and Savings Clause Analyses and to develop the Operation Manual. Results from the spreadsheet model will be available by March 1. Existing data used for the AFB will be used for plan formulation and comparison. The preliminary Draft FWCA Report and the Draft PIR will be completed by March 23 and Final drafts printed in the Federal Register by April 13, 2007. The

Final PIR and FWCA Report are due June 29 and will be published in the Federal register by July 27, 2007.

The Service met with the Corps and District on February 7, 2007, to discuss outstanding threatened and endangered species issues for consultation. Additional information is needed for consultation on wood storks, snail kites, and caracara.

Service staff participated in the February 7, 2007, interagency teleconference regarding modeling needs for Assurances and Savings Clause Analyses.

Service staff conducted two site visits, February 7 and 8, 2007, to determine if the caracara territory and nest site off State Road 80 is active this year. A pair of caracara were observed perched near the nest tree which had been used last year. Although the territory is occupied, no nesting activity was observed. Follow-up surveys will be conducted through the end of April to determine if a nest is initiated this year.

Service staff participated in two project status teleconferences held February 20, 2007, and February 27, 2007. The project team is working on the draft PIR and Service staff is working on the draft FWCA Report.

The Service attended the February 21, 2007, interagency site visit to evaluate wetlands and potential wood stork foraging habitat within the C-43 West Reservoir footprint.

The Service submitted the Draft Fish and Wildlife Coordination Act Report to the Corps via letter dated March 19, 2007.

On April 10 and 17, 2007, Service staff participated in the weekly C-43 interagency conference calls to review project status. The project team is in the process of reviewing the Draft PIR and making changes as appropriate due to comments received to date. The Final FWCA Report will be completed by July 12, 2007, and the Final PIR by July 20, 2007.

The Service participated in a May 15, 2007, interagency meeting to review the water quality modeling section of the Draft PIR and the Draft Project Operating Manual and Monitoring Plan. The major outstanding water quality issue is if operation of the reservoir will meet the State's requirement for the project to "not cause or contribute" to existing water quality problems in the Caloosahatchee River and Estuary. Specifically, the annual nitrogen load will not change as a result of the project but a seasonal shift in the loads will occur with a significant increase of nitrogen loading during the dry season (*i.e.,* November through May).

The Service met with the Corps and District on May 15, 2007, to discuss outstanding threatened and endangered species issues in order to complete informal and formal consultation on the effects of the C-43 project. Outstanding issues included incorporation of CERP Thermal Guidelines in Manatee-Accessible Waters in the project monitoring plan, compensation for impacts to wood stork foraging habitat, and compensation for impacts to crested caracara habitat.

On May 17, 2007, the Service attended the Corps and District public workshop on the Draft PIR in LaBelle. No new issues significant to the design and operation of the reservoir were raised by the public.

On May 22, 2007, the Service met with the Superintendent of Duda and their consultant to confirm the location of the caracara nest on Duda property southeast of the reservoir.

The Service held a conference call with the Corps and District on June 5, 2007, to discuss the outstanding issue regarding incorporation of CERP Thermal Guidelines in Manatee-Accessible Waters in the project design and monitoring plan. Both operational and structural modifications to the reservoir project were discussed.

The Service received the Intermediate Design Report (*i.e*, 60 percent design) via overnight mail on June 7, 2007, and the associated design plans on June 8, 2007.

On June 7, 2007, an interagency conference call was held to discus the thermal guidelines for manatees. The District obtained temperature data for the Townsend Canal and the Caloosahatcee River in the vicinity of the Townsend Canal from the Florida Department of Environmental Protection (DEP) and provided that data as well as temperature data from the Test Cell project to the participants on the conference call.

On June 7, 2007, the Service and FWC further developed monitoring protocol to define what constitutes a shift in manatee distribution as a result of warm-water discharges into the Townsend Canal.

The Corps, EPA and the Service participated in a teleconference on June 12, 2007, to finalize the UMAM Scores for the Caloosahatchee River and Estuary and the tapegrass beds in the upper Caloosahatchee Estuary that will be used for mitigation for on-site wetland impacts and compensation for the loss of on-site wood stork foraging habitat.

On June 20, 2007, the Service, Corps and District held a conference call to discuss a timeline for resolving the outstanding manatee issues. The Corps and District are researching appropriate weirs or gates that would serve as a barrier to prevent manatee access to the Townsend Canal while still achieving desired flow rates through the canal. The Corps requested more time to research barriers and develop cost estimates for construction and operation and maintenance of a structure. They requested we reach a resolution by August 1, 2007.

III. AREA SETTING

A. Project Location

The project study area encompasses the Caloosahatchee River Basin (*i.e.*, C-43 Basin) located in southwest Florida and downstream estuarine habitats including the Caloosahatchee Estuary, San Carlos Bay, Matlacha Pass, and Pine Island Sound (Figure 1). The Caloosahatchee River serves as a major outlet from Lake Okeechobee to the Gulf of Mexico, extending about 70 miles

from Lake Okeechobee to San Carlos Bay. The river drains an area of about 1,327 square-miles in Glades, Hendry, Charlotte, and Lee Counties, and is the major source of surface water supply for the Lower West Coast region. The river basin constitutes the northern portion of the District's Lower West Coast Water Supply planning area.

The Caloosahatchee River and Estuary is at the head of a vast estuarine and marine ecosystem that includes aquatic preserves managed by the State of Florida [*e.g.*, Matlacha Pass Aquatic Preserve (AP), Estero Bay AP, Pine Island Sound AP], and the federally designated Charlotte Harbor National Estuary (CHNE); the J. N. "Ding" Darling National Wildlife Refuge (NWR) Complex which includes the Caloosahatchee, Matlacha Pass, Pine Island, and Island Bay NWRs; along with numerous other state and local parks and recreation areas. Restoration of a healthy, productive aquatic ecosystem in the Caloosahatchee River is essential to maintaining the ecological integrity and associated economic activity in these publicly owned and managed areas.

The Caloosahatchee Estuary, which is generally considered to be that portion of the Caloosahatchee River west of the W. P. Franklin Lock and Dam, including the Matlacha Pass, San Carlos Bay, and Pine Island Sound at the mouth of the Caloosahatchee River, encompasses approximately 80 square miles of estuarine habitat on Florida's southwest coast in the vicinity of Fort Myers, Florida. The Fort Myers area, including Cape Coral, Fort Myers Beach, Sanibel and Captiva Islands, Bonita Springs and unincorporated areas is one of the fastest growing areas in the southeastern United States (2000 population was approximately 440,000 according to U.S. Census figures) and is an extremely popular tourist destination.

The proposed reservoir footprint is located in Hendry County west of LaBelle, Florida. The site is approximately 10,492 acres located a few miles south of State Road 80 and approximately two miles west of State Road 29 (Figure 2).

B. Description of Study Area

1. Hydrological Description

The Caloosahatchee River was originally a shallow, meandering river with headwaters in the proximity of Lake Flirt (Kimes and Crocker 1998). The Caloosahatchee River historically bisected its basin and probably only rarely received water from outside its watershed or from Lake Okeechobee except during extreme regional flooding events that sent water to the marshlands at the headwater of the river. The Caloosahatchee was connected to Lake Okeechobee in 1881 as an attempt to lower the Lake's water table. The river now functions as a primary canal (*i.e.,* Canal-43 or C-43) ranging from about 50 to 130 meters (164 to 426.5 feet [ft]) in width and 6 to 9 meters (19.7 to 29.5 ft) deep that conveys both basin runoff and regulatory releases from the lake. Wet season runoff that was historically retained within the undeveloped Caloosahatchee Basin now reaches the river in greater volume and less time through an intricate canal system (Corps 1957) and is often compounded by lake releases.

The river has undergone a number of alterations to facilitate navigation, flood control, and regulatory releases, including channelization, bank and levee stabilization, and the addition of three locks and dams. The locks and dams were constructed to control flow and stage height in the lake and river. The Moore Haven Lock (S-77), located on the southwest shore of Lake Okeechobee, regulates Lake Okeechobee waters. The Ortona Lock (S-78) aids in control of water levels on adjacent lands upstream and separates the Caloosahatchee watershed into eastern and western basins. Water levels upstream of S-78 are maintained at approximately 11 ft National Geodetic Vertical Datum (NGVD), and 3 ft NGVD downstream. The W.P. Franklin Lock and Dam (S-79) is the most downstream structure and marks the beginning of the Caloosahatchee Estuary. The S-79 structure regulates freshwater discharge into the estuary and maintains an upstream level of approximately 3 ft NGVD and a downstream level near 1 ft NGVD. S-79 also acts as barrier to saltwater intrusion and tidal action which historically extended far upstream. Thus, S-79 truncates the estuary and now spatially limits the dry season oligohaline (*i.e.,* freshwater and low salinity brackish water) zone of the estuary, as well as the free passage of organisms seeking refuge, nursery, and breeding areas characteristic of this zone (Chamberlain and Doering 1998a; 1998b, Doering et al. 2002; District 2002). The operation schedule for these structures is dependent on rainfall conditions, agricultural practices, the need for regulatory releases from Lake Okeechobee, and the need to provide water quality control for the Public Water Supply facilities. Detailed operation information for structures S-77, S-78 and S-79 can be obtained from the Water Control Plan for Lake Okeechobee and the Everglades Agricultural Area (EAA), Jacksonville District, USACE, July 2000.

The Caloosahatchee Estuary now extends approximately 42 kilometers (26 miles) from S-79 to Shell Point. The estuary width between S-79 and Shell Point is irregular, ranging from 160 meters (524.9 ft) in the channelized upper portion of the estuary to 2,500 meters (8,202.1 ft) downstream (Scarlatos 1988). The narrow portion extends about 12 kilometers (7.6 miles) downstream from S-79 to Beautiful Island and has an average depth of about 6 meters (19.7 ft), while the overall mean depth of the estuary in the section downstream of Beautiful Island is 1.5 meters (4.9 ft; Scarlatos 1988). Water leaving the Caloosahatchee Estuary passes Shell Point and enters lower Charlotte Harbor through San Carlos Bay, which is at the confluence of Pine Island Sound to the west, Matlacha Pass to the north, and the Gulf of Mexico to the south (Figure 1). Most of the fresh water that enters southern Charlotte Harbor comes into San Carlos Bay from the Caloosahatchee Estuary and normally leaves the system by moving south under the Sanibel Causeway to the Gulf of Mexico (Goodwin 1996). However, when freshwater inflows are high, some of this fresh water is pushed by Gulf of Mexico tides up into Pine Island Sound and Matlacha Pass.

a. Primary Drainage Basins

The Caloosahatchee River Basin can be divided into three primary basins (Figure 3) based on their hydrologic characteristics, hydrologic control features, and topography as defined in the District's Caloosahatchee Water Management Plan (CWMP), April 2000 Planning Document. The freshwater portion of the Caloosahatchee River extends approximately 68 kilometers (42 miles) from Lake Okeechobee to S-79 and can be divided into two primary basins. The East Caloosahatchee basin includes 285,502.5 acres of land that drains into the river between Lake

Okeechobee and S-78. The West Caloosahatchee basin includes 324,979.3 acres (includes S-4) of land that drains into the river between S-78 and S-79. The predominant land use in both of these basins is agriculture. While all of the East Caloosahatchee basin is upstream of the proposed reservoir, approximately 70 percent of the West Caloosahatchee basin is upstream of the planned reservoir.

The Caloosahatchee Estuary basin is downstream of S-79 and contains three watershed planning units: Telegraph Swamp, Orange River, and Caloosahatchee Estuary. Within these three planning units, land use patterns transition from agricultural and natural areas in the east to residential in the west. The Caloosahatchee Estuary basin includes 289,982.4 acres of land that drains to the Caloosahatchee Estuary downstream of S-79. Two major tributaries in this basin are the Orange River and Telegraph Swamp, which drain into the river west of S-79. However, the Orange River planning unit contributes a small amount of the total fresh water entering the estuarine system (Scarlatos 1988; Bierman 1993).

The S-4 and S-236 Basins can drain into, or use irrigation from, the Caloosahatchee River Basin depending on hydrologic conditions. Antecedent water levels, runoff volume, and location of man-made structures determine the direction of storm water drainage. Drainage water from the C-21 is released into the Caloosahatchee River through S-235 when the lake stage is greater than 15.5 ft or the stage exceeds the Lake Regulation Schedule. Stormwater runoff from this basin may be discharged into C-43 through a private drainage pump or discharged into Lake Hicpochee through private drainage pumps.

Each of these primary basins contains several tributaries such as native streams, sloughs, and canals and many small tributaries that drain small areas adjacent to the Caloosahatchee River (Figure 3). There are also several small tributaries that drain directly to the estuary.

b. Surface and Ground Water

Water for urban and agricultural uses in the C-43 basin is supplied from both groundwater and surface water systems. Surface water is used primarily for agricultural irrigation, with groundwater being used in areas that do not have access to the river. In addition, the Caloosahatchee River is a source for potable water supply in Lee County. Groundwater and surface water are dependent upon rainfall for recharge.

The C-43 Canal receives water from Lake Okeechobee, runoff from the basin, and base flow from the Surficial Aquifer System (SAS). The river in turn supplies water for public supply, agriculture, and the environment. This source can be unreliable during the dry season or periods of inadequate rainfall, when releases are required from Lake Okeechobee to meet demand. The Corps manages the C-43 Canal via a regulation schedule, which presently accommodates navigational, flood protection, water supply, and environmental needs.

The Lake Okeechobee Demand Service Area is defined as the area that is or could be supplied by surface water from the Caloosahatchee River and is the primary source for agricultural

irrigation and potable surface supply water in the Caloosahatchee Basin. This area extends from the S-79 eastward to the S-77 and includes land in Lee, Glades, and Hendry Counties.

Other surface water bodies in the Caloosahatchee Basin area include lakes, rivers, and canals. These areas provide storage and allow conveyance of surface water. Lake Hicpochee is the largest lake in the area and is bisected by the C-43 just west of Lake Okeechobee. Numerous canals and tributaries in the basin area drain into the Caloosahatchee River. The majority of the canals in the basin were constructed as surface water drainage systems rather than for water supply purposes.

Surface water flows are derived from rainfall within the basin and discharge from Lake Okeechobee. Runoff from the West Caloosahatchee Basin is slightly higher than runoff from the East Caloosahatchee Basin indicating greater flow attenuation in the eastern basin due to the flatness and thick, sandy soils (Fan and Burgess 1983). Inflow from Lake Okeechobee is the primary flow in the river during the dry season. Water is released from the lake to meet the supplemental agricultural water demand as well as supplying water for municipal consumptive use. Water is also released to reduce lake stage before the hurricane season that may result in high flows to the estuary. There is little water storage in the basin. The intensive drainage on the south side of the river provides little storage. The north side of the river is largely undeveloped west of Lake Hicpochee and while there is considerable wetland water storage it is not managed water storage.

Ground water is an important component of the agricultural water supply in the freshwater portion of the Caloosahatchee Basin. The ground water resources in the area include the SAS, the Intermediate Aquifer System (IAS), and the Floridan Aquifer System (FAS). The yield and storage of the groundwater is highly variable throughout the basin, and surface water has been used for irrigation where possible. The SAS is used for some irrigation in eastern Hendry and Glades Counties.

The IAS is used primarily for irrigation in the western portion of Hendry County. There is local recharge to both the SAS and the IAS. The FAS is used in northern Glades County for irrigation and in the northwest corner of the basin and mixed with surface water for irrigation. The water from the FAS is too mineralized elsewhere in the basin. This deep aquifer is recharged from outside the area.

2. Geology and Soils

The major physiographic provinces of the Caloosahatchee River Basin are the Caloosahatchee Valley, Gulf Coast Lowlands, DeSoto Plain and the Immokalee Rise. Within the study area, the Immokalee Rise includes most of Hendry County and eastern Lee County. The average elevation is about 8 meters (25 ft) but can peak at 11 to 13 meters (36 to 43 ft) in some areas. All soils are deep, nearly level, and poorly drained, with a water table less than 25 centimeters (10 inches) from the surface during at least part of the year.

The soils of the Caloosahatchee River Basin are predominately Spodosols with some Entisols, Histols south of the river, and miscellaneous types in coastal areas. Spodosols are dominated by somewhat poorly to poorly drained sandy soils with dark sandy subsoil layers. They have a subsurface zone where there has been an accumulation of iron, aluminum, and organic matter that has cemented into a layer that may inhibit water flow. Entisols are new or recent soils of limestone origin, underlain by marl and limestone and they are dominated by very poorly drained, coarse and thin, sandy soils. Histols are organic soils such as muck and peat and they are very poorly drained soils underlain by marl and limestone. Coastal sediments mostly consist of Entisols and Histols.

A geotechnical engineering evaluation was performed for at the project site. The subsurface conditions encountered at the site consist of a surficial layer of sands with isolated zones of silty sand material. This sandy deposit varies in thickness from 1 to 15 ft. Below this sandy deposit, a layer of interbedded zones of silty sand, clayey sand, sandy clay, and sandy silt materials was encountered. This layer varies in thickness from 1 to about 20 ft. Below this sand, silt, clay mix deposit, limestone material was generally encountered with a thickness ranging from 2 to 12 ft, with isolated areas where the limestone deposit was thicker than 30 ft. Some of the borings performed did not encounter the limestone material. Below the limestone material and until boring termination depths, clayey deposits were encountered. These clayey deposits mainly consist of sandy silt, sandy clay, and clayey sand materials.

3. Land Use

Land use in the eastern Caloosahatchee River Basin is primarily agriculture (*i.e.,* improved and unimproved pasture, citrus, and sugarcane), interspersed with higher-quality natural areas (*i.e.,* pine flatwoods, hardwood forests, freshwater marshes, and cypress). Sugarcane production in the Caloosahatchee Basin occurs in close vicinity to Lake Okeechobee in Hendry and Glades Counties, where transportation costs to the mills can be minimized. Seasonal crops (*i.e.*, row and field crops such as tomatoes or wheat) are minimally present. Land use in the western portion of the basin is primarily urban and residential, and the spatial extent of natural areas is reduced.

4. Water Quality

Water quality data are collected by numerous agencies and volunteer organizations in the project impact area including the U.S. Geological Service (USGS), Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network, DEP, FWC, Fish and Wildlife Research Institute (FWRI), District, Lee County, Lee County Hyacinth Control District, Cities of Cape Coral and Sanibel, and the Charlotte Harbor National Estuary Program (CHNEP). All of these entities have water quality monitoring programs that sample at varying frequencies for various core parameters and the results are normally placed into a central database that is maintained by the State of Florida. The database STOrage and RETrieval (STORET) is a structure used nation-wide for water quality analysis.

The DEP is responsible for identification of impaired waters pursuant to the Impaired Waters Rule (IWR) adopted in 2001 as Chapter 62-303, Florida Administrative Code. The IWR

establishes a methodology to identify surface waters of the state that will be included on the state's planning list. It also establishes a scientific methodology for analyzing environmental data to determine if a waterbody is impaired or healthy. DEP must list waters that do not meet applicable quality standards and establish Total Maximum Daily Loads (TMDLs) for those waters on a prioritized schedule. TMDLs establish the maximum amount of pollutants a water body can assimilate without exceeding water quality standards.

The construction of canals, levees, and roads within the Caloosahatchee Basin have resulted in changes to the timing, quantity, and quality of surface waters within and around the project area. Groundwater flow and quality throughout the project area may also be influenced by these anthropogenic features. Additional impacts include nutrient loads from agricultural activities, anthropogenic organic compounds, trace elements, as well as overall urban growth and development within the basin. San Carlos Bay and Pine Island Sound are Class 2 waters which are designated for shellfishing. The Caloosahatchee Basin and Estuary are Class 3 waters which are designated for swimming and fishing. The DEP's IWR Assessment determined the following conditions at locations within and adjacent to the project area (Figure 4):

- Six water bodies in the East Caloosahatchee basin are impaired for lead, coliforms, iron, dissolved oxygen, copper, and nutrients.
- Three water bodies in the West Caloosahatchee basin are impaired for iron, copper, lead, and nutrients.
- There are no impaired waters in Telegraph Swamp planning unit.
- The Caloosahatchee estuary has 13 impaired water bodies. All thirteen listed water body segments are impaired for coliforms (either total or fecal), seven are impaired for nutrients, six are impaired for dissolved oxygen, three are impaired for heavy metals (copper, lead), and one is impaired for specific conductivity.

The DEP Caloosahatchee Basin Status Report (DEP 2002) states that the observed water quality violations are probably linked to urban land uses within the Caloosahatchee Estuary planning unit, poorly flushed residential tributary streams, and the effect of heavy pollutant loads discharged from upstream sub-basins. Water quality pollutant loading upstream of the S-79 structure is composed of loading from runoff generated within the basin and Lake Okeechobee releases. Excluding the load from Lake Okeechobee releases, approximately 50 percent of the total nitrogen load resulting from runoff in the Caloosahatchee Basin comes from basin lands upstream of S-79. Similarly, excluding the phosphorus load from Lake Okeechobee releases, approximately 65 percent of the total phosphorus load resulting from runoff in the Caloosahatchee Basin comes from basin lands upstream of the S-79. When Lake Okeechobee flows and loads are included, more than 75 percent of total nitrogen and total phosphorus loads to the Caloosahatchee Estuary are a result of discharges at S-79 (ERD 2002).

The Caloosahatchee pollutant loading report (ERD 2002) includes pollutant-loading estimates for the four largest sewage treatment plants in the Caloosahatchee Estuary as well as for eight tributaries downstream of the S-79 structure. This report includes loading estimates for the following pollutants: ammonia, nitrate, nitrite, total kjeldahl nitrogen, total nitrogen, orthophosphorus, and total phosphorus, and total suspended solids. With the exception of

ammonia, 10 percent or less of the wet or dry season load of each of these pollutants to the Caloosahatchee Estuary comes from the portion of the watershed downstream of the S-79 structure. During the dry season, approximately 5 percent of the total ammonia load in the estuary comes from the portion of the watershed downstream of the S-79 structure; however, during the wet season, approximately 40 percent of the ammonia load to the estuary comes from downstream of the S-79 structure. A relatively large amount of the ammonia loading from downstream of the S-79 structure comes from the four large sewage treatment plants. The Caloosahatchee Estuary non-point sources of total nitrogen and phosphorus contribute around 20 percent of the total loads delivered to the estuary.

5. Ecological Description

a. Upland and Freshwater Habitats

Upland plant communities serve as recharge areas, absorbing rainfall into soils where it is distributed into plant systems or stored underground within the aquifer. Ground water storage in upland areas reduces runoff during extreme rainfall events, while plant cover reduces erosion and absorbs nutrients and other pollutants that might be generated during a storm event. With few exceptions the functions and values attributed to wetlands also apply to upland systems. Upland and wetland systems are ecological continuums, existing and adapting to geomorphic variation. The classification of natural systems is artificial and tends to convey a message that they survive independently of each other. In reality, wetland and upland systems are interdependent. To preserve the structure and functions of wetlands, the linkage between uplands and wetlands must be maintained (Mazzotti et al. 1992). Existing upland and wetland habitats in the Caloosahatchee Basin are shown in the 2000 land cover and land use map (Figure 5).

Based on the 2000 land use and land cover data and maps, wetlands comprise approximately 135,277 acres (15.9 percent) of the land cover within the C-43 Basin. The wetland cover classes occurring in the C-43 Basin include freshwater marsh and wet prairie, slough waters, wetland hardwood forest, wetland coniferous forest (cypress swamp and cypress, pine, cabbage palm) wetland mixed forest, mangrove swamp, and salt marsh. Other aquatic habitats in the C-43 Basin include streams and waterways, lakes, and reservoirs. Those habitats comprise approximately 21,682 acres (2.5 percent) of the land cover within the C-43 Basin.
Pine flatwoods continue to dominate the landscape of the study area even though their pre-development aerial extent has been reduced by agricultural and urban development. Large areas of flatwoods are found throughout Hendry and Lee Counties, as well as portions of Charlotte and Glades Counties. They are interspersed with tropical hardwood hammocks, Florida scrub, dry or wet prairies, freshwater marshes, and freshwater forested wetlands.

Pine Flatwoods
Pine flatwood occur in areas of level topography and poorly drained sands. They range from open forests of scattered pines with little understory to dense stands with a dense undergrowth of grasses (paticularly wire grass, *Aristida stricta*), saw palmettos (*Serenoa repens*), and other low shrubs (Abrahamson and Hartnett 1990). The majority of the pine flatwoods that occur within the C-43 Basin are hydric pine flatwoods.

Hydric pine flatwoods occur in seasonally inundated flatlands with sandy soils and have canopies of slash pine (*Pinus elliottii* var. *densa*), pond pine (*P. serotina*), and cabbage palm. They have an understory of mixed hydrophytic shrubs such as wax myrtle (Myrica cerifera), gallberry (*Ilex glabra*), grasses, and forbs that varies with fire frequency. Mesic flatwoods occur on sandy, seldom inundated soils and have canopies of slash pine (*P. elliottii* var. *elliottii* and var. *densa*) and longleaf pine (*P. palustris*) with a dense understory of saw palmetto. Gallberry, *Lyonia* spp., wax myrtle, and wiregrass are also abundant.

The hydric pine flatwoods of south Florida are of critical, regional importance as: (1) one of the principal dominant forest covers of south Florida that provides essential forested habitat for wildlife including wide-ranging species such as the Florida panther, the Florida black bear, mid-sized carnivores, fox squirrels, and deer; (2) the major tree canopy for canopy-dependent species including neotropical migrants, tree-cavity dependent species, and tree-nesting species; (3) a habitat that seasonally functions as both a wetland and an upland. The relatively predictable nature of this hydrologic transformation allows for an abundant diversity of plant life, including both wetland and upland annuals, and supports a diverse invertebrate fauna and, as a result, a diverse vertebrate fauna. The hydric pine flatwoods of south Florida provide essential habitat to the breeding life cycle of aquatic and wetland-dependent animals, and a major forest cover for cover-dependent species. Hydric pine flatwoods provide both aquatic habitat for young and adult amphibians and adult tree frog climbing areas. Hydric flatwoods serve as wading bird foraging areas, black bear foraging, denning, and travelways, and essential red-cockaded woodpecker foraging and nesting habitat. Hydric pine flatwoods are an important habitat for a number of common pine flatwoods vertebrate species, including the pine woods tree frog (*Hyla femoralis),* oak toad (*Bufo quercicus),* box turtle (*Terrapene carolina),* eastern diamondback rattlesnake (*Crotalus adamanteus),* black racer (*Coluber constrictor),* brown-headed nuthatch (*Sitta pusilla),* Bachmans sparrow (*Aimophila aestivalis*), pine warbler (*Dendroica pinus),* great horned owl (*Bubo virginianus),* least shrew (*Cryptotis parva),* cotton mouse (*Peromyscus gossypinus)*, cotton rat (*Sigmodon hispidus),* and gray fox (*Urocyon cinereoargenteus)* (Layne 1974; Layne et al. 1977).

Tropical hardwood hammocks

Tropical hammocks are found nearly throughout the southern half of south Florida, with large concentrations in Miami-Dade County on the Miami Rock Ridge, in Miami-Dade and Monroe Counties in the Florida Keys and along the northern shores of Florida Bay, and in the Pinecrest region of the Big Cypress Swamp. Analogous communities are also found in the Bahamas and the Greater Antilles (Robertson 1955). Most maritime hammocks on barrier islands in south Florida are similar to this community. Large areas of tropical hardwood hammocks are still found in Everglades and Biscayne National Parks in Miami-Dade County, throughout the Florida Keys in Monroe County, and in Big Cypress National Preserve in Collier County. Tropical hardwood hammocks also persist in small preserves along the Atlantic coastal strip from Miami-Dade County north to Martin County.

Tropical hardwood hammocks are rare in the basin. This diverse woody upland plant community occurs on elevated areas, often in Indian shell mounds along the coast, or on marl or

limestone outcroppings inland. As a result of urban development, tropical hammocks are among the most endangered ecological communities in south Florida.

Tropical hardwood hammock is a closed canopy forest, dominated by a diverse assemblage of evergreen and semi-deciduous tree and shrub species, mostly of West Indian origin. It is also important habitat for ferns and orchids of West Indian origin. Tropical hardwood hammock is not a fire maintained community, although fire may burn into tropical hardwood hammocks under certain conditions. Soils in tropical hardwood hammocks are primarily composed of organic material which has accumulated directly on top of mineral substrate, and are moist, but rarely inundated.

Except for some birds and bats, most vertebrate animal species found in tropical hardwood hammocks are temperate in origin (Snyder et al. 1990). While plant species can be transported by birds, waves, or wind from the Caribbean, most animal species have to travel to south Florida by land, and a land bridge has never connected south Florida with the Caribbean. Tropical hardwood hammocks provide food, cover, roosting, and nesting sites to a wide variety of wildlife species.

Florida Scrub

Interior Florida scrub occurs sporadically on well-drained sandy ridges on the Georgia Fall Line and within the Florida peninsula from Kingsley Lake, Clay County south to Immokalee, Collier County (Myers 1990; Wharton 1978). Most interior Florida scrubs are associated with north-south tending ridges that were formed by wind and wave action during periods of higher sea level. The expansive stands of sand pine in the Ocala National Forest in Lake and Marion Counties are forests, not scrub, and occupy a landscape with yellow sand that may have supported high pine savanna during the earlier Holocene. Within the South Florida Ecosystem, interior Florida scrub occurs on the Lake Wales, Winter Haven, Lake Henry, Lakeland, and Bombing Range ridges (White 1970) in Polk, Osceola, and Highlands Counties; on lesser ridges within the Osceola Plain and Eastern Valley in Osceola, Okeechobee, Indian River, St. Lucie, and Martin Counties; and scattered on small rises in Hardee, DeSoto, Glades, Hendry, and Collier Counties.

Florida scrub soils are well-drained, nutrient-poor, and sandy. Depending on elevation, scrub has a fire return frequency of 10 to 80 years. "Florida scrub can be identified by the dominance of several species of woody shrubs, especially myrtle oak or scrub oak (*Quercus myrtifolia* or *Q. inopina*), sand live oak (*Q. geminata*), Chapman's oak (*Q. chapmanii*), crookedwood (*Lyonia ferruginea*), saw palmetto (*Serenoa repens*) and Florida rosemary (*Ceratiola ericoides*); the absence of a tree canopy; the absence of a continuous vegetative ground cover; and the absence of longleaf pine (*Pinus palustris*), wiregrass (*Aristida beyrichiana*), and turkey oak (*Q. laevis*). When sand pines (*Pinus clausa*) are present in scrub, they do not form a continuous canopy, but occur as scattered individuals or clumps of individuals. Most scrubs occur on white sand and patches of bare sand with or without scattered clumps of ground lichens" (Service 1999).

Scrubby flatwoods is an intermediate between mesic pine flatwoods and scrub, and sometimes occurs as an ecotone between them (Abrahamson and Hartnett 1990). "Scrubby flatwoods is

more hydric than scrub, has a higher water table, denser vegetation, and almost never has standing water" (Abrahamson et al. 1984). It also "differs from scrub by the presence of scattered wiregrass and a preponderance of flatwoods species such as fetterbush (*Lyonia lucida*), wax myrtle, and gallberry. Shrubby oaks, including sand live oak, Chapman's oak, and myrtle oak or scrub oak, are often dominant and slash pine, sand pine, or longleaf pine may be present. Plant species typical of scrubby flatwoods that may be considered indicators of the community include tarflower (*Befaria racemosa*), scrub St. John's wort (*Hypericum reductum*), and pennyroyal (*Piloblephis rigida*)" (Service 1999).

Scrub habitats in south Florida are important for a number of xeric-adapted species including: Florida gopher frog (*Rana capito*), Florida mouse (*Podomys floridana*), short-tailed snake (*Stilosoma extenuatum*), scrub lizard (*Sceloporus woodi*), rufous-sided towhee (*Pipilo erythrophthalmus*), gopher tortoise (*Gopherus polyphemus*), Florida worm lizard (*Rhineura floridana*), other subspecies of mole skink (*Eumeces egregius sspp.),* and the crowned snakes (*Tantilla spp.).* Federally listed scrub inhabitants include the Florida panther, Florida scrub-jay (*Aphelocoma coerulescens*), eastern indigo snake, blue-tailed mole skink (*Eumeces egregius lividus*), and sand skink (*Neoseps reynoldsi*; Service 1999).

Wet Prairies and Freshwater Marshes

Wet prairies and freshwater marshes are interspersed throughout the study area. The differences between the two are based on hydroperiod. Wet prairies are flooded less than 6 months per year (short hydroperiod). Freshwater marshes can be flooded 6 to 9 months per year (intermediate hydroperiod) or more than 9 months per year (long hydroperiod). As a result, wet prairies are more susceptible to fire, and burn more frequently than marshes. These differences in hydroperiod and fire regime are reflected in the vegetative communities. The common plants of wet prairies are sawgrass (*Cladium jamaicense*), muhly grass (*Muhlenbergia capillaris*), beakrush (*Rhynchospora* spp.), black sedge (*Schoenus nigricans*), wiregrass (*Aristida* spp.), and dwarf cypress (*Taxodium* spp.; Service 1999).

Freshwater marshes are frequently categorized based on their dominant vegetation [*e.g.,* sawgrass marsh; cattail marsh; flag marsh (*Pontederia lanceolata* and one or more *Sagittaria* spp.); mixed emergent grass and sedge marsh; maidencane (*Panicum hemitomon*) marsh; beakrush and spike rush (Eleocharis spp.) marsh; or floating vegetation marsh (the water lilies *Nymphaea odorata* and *Nuphar luteum*, and floating hearts, *Nymphoides aquatica*)]. The majority of freshwater marshes in the study area are beakrush, maidencane, and pickerelweed flag marsh (Kushlan 1990). Marshes can also be categorized based on physiognomy. Flatwoods marshes, also called depressional marshes, are small, elliptical wetlands that occupy the low areas within pine flatwoods. They have moderate to long hydroperiods with depths less than a meter, and are generally disconnected (Kushlan 1990). Conversely, sloughs are larger, linear, connected marshes with deeper water and long hydroperiods (Service 1999). Good examples of flatwoods marshes and sloughs can be found in the study area at the Allapattah Ranch and Cane Slough in Martin County.

Regardless of their category, marshes and wet prairies are another "vital component for the biodiversity of south Florida" (Service 1999). Federally listed birds such as snail kite (*Rostrhamus sociabilis plumbeus*), wood stork (*Mycteria americana*), whooping crane (*Grus americana*), and Audubon's crested caracara [*Polyborus* (= *Caracara*) *plancus audubonii*], and state listed birds such as Florida sandhill crane (*Grus canadensis pratensis*), roseate spoonbill (*Ajaia ajaja*), little blue heron (*Egretta caerulea*), reddish egret (*Egretta rufescens*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), and white ibis (*Eudocimus albus*) all use these habitats for nesting and foraging. The growth, maintenance, and reproduction of many other species of birds, amphibians, reptiles, fish, invertebrates, and mammals are directly linked to the quality and quantity of these wetland habitats.

Dry Prairie

Florida dry prairie is a natural landscape that is endemic (Fitzgerald and Tanner 1992, Bridges 1997) to the state, with no similar communities found in adjacent states. It is geographically restricted to the interior of central, south-central and west-central peninsular Florida. Dry prairie is often (but not exclusively) found on the same soil series, topographic positions, and moisture regimes as mesic flatwoods, with dry prairie being the essentially treeless endpoint of a continuum of variation in canopy cover across pine flatwoods landscapes in central Florida.

Dry prairie is an essentially treeless (Harshberger 1914), pyrogenic community with a ground cover diverse in regionally endemic plant taxa. It is most commonly dominated by wiregrass, sparse, scattered, low stunted saw palmetto, and low-growing runner oak (Bridges 1997). Quantitative sampling of vegetation across hydrologic gradients within dry prairie at Avon Park AFR (Polk and Highlands Counties), Kissimmee Prairie State Preserve (Okeechobee County), Ordway-Whittell Kissimmee Prairie Sanctuary (Okeechobee County) and Three Lakes WMA (Osceola County) in 1995 and 1997 confirm that these three species share dominance in most frequently burned dry prairies (Bridges and Reese 1998). Other common shrubs of dry prairie include *Lyonia fruticosa*, *Lyonia lucida*, *Ilex glabra*, and *Vaccinium myrsinites* (Bridges 1997; Huffman and Judd 1998). Infrequently burned sites, shrub cover is reduced, resulting in a diverse herbaceous ground cover (Bridges 1997; Cole et al. 1994a). Other characteristic grasses of dry prairie include *Andropogon ternarius* var. *cabanisii*, *Andropogon virginicus* var.*decipiens*, *Schizachyrium stoloniferum*, and *Sorghastrum secundum*. Typical dry prairie has a mixture of wetland and upland plants, the most characteristic of these mixtures being the co-occurrence of *Quercus minima* and *Xyris elliottii* (Bridges 1997). As wetter areas are reached, there tends to be an increase in wet-mesic species such as *Ctenium aromaticum* and *Xyris ambigua* (Bridges 1997).

There are many common faunal components of dry prairies. Both breeding and seasonal migrants utilize dry prairies extensively. Breeding birds of the dry prairies include the Florida mottled duck (*Anas fulvigula*), common nighthawk (*Chordeiles minor*), red-winged blackbird (*Agelaius phoeniceus*), common yellowthroat (*Geothlypis trichas*), eastern towhee (*Pipilo erythrophthalmus*) and eastern meadowlark (*Sturnella magna*) (T. Dean, Department of Forestry and Wildlife, University of Massachusetts, personal communication 1998). Seasonal use by northern avian species during the winter season substantially increases the avifauna diversity of dry prairie (T. Dean, Department of Forestry and Wildlife, University of

Massachusetts, personal communication 1998). Species that migrate into the central Florida area and overwinter within dry prairie include the savannah sparrow *(Passerculus sandwichensis)*, swamp sparrow *(Melospiza georgiana)*, Henslow's sparrow *(Ammodramus henslowii)*, as well as the northeastern race of grasshopper sparrow *(Ammodramus savannarum pratensis)* (T. Dean, Department of Forestry and Wildlife, University of Massachusetts, personal communication 1998). Other wintering species include yellow rail *(Coturnicops noveboracensis noveboracensis)*, palm warbler *(Dendroics palmarum)*, and a variety of other songbirds. In addition, a variety of avian predators, including northern harrier *(Circus cyaneus)*, American kestrel *(Falco sparverius)*, and *Accipiter* spp. (hawks) migrate into central Florida (T. Dean, Department of Forestry and Wildlife, University of Massachusetts, personal communication 1998). The effect of this influx on the resident avifauna is uncertain, and the importance of Florida dry prairie as wintering grounds for the seasonal residents is poorly known (T. Dean, Department of Forestry and Wildlife, University of Massachusetts, personal communication 1998). Herpetofauna of the dry prairies include common species such as Florida boxturtle *(Terrapene carolina bauri)*, glass lizards *(Ophisaurus* spp.), ground skink *(Scincella lateralis)*, Florida ribbon snake *(Thamnophis sauritus sackenii)*, Florida banded water snake *(Nerodia fasciata)*, black racer (*Coluber constrictor priapus)*, and rough green snake *(Opheodrys aestivus)* (T. Dean, Department of Forestry and Wildlife, University of Massachusetts, personal communication 1998). Amphibians including oak toad *(Bufo quercicus)*, southern cricket frog *(Acris gryllus gryllus)*, and pine woods tree frog *(Hyla femoralis)* are also abundant in dry prairies (T. Dean, Department of Forestry and Wildlife, University of Massachusetts, personal communication 1998). Common mammals include eastern cottontail *(Sylvilagus floridanus)*, hispid cotton rat *(Sigmodon hispidus)*, oldfield mouse *(Peromyscus polionotus)*, spotted skunk *(Spilogale putorius)*, and bobcat *(Lynx rufus floridanus)* (T. Dean, Department of Forestry and Wildlife, University of Massachusetts, personal communication 1998).

Freshwater Forested Wetlands

Freshwater forested wetlands are present in the study area both in the form of flowing water swamps and the more stagnant seepage swamps. The flowing water swamps can be classified further as floodplain wetlands - those along clearly defined river channels; and strand swamps - those of shallower and more diffuse flow-ways. The vegetative community of flowing water swamps is frequently dominated by bald cypress (*Taxodium distichum*). Pop ash (*Fraxinus caroliniana*) and pond apple (*Annona glabra*) may also be present. "Other typical plant species include, red maple (*Acer rubrum*), cabbage palm (*Sabal palmetto*), strangler fig (*Ficus aurea*), swamp bay (*Persea palustris*), sweetbay (*Magnolia virginiana*), royal palm (*Roystonea regia*), coastal plain willow (*Salix caroliniana*), wax myrtle, myrsine (*Rapanea* spp.), poison ivy (*Toxicodendron usneoides*), swamp lily (*Crinum* spp.), leather fern (*Acrostichum* spp.), and royal fern (*Osmunda regalis*). The canopy plants are mainly temperate, while the understory and epiphytic plants are generally tropical" (Service 1999).

"Seepage swamps are forested wetlands characterized by saturated soils rather than periodic inundation. They include baygalls at the base of seepage slopes, bayheads in peat-filled depressions or at the downstream ends of Everglades teardrop islands, and hydric hammocks on low sand or limestone rises within periodically inundated wetland systems. Baygalls and bayheads are dense evergreen forests or shrub thickets with a spongy understory of sphagnum

moss and ferns. The canopy is composed of tall, densely packed, generally straight-boled evergreen hardwoods dominated by sweetbay (*Magnolia virginiana*), swamp bay (*Persea palustris*), red bay (*Persea borbonia*), dahoon holly (*Ilex cassine*), and loblolly bay (*Gordonia lasianthus*). There is typically a more or less open understory of shrubs and ferns and a ground surface of sphagnum mats interlaced with convoluted tree roots. Hydric hammocks are open forests dominated by cabbage palms and laurel oaks (*Quercus laurifolia*) mixed with other hardwoods. They often have minimal understory and a floor carpeted by fallen palm fronds" (Service 1999).

Many animal species utilize these forested wetlands in south Florida including the following federally listed species: Florida panther, bald eagle (*Haliaeetus leucocephalus*), wood stork, and eastern indigo snake (*Drymarchon corais couperi*) (Service 1999).

b. Coastal and Estuarine Habitats

The Caloosahatchee Estuary, San Carlos Bay, Matlacha Pass, and Pine Island Sound include important mangrove and marsh habitats, a rich diversity of native wildlife, and habitat for several notable threatened and endangered species. The estuarine system consists of innumerable small islands, tidal bars, and channels, which provide the following habitat types:

Submerged Aquatic Vegetation (SAV)
Both fresh- and salt-water SAV beds are some of the most productive and valuable habitats in the Caloosahatchee Estuary and San Carlos Bay. They convert sunlight into food for fish, sea turtles, manatees, invertebrates, and other species; they provide habitat for many aquatic organisms; they provide oxygen; and they reduce turbidity by stabilizing sediments and removing nutrients from the water column that might otherwise cause harmful algal blooms. Many commercial and recreational fisheries (*e.g.*, clams, shrimp, lobster, and fish) are dependent upon healthy seagrass beds (Service 1999). Each species of SAV has a specific temperature and salinity tolerance range and their tolerance towards variations in salinity is similar to their tolerances for variations in temperature. Furthermore, estuarine biota is well adapted to and depends upon natural seasonal changes in salinity. When salinity falls outside of these normal and seasonal ranges, it may result in a reduction in densities and shifts in distribution of both SAV species and organisms dependant upon them (Chamberlain and Doering 1998b). Currently, the cover, density and geographic extent of existing SAV in the estuary have been reduced, eliminated, or shifts in their community composition have occurred due to extreme salinity fluctuations, increased turbidity, sedimentation, nutrient enrichment, and algal blooms which can all influence light penetration (Corbett 2006; Greenawalt-Boswell et al. 2006).

Tape Grass
Tape grass (*Vallisneria americana)* is the dominant SAV in the upper Caloosahatchee Estuary and occurs in well-defined beds in shallow water (Figure 6). Tape grass is an important habitat for a variety of freshwater and estuarine invertebrate and vertebrate species, including some commercially and recreationally important fishes (Bortone and Turpin 1999). During times of extended low inflow conditions, when salinity is too high, tape grass becomes very sparse and can disappear completely (Chamberlain et al. 1995; Doering et al. 2002; District 2000).

Vallisneria beds occur within the 40-acre Caloosahatchee NWR, a satellite refuge located the upper estuary administered under the J.N "Ding" Darling NWR Complex.

Seagrasses

McNulty et al. (1972) and Harris et al. (1983) mapped SAV in the lower estuary upstream of Shell Point, as well as throughout the outer embayments. Shoal grass (*Halodule wrightii*) is the only seagrass species consistently located upstream of Shell Point (Figure 6) until it mixes downstream with turtle grass (*Thalassia testudinum*) in San Carlos Bay. Shoal grass has a wide salinity tolerance (McMahan 1968); it does not survive below 3.5 parts per thousand (ppt) and prefers salinity as high as 44 ppt (Zieman and Zieman 1989). This wide tolerance is probably why it is the only true seagrass species encountered upstream of Shell Point. District monitoring results (Chamberlain et al 1995, Chamberlain and Doering 1998b, Doering et al. 2002) indicate that shoal grass biomass is lowest upstream where salinity is lowest and most variable. The greatest biomass occurs where salinity is consistently above 20 ppt. Literature summarized by Zieman and Zieman (1989) indicates that the optimum salinity range for turtle grass is 24 to 35 ppt. The maximum photosynthetic activity of turtle grass occurs in full strength seawater and decreases proportionately with decreasing salinity. Turtle grass does not grow in areas with salinity below 17 ppt and will suffer significant leaf loss when exposed to lower salinity. Turtle grass does not exist upstream of Shell Point where salinity during the District study was more variable.

Oyster Reefs and Bars

The American or eastern oyster (*Crassostrea virginica*) is an important recreational and commercial species that occupies sediment-free, firm bottom substrates in brackish and saltwater. Adults can survive salinities of 5 to 40 ppt, but the optimal range is 10 to 20 ppt. Oysters spawn at water temperatures over 20°C (68°F), with mass spawning occurring in the Gulf during spring and fall. Larval development normally requires two weeks, and can occur at salinities of 7.5 to 35 ppt, although growth is slower between 7.5 and 10 ppt. Following larval development, attachment (or settling) occurs and requires a salinity range of 5 to 35 ppt, with an optimal range of 10 to 30 ppt. The ideal substrate is shell or a firm mud-sand-shell mix. Soft muds or shifting sands are unsuitable. In addition to substrate type, the local distribution of oysters can be controlled by tidal currents. Water currents import food and remove waste. If the currents are too slow, growth is reduced. If the currents are too fast, erosion of substrate or reduction of settling can occur. Excessive turbidity and large volumes of stormwater runoff can also adversely affect oyster growth or reproduction. Predators to oysters, besides humans, include American osytercatcher (*Haematopus palliatus*), stone crab (*Menippe mercenaria*), blue crab (*Callinectes sapidus*), oyster drills (*Thais haemastoma*), sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*) and other fish and crustaceans.

Oyster reefs and bars are other valuable, aquatic, benthic habitats needed for healthy, diverse, and productive estuarine ecosystems. They provide food for fish and crustaceans, provide solid structure within the water column for sessile organism attachment (*e.g.*, barnacles and sea anemones), provide habitat as nursery areas and for organisms seeking refuge from predation (*e.g.*, polychaete worms and soft-shell blue crabs), provide spawning substrate for fish (*e.g.*, gobies and blennies), stabilize bottom sediments for other benthic organisms (*e.g.*, hard

clams) and aquatic plants, and concentrate prey for larger predator fishes (*e.g.*, red drum and striped bass (Maryland Sea Grant 2000)). Another important function of oysters, relative to the restoration of the Caloosahatchee Estuary, results from their mode of feeding. Like all bivalves, oysters are filter feeders and they can remove suspended algae and particulates from the water and greatly increase water transparency. This, in turn, can allow seagrasses to grow better and at greater depths within the estuary and lagoon.

The general distinction between an oyster reef and a bar is that a reef occupies that area between the high and low tide lines, and bars (or beds) are submerged (Bahr 1981). Intertidal populations are different in structure and ecology from their subtidal counterparts. Reefs are generally less diverse. Bahr (1981) estimated that 50 macrofaunal species occupy oyster reefs in Georgia. Wells (1961) listed 303 species associated with both oyster reefs and bars. The wide distribution of oysters (along the Atlantic and Gulf coasts from Canada to Mexico) is based, in part, on their tolerance of a wide range of salinity, temperature, turbidity, and dissolved oxygen. However, even with this tolerance, populations have decreased dramatically throughout their range due to over harvesting, habitat destruction, disease, sediment deposition, and pollution. Historic oyster bars upstream of Shell Point have been mined and removed to be used for road construction.

Salt Marsh

Saltwater marsh habitat is found landward or is interspersed on the upland side of mangrove fringing forest where it is periodically inundated at high spring tides and during storm surge. Salt marshes vary in structure and are commonly described as needle rush marshes dominated by *Juncus roemerianus*; salt flats or salterns dominated by saltgrass (*Distichlis spicata*), seashore dropseed (*Sporobolus virginicus*), sea purslane (*Sesuvium* spp.), glassworts (*Salicornia* spp.) sea lavender (*Limonium carolinianu*), sea blite (*Suaeda* spp.); and cordgrass marshes dominated by *Spartina patens* or *S. bakeri*. The borders or high areas in these saltmarshes often include groundsel tree or false-willow (*Baccharis augustifolia*), wax myrtle, marsh elders (*Iva* spp.), and Christmas berry (*Lycium carolinianum*).

Mangrove Forest

Mangroves are another highly productive and vital ecosystem of estuarine systems. They contribute significantly to the economy of the coastal communities of Lee and Charlotte Counties and southwest Florida. By occupying the lower wave energy shorelines, they provide a wide variety of benefits to both aquatic and terrestrial ecosystems. Their roots provide habitat for many plants and animals, including commercially and recreationally important fish, crustaceans, and shellfish; their canopies provide habitat for birds, and some mammals and reptiles. Mangrove shorelines act as storm buffers, and wind and wave breaks. They reduce turbidity by stabilizing sediments and recycling nutrients. Mangrove forests occur in the intertidal zone of estuaries. Three species of mangrove are the major components of the mangrove forest: the red mangrove (*Rhizophora mangle*); the black mangrove (*Avicennia germinans*); and the white mangrove (*Laguncularia racemosa*). Another species, the buttonwood (*Conocarpus erectus*), is classified as a "mangrove associate" and forms an important upland fringe in Florida's mangrove ecosystems (Tomlinson 1980, 1986). Red mangroves comprise the dominant vegetation on most of the islands, particularly on the fringe along the bays and tidal creeks. Black and white mangroves comprise mixed forests on island

interiors and in the tidally flushed basins located more landward. Buttonwood is common on beach strands of outer islands and on natural and man-made levee ridges near mainland margins. Mangrove understory in some areas contains saltmarsh species, such as glasswort, saltwort (*Batis maritima*), sea purslane (*Sesuvium portulacastrum*), and sea ox-eye (*Borrichia frutescens*); as well as leather fern (*Acrostichum* spp.); spider lily (*Hymenocallis latifolia*); sea blite; marsh elder (*Iva frutescens*); and lianas, such as *Ipomoea tuba* and *Hippocratea volubilis*.

Coastal Strand
Coastal strand vegetation dominates high-energy coastal barrier islands that are exposed to moderate and high-energy wave action and sediment transport via littoral currents. Vegetation includes sea oats (*Uniola paniculata*), beach carpet (*Philoxerus vermicularis*), sea blite, and railroad vine.

Coastal Hammock
This habitat occurs within the scattered shell mounds of mangrove forest and marsh habitats. This assemblage is dominated by stoppers (*Eugenia axillaries*), gumbo-limbo, live oak, red bay (*Persea borbonia*), cabbage palm, nicker bean (*Caesalpinia crista*), and sea grape (*Cocoloba uvifera*).

6. Fish and Wildlife Resources

a. Federally Listed and Candidate Species

Seventeen federally listed threatened or endangered animal species, two listed plant species, and one endangered fish species are present or potentially present in the study area or proposed project footprint, and may be impacted by the construction and operations of the project. Many of these species have been previously impacted by adverse effects on habitat due to wetland drainage, alteration of hydroperiod, wildfire, and water quality degradation. Those species not directly affected by the project include species that are rare in the project area or utilize estuarine habitat that is only indirectly affected by the restoration project.

Although some of these species may be impacted by the loss of habitat within the project footprint, when implemented, the project has the potential to significantly contribute towards environmental restoration beyond the project footprint. For additional information on these species please refer to the District's Final BA for the C-43 West Storage Reservoir Project, Hendry County, Florida in the Environmental Annex A of the Draft PIR/EIS. The site information included in this report is based on surveys referenced in the BA. Table 1 lists the threatened and endangered species within the C-43 Basin Storage Reservoir Project study area.

Everglade Snail Kite
The snail kite (*Rostrhamus sociabilis plumbeus*) inhabits the watersheds of the Everglades, lakes Okeechobee and Kissimmee, the upper St. Johns River, and the Caloosahatchee basin. Critical habitat for the snail kite is present immediately adjacent to the Caloosahatchee basin inside of the Herbert Hoover Dike in Lake Okeechobee. The snail kite can also be found foraging in a number of native wetlands and in canals and ditches adjacent to the project area. This medium-

sized rapter has a highly specific diet composed almost entirely of Florida apple snails (*Pomacea paludosa*), which are found in palustrine emergent, long hydroperiod wetlands. As a result, the snail kite's survival is directly dependent on the hydrology and water quality of its habitat (Service 1999).

One snail kite was observed perched on a wire and eating a snail along SR 80 during a February 2006 survey. This location was approximately 0.75 miles west of the project footprint. In addition, during several field visits between 2004 and 2006, of two species of apple snails, the Florida apple snail (*Pomacea paludosa*) and the exotic ramshorn apple snail (*Marisa cornuarietis*), were observed in large ditches of the project site. The network of large agricultural ditches provides suitable foraging opportunities but evidence of foraging and feeding (shell discards) was not observed.

Table 1. Federally Listed Threatened (T) and Endangered (E) Species known or expected to occur within C-43 Basin Storage Reservoir Study Project Area

Common Name	Scientific Name	Status
REPTILES		
American crocodile	*Crocodylus acutus*	E
Eastern indigo snake	*Drymarchon corais couperi*	T
Atlantic green sea turtle	*Chelonia mydas mydas*	E
Hawksbill sea turtle	*Eretmochelys imbricata*	E
Kemp's ridley sea turtle	*Lepidochelys kempi*	E
Loggerhead sea turtle	*Caretta caretta*	T
Leatherback sea turtle	*Dermochelys coriacea*	E
BIRDS		
Audubon's crested caracara	*Polyborus plancus audobonii*	T
Everglade Snail kite	*Rostrhamus sociabilis plumbeus*	E
Florida grasshopper sparrow	*Ammodramus savannarum floridanus*	E
Florida scrub jay	*Aphelocoma coerulescens*	T
Piping plovers	*Charadrius melodus*	T
Red-cockaded woodpecker	*Picoides borealis*	E
Southern bald eagle	*Haliaeetus leucocephalus*	T
Wood stork	*Mycteria americana*	E
MAMMALS		
Florida panther	*Puma concolor coryi*	E
West Indian manatee	*Trichechus manatus*	E
PLANTS		
Beautiful pawpaw	*Deeringothamnus pulchellus*	E
Okeechobee gourd	*Cucurbita okeechobeensis*	E

FISH*

Smalltooth Sawfish	*Pristis pectinata*	E

* Federally listed fish species are regulated by the National Oceanic and Atmospheric Administration- National Marine Fisheries Service (NOAA Fisheries Service).

Wood Stork

The wood stork (*Myctria Americana*) is primarily associated with freshwater and estuarine habitats for nesting, roosting, and foraging. They have nested, at one time or another, in every county in south Florida. Typical foraging sites include freshwater marshes and stock ponds, shallow, seasonally flooded roadside or agricultural ditches, narrow tidal creeks or shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Wood storks use a specialized feeding behavior called tactolocation, or grope feeding. A foraging wood stork wades through the water with its beak immersed and partially open (7 to 8 cm) (2.7 to 3.9 inches). When it touches a prey item, a wood stork snaps its mandibles shut, raises its head, and swallows what it has caught (Kahl 1964). This unique feeding method of the wood stork gives it specialized habitat requirements; the habitats on which wood storks depend have been disrupted by changes in the distribution, timing, and quantity of water flows in south Florida. The loss or degradation of wetlands in central and south Florida is one of the principal threats to the wood stork.

The reservoir footprint overlaps the 18.6-mile core foraging areas (CFA) of three wood stork colonies. Individuals have been observed foraging and loafing onsite, although not frequently.

West Indian Manatee

The West Indian manatee (*Trichechus manatus*) is recognized as an endangered species by both the Service and FWC. Manatees are also protected under the provisions of the Marine Mammal Protection Act of 1972, as well as Florida law. The manatee, or sea cow, is a large, plant-eating aquatic mammal that can be found in the shallow coastal water, rivers, and springs of Florida. Florida is essentially the northern extent of the West Indian manatee's range, though some manatees occasionally are reported from as far north as Virginia and the Carolinas (FP&L 1989). The endangered West Indian manatee is regularly found in the Caloosahatchee River and the Charlotte Harbor estuary. This large, aquatic mammal migrates along the Florida coast through fresh, brackish, and marine waters, with a seasonal distribution based on water temperatures. Water depths of at least 3 to 7 ft are preferred. Water colder than 20 degrees Celsius (68 degrees Fahrenheit) increase the manatee's susceptibility to cold-stress and cold-induced mortality. Distribution is also controlled by aquatic vegetation availability, proximity to channels of at least 2 meters (6.6 ft) in depth, and location of fresh water sources (Service 1999). During the summer months manatees range throughout water bodies of south Florida, usually in small groups. In the winter months they tend to congregate in warm water areas such as springs and electric generation facilities (FP&L 1989).

Designated critical habitat for the manatee is located in the Caloosahatchee River Basin. Critical habitat extends downstream from the State Highway 31 Bridge and includes all U.S. territorial waters adjoining the coast and islands of Lee County.

Primary threats to manatees today are collisions with watercraft, degradation of seagrasses and accidents occurring at water control structures. Navigational locks along the Caloosahatchee River have a history of causing manatee mortality. Sixteen navigational locks and water control structure-caused manatee deaths have been recorded near Ortona Lock (S-78) between 1980 and 2001. Throughout those same years, six were discovered near S-77 at Moore Haven, and just one in 1999 at the Franklin Lock (S-79). Existing operational protocols for the structures and locks (unaffected by project planning for the C-43 reservoirs) are important considerations in reducing these deaths.

Manatees have been known to utilize the Townsend Canal, which lies immediately adjacent and to the west of the project footprint. During times of inflow from the Caloosahatchee River, manatees are capable of passing over the weir and traveling southward into the Townsend Canal. Individuals have been observed at the outfall area immediately west of the project boundary as well as at the mouth of the canal in the Caloosahatchee River. However, manatees cannot access the main distribution canal (*i.e.*, Header Canal) for the grove property due to differences in elevation.

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is currently listed as a threatened species by both the Service and FWC. However, the Service has recently determined that the bald eagle has recovered and published the Final Rule to delist the bald eagle in the Federal Register on July 9, 2007. Removal of the bald eagle from the list of endangered and threatened wildlife will be effective August 8, 2007. Accordingly, the bald eagle is considered common in Florida and known to breed throughout the state. Nest sites are usually located near large rivers, lakes, or estuaries where they feed primarily on fish and water-dependent birds. Their distribution is influenced by the availability of suitable nest and perch sites near large, open waterbodies, typically with high amounts of water-to-land edge (Service 1999). The bald eagle is the only eagle unique to North America. It ranges over most of the continent, from the northern reaches of Alaska and Canada down to northern Mexico. Current threats to the bald eagle include habitat loss and fragmentation, collisions with cars and powerlines, and shooting (Service 1998).

Data obtained from the FWC 2004 Eagle Nest Database indicate that the closest documented bald eagle nest, HE002, is located 3.4 miles east of the project, eastward of SR 29. This nest is documented to be last active as of the 2003 nesting season (was not active in the 2004 nesting season). No other nests were observed in the project vicinity during summer 2004 or spring 2006 field efforts.

Eastern Indigo Snake

The threatened eastern indigo snake (*Drymarchon corais couperi*) is present throughout the state, but its abundance is reduced to a point where it is uncommon. Habitat includes pine flatwoods, scrubby flatwoods, high pine, dry prairie, tropical hardwood hammocks, edges of freshwater marshes, agricultural fields, coastal dunes, and human altered habitats. This species was listed as a result of dramatic population declines caused by over-collecting for the domestic and international pet trade as well as mortalities caused by rattlesnake collectors who gassed gopher tortoise burrows to collect snakes. Since its listing, habitat loss and fragmentation by residential

and commercial expansion have become much more significant threats to this species (Service 1999).

The project study area contains suitable habitat for the eastern indigo snake. Although the eastern indigo snake was not observed during field visits, habitat exists on the project site; therefore, it could potentially occur. The species is known to utilize a variety of habitat types including citrus grove (Service 2006).

Florida Scrubjay
The Florida scrubjay (*Aphelocoma coerulescens*), a threatened species, is present in limited areas of scrub habitat in the study area. It is a relict species of fire-dominated oak scrub habitat that occurs on well-drained sand soils in peninsular Florida. Scrub-jays are extremely habitat-specific, sedentary, and territorial. Florida scrub-jays form family groupings; fledglings remain with their parents in their natal territory as helpers. The Florida scrub-jay is listed as a threatened species because of loss, fragmentation, and degradation of scrub habitats throughout Florida, due primarily to urbanization, agriculture, and fire suppression. During the last 10 to 23 years, the population has declined by an estimated 25 to 50 percent, and they have been extirpated from seven counties statewide.

No individuals, nests, or appropriate habitat were detected in the project footprint during site visits. The nearest documented Florida scrub jay habitat and population occurs 1.1 miles west of the project area. This colony is beyond the foraging distance for the species to access the project area.

Red-cockaded Woodpecker
The red-cockaded woodpecker (*Picoides borealis*) was listed as threatened in 1970. The red-cockaded woodpecker is one of 22 species of woodpeckers native to North America. Its historic range encompasses the southeastern U.S. from eastern Texas to Oklahoma to New Jersey, and it was characterized as "abundant" in the 19th century literature. Throughout the 20th century, however, the species' distribution within its historic range has become fragmented, and its total population numbers have decreased dramatically due to the destruction of its habitat. The primary threat to the species continues to be the destruction or degradation of its habitat as a result of timbering and other land-clearing activities. Although south Florida is not a designated recovery population for the red-cockaded woodpecker, the area contains support populations for recovery of the species in the southeast. Additional population surveys and research on habitat requirements within the hydric pine flatwoods of south Florida are needed to assess the current status of the birds and to adapt conservation measures used elsewhere to the distinct conditions in this area. The nearest documented red-cockaded woodpecker population occurs approximately 14 miles northwest of the project area (FWC data).

Florida Panther
The Florida panther (*Puma concolor coryi*), a subspecies of mountain lion, is one of the most endangered large mammals in the world. The most recent population estimate for the Florida panther is a total of 87 individuals, not including denning kittens (McBride 2003). This small population in south Florida represents the only known remaining wild population of an animal

that once ranged throughout most of the southeastern United States from Arkansas and Louisiana eastward across Mississippi, Alabama, Georgia, Florida, and parts of South Carolina and Tennessee. The panther presently occupies one of the developed areas in the eastern United States; a contiguous system of large private ranches and public conservation lands in Broward, Collier, Glades, Hendry, Lee, Miami-Dade, Monroe, and Palm Beach Counties totaling more than 809,400 hectares (2,000,070.9 acres). Panthers have a strong affinity for hardwood forests and mixed swamps but also use freshwater marshes, prairie and shrub and scrub habitats, agricultural lands (*i.e.,* wooded pasture, rangeland, citrus groves, row crops, etc.), and even urban areas. Geographic isolation, habitat loss, population decline, and associated inbreeding have resulted in a significant loss of genetic variability and overall health of the Florida panther population. Natural gene exchange ceased when the panther became geographically isolated from other subspecies of *Puma concolor*. Population viability projects have concluded that, under current demographic and genetic conditions, and without implementation of recovery actions, the panther would probably become extinct within two to four decades.

The Caloosahatchee basin plays an important role in the recovery of the Florida panther. The Service has organized a multi-agency subgroup of the Multi-species and Ecosystem Recovery Implementation Team (MERIT) to produce a Florida panther landscape conservation strategy. That strategy included the identification and prioritization of habitat zones (Dispersal, Primary, and Secondary Zones) that are essential for effective Florida panther conservation (Kautz et al. 2006). In addition to protection of habitat for adult home ranges, the strategy includes corridors for dispersal of juveniles between larger areas of contiguous habitat. Dispersal across the Caloosahatchee River, between existing primary habitat south of the river and habitat that is presently only occasionally used by panthers north of the river, is considered essential for recovery of the species.

A large portion of the proposed project is located outside the panther focus area (PFA), while the remainder of the project area is located in an agricultural area that provides some functional value for panthers. This portion of the proposed project would impact areas within the panther primary, secondary, and "other" zones, as identified by the Florida panther subteam of the MERIT and Service's PFA updates. The most recent available FWC telemetry data of radio collared Florida panthers, current through January 2004, depicts three (3) Florida panthers and one (1) Texas cougar (*Felis concolor*) within a five-mile radius of the project area. The status and activities of uncollared Florida panthers within the project area are unknown. The Service believes the project site may occasionally be used by foraging and dispersing panthers because it contains habitat types used by panthers and their prey and the project vicinity has been used historically by panthers as indicated by telemetry locations over a 10-year period. A more landscape level inspection (25-mile radius) identifies habitat utilization by several additional panthers, particularly within Okaloacoochee Slough and other conservation lands.

Audubon's Crested Caracara

Audubon's crested caracara (*Polyborus plancus audobonii*) is another federally listed species present in the Caloosahatchee basin. It is a large, boldly patterned raptor, with a crest and unusually long legs. It is a resident, diurnal, and non-migratory species that occurs in Florida as well as the southeastern United States and Central America. In Florida, this species is found in

the prairie area of the south-central region of the state. Historically, this species was a common resident in Florida from northern Brevard County, south to Ft. Pierce, Lake Okeechobee, and Hendry County. Today, the region of greatest abundance for this large raptor is a five-county area north and west of Lake Okeechobee. The preferred native habitat is dry or wet prairie with scattered cabbage palms (Service 1999). Improved and unimproved pastures are also highly utilized. Effect determinations for caracara are based mostly on potential impacts within the primary nest zone (*i.e.*, within a radius of 985 ft from a nest tree) or the secondary zone (a radius of 6,600 ft). Additionally, potential effects within juvenile congregation areas are also considered.

The project falls within the Service's caracara Consultation Area. One caracara nest site was confirmed to the north of the project during spring 2006 surveys. This nest is located along the southern edge of the SR 80 right-of-way (ROW) and approximately 4,750 ft north of the project boundary. While individuals were not observed foraging in the project footprint, a portion of the project falls within 2000 meters (secondary zone) of this nest, as defined in the Standard Local Operating Procedures for Endangered Species (SLOPES). Another caracara nest was confirmed approximately 1,065 ft southeast of the project boundary, within a pasture of the A. Duda & Sons, Inc. property. Individuals were observed flying into and out of the C-43 reservoir site by staff of Scheda Ecological Associates, Inc. during the 2006 surveys. While the C-43 project area provides only sub-optimal foraging habitat for the species, and individuals were only observed utilizing the project area in the southeast portion of the footprint, it does fall within the home range of both the confirmed and possible nests.

Florida Grasshopper Sparrow

The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) is a subspecies of grasshopper sparrow that is endemic to the dry prairie of central and southern Florida. This subspecies is extremely habitat specific and relies on fire every two to three years to maintain its habitat. It is now known to occur only from Highlands, Okeechobee, Osceola, and Polk Counties, but other populations may occur in Glades County, which may bring it into the study area considered here. The species is not known to occur in Hendry County but populations may occur in nearby Glades County as documented in our April 11, 2002 Planning Aid Letter. The nearest Florida grasshopper sparrow record in the 1999 FNAI database is a 1984 observation located 17.3 miles north of the project. Mapping of potential Florida grasshopper sparrow habitat (Shriver and Vickery 1999) shows marginal habitat zones to the northeast and southeast of the project, and the project area falls within the Service's Florida grasshopper sparrow CA. However, the nearest marginal habitat zone is located approximately 2.5 miles to the southeast of the project footprint. No grasshopper sparrows were observed during field surveys and no suitable habitat exists in the project area.

Piping Plovers

A wintering population of piping plovers (*Charadrius melodus*) uses the tidal area of the Caloosahatchee River. The piping plover was listed as threatened along the Atlantic coast in 1985. It is a small, migratory shorebird that breeds only in three geographic locations of North America: on sandy beaches along the Atlantic Ocean, on sand shorelines throughout the Great Lakes, and on riverine systems and prairie wetlands of the Northern Great Plains. This species

does not breed in Florida, but all three breeding populations winter here. Bunche Beach, at the mouth of the Caloosahatchee, has a population of wintering piping plovers and is also designated critical habitat for this species. The Service established critical habitat areas for the species, which include several locations on barrier islands west of the Caloosahatchee Estuary. The nearest piping plover critical habitat zone to the project area includes Punta Rassa, a mainland location at the southwestern edge of the Caloosahatchee Estuary, and Bunch Beach.

Okeechobee Gourd

The Okeechobee gourd (*Cucurbita okeechobeensis*) is a vine that was locally common in the extensive pond apple forest that once grew south of Lake Okeechobee (Small 1922). It is a vine that is now restricted in the wild to two small distinct populations; one along the St. Johns River which separates Volusia, Seminole, and Lake Counties in north Florida, and a second around the shoreline of Lake Okeechobee in south Florida. Although the gourd occurs within the Caloosahatchee Basin, no individuals occur in the project area or would be impacted by reservoir releases.

American Crocodile

The Service and the FWC list the American Crocodile (*Crocodylus acutus*) as endangered. This species occurs in extreme south Florida primarily in Biscayne and Florida Bays. Crocodiles have been observed as far north as the coasts of Lee and Collier Counties, but these counties are not thought to support a significant resident population of crocodiles. The American crocodile has not been documented in Hendry County. The nearest documented individual occurrence to the project is on Sanibel Island in Lee County. The American crocodile is known to inhabit mangrove and seagrass habitats in coastal areas of south Florida.

Sea Turtles

Sea turtles including the Atlantic loggerhead turtle (*Caretta caretta*), Atlantic green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), Kemp's ridley turtle (*Lepidochelys kempii*), and hawksbill turtle (*Eretmochelys imbricata*) are listed as endangered by the Service and the FWC with the exception of the loggerhead turtle, which is listed as threatened. These are marine species with a presence in south Florida waters and are known to utilize bays and estuarine habitats, such as the Caloosahatchee estuary, for feeding and resting. Sea turtles forage in the near shore waters, bays and sounds of Florida and come ashore at night to nest on the beaches above the high tide line. Alterations in the timing and quantity of freshwater flowing through the estuary has an impact on natural biodiversity by affecting food availability, predation pressure, reproductive success, and most likely has caused chronic and acute stress to these species.

Estuarine Fishes

One endangered fish, the smalltooth sawfish *(Pristis pectinata)*, occurs or may occur in estuaries downstream of the project area. Federally listed fish species are regulated by the NOAA Fisheries Service.

b. State-listed Species

The following fish and wildlife species (Table 2) are State-listed as threatened (T), endangered (E), or species of special concern (SSC), and may occur or are known to occur in the study area.

Table 2. Species listed by the Florida Fish and Wildlife Conservation Commission as threatened (T), endangered (E), or of special concern (SSC) that potentially occur within the Caloosahatchee River Basin (Charlotte, Lee, Collier, Hendry, and Glades Counties) or the Proposed C-43 West Reservoir footprint excluding federally listed species (Florida Natural Areas Inventory 2001).

Common Name	Scientific Name	Status	C-43 West
REPTILES			
American alligator	*Alligator mississippiensis*	SSC	X
Florida pine snake	*Pituophis melanoleucus mugitus*	SSC	
Gopher tortoise	*Gopherus polyphemus*	SSC	X
AMPHIBIANS			
Gopher frog	*Rana capito*	SSC	X
BIRDS			
American oystercatcher	*Haematopus palliatus*	SSC	
Black skimmer	*Rynchops niger*	SSC	
Brown pelican	*Pelecanus occidentalis*	SSC	
Florida burrowing owl	*Speotyto cunicularia*	SSC	X
Florida sandhill crane	*Grus canadensis pratensis*	T	X
Least tern	*Sterna antillarum*	T	
Limpkin	*Aramus guarauna*	SSC	X
Little blue heron	*Egretta caerulea*	SSC	X
Reddish egret	*Egretta rufescens*	SSC	
Roseate spoonbill	*Ajaia ajaja*	SSC	X
Roseate Tern	*Sterna dougallii*	T	
Snowy egret	*Egretta thula*	SSC	X
Southeastern American kestrel	*Falco sparverius paulus*	T	X
Southeastern snowy plover	*Charadrius alexandrinus tenuitrostris*	T	
Tricolored heron	*Egretta tricolor*	SSC	X
White ibis	*Eudocimus albus*	SSC	X
MAMMALS			
Big Cypress fox squirrel	*Sciurus niger avicennia*	T	X
Everglades mink	*Mustela vison evergladensis*	T	
Florida black bear	*Ursus americanus floridanus*	T	X
Florida (Wagner's) mastiff bat	*Eumops glaucinus floridanus*	E	X
Sherman's fox squirrel	*Sciurus niger shermani*	SSC	X
Sherman's short-tailed shrew	*Blarina carolinensis shermani*	SSC	

MOLLUSCS		
Florida tree snail	*Liguus fasciatus*	SSC

c. Other Fish and Wildlife Resources

In 1994, the FWC (Cox et al. 1994) assessed Florida's wildlife habitat conservation system in order to provide recommendations to meet minimum conservation goals for declining wildlife species and rare plant and animal communities. The report (termed the GAPS report) described habitat areas in Florida that should be conserved if key components of the state's biological diversity were to be maintained. A GIS was used to assess land use, geographic data sets of fish and wildlife species, rare plants, and habitats to recommend lands (Strategic Habitat Conservation Areas [SHCA]) for additional protection. The SHCAs are lands needed to meet minimum conservation goals for 30 species of wildlife inadequately protected by conservation lands, rare habitats, bat maternity caves and winter roost caves, wetlands important to the breeding success of eight species of wading birds, and lands important to the long-term survival of 105 globally rare plant species. The project also identified Regional Biodiversity Hot Spots (RBHS) where large numbers of 52 selected species co-occur with areas that support rare plant and wildlife communities and coastal areas that support key components of biological diversity. The SHCAs encompass 4.82 million acres or approximately 13 percent of the land area in Florida.

The Southwest Florida Region was identified in the GAPS report as the most important region in Florida in terms of maintaining several wide-ranging species. The C-43 West Storage Reservoir project is included in Area 1 of the region which contains SHCAs for the Florida panther, Florida black bear, wood stork, American swallow-tailed kite, Florida sandhill crane, Everglade snail kite, Audubon's crested caracara, Florida scrub jay, snowy egret, little blue heron, glossy ibis, great egret, mottled duck, eastern indigo snake, and large flowered flax.

In 1999, the Service finalized the South Florida Multi-Species Recovery Plan. This plan is an ecosystem-based recovery plan to restore and maintain the biodiversity of native plants and animals, as well as the threatened and endangered species of south Florida. The plan identifies several ecological communities that are found in the C-43 West Storage Reservoir project area, including mesic temperate hammock, tropical hardwood hammock, forested wetlands (cypress forest), mesic and hydric flatwoods, and freshwater marshes and wet prairies.

Migratory Birds

Migratory birds are protected under the Migratory Bird Treaty Act (16 U.S.C. 703-712). The South Florida ecosystem is located along one of the primary migratory routes for bird species that breed in temperate North American and winter in the tropics of the Caribbean and South America. Many species of neotropical migrants have been recorded in the South Florida Ecosystem. In 1995, the Service prepared a list of migratory nongame birds of management concern in the U.S. to stimulate a coordinated effort by Federal, State, and private agencies to develop and implement comprehensive and integrated approaches for management of these

selected species (Service 1995). Forty-three of these species are found in the south Florida Ecosystem. Other migratory species like the tanagers (*Pirange* spp.), chimney swifts (*Chaeturaa pelagica*), tree swallows (*Iridoprocne bicolor*), nighthawks (*Chordeiles minor*), royal terns (*Sterna maxima*), and blue-winged teal (*Anas discors*) also have major migratory pathways through and to (as winter residents) south Florida. More than 129 bird species migrate to the South Florida Ecosystem to overwinter. Another 132 bird species breed in south Florida. Because the South Florida Ecosystem is located near Cuba and the West Indies, it draws tropical species that rarely appear elsewhere in North America. Examples include the smooth-billed ani (*Crotophaga ani*), mangrove cuckoo (*Coccyzus minor*), Antillean nighthawk (*Chordeiles gundlachii*), white-crowned pigeon (*Columba leucocphala*), gray kingbird (*Tyrannus dominicensis*), short-tailed hawk (*Buteo brachyurus*), Everglade snail kite, and black-whiskered vireo (*Vireo altiloquus*). The South Florida Ecosystem has an endemic race of the yellow warbler (*Dendroica petechia*) and contains the majority of the nesting locations for the reddish egret (*Egretta rufescens*), roseate spoonbill (*Ajaia ajaja*), swallow-tailed kite, and short-tailed hawk in the United States.

Southwest Florida has been identified as a core conservation area for the swallow-tailed kite (Meyer 1996). The swallow-tailed kite requires tall, accessible trees for nesting with open areas that provide sufficient small, easily subdued prey. Suitable habitat may be small stands or tree islands in prairie-like settings, low-density forests of uneven structure interrupted by open areas of shrub, swamp, or marsh vegetation, or denser forest, frequently interspersed with various sorts of openings (Meyer 1995). A large, pre-migratory roost (280 birds in 1988) of swallow-tailed kites has been documented 27 km (16.8 miles) away in Corkscrew, Collier County (Meyer and Collopy 1990).

Fifteen species of herons, storks, and ibises nest in south Florida and are considered ecological indicators because of their wide foraging ranges, relatively narrow food requirements, and relatively specific habitat requirements. Their breeding success reflects the health of the wetland and coastal habitats of south Florida. Migratory songbirds, raptors, and wading birds utilize a variety of habitats within the C-43 West Storage Reservoir project area and represent an important trust resource for the C-43 West Storage Reservoir project area. The Audubon WatchList for the State of Florida (Muehter 1998) also includes several avian species known to inhabit the C-43 West Storage Reservoir project area (*i.e.*, American swallow-tailed kite, and loggerhead shrike [*Lanius ludovicianus*]). State WatchLists promote the conservation of local bird populations and serve as an early warning system that focuses attention on at-risk bird species before they become endangered.

Essential Fish Habitat

Aquatic habitats within the Caloosahatchee Basin have been altered through the channelization of the river. Nevertheless, the basin continues to support fishery resources of some recreational or commercial importance. At least 70 percent of Florida's recreationally or commercially sought fishes depend on estuaries for at least part of their life histories (Harris et al. 1983; Estevez 1998; Lindall 1973). Seagrass communities within the Caloosahatchee estuary provide critical refugia for juvenile fish such as redfish, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall

decrease in species richness may be related to the loss of seagrass habitat and a result of alterations in the salinity regime and the timing of the freshwater discharges from the S-79 structure. The "without project" condition would impact essential fish habitat by projected further disruptions in the distribution, timing and quantity of water flows into the Caloosahatchee estuary.

C. Description of Proposed C-43 West Storage Reservoir Site

The proposed C-43 West Basin Reservoir footprint is located in Hendry County west of LaBelle, Florida. The site is located on approximately 10,492 acres south of State Road 80 and approximately two miles west of State Road 29 (Figure 2). The majority of the property is owned by the District and is under a lease agreement with Jack M. Berry, Inc. for continued citrus grove operations.

At the landscape level, the C-43 project is surrounded by a matrix of agricultural, forested, and wetland land covers with pockets of urban land use. Citrus groves, row crops and improved pasture with scattered cypress and mixed wetland hardwoods surround the project to the north, east, and south. The area to the north also contains some low-density residential areas. Forested uplands, parceled into low-density residential lots in various stages of development, comprised of pine flatwoods, longleaf pine-xeric oak, sand pine, and xeric oak are adjacent to the west of the project. Urban areas are present to the southwest and northeast of the project area with small parcels along the Caloosahatchee River. Regions to the northwest and southeast of the project area are generally undeveloped.

Natural and biological features and land use within the reservoir footprint were initially reviewed using the 2000 Florida Land Use, Cover and Forms Classification System (FLUCCS) Geographic Information System (GIS) data (District 2000). Citrus grove covers approximately 90 percent of the study site, more than any other land cover type. The citrus grove land use classification includes acreage covered by citrus trees, grove maintenance roads, and small berms, brush piles, and other small features related to citrus grove operations. Water comprises 8.9 percent of the site and includes extensive agricultural canals and ditches, classified as streams and waterways, and excavated ponds, classified as reservoirs less than 10 acres in size. Wetland comprises 1.1 percent of the site and includes mixed wetland hardwoods, willow and elderberry, exotic wetland hardwoods, cypress, wetland shrub, and freshwater marsh.

The project site has numerous agricultural canals and ditches for irrigation and drainage. The site contains three major arterial canals that transport water for the purpose of irrigation and attenuation of Caloosahatchee Basin runoff waters. Two of the primary canals, Roberts and Townsend, lie along the eastern and western perimeters of the footprint, respectively. The Header Canal, also called the LPDD Canal, bisects the entire reservoir area and is used primarily to cross-feed water between the Roberts and Townsend Canals.

Most of the reservoir footprint contains north and south oriented tertiary canals spaced every tenth row of trees (*i.e.,* approximately every 250 ft) to irrigate the citrus beds. The tertiary canals drain into a network of larger secondary canals, both of which are considered jurisdictional

waters of the United States by the Corps. The secondary canals drain into the Header Canal. Water eventually flows the Header Canal to the Caloosahatchee River through the Townsend or Banana Branch and Roberts canals or through Fort Simmons Branch (Figures 13). The planned reservoir intake is located on the Townsend Canal immediately downstream from the segment identified by DEP as impaired for copper and lead.

Intensive agriculture in the study area occurs mainly as citrus, with some row crops, sod farms, plant nurseries, and sugar cane. These disturbed areas are generally less desirable habitats for fish and wildlife. They exhibit habitat uniformity and are subject to disturbance from humans, machinery, and pesticide usage. Still, some wildlife is usually present in these areas as either residents or transients from native habitats. Mazzotti et al. (1992) reported on wildlife usage in citrus groves southwest of Lake Okeechobee. They found 203 vertebrate species out of a possible total of 380 that were regionally present, however, 78 percent of those were observed not in the production areas, but in associated agricultural reservoirs or wet detention areas.

IV. FISH AND WILDLIFE RESOURCE CONCERNS

A. Introduction

The Service recognizes the importance of this project as an initial step to improve the timing and quantity of freshwater flows to the Caloosahatchee estuary and adjacent waters and to enhance or conserve aquatic and estuarine habitats. The principal focus of this report is the protection, conservation, and enhancement of fish and wildlife resources in the region, consistent with the project purposes of promoting an ecologically viable salinity regime in the Caloosahatchee estuarine system.

As mentioned previously, the Caloosahatchee River and Estuary is at the head of a vast estuarine and marine ecosystem that includes aquatic preserves managed by the State of Florida (*e.g.*, Matlacha Pass AP, Estero Bay AP, Pine Island Sound AP), and Federal entities (*i.e.*, the CHNE Program, and the J.N. "Ding" Darling NWR Complex) along with numerous other State and local parks and recreation areas. Restoration of healthy, productive aquatic ecosystems in the Caloosahatchee River and estuary is essential to maintaining the ecological integrity and associated economic activity in these publicly owned and managed areas. The intent of this section is to define fish and wildlife resource values in terms of the issues and areas of concern generated by the proposed project.

B. Resource Concerns

1. Protection of Estuarine and Marine Resources

The Caloosahatchee estuary extends from S-79 about 40 km downstream to Shell Point where it empties into San Carlos Bay and adjacent waters (Figure 7). Major environmental concerns for the Caloosahatchee estuary and adjacent waters are altered freshwater inflows and extreme variation in salinity levels, eutrophication, and habitat loss. Altered salinity in the estuary has resulted from hydrological modifications that have dramatically changed the natural quantity,

quality, timing, and distribution of freshwater flows to the estuary (Haunert et al. 2000). Salinity is a major ecological variable that controls important aspects of the estuarine community structure and food web (Myers and Ewel 1990). Flow alterations impact the natural biodiversity of the estuary by affecting food availability, predation pressure, and reproductive success, as well as directly causing chronic and acute stress on biota. Altered freshwater inflow can also influence primary productivity, zooplankton biomass, and nekton abundance by influencing nutrient concentrations and light attenuation.

a. Management of freshwater flows and salinity conditions

The excessive variation in discharge and salinity in the Caloosahatchee Estuary (Figure 8) maintains estuarine biota in a constant flux between those favoring higher salinity and those favoring lower salinity (Chamberlain and Doering 1998a; Bulger et al. 1990). Optimal salinity conditions may not last long enough for organisms to complete their life cycle and the estuary can become devoid of some populations, even keystone species that support major ecosystem components along the estuary's salinity gradient such as oysters or submerged aquatic vegetation.

Depending on day of the year, the long-term mean daily discharge at S-79 ranges between 300 and 3,000 cfs. However, daily and monthly inflows often exceed this long-term average particularly in the wet season, with prolonged inflows commonly exceeding 4,500 cfs, which adversely affects the San Carlos Bay area and the Caloosahatchee and Matlacha Pass NWRs. Flows reaching above the 4,500 cfs threshold and those occasionally exceeding 10,000 cfs can push freshwater into Pine Island Sound and the Gulf of Mexico, thus impacting ecologically and commercially important high-salinity marine resources that historically were not directly affected by Caloosahatchee River discharges. During the dry season, the combination of limited rainfall, lack of water storage in the basin and withdrawals to meet human demands for irrigation and potable water often results in periods of no freshwater discharge to the estuary. Saltwater can intrude all the way upstream to S-79, threatening species that require low salinity to complete their life cycle (Chamberlain and Doering 1998a; 1998b, Doering et al. 2002; District 2002).

Environmental research by the District began in the Caloosahatchee Estuary during the mid-1980s and focused on the impacts associated with the extreme variability in freshwater inflow from S-79 (Chamberlain and Doering 1998a). The purpose of the research was to determine the proper timing and volume of water quantity required to support valued ecosystem components (VECs), such as oysters and SAV, as well as the impacts of flows on general biotic indicators, such as plankton and benthic invertebrates (District 1998). This research has resulted in the development of optimum S-79 flow ranges and delivery patterns for the estuary (Chamberlain and Doering 1998b; Doering et al. 2002; Volety et al. 2003). This information has formed the basis for development of hydrologic performance measures for CERP, Southwest Florida Feasibility Study (SWFFS), and the Lake Okeechobee Regulation Schedule, as well as meeting legislative mandates for the establishment of the Caloosahatchee River and Estuary Minimum Flow and Level (MFL) (District 2000, 2003).

The MFL was based on a flow-salinity relationship that was based on flows at S-79 and downstream salinity levels. The MFL salinity criteria were initially designed to protect tape grass upstream of Ft. Myers but those criteria are also beneficial for other organisms that utilize this low salinity region of the estuary (Chamberlain and Doering 1998b; Doering et al 2002). Additionally, the MFL study determined that the proposed criteria for the Caloosahatchee River and Estuary will be exceeded on a regular and continuing basis until additional storage is provided in the basin to supply the additional water needed.

The optimum distribution of flows at S-79 and salinity criteria (*i.e.*, hydrologic performance measures) were derived from relationships between the distribution, abundance, growth, and survival of estuarine organisms or VECs and the changes in salinity or freshwater discharge to the estuary. Initially, the salinity tolerances of submerged grasses were used to identify minimum and maximum inflows at S-79. A distribution of monthly average inflows with the greatest frequency range from 300 to 1,500 cfs and a peak between 300 and 800 cfs was originally identified as the most beneficial for the species evaluated. Mean monthly flows less than 300 cfs were thought to allow salinity in the upper estuary to exceed the tolerance of tape grass and cause mortality. Flows greater than 2,800 cfs reduce salinity in the lower estuary and threaten the marine shoal grass typical of this region (Chamberlain and Doering 1998b; Doering et al. 2002). Research has shown that the flows from 300 to 1,500 cfs with a peak between 300 and 800 cfs, can benefit other organisms as well (*e.g.*, oysters, plankton, blue crab, and redfish) (Chamberlain and Doering 1998b; Volety et al. 2003).

As more information about the salinity requirements of key biota became available, the original frequency distribution would be updated (Chamberlain and Doering 1995, 1998a, and 1998b). The MFL identified 300 cfs as the minimum average monthly inflow at S-79 needed to prevent significant harm to the oligohaline zone of the estuary and tape grass. However, salinity in the estuary is influenced by additional inflows from creeks and groundwater downstream of S-79. When flow at S-79 is 300 cfs, an additional 150 to 200 cfs comes from sources downstream of S-79 for a total inflow of approximately 450 cfs. During low flow conditions, the entire system is drier than normal and the downstream contribution is much lower than 150 to 200 cfs. Thus, a minimum flow of 300 cfs at S-79 is insufficient to achieve the MFL salinity criteria. The original basin flow optimization model used historic S-79 flow data from 1965 to 1990 to recommend a time series of basin flows (Labadie 1995; Otero et al 1995). More recent modeling efforts for the CERP, the CWMP, and the proposed C-43 West Storage Reservoir project use a 2000 Base and have resulted in reconsideration of the original time series of flows to the estuary. The EST05 time series (*i.e.,* an average monthly flow distribution between 450 and 2,800 cfs at S-79) provides a higher level of protection in the upper estuary than the previous time series by establishing a low flow limit of 450 cfs at S-79. Likewise, the EST05 distribution is consistent with the total flow requirements associated with the MFL and its salinity criteria for protecting tape grass.

In an ordinary year, flows less than 450 cfs at S-79 occur approximately 4.2 months per year and flows greater than 2,800 cfs at S-79 occur approximately 2.6 months per year. Thus, flows are less than or greater than the target range about seven months per year, reinforcing the need for the additional basin storage identified by the CERP, CWMP, and the MFL, and reaffirmed by the

proposed C-43 West Storage Reservoir project. High water levels in Lake Okeechobee from the 2005 hurricane season and heavy basin rains resulted in a single day's discharge of 21,000 cfs and extremely high mean monthly flows at S-79 during the wet season of Water Year (WY) 2006 which extended from May 2005 to April 2006 (Figure 9). The mean monthly flows were above the upper limit of the EST05 flow range during the first eight months (*i.e.*, May through December 2005). Flows exceeded 4,500 cfs during six of those eight months and decreased salinities as far as San Carlos Bay which can adversely impact seagrasses in that area significantly. Half (four) of those exceedances were average monthly flows greater than 8,000 cfs, which can decrease salinities well into lower Pine Island Sound and impact estuarine resources in the J.N. "Ding" Darling NWR, and Sanibel, Pine, and possibly Captiva Islands. However, the current dry season extending into 2007 has been extremely dry. Thus, the resultant salinity levels have exceeded the monthly criteria in the upper estuary (*i.e.*, the Fort Myers salinity sensor), and the tape grass beds have almost disappeared.

Effects on Tape Grass

Tape grass beds had essentially vanished from the upper estuary as a result of extremely high salinity levels during the 2001 drought. Tape grass density remained low and started a slight increasing trend during the growing season of 2003. The beds began to recover while salinity conditions were favorable during the spring and summer growing seasons of WY2004 and WY2006.

Before the 2001 drought, plant density was significantly greater at Station 2. WY2006 was the first time since the drought that this pattern was evident. During the high freshwater inflows in June, plant density decreased upstream at Station 1, possibly due to the associated drop in water clarity, while more plants persisted at Station 2 during November 2005 through March 2006 than in previous years since 2001. However, due to the unusually high salinity associated with the 2007 dry season the plants have again almost disappeared.

Effects on Oysters

Salinity is also important in determining the distribution of coastal and estuarine bivalves, such as oysters. Short pulses of freshwater inflow can greatly benefit oyster populations by killing predators, while excessive freshwater inflows may kill entire populations of oysters (Gunter 1953; Schlesselman 1955; MacKenzie 1977). Although an oyster population still exists within the lower Caloosahatchee Estuary, historical accounts of the river indicate that oysters were once a more prominent feature in the area upstream (Sackett 1888). Oysters are more than an important recreational and commercial fisheries resource; their reefs serve as essential fish habitat. Oyster reefs provide a complex, three-dimensional, reef structure used as nesting habitat and refugia by numerous species of invertebrates and fishes (*e.g.*, blue crab, stone crabs, mud crabs, grass shrimps, blennies, gobies, killifishes). Furthermore, many of those organisms serve as forage for other important fisheries (*e.g.*, snook, sheepshead, grouper, redfish, spotted sea trout, black drum), birds (*e.g.*, American oystercatchers, pelicans, osprey), and mammals (*e.g.*, raccoons). They also promote the growth of sea grasses by improving water clarity. Individual oysters can filter 4 to 34 liters (1 to 9 gallons) of water per hour, removing phytoplankton, sediments, pollutants, and microorganisms from the water column (Volety 2003).

Aerial surveys for oysters conducted during WY2004 found only 3.02 acres of oysters in the lower Caloosahatchee Estuary near Shell Point and only 15.04 acres in lower Charlotte Harbor. This low number of oysters, especially near Shell Point, is most likely a result of a combination of: (1) high freshwater inflows into the estuary from the C-43 basin and Lake Okeechobee; (2) the lack of suitable shell or a firm mud-sand-shell mix substrate; and (3) shell mining in the 20th century for construction material that decimated the live oyster population and destroyed the existing reefs.

Monitoring of the health and recruitment of oysters in San Carlos Bay and lower Charlotte Harbor began in 2000 (Corps and District 2007). Results indicate that oysters in the Caloosahatchee Estuary spawn continuously from April through October, a period that coincides with freshwater releases into the estuary. High freshwater flows flush out oyster larvae and spat from upstream areas with suitable for cultch settlement and reduce salinities to levels that reduce larval growth rates and survival (Dekshenieks et al. 2000). The high flows from Lake Okeechobee and basin runoff following Hurricanes Katrina, Rita, and Wilma during WY2005 reduced salinities (Figure 8) in the estuary and flushed out spat, resulting in one of the lowest years of oyster recruitment observed (Corps and District 2007). Drastically high flows during June 2006 resulted in another poor year for oyster survival and recruitment, particularly upstream of Shell Point.

A preliminary target for the aerial extent of oyster reefs in the lower Caloosahatchee Estuary and lower Charlotte Harbor is 40 and 60 acres respectively, during the next 10 to 15 years. With the addition of hard substrate, this target can be increased to 200 to 300 acres upstream of Shell Point and 150 to 200 acres downstream from Shell Point. Eighty-seven volunteers from Florida Gulf Coast University, concerned citizens, District, and other state, federal, and local agencies placed 200 shell-bags at two locations upstream of Shell Point (*i.e.,* Iona Cove and Piney Point) during October and November 2005 to provide substrate for oyster recruitment and reef development.

Effects on Seagrasses

Aerial surveys of seagrass cover throughout the Lower Charlotte Harbor region (*i.e.*, the lower Caloosahatchee estuary, Matlacha Pass, San Carlos Bay, and Pine Island Sound) were conducted in 1999, 2002/2003, and 2004. No aerial surveys were conducted during 2005 or 2006. The aerial extent of seagrasses increased dramatically from approximately 38,197 acres during WY1999 to 43,591 acres during 2002 and 2003. That increase may be due to improved photography, different methodologies, or other differences between surveys rather than a real change (Corbett et al. 2006). However, that increase followed the 2000 and 2001 drought when flows from S-79 were low and salinity in the Lower Charlotte Harbor region was consistently within the optimal ranges of seagrasses. Results of the 2004 survey indicate that there are approximately 38,494 acres in the lower Caloosahatchee estuary, Matlacha Pass, San Carlos Bay, and Pine Island Sound combined, with coverage in each of those areas area of 62 acres, 7,168, 3,905, and 27,359 acres, respectively.

b. Water Quality Improvement

The American Rivers organization listed the Caloosahatchee River as one of the top ten endangered rivers in the United States (American Rivers 2006). The need for water quality improvements in the Caloosahatchee Estuary has been well documented. During the 1980s, the Florida Department of Environmental Regulation conducted waste load allocation studies and, based on elevated chlorophyll *a* levels and low dissolved oxygen (DO) concentrations, concluded that the Caloosahatchee had reached its nutrient loading limits (Doering and Chamberlain 2004). Subsequent water quality studies have found that nitrogen is the most likely limiting nutrient for primary production in the Caloosahatchee estuary and total nitrogen concentrations exceeded the state median (McPherson and Miller 1990; Doering and Chamberlain 1998, 1999, 2004). These studies also found that the highest concentrations of Chlorophyll *a*, total nitrogen, total phosphorus, and color tended to occur most frequently in the upper estuary, most likely as a function of discharges at S-79. Similarly, the occurrences of low DO levels (*i.e.*, less than 2 milligrams/liter) were also observed at the head of the Caloosahatchee estuary. The discharge of water at S-79 is also a major determinant of macro-nutrient concentrations and other aspects of water quality in the Caloosahatchee Estuary. Influence of this discharge can be detected nearly 60 kilometers (37.2 miles) downstream in Pine Island Sound (Doering and Chamberlain 1999). This control of water quality stems from the overwhelming dominance of Caloosahatchee River flows at S-79 over local runoff, as a source of nutrients and other materials to the downstream estuary.

As mentioned previously, the DEP has recently identified impaired water bodies in the Caloosahatchee Basin as part of their TMDL Program (DEP 2004). DEP lists the tidally influenced Caloosahatchee River and Estuary as impaired due to high levels of nutrients (*i.e.*, Chlorophyll *a*), metals (*e.g.*,copper), and fecal coliform, and due to low levels of DO (Figure 4). Under DEP's IWR, estuarine segments are considered impaired if the average annual chlorophyll *a* concentration is greater than 11 mg/l. Chlorophyll *a* concentrations reported for three estuarine water bodies in the Revised Draft Verified List of Impaired Waters for the Caloosahatchee River Basin ranged from 17.21 to 24.77 mg/l during 2000 (DEP 2004). Additionally, high nutrients were identified as the causative pollutant for DO impairment.

High nutrient loads may adversely impact the natural resources within the Caloosahatchee River estuarine system, including the state-managed aquatic preserves, the CHNEP, and the J.N. "Ding" Darling NWR Complex, and the fish and wildlife populations that depend on those resources during various stages of their life cycles. Estuarine habitats provide suitable escape, feeding, breeding and spawning, brood rearing and nursery, and wintering sites for a wide variety of aquatic, estuarine, and wetland-dependent organisms for which the Service has Federal-trust conservation responsibilities (*e.g.*, migratory waterfowl, wading birds, shorebirds, seabirds, other water birds, neotropical migratory songbirds, threatened and endangered species, and interjurisdictional fisheries).

Increased nutrient levels such as nitrogen and phosphorus stimulate phytoplankton and algal blooms and thus, reduce light penetration which can lead to reduced SAV abundance in fresh and marine habitats. The loss of feeding and nursery habitat can lead to population declines in

commercial and sport fishes (*i.e.*, anchovy, redfish, black drum, and spotted seatrout) and shellfishes (*i.e.*, oysters, pink shrimp, and blue crab), and shifts in species composition.

Additionally, changes in abundance and distribution of SAV in the estuary may also impact manatees by increasing travel distance between warm water refugia and suitable food sources. A change in manatee use of the estuary during periods of cold stress could also change exposure to boat traffic.

Likewise, siltation is known to have deleterious effects on epiphytic organisms that are found on mangrove prop roots. High turbidity levels affect fish feeding and growth because the ability of fish to find and capture food is impaired at higher turbidity levels. In addition, gill function in some fish may be impaired after prolonged exposure to high turbidity levels. Sediments can also be contaminated with potentially toxic concentrations of metals, herbicides, and pesticides. Unnatural sediment deposition can limit the quality of the benthic communities (*e.g.*, seagrasses and oyster bars) by abrasion, habitat loss, and reduction of dissolved oxygen concentrations. These limitations, in combination with "freshwater shock," negatively affect the overall ecological health of the estuary.

Sediment loads can also increase oxygen demand. When turbidity is largely due to organic material, dissolved oxygen depletion may occur. Organics contain excess nutrients that encourage microbial breakdown, a process that requires valuable dissolved oxygen. The concentration of dissolved oxygen in the estuary is crucial to fish production, and fish kills often result from extensive or extended oxygen depletion.

c. Preservation of Habitat Quality

Loss of habitat has also been of concern. Hardening of the shoreline, increased freshwater discharge, and oyster mining are thought to have singly or in combination, reduced mangrove, seagrass and oyster bar habitats (Harris et al 1983). Riverine mangrove wetlands occur in floodplains near the mouth of freshwater systems and may be composed of all mangrove species. These wetlands receive nutrients from freshwater flow and are most sensitive to variations in this flow, as well as variations in water quality. Decreasing riverine runoff through channelization of adjacent drainages reduces inputs of nutrients and sediments to these forests and reduces water ventilation of mangrove roots (Lugo 1976).

2. Hydrologic Modeling Issues

a. Errors in MIKE SHE Irrigation Module

Plan formulation and selection of the recommend plan for the C-43 project was based on output produced by the MIKE SHE hydrologic model containing a significant error in the water budget. The Corps identified a water budget discrepancy during review of the model results for the suite of alternatives. The source of this water budget error was within the MIKE SHE irrigation routines and was caused by the irrigation module pulling water from an external source treated as an infinite source of water when irrigation demands were not met by surface and groundwater

systems. The quantity of water coming from external sources also varied significantly among the various model runs. The average-annual volume of water coming from external sources ranged from 125,100 ac-ft for the 2000 without-project run to 260,500 ac-ft for one of the with-project runs. For certain model runs this discrepancy equates to greater than half of the total irrigation volume coming from an artificial external source of water. The precise impacts of these discrepancies on the hydrologic performance of, and habitat benefit calculations for, the alternatives are not clear.

b. Modeling Uncertainty

Different models were used for plan formulation, alternative selection, and assurance analyses adding complexity and uncertainty to alternative comparisons. Ground and surface water hydrology and hydraulics of the Freshwater Caloosahatchee River Basin (FCRB) watershed from S-77 to S-79 were simulated using the MIKE SHE model. Output from the regional South Florida Water Management Model (SFWMM), which simulates the hydrology and water management of Lake Okeechobee and south Florida, was used as input for boundary conditions to the FCRB. Output from the FCRB model was then used in a salinity regression model to simulate the salinity in the tidally influenced Caloosahatchee Estuary. Output from both the FCRB and salinity regression models were used to evaluate system-wide effects of the proposed alternatives and to select the recommended plan based on comparisons of hydrologic performance measures and calculation of estuarine habitat benefits from these models despite the issues previously outlined. The next added increment (NAI) analysis of alternative 3B was performed to ensure compliance with savings and takings clause requirements using a spreadsheet analysis based on output from the regional SFWMM and a localized reservoir MIKE SHE model application for project level impacts. The NAI saving clause compliance spreadsheet model was based primarily on achieving the EST05 flow targets for S-79 using output from the SFWMM hydrologic simulation model and fill and release rates from the reservoir.

Differing model capabilities and assumptions, boundary conditions, spatial and temporal resolutions, discretization and input of model parameters, and the source code error in the FCRB model, all contribute to risk and uncertainty associated with model results, adding complexity to alternative comparisons. Design of project features, (*i.e.*, levees, canals and structures) account for this uncertainty by applying the factor of safety principle. However, the operational flexibility allowed through soundly engineered features combined with ecologic and hydrologic monitoring and an adaptive management program ensure that projected environmental benefits predicted are actually achieved upon implementation.

c. Analyses Required by WRDA 2000

The post-project MIKE SHE model is complex. It includes a 10,500 acre reservoir (16.4 mi2) with proposed operational water depths greater than 10 feet; conceptualization of the reservoir construction technologies; and complex operational rules for existing and proposed water control structures. Annex C of the PIR describes the Savings Clause and Takings analyses required by WRDA 2000. The "no adverse effects within the local watershed" MIKE SHE output presented

in Annex C required a blend of applying sound engineering practices coupled with best professional judgment during an iterative process requiring multiple simulations to achieve the outcome. The model uncertainty briefly discussed above only tangentially addresses the issue and its significance with respect to the design of water management structures and their associated operational criteria. Applying these models and achieving desired results is often a trial and error proposition that results from ill-formed input assumptions. For example, discretization and input of model parameters (*i.e.,* hydraulic conductivity, Manning's *n* and evapotranspiration) often require a merging of values available through the literature with those developed through local evaluations and other correlations all the while applying best professional judgment. As such, these parameters are frequently changed to achieve a best fit match to the observed historical hydrologic data during the calibration and verification process.

To achieve the "no adverse effects within the local watershed" more than 20 simulation runs were required to fine tune the operational criteria. Models were used to predict project induced changes in depth to groundwater and overland flow in the project vicinity. However, historical hydrologic data for the watershed immediately adjacent to the reservoir (*i.e.,* water levels in adjacent wetlands southeast of the reservoir) or further upstream of the project area (*i.e.*, SOW and the OSSF WMA) is limited or not available. The Roberts Canal extends from the C-43 West Reservoir project area approximately 10 to 12 miles southeast and terminates in SOW WMA which is adjacent to and hydrologically connected to the OSSF WMA, particularly during wet periods. Water levels in Roberts Canal upstream of the proposed C43-S15 structure were not available for the calibration and verification. As such, the model could easily be predicting surface water depths with an error of plus or minus 1.0 ft from existing conditions in the adjacent natural areas and the SOW WMA. Additionally, the duration of time water depths are above the ground surface may not be accurately represented, (*i.e.,* hydroperiods 30 to 60 days shorter or longer than existing, or both).

The timing, depth, and duration of flooding are extremely important in maintaining wetland function and community structure and associated fish and wildlife populations (Mitsch and Gosselink 1993). Altering wetland depth by inches or the timing and duration of flooding by days can result in significant changes in wetland function and vegetation community composition and structure. Likewise, such changes can significantly affect the distribution and productivity of fish and wildlife populations using those wetlands. Studies have shown that canal systems can impact adjacent wetland hydrology as far as a mile from the wetland and canal interface (Duever 2006). Thus, the Service is concerned that operation of the C43-S15 structure on the Roberts Canal could impact nearby wetlands southeast of the reservoir and those as far as the SOW and OSSF WMAs. Those areas support state- and federally-listed species species such as the Florida panther, Florida black bear, Audubon's crested caracara, and wood stork. Those areas are also included in the primary panther habitat zones as designated by Kautz et al. 2006.

Low confidence in the calibration and verification is not limited to water level data. Simulated MIKE SHE flows could easily be an order of magnitude from those that currently observed. These factors preclude acceptance of the key assumption "that with the exception of changing flows to the estuary downstream of S-79, there will be no impact on the West Caloosahatchee Basin" made in Annex C of the DPIR. To summarily dismiss the hypothesis that water levels in

the project watershed will not change as a result of the project is not logical because many of the simulations showed that water levels would increase in adjacent areas as a result of the project (*e.g.,* location 10 in the simulated groundwater levels). Only through changing the operational criteria at the C43-S15 structure could the effects to adjacent and upstream wetlands be minimized. This highlights the models sensitivity to the operational criteria yet operational criteria are not clearly articulated in the Draft Project Operational Manual (DPOM), Annex D of the DPIR. No sensitivity analysis was performed to determine which one of 20 or more simulations gave the most accurate predictions. Therefore, the Service recommends that the hydrologic monitoring plan in Section D.2 of Annex D in the PIR be expanded beyond the immediate footprint of the reservoir to include both existing canals and adjacent and upstream wetlands to ensure operation of the reservoir will not result in adverse impacts to the SOW and OSSF WMAs, and that the Corps formulate and incorporate related ecological hypotheses to be tested in the adaptive management protocol in Section D.4 of Annex D in the PIR.

3. Adverse Effects of Reservoir Construction

a. C-43 Basin Storage Reservoir and the STAR Recommendations

The primary goal of the C-43 reservoir is to increase water storage in the C-43 Basin to provide environmental water supply deliveries to the Caloosahatchee Estuary. The C-43 reservoir is likely to exhibit widely fluctuating water levels ranging from dry to 15 to 25 ft deep that are incompatible with the establishment of high-quality, native, fish and wildlife habitat.

As per the Restudy, one of the goals and objectives of CERP projects is to enhance Everglades ecosystem ecological values by: (1) increasing the spatial extent of natural areas; (2) improving habitat and functional quality; and (3) improving native plant and animal species abundance and diversity (Corps and District 1999). CERP will create more than 118,000 acres of reservoirs and 36,000 acres of Stormwater Treatment Areas (STAs) in south Florida, including the C-43 West Reservoir, to replace lost natural water storage, improve water quality, and provide other ecological benefits. Thus, the Service developed *Fish and Wildlife Recommendations for Comprehensive Everglades Restoration Plan: Stormwater Treatment Area and Reservoir Operation and Design* (STAR recommendations) to provide guidance for the incorporation of fish and wildlife features into the construction and operation of reservoirs and STAs and reservoirs (*i.e.*, facilities) (Appendix B; Service 2005). The STAR recommendations are provided in Appendix A of this report.

CERP presents an opportunity to provide extensive wildlife habitat compatible with the primary function and expected environmental benefits of these facilities. The primary functions of STAs and reservoirs are improvement of water quality by reduction of nutrients and pollutants released downstream and water storage during peak periods of stormwater discharge into estuaries and marine environments. Existing facilities prove that wildlife usage is compatible with their primary functions. Those in current operation provide valuable insight into design features that attract wildlife, and methods to minimize contamination issues that pose risk to wildlife during construction and operation.

Location and Design of Facilities

The Service was an active participant in the C-43 BSR planning process and supports the approach used to select the reservoir location. Site selection for the C-43 reservoir footprint was based primarily on the potential for a site to meet the project objectives and secondarily on the suitability of a land parcel for the project (Corps 2005). Suitability was based on the parcels location in the C-43 Basin and its potential storage capacity. Additionally, parcels located in natural upland and wetland habitats, significant threatened and endangered species resources, known superfund sites, and known cultural resources were less suitable. The site screening process is described in more detail in the Corps' Formulation Scoping Meeting Report for the C-43 West Storage Reservoir project. Thus, the site selection process was consistent with the STAR recommendations, and the reservoir was preferentially located in an area of active citrus operations. Although citrus groves do provide habitat for many species (Mazzotti et al. 1992), groves are generally considered less valuable than other more natural habitats.

The Service met with the District and Corps on February 11, 2005, to review the STAR recommendations and to determine which features would be compatible with the C-43 BSR Reservoir objectives, design, and operations. The following fish and wildlife features have been incorporated in the planning and design of the reservoir:

- Phase I and II Environmental Site Assessments (ESA) were performed to identify and characterize any contaminated areas within each of the five parcels acquired for the C-43 reservoir project and Environmental Risk Assessments (ERA) where necessary. Results of those assessments are summarized in the next section;

- Existing canals, depressional wetlands, and agricultural reservoirs will be maintained within the reservoir footprint to provide deep-water refugia for fisheries and other aquatic resources during periods of low water or dry conditions. The only areas that will be graded during site preparation are those in close proximity to the dams to maintain their integrity;

- Existing cypress wetlands will not be cleared from the interior of the reservoir during site preparation to provide underwater structure for fisheries and aquatic invertebrates, and perching and roosting habitat for birds;

- Less than 40 acres of shallowly-sloped littoral habitats will be created along the perimeter seepage canal of the reservoir. That acreage is low compared to the size of the reservoir; however, rights-of-way must be maintained for adjacent landowner access, and for proposed ASRs to be constructed along the perimeter if they are deemed feasible. The interior walls of the reservoir will be lined with a soil and bentonite mixture to prevent erosion; thus, no emergent wetland vegetation is expected to establish on the interior dams.

b. Reservoir Water Quality

The need for water quality improvements in the Caloosahatchee River and Estuary was described above. Reservoirs and natural storage areas have proven to be successful at removing nutrients and total suspended solids and their efficiency can be evaluated based on hydrologic retention time and measured using hydrologic models. In our March 29, 2005, Planning Aid Letter, we recommended that the Corps and the District design the C-43 West Reservoir to provide water quality benefits by reducing nutrient loads to the river and estuary in accordance with CERP Guidance Memorandum Number-Revision 023.01 (GM 023.01). The C-43 Project is described in the Restudy as a Category B project. Category B projects are not required to include specific water quality improvement features, but are to be designed to achieve water quality improvement. Evaluation criteria must be developed ". . . for alternative plan evaluation, comparison, and selection purposes, as well as for maximizing the water quality improvement efficiency during design of the selected plan" (District and Corps 2004). The intent of GM 023.01 was to maximize nutrient and total suspended solid reductions of proposed alternatives without significant loss of water storage potential or the addition of water quality improvement features.

Additionally, the State of Florida's environmental resource permit (ERP) program regulates virtually all alterations to the landscape, including all tidal and freshwater wetlands and other surface waters (including isolated wetlands), and uplands. Impacts to water quality and quantity are also regulated under that program, and issuance of the ERP also constitutes a water quality certification under section 401 of the Clean Water Act, 33 U.S.C. 1341. At a minimum, the reservoir project must not adversely affect the quality of receiving waters such that state water quality standards would be violated, nor cause adverse secondary impacts to water resources. To meet state water quality standards, the proposed project may not increase average annual chlorophyll *a* concentration in the Caloosahatchee Estuary above 11 mg/l. Janicki Environmental (2003) identified a critical annual load threshold of 3,000 tons per year for Total Nitrogen (TN) at S-79 to meet state standards. Monthly critical load thresholds for TN were also identified by season. The critical load threshold for the dry season is 190 tons of TN and 350 tons of TN in the wet season. Thus, water quality analyses were conducted for plan formulation to determine if the selected plan meets the following criteria (PIR Appendix C):

1. The quality of the water discharged from the reservoir should be no worse than the quality of the water pumped into the reservoir, measured in terms of projected flow-weighted nutrient concentrations at the reservoir;

2. Operation of the reservoir should not result in an increase in the frequency of wet or dry season high nutrient loading periods, measured as the number of times monthly TN loads exceed the critical load thresholds developed for the DEP by Janicki Environmental (2003).

3. Operation of the reservoir should not result in an increase in the frequency in which annual nutrient loads exceed a previously defined threshold quantity.

4. Operation of the reservoir should not result in an increase in the total nutrient load discharged into the estuary at the S-79 structure.

5. The operation of the reservoir should not result in a substantial shift of nutrient loading from the wet season to the dry season.

The analyses presented in the Appendix C of the PIR indicate that the reservoir is unlikely to cause or contribute to water quality degradation downstream of the reservoir discharge point. Although the proposed project is not likely to increase the average annual critical load threshold of 3,000 tons of TN per year at S-79, a shift in nutrient (TN) loads from the wet season to the dry season will most likely occur. Results indicate, however, that the frequency of exceeding the seasonal critical load threshold of 190 tons of TN per month is unlikely to increase as a result of the project, and that the frequency of exceeding the wet season critical load threshold of 350 tons of TN per month will be reduced by approximately 25 percent. Likewise, the proposed project will not increase average annual chlorophyll *a* concentration in the Caloosahatchee Estuary above the 11 *mg*/l state standard.

As mentioned previously, the Service recommended in our March 29, 2005, PAL, that the Corps and the District design the C-43 West Reservoir to provide water quality benefits by reducing nutrient loads. However, the proposed design and operation of the C-43 West Reservoir project primarily focuses on salinity control by improving the timing and volume of freshwater delivery to the estuary and does not address other water quality needs within the river basin and estuary. Reservoirs and natural storage areas have proven to be successful at removing nutrients and total suspended solids and their efficiency can be evaluated based on hydrologic retention time and measured using hydrologic models. The Service notes that by not including design features to provide water quality benefits and adopting state water quality standards as a minimum "target", the C-43 West Reservoir project does little to reduce nutrient loading at S-79 to restore water quality in the estuary.

In 2006, the District constructed two test cells within the footprint of the reservoir (*i.e.*, the C-43 West Reservoir Test Cell Project) primarily to evaluate on-site seepage and seepage control methods and the suitability of on-site materials for project construction. However, the District implemented a C-43 Storage Reservoir Test Cell Water Quality Monitoring Plan (WQ Plan; WSI 2005) to evaluate potential water quality impacts resulting from initial flooding of on-site soils, steady-state water quality conditions, and the effects of water residence time, drawdowns, and seepage on water quality. The WQ Plan focuses on nutrients (nitrogen and phosphorus), but includes other chemical, physical, and biological parameters. Monitoring began in June 2006 and will continue for 12 months. The Service recommends that the Corps evaluate results of the Test Cell Water Quality Monitoring Plan and incorporate that information in the reservoir design and water management operation and maintenance plan to maximize the reduction of nutrient loads from C-43 West Reservoir outflows.

c. Loss of On-site Wetland Habitats

The project site is an active citrus grove. Upland habitats associated with the grove include citrus trees, grove maintenance roads, small berms, brush piles, and other features related to citrus grove operations. There are no natural upland areas within the project site. The project site includes approximately 1,061.3 acres of jurisdictional Waters of the United States, including 934.6 acres of man-made ditches and canals which serve as irrigation and drainage conveyances for the citrus operation and 126.7 acres of wetlands (Figure 10). On-site freshwater wetlands are primarily impacted wetlands functioning as agricultural retention and detention areas. Existing wetland communities include mixed wetland hardwoods, exotic wetland hardwoods, cypress swamp, wetland shrub, and freshwater marsh. Although the hydrology of agricultural canals and ditches is dependent on rainfall and irrigation, they may provide suitable habitat for wetland-dependent or aquatic species. As a result of the recommended plan, the project area will be converted primarily to an open-water, aboveground reservoir including associated structures and a seepage canal.

The Corps, District, and Service, used the WRAP and the UMAM (Chapter 62-345, F.A.C. [effective date 02-04-2004]) to evaluate the current condition (*i.e.*, wetland value) of the existing wetlands (126.7 acres) and drainage canals and ditches (934.6 acres) within the project area and the proposed compensation for that wetland loss. Aerial surveys were conducted during on June 14 and 15, 2004 to classify wetlands based on the percentage of woody, herbaceous, native, and exotic/nuisance vegetation present (Table 5). WRAP and UMAM assessments of randomly selected representative wetlands and agricultural ditches and canals were conducted on the ground on June 8, 9, and 10, 2004; and July 13, 14, and 15, 2004. Data sheets are provided in Appendix B of this report. Functional scores for the existing conditions were averaged by wetland type, then the functional scores for the future with project condition were subtracted and then the difference was multiplied by the total acreage of that wetland type. A total of 141.39 functional wetland units will be lost as a result of the C-43 West Storage Reservoir project (Table 5).

The Service understands that the Corps will account for the unavoidable adverse impacts to wetlands and other aquatic resources resulting from both he C-43 West Storage Reservoir project in an Acceler8 system-wide mitigation ledger which includes the C-43 West Storage Reservoir project. As described in the Corps' April 30, 2007, Public Notice (PN), that ledger includes accounting for system-wide interdependencies and watershed benefits of the District's Acceler8 projects (*i.e.*, Band 1 projects) in satisfying the regulatory mitigation requirements for wetland and other aquatic resource impacts resulting from construction of individual Acceler8 projects. The Corps is using the UMAM to assess the function and value of aquatic resources adversely impacted by construction of the C-43 West Storage Reservoir project and to assess the anticipated environmental lift to the Caloosahatchee Estuary (Appendix B) as a result of implementation of Alternative 3B and the remaining Acceler8 projects (*i.e.*, Band 1 projects) (Table 5). Through implementation of CERP (and Acceler8), the quality, quantity, timing, and delivery of water to the south Florida ecosystem will be improved.

Although not considered as compensatory mitigation, the proposed C-43 West Storage Reservoir project incorporates features that will enhance fish and wildlife habitat. The existing agricultural canals and interior borrow areas excavated for fill material will provide deep-water refugia for fish and other aquatic organisms within the reservoir during drawdown conditions. The exterior face of the external embankments will be planted and maintained as grass. However, the interior face of the external embankments will be covered in concrete to reduce erosion potential and will not possess a vegetated littoral area. The perimeter canal will include approximately 109 acres of littoral zones to provide foraging and nursery habitat for aquatic fauna (*e.g.*, wading birds, fish, herpetofauna, etc.). Also, portions of the test cell embankments will be left in places to provide roosting habitat for birds, turtles, and other fauna when the reservoir is full.

Accordingly, the restoration and enhancement of approximately 16,300 acres in the upper (*i.e.*, 4,130 acres) and middle and lower (*i.e.*, 12,170 acres) Caloosahatchee Estuary will provide approximately 1,139 wetland mitigation credits (Table 5) and will compensate for the loss of approximately 141.4 functional wetland units over 1,061.3 acres of impacted wetlands and agricultural canals and ditches on-site.

4. Contaminants

As noted above, the Service is concerned about the disposal or use of potentially contaminated soils during construction of the reservoir. Agricultural areas are frequently contaminated with metals, pesticides, and petroleum products. In high enough concentrations, these pollutants indicate a degraded habitat condition and a potential threat to plant and animal species. All five of the land parcels (*i.e.*, Berry Groves-LaBelle Congen, Bryan Paul Citrus Groves, Bob Paul Citrus Groves, Winthrop Citrus, and Griffin Brothers) acquired for this reservoir project, were active citrus groves (Figure 11). According to District and Service guidelines (*e.g.*, District Guidance in the Design of a Project-level Monitoring and Assessment Plan for Mercury, Pesticides, and Other Toxicants; and our Ecological Risk Assessment Guidance for Wetland Restoration on Agricultural Lands in South Florida *in* the STAR recommendations; Appendix A), Phase I and II ESAs were performed to identify and characterize any contaminated areas within each of the five parcels acquired for the C-43 reservoir project, and ERAs were performed where necessary. In addition to identifying human health impacts, the site assessments also investigated the presence of widespread residual soil contamination in the cultivated areas to determine if the level of contamination might pose a threat to fish and wildlife during long-term facility operation and maintenance. A primary concern is the common application of fungicides containing copper in citrus groves and its potential to bio-accumulate in the food chain.

The Service believes that the Corps and District are adequately assessing the potential ecological risks on the five parcels. The Phase I and II ESAs were coordinated early and throughout the plan development process with the Service, and were well-designed, comprehensive in scope, and represent the state-of-the art in ecological risk assessment. The environmental assessments for each parcel are summarized below.

Berry Labelle–Congen Groves
Phase I/II Environmental Site Assessment Soil sampling has identified seven grids (*i.e.*, grids 56, 58, 124, 125, 134, 135, and 143) that will require remediation due to copper impacts (Figure 11). The Service recommended remediation for the entirety of Grids 124, 125, 134, 135, and 143 (*i.e.*, 250 acres) and for the portions of Grids 56 and 58 that will be within the footprint of the proposed reservoir. The Service concurred that removing contamination from the seven grids would remove the risk of direct impacts to Service trust resources; however, it was noted that the remaining copper concentration in some areas of the property may be high enough to adversely impact benthic organisms. No further copper application was recommended for Grids 38, 39, and 145, since copper concentrations in those grids were close to the interim screening level.

Bryan Paul Citrus Grove
The 2004 Phase I/II Environmental Site Assessment on this 600-acre property identified seven point source areas that were recommended by the contractor, and agreed to by the Service, for remediation. These areas included pump stations, a nursery barn, a mix station, an auxiliary tank area, a graded area, burn areas, and irrigation canals. This assessment also identified two 50-acre grids with chlordane concentrations (100 µg/kg and 22.5µg/kg) above the DEP Sediment Quality Assessment Guideline (SQAG) probable effects concentration (18 µg/kg). The 2006 Additional Soil Assessment for the property delineated the chlordane contamination to be within a 20-acre area (Figure 11). The proposed remedial action included removing the top two ft of soil in the contaminated area and relocating it in dams constructed for the creation of the C-43 water retention reservoir. The Service agreed to an 18 µg/kg cleanup target level for chlordane.

Bob Paul Citrus
The 2005 Phase I/II Environmental Site Assessment for this 2,025-acre property identified eight point source areas that required remediation. The recommend corrective action for the majority of these point sources included on-site burial of contaminated soils. Since this might present a risk to groundwater, the Service suggested consulting with the DEP regarding this method of corrective action. Within the cultivated area, two 50-acre grids were identified as having minor organichlorine pesticide contamination. To delineate this contamination, individual discrete samples were analyzed. The organochlorine pesticides 4,4′-DDE and chlordane were detected at concentrations exceeding their respective SQAG threshold effect concentrations (3.2 µg/kg). A screening level ecological risk assessment identified no risk to avian species that feed across the site; however, there was the possibility of risk from 4,4′-DDE exposure for species with small home ranges, such as the clapper rail. The contractor recommended further sampling to delineate contamination.

Winthrop Citrus
Phase II soil sampling in the cultivated areas identified the pesticides aldicarb, aldrin, and paraquat as contaminants of concern. The contractor recommended no further application of aldicarb at least 12 months prior to project implementation and immediate cessation of paraquat. After review of the fugacity-based food chain model done by the contractor, the Service agreed that the single 50-acre grid where aldrin was detected was not likely to present a significant ecological risk. Metals, petroleum hydrocarbons, and pesticides were detected in soils around the maintenance areas. In order to remove the potential ecological risk from these point sources, soil removal was recommended and is included in the remediation plan for the proposed project.

Griffin Brothers
The Phase I/II ESA for this 954-acre property detected concentrations of the pesticide aldicarb in the cultivated area that exceeded its site-specific SQAG (1.75 µg/kg). The Service concurred that aldicarb degrades quickly and would present little to no risk to ecological resources, provided that its application is discontinued at least six months before inundation. Contamination of metals and polycyclic aromatic hydrocarbons was detected in the burn area, chemical barn, and fertilizer mix and load area. The Service concurred that removing the top 12-inches of soil from these point sources would adequately remediate contamination. A sediment sample from a canal detected pentachlorophenol (an organochlorine pesticide) at a concentration (32 µg/kg) exceeding the Florida Administrative Code Soil Cleanup Target Levels based on groundwater criteria (30 µg/kg). Since this pesticide is often associated with highly toxic dioxin compounds, the Service recommended further delineation within the canals. After review of Service comments and recommendations, the contractor calculated a site-specific SQAG for pentachlorophenol (617 µg/kg) to determine if further delineation was necessary. Since the detected value of pentachlorophenol was much less than the calculated site-specific SQAG, the Service agreed that no further delineation was necessary.

5. Recreational Opportunities

The Service recommends that compatible public recreational opportunities, which do not conflict with the primary function of the reservoir, be provided. Proposed recreational opportunities include a 12-mile multi-purpose trail loop atop the levee for nature study, hiking, and horseback riding, as well as boat and bank fishing, canoeing or kayaking, boating and hunting. Reservoir operations will be monitored for 1 to 2 years to determine safe boating access per reservoir water regulation schedules. Boat access will be regulated by type (*e.g.*, non-motor or motor) and operation or through closures to prevent conflict with project purposes in accordance with State Rule 40E-7, Special Provisions for Impoundment Areas of the District Open to the Public. For example, the type and extent of boat access will be tied to the reservoir operations schedule and therefore, recreational boating may only be allowed during the wet season when there is ample water in the reservoir.

Rule 40E-7.5384, permits boats in impoundments managed by the District under the following limitations:

- Vessel and vessel operation limitations shall be posted by sign;
- Vessel and vessel operation limitations shall be made specific to each Impoundment Area for: resource protection; protection of District structures, equipment, and levees; and operation and maintenance of the Impoundment Area;
- Vessels shall be limited as motorized or non-motorized, and by engine horsepower, engine type, and vessel type;
- Airboat operation shall be limited to designated areas; and
- Vessel operation shall be limited by area, water depth, by distance from District structures, equipment, or levees, and by speed.

That rule also prohibits the following from occurring in District-managed impoundments:

- Personal watercraft;
- Vessel operation greater than Idle Speed within 300 feet of any District, structure or equipment;
- Vessel operation which causes damage to plants, injures animals or fish, or other environmental resources;
- Vessel operation within an area delineated by vessel barriers; and
- Anchoring or tying a vessel or watercraft to a road, levee, maintenance berm, structure, fence, tree, post, sign, gauge, data recorder, weed barrier or vessel barrier.

6. Integrating the Project with Comprehensive Restoration Efforts

The effects of Lake Okeechobee discharges to the Caloosahatchee River and Estuary need to be evaluated for specific impacts to seagrasses and biological resources as part of the Lake Okeechobee Regulation Schedule Study. Recently, due in part to the active 2004 hurricane season, the current management scheme (Water Supply and Environment) has been undergoing evaluation by the District and Corps of Engineers to determine whether alternate levels of water in the Lake may be appropriate. Additionally, the Lake Okeechobee Estuary Restoration program has identified that outfall structures from the lake will be changed in order to reduce the sediment load going to the Caloosahatchee River.

V. EVALUATION METHODOLOGY

A. Evaluation of Estuarine Habitat Benefits for System Formulation

The primary functions of the reservoir are two-fold: to capture excess basin runoff and discharges from Lake Okeechobee during wet periods, and to provide an additional source of water to maintain desirable salinity in the Caloosahatchee Estuary during dry periods. Due to the complex nature of this ecosystem, there is no single resource which tells the full story. Thus, the study team based the environmental evaluations on five attributes:

- Average Habitat Suitability Index (HSI) for eastern oyster *(Crassostrea virginica)* - based on all seasons of dry years and all seasons of wet years.
- Average HSI for *Vallisneria* - based on dry seasons of dry years.
- Average HSI for seagrass - based on wet seasons of wet years.
- Extreme Events - Average HSI of oyster, *Vallisneria*, and seagrass during the three driest months and three wettest months in the period of record.
- EST05 Index - This attribute reflects the percentage of weeks each alternative matches our target flow (EST05). EST05 is a time series of flow developed to maximize beneficial conditions for a suite of organisms in the C-43 estuary. EST05 was adopted as the system-wide performance measure for the Caloosahatchee estuary (NE-03) by the Restoration Coordination and Verification (RECOVER) team.

After a quality index was determined for each benefit attribute, these were combined to calculate a total project habitat unit score for each alternative (Tables 3 and 4).

Habitat Suitability Indices
The forecasting model used to evaluate alternatives for the C-43 West Reservoir project consisted of a set of stressor-response (habitat suitability) models for individual species. These HSI models were developed from scientific literature, expert knowledge, and available field data. The HSIs portray each stressor variable spatially and temporally across the study area at a scale appropriate to the organism or community being portrayed. HSI models were incorporated into a Geographic Information System (GIS) to describe responses spatially and temporally for the selection of restoration alternatives for each project.

Models were created for species of ecological, recreational, or economic importance, and that have a well established linkage to stressors of management interest. The models include the eastern oyster, blue crab (*Callinectes sapidus*), spotted seatrout (*Cynoscion nebulosus*), tape grass, turtle grass, shoal grass, and selected species of zooplankton. Habitat suitability for each species was determined using specific life stages of the organism with the most limited, restricted, or tightest range of suitable conditions. By doing this, the highest sensitivities of the organisms to environmental changes associated with the planned restoration activities are captured. For the eastern oyster, habitat suitability is modeled for both adult and larvae life stages because of the tighter range of suitable conditions necessary for larval success. The adult blue crab tolerates a very wide range of salinity conditions, so the limiting conditions for successful blue crab habitat are the more restricted conditions necessary for blue crab recruitment. As a result, the blue crab habitat suitability indices are focused on the megalopae larvae and spawning female life stages. Spotted seatrout require specific conditions for forage and spawning, including suitable habitat and the proximity of that habitat to deeper refugia. Flow is important, as large inputs of freshwater can cause spotted seatrout eggs to sink, reducing survival of the larvae. Therefore, the spotted seatrout model will include forage and spawn components.

Each HSI model describes a response surface of habitat suitability values between 0 (unsuitable) and 1 (most suitable) that varies spatially according to stressor levels throughout the estuary and temporally according to temporal patterns in stressor variables. Much of the temporal variation is a result of temporal cycling of important stressor inputs, such as salinity. The models calculate habitat suitability monthly as the weighted geometric mean of the environmental variables identified as important for each model. The geometric mean is derived from the product of the variables rather than the sum (as in the arithmetic mean), and has the appropriate property that if any of the individual variables are unsuitable for species success (*i.e.*, the value of the variable is zero) then the entire index goes to zero. This HSI value was then multiplied by the area within each grid cell and the grid cell values added to calculate Habitat Units for each species. Figure 12 represents how the various HSIs were combined to generate habitat unit scores and support the cost effectiveness and incremental cost analysis (CE and ICA) effort.

After results of initial models runs were reviewed, the study team decided to narrow the full analysis to three species - oysters, *Vallisneria* and seagrasses. It was useful to run all of the

species models, as they affirmed that all species showed an improvement over base conditions. However, it was determined that some species would be dropped for purposes of quantification for the final analysis because:

- They were mobile species that can move to areas of more favorable conditions so they were less sensitive to changes between alternatives;
- They were redundant and added little additional value; and
- The team decided to focus on habitats rather than individual species.

The final group of species included in the benefits analyses covers a full range of both temporal and spatial attributes. Oysters are found in the 5,829 acres of the middle estuary (Figure 12a) and are impacted by both extreme flows during the wet and dry season. Seagrasses are found in the lower estuary or San Carlos Bay area (12,547 acres) (Figure 12b) and are most impacted by the extreme wet season. *Vallisneria* is limited to the 4,129 acres in the upper or fresher portions of the estuary (Figure 12c) and is most impacted by the dry season. Thus, benefits were calculated using the appropriate period of record to reflect flows and salinity conditions when species are most affected. Wet years analyzed include 1979, 1982, and 1983. Dry years include 1980, 1981, and 1985. The wet season was defined as July through November. The dry season was defined as December through May. June was not included, because for some years June is dry and for some years it is wet, therefore it causes inconsistency in the benefits calculations. However, in practice benefits will be realized in June based on the current recommended operations.

The HSI formulas for each species are as follows:

Eastern Oyster HSI$_{\text{May-November}}$ = MIN (LarvaeComponentIndex, AdultComponentIndex)
Eastern Oyster HSI$_{\text{December-April}}$ = (AdultComponentIndex)
LarvalComponentIndex = (Salinity^{w} * Temperature^{w} * Flow^{w})
AdultComponentIndex = (Salinity^{w} * Temperature^{w})
Seagrass HSI = (Previous^{w} * Salinity^{w} * Temperature^{w} * LightAvailability^{w})

***Vallisneria* HSI** = (Previous^{w} * Salinity^{w} * Light Availability * Temperature^{w})

Where *w* is a weight between 0 and 1 assigned to each variable and where "previous" means that the current month's suitability also depends on the how well the grass was doing last month (previous score) (*e.g.*, Previous = previous_month_HSI + 0.05 (not to exceed 1.0) - This allows for growth from month to month if other conditions are suitable).

Extreme event
The extreme event attribute is perhaps the best indicator of how the reservoir alternatives will perform during high and low flow events. This calculation indicates the gain in benefits for eastern oyster (wet and dry months), *Vallisneria* (dry months), and seagrass (wet months) during the three most extreme (wettest and driest) events for the nine-year period of record analyzed. This benefit is calculated by averaging the HSI for the most stressful months (based on highest

and lowest average monthly flows during model runs for 2050 without project conditions) in the period of record for each of the three species. The months and years used were as follows:

- Wet - Oct 82, March 83, April 83
- Dry - March 81, April 81, May 81

After a score is calculated for each species during the extreme events, the HSI of the three species is averaged for one extreme event HSI score for each alternative.

EST05 Index
As described above in Section IV.B.1.a, the EST05 flow distribution is a hydrologic target for a suite of estuarine organisms. Because it represents a time series and flow range necessary for an ecological balance within the estuary, it may not reflect the optimal hydrology for any one species. Because all of the species indicators are also somewhat dampened by the effect of averaging over months, seasons, spatially, etc... the team thought it would be beneficial to have at least one benefit attribute which evaluates how well each alternative is matching the EST05 target flow. This is why a benefit stream has been derived by the percentage of fit to EST05. This time series of flows was initially created to benefit the ecology of the estuary and as a result, an alternative that can most closely mimic this time series would be most beneficial to the estuary as a whole.

A method for evaluating flows associated with the C-43 West Reservoir project was developed to easily compare potential project flows (cfs) with the percent distribution of the target flows from S-79 for any time period (one year or longer). The resulting index scale (0 to 1) reflects the relative amount that the project related flows move toward the target flows (score of 1) from the base condition (score of 0) for the period being evaluated. For application purposes, the C-43 West Storage Reservoir project used the year 1982 as the base condition to calculate the Target Flow Index Base Condition for the representative years 1978 to 1986 that were evaluated by the project. This year represents the worst single year regarding flows that exceed EST05 on both the dry and wet extremes. This score can then be expressed as the percent toward achieving the target flows (percent of target achieved: PTA).

Habitat Unit Combination Methodology (HUCM)
In order to use the Habitat Units for the project in further comparisons (*i.e.*, CE and ICA), it is useful to produce one single HU number for the project. Therefore a HUCM was created. The basis of the HUCM is that the total quality index values in any one area are summed and then divided by the total number of quality index scores for that area to find an average quality score for the area. Then that score is multiplied by the number of acres for that area. Two of the attributes cover the entire area of benefit (*i.e.*, extreme event and EST05). Therefore, all areas have at least those two scores in addition to any species specific HSI values. For example, the only species specific HSI calculated for the area in red in Figure 13 was for oysters. To calculate the HUCM, the oyster score would be added to the extreme event score and the EST05 score, and the total would be divided by 3. That value would then be multiplied by the number of acres in red. The habitat units calculated for each area are then added together to quantify the total

HUs for the project. By using this method, there is no "double counting" of benefits, even where scores have been calculated for overlapping attributes.

The equation used to calculate the total HUs for the C-43 project using the HUCM is as follows:

Total Project Habitat Units =
((Vallisneria score + Extreme Event score + EST05 score)/3) x 4130) +
((Oyster score + Extreme Event score + EST05 score)/3 x 2392) +
((Seagrass score + Extreme Event score + EST05 score)/3 x 9041) +
((Seagrass score+ Oyster score+ Extreme Event score+ EST05 score)/4 x 3506) +
((Extreme Event score + EST05 score)/2 x 51910)

Hydrologic Modeling
For plan formulation, MIKESHE hydrologic model output was used to calculate all five of the environmental attributes and estuarine habitat units (*i.e.*, HUCM) to evaluate system-wide effects of the proposed alternatives and selecting the recommended plan.

B. Evaluation of Hydrologic Performance

As discussed in Section IV.B.1.a of this report, the optimum distribution of flows (*i.e.,* EST05) at S-79 (Table 6) and salinity criteria (*i.e.,* hydrologic performance measures) were derived from relationships between the distribution, abundance, growth, and survival of estuarine organisms or VECs and the changes in salinity or freshwater discharge to the estuary (Chamberlain and Doering 1998b; Doering et al. 2002; Volety et al. 2003). The EST05 frequency distribution targets mean monthly inflow between 450 and 2,800 cfs during all months. Low flows events occur when the mean monthly inflow at S-79 falls below a flow limit of 450 cfs. High flows greater than 2,800 cfs typically occur as a result of Lake Okeechobee regulatory releases in combination with flows from the C-43 Basin. The hydrologic performance or flow frequency distribution, of each of the alternatives will be compared to the targeted EST05 frequency distribution of freshwater inflows through S-79 from the watershed and Lake Okeechobee for the nine year period of record (nine years out of 36 year period of record containing three wet, three dry and three normal years on record). The alternative with the flow frequency distribution that best emulates the EST05 distribution will be considered better for protecting estuarine resources, while further promoting biotic diversity. Hydrologic performance comparisons were also based on the MIKE SHE hydrologic model output used to evaluate system-wide effects of the proposed alternatives and select the recommended plan or SAP.

C. Next-added Increment Analysis

Hydrologic performance comparisons were also based on the MIKE SHE hydrologic model output used to evaluate system-wide effects of the proposed alternatives and select the recommended plan or SAP. The CERP Programmatic Regulations require evaluation of the tentatively selected plan as the "next-added increment." The next-added increment (NAI) analysis evaluates the effects, or outputs, of the tentatively selected plan as the next project to be added to the group of already approved CERP projects to evaluate the amount of benefits the

selected alternative plan contributes without regard to future CERP projects. Only the SAP was evaluated for the NAI analysis. A separate spreadsheet analysis utilizing modeling output from the SFWMM regional hydrologic simulation model was used in the next added increment analysis but only for the SAP. The spreadsheet model output was then used to calculate all five of the environmental attributes and estuarine habitat units (*i.e.*, HUCM) to justify and describe the benefits of the C-43 Basin Storage Reservoir as a stand-alone project without the system wide benefits attributed to other CERP projects.

VI. FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

The study area is experiencing extremely rapid population growth. Most of Hendry and Glades Counties are presently in agricultural use and the western portion of Lee County is largely urban and residential. Even with county growth restrictions, the population of the coastal areas is and will continue to gradually spread eastward. In doing so, agricultural areas along State Road 80 are likely to become more residential, including the reservoir footprint, and the magnitude of short-term, high-volume runoff will increase. Proposals for larger residential and commercial enterprises are in the planning stages for Hendry and Glades Counties to expand their tax base. As more residential areas are built to the east, agricultural areas will be reduced. Land use projections for 2050 predict that the acreage of natural habitats (*e.g.*, upland forests) and low intensity agricultural lands (*e.g.*, unimproved and woodland pastures) in the area will decline. The extent of natural areas, such as scrub, pine flatwoods, and cypress will likely decline to make room for more citrus, row crops, sod farms, rangeland, and residential developments. The number and sizes of ditches and canals will likely increase causing additional losses in wetland habitat and associated species.

The Service does not fully accept the modeling assumptions used in the PIR for the projection of 2050 land use for the C-43 West Storage Reservoir project. Specifically, the modeling assumed only a slight change in the total area of irrigated agriculture (primarily citrus groves). This assumption is dependent on urban development pressure and on long-range market trends for the citrus industry in Florida, which in turn are dependent on international competition with foreign citrus growers. The model also assumed that the total area of wetlands would remain unchanged by 2050. This analysis is not supported by the current Corps and District regulatory process, which has consistently allowed impacts to large areas of wetlands in favor of off-site mitigation strategies and at ratios that do not replace the geographic extent, type, or watershed functions of many wetlands. The Service believes that continued loss of wetlands will be unavoidable under the current regulatory process.

Because the area of irrigated agriculture is assumed to increase by 2050, and substantial areas of active or recently abandoned citrus will be converted to urban development, the model predicts total acreage of improved and unimproved pasture and rangeland will decrease from 201,420 acres in 2000 to 103,437 acres by 2025 and remain the same through 2050, resulting in a reduction in pasture and rangeland of approximately 51 percent within the study area. The District assumed that the citrus production predicted to be removed by urban development would all be compensated by conversion of pasture and rangeland to citrus. Displaced citrus production will most likely be developed in rangeland; however, the Service believes that some wetland

habitats will also be converted to agricultural and urban developments. The extent of forested uplands, primarily pine flatwoods and some hardwood hammocks, is expected to decline by almost 25 percent by 2025 through conversion to urban development.

As natural areas are developed or converted to more intensive uses, fish and wildlife habitat quantity and quality will likely decrease and become more fragmented. Habitat losses without the project might be even greater than predicted as continued degradation of habitat conditions due to fire suppression in some habitats, unnatural timing of fire in others, additional draining and/or filling of wetlands, and uncontrolled expansion of exotic vegetation. As a result, fish and wildlife populations dependent on upland forests, pastures, and wetlands may decrease, including threatened and endangered species such as the RCW, Audubon's crested caracara, Everglade snail kite, Florida panther, and wood stork.

The future without project condition would exacerbate the altered timing, distribution, quality, and quantity of freshwater flows to the Caloosahatchee Estuary. Urban development and expansion at the expense of undeveloped land and low intensity agricultural land is expected to increase runoff to local drainage systems and the C-43 canal during the wet season, thereby increasing flow rates and contributing to poor water quality. The same increase in urban land area and impervious surfaces is expected to further decrease low flows during the dry season, as less water is conducted to groundwater systems, water tables decline, and base flows to surface canals and rivers decrease. Increased water supply and flood control demands will further decrease available water for the environment. Thus, annual variability in flow and salinity will remain high and established MFLs for the Caloosahatchee River at S-79 will not be met. Such conditions will likelyresult in salinity extremes outside of the tolerance ranges of many estuarine organisms, and will, therefore, result in decreased species diversity.

Declines in estuarine habitats such as seagrasses and oysters and the species that utilize these habitats are expected. Without the reduction of extreme flow and high salinity events, oyster reefs will eventually loose a large percent of the adult population and the ability to produce enough spat to reestablish previously stressed reefs. Without continued settlement, reefs (*i.e.*, hard substrate) will eventually break down and become buried in the soft organic sediments. SAV populations (*i.e.*, turtle grass and shoal grass) will continue to follow current trends of spatial reduction. There will be substantial losses of *Vallisneria* and its seed bank, possibly to the point of no recovery in the low salinity areas, as it tends to be more fragile than the higher salinity species.

In addition, water clarity is expected to decrease resulting in additional stress on the SAV. The deterioration of SAV and marsh habitats may temporarily benefit some estuarine-dependant fisheries, but an eventual decline in productivity will result as detrital input and SAV are significantly reduced due to extreme variations in salinity levels. The long-term loss of nursery habitat will result in population declines for many species of estuarine and marine fishes and macroinvertebrates, including those whose young of the year use fresher (less saline) habitats. At least 70 percent of Florida's recreationally or commercially sought fishes depend on estuaries for at least part of their life histories (Harris et al. 1983, Estevez 1998, Lindall 1973). Seagrass communities within the Caloosahatchee Estuary provide critical refugia for juvenile fish such as

redfish, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall decrease in species richness may be related to the loss of seagrass habitat and a result of alterations in the salinity regime and the timing of the freshwater discharges from the S-79 structure. As freshwater, estuarine, and associated marine ecosystems would further deteriorate, the economic income from eco-tourism, commercial and recreational fishing, and real estate would be greatly reduced.

VII. DESCRIPTION OF SELECTED PLAN AND OTHER ALTERNATIVES

A. Background

The formulation completed and described in the Restudy served as the foundation for the formulation of alternatives for the PIR. The alternative described in the Restudy used the Everglades Screening Model to identify approximately 160,000 acre-feet of storage volume as the targeted amount of storage necessary to capture wet season flows and to meet dry season minimum flows in order to provide desired salinity levels in the Caloosahatchee estuary. The project team used the Restudy alternative (construction of above ground storage reservoirs totaling approximately 160,000 ac-ft) as a starting point for the basis of developing of alternatives. At a minimum, the alternatives considered encompassed the following range of scales and features:

- No Action – same as future without condition
- Alternative(s) with smaller storage volumes than the Restudy
- Alternative(s) with storage volumes similar to the Restudy
- Alternative(s) with larger storage volumes than the Restudy

The screening and evaluation of plan components proposed in the Restudy determined that above ground water storage provided the most cost effective means for freshwater attenuation. Reservoirs were the major management measure suggested for this project along with associated canal improvements to move water to and from the reservoirs. Improvements in the timing, distribution, and magnitude of water deliveries to the estuary should result from improvements in the distribution of surface storage. Additional in-basin storage can potentially supplement other water uses in the study area.

Originally, an in-depth site analysis was performed for both the upper and lower (east and west) Caloosahatchee basins to identify potential reservoir sites prior to the splitting of the project into two phases. For the West Caloosahatchee Basin, in addition to the Berry Groves site, six additional sites were investigated as possible locations for placement of storage reservoirs. As a result of the in-depth screening analysis, all six sites were eliminated either due to impacts to threatened or endangered species or due to geotechnical concerns with seepage rates of the soils on site. Based on this analysis the Berry Groves site was selected (Figure 2) since it represented the most promising site given the location, land use, geology, soils, and cost. Once the potential site location for locating components was determined, the next step was to develop preliminary designs of reservoirs that would utilize the site to its fullest potential. The design of the reservoirs took into consideration the amount of useable land, proximity to major and minor

canals, water table conditions, topography, land uses and required minimum and maximum levee heights.

Since the time of the Restudy, additional information has been developed (improved modeling, improved analysis of local hydrology and water budgets, and new estimates of land use and water demands) that has increased the amount of storage necessary to meet the needs of the Caloosahatchee estuary and basin.

In 1998, the District undertook a water supply planning initiative to ensure prudent management of south Florida's water resources in the Caloosahatchee River Basin (District 2000). The resultant CWMP analysis determined that the projected surface water needs of the Caloosahatchee River and Estuary could be met during a 1-in-10 drought condition with the development of water management and storage infrastructure that effectively captures and stores surface water flows in the basin. The CWMP determined that improved management for surface water through storage could increase freshwater availability in the region and reduce potential impacts resulting from water use. The CWMP determined that a storage reservoir with a capacity of 220,000 acre-feet located in the lower Western C-43 Basin at Berry Groves would provide for environmental restoration of the Caloosahatchee Estuary. Thus, both the Restudy and the CWMP determined that above ground water storage areas were the most cost effective and appropriate means for attenuation of freshwater runoff and capture of Lake Okeechobee inflows in the C-43 Basin Project area.

Additional information has been developed out of the District's Acceler8 planning process that recommends a 170,000 acre-foot reservoir. As part of the Acceler8 and C-43 PIR planning process various site configurations were evaluated. Some of the features screened from consideration through these processes were multiple pump stations and larger footprint and multiple cell configurations of the 170,000 acre-foot option. Preliminary analyses determined that a single pump station in the northwest corner of the site was the most cost effective configuration, saving approximately $13 million over a two pump station option with the same pumping capacity. In terms of reservoir layout configurations, a two cell 9,530 acre reservoir alternative was found to be more cost effective in providing a given storage volume than a three cell option utilizing approximately 2,100 additional acres. The larger footprint with a three cell option, while having a somewhat lower dam embankment height, was estimated to increase cost by 14 to 15 percent while maintaining the same storage volume.

B. Alternatives Considered

The final array of alternatives consists of seven alternative plans, including the no action alternative and variations on three reservoir capacities of 100,000, 170,000 and 220,000 acre-feet. Option 4b, would require the purchase of approximately 5,610 additional acres to support an expanded footprint and lower dam heights. This array of alternatives would serve the needs of the C-43 Basin through the creation of a single reservoir in a location that would capture water from Lake Okeechobee and basin runoff from a majority of the C-43 Basin. The Berry Groves location also provides for efficient and flexible management of the stored water.

The reservoir options were designed based on the latest design guidelines and standards at the time of this report. The conceptual designs have been developed to withstand hurricane force winds of over 150 mph as well as combinations of both severe wind and rain conditions. The alternatives under consideration were developed as a result of the analysis of numerous reservoir sizes and cell configurations and represent cost effective options. The design of the reservoirs took into consideration the amount of useable land, proximity to major and minor canals, water table conditions, topography, land uses and required minimum and maximum levee heights.

Alternative 1 - No Action Plan

Alternative 1 is the No Action Plan, which is also the Future Without Project Condition. This alternative was developed from the existing hydrology with modifications for anticipated changes in the watershed due to land use changes, water supply changes, water quality changes, and changes caused by other water resource projects in the watershed.

The following assumptions were made to predict Future Without Project Condition in the C-43 Basin:

1. Non-CERP projects as described below are successfully implemented by 2050 (including the implementation of best management practices).

2. Lake Okeechobee Releases will continue following the current WSE schedule.

3. No CERP projects would be implemented. Despite some minor improvements in flow conditions, it is anticipated that the principal problems associated with harmful flows to the estuary will remain unaddressed.

Future land use, the operation schedule of Lake Okeechobee, and the implementation of Best Management Practices (BMPs) to control nutrient discharges will strongly influence future water quality conditions in the basin. It is assumed that the State of Florida will still be compelled by the TMDL regulations to achieve reductions in nutrient loads in order to meet requirements of the Federal Clean Water Act. This alternative also assumes that local government stormwater retrofits will be constructed in urban areas, and that State, District, and County Surface Water Improvement projects (*e.g.,* District Lake Okeechobee Protection Plan; DEP Lake Okeechobee TMDL; District Caloosahatchee MFL; District Caloosahatchee River Water Management Plan; DEP Caloosahatchee Basin TMDL; FDACS/DEP Agricultural BMP Program for the Caloosahatchee Basin; District Urban Irrigation and Landscape BMP Implementation Projects; District Stormwater Management Regulations; and Lee and Hendry Counties Stormwater Management Projects) will all be in place. When implemented, these programs should result in a reduction of nutrients contained in Lake Okeechobee discharges which in turn will reduce nutrient loading to the Caloosahatchee Estuary. However, even with the noted programs and features in place, degradation of the Caloosahatchee estuary will continue to occur in the future without project condition.

Alternative 2 - 100,000 acre-foot Reservoir with 1,500 cfs Pumping Capacity

Alternative 2 was developed as a smaller restoration alternative for the Lower Caloosahatchee Basin. This alternative is consistent with the CERP recommendation for a reservoir in this area, but it should be noted that this alternative's total storage volume of 100,000 acre-feet is significantly reduced from the 160,000 acre-feet of storage CERP estimated would be needed in this sub-region.

Alternative 2 is a two-cell reservoir with a "normal pool" storage capacity of 100,000 acre-feet. See Figure 14 and Table 7 configuration and design details. The two-cell design was selected based on the fact that an internal embankment reduces wind set-up and wave-run up helping to reduce the embankment size and cost and it also allows for independent dewatering for unscheduled maintenance if necessary. The reservoir design includes a pump station (1,500 cfs capacity) to pump water from the C-43 Canal through the Townsend Canal to fill the Reservoir. While a two pump station design was considered, the single pump station option was found to be most cost effective. Locating the pump station in the northwest corner minimizes improvements necessary for the Townsend Canal.

The water surface elevation of 35 ft NAVD88 at "normal pool" is constant within the cells, with the depths ranging from 10 to 15 ft based on the elevation of the existing land surface. Dam heights for Alternative 2 will range from 27 to 32 ft. The maximum water depths and dam heights will occur in Cell 1, due to lower land surface elevations. The exterior and interior dams are to have a top width of 15 ft. The side slopes are 3 Horizontal: 1 Vertical (3H:1V). The exterior dams are to be constructed from existing on-site material and have a low permeability core. A graded filter is to be provided on the exterior side of the dam to direct seepage. Soil cement protection would be included on the interior side of all reservoir slope faces. A freeboard of 17 ft was used based on detailed analysis of wind and wave height run-up.

A Perimeter Canal (seepage canal) is provided on the south, east, and north sides of the reservoir. The existing Townsend Canal will act as a seepage canal on the west side of the reservoir. In addition to seepage collection, the Perimeter Canal will also convey discharges from the Reservoir; convey surface runoff from the south and east of the Reservoir including improved drainage for S.R. 29; provide flows to the Crawford Canal, Banana Branch and Fort Simmons Branch; and maintain the surface water elevation in the expanded NE Rim Ditch that provides irrigation for the A. Duda and Sons (Duda) citrus operations, located to the south of the reservoir. A 17-foot cutoff wall along the perimeter of the dam embankment has also been included.

Improvements to the Townsend Canal are based on the necessary capacity to meet maximum pumping requirements to fill the Reservoir. Pre-storm and post-storm event flows have been simulated to evaluate flows in the Townsend Canal and other local canals and tributaries. Storm event flows in the Townsend Canal will be decreased over existing conditions with the construction and operation of the Reservoir.

Each cell in the alternative is designed to discharge independently through separate discharge structures (Figure 14). Cell 1 discharges via S-1 into the Townsend Canal. Cell 2 discharges via S-8 into the Perimeter Canal. These structures will be designed for incremental operation allowing required flows to be released to the C-43 Canal during periods of low flow. These structures could also serve as design storm control structures for releases prior to and during a storm event. The storm releases must be balanced with the targeted maximum flow allowed over S-79, which is 4,500 cfs. An emergency spillway with a crest elevation based on retaining the 25-year, 72-hour storm event is to be provided within each cell's discharge structure. The 25-year, 72-hour storm captured in the reservoir would be a "control release" after the storm event in order to restore the water surface to the normal pool elevation while not exceeding the maximum flow of 4,500 cfs at S-79. The final design of the emergency spillway(s) will be in accordance with the requirements of Design Criteria Memorandum 3 (DCM-3).

Within the reservoir, structure S-12 hydraulically connects the reservoir cells and is designed to be gated so that either cell can be "isolated" for operational or maintenance purposes. A number of other culverts, weirs, and spillways are included to operate the reservoir and maintain appropriate water levels in existing canals and the perimeter canals.

Alternative 3A and B – 170,000 acre-foot Reservoir with 1,500 cfs Pumping Capacity

This alternative comes closest to approximating the Restudy C-43 recommended volume of an approximately 160,000 acre-foot storage reservoir and is the size evaluated and recommended in the Acceler8 planning process. Alternative 3 is a two-cell reservoir with a "normal pool" storage capacity of 170,000 acre-feet. The reservoir design includes a pump station with 1,500 cfs capacity to pump water from the Townsend Canal to fill the Reservoir. The site layout would remain unchanged. Table 7 provides design details. The key distinction between alternatives 3A and 3B is the operational methodology related to filling and draining the reservoir, rather than any structural differences. In general, Alt 3A attempts to maintain very specific flow rates at S-79 at all times while Alt3B attempts to meet the dynamic flow targets supplied by the ecological sub team (EST05).

For alternative 3 the water surface elevation would be 42 ft at "normal pool" (NAVD88), with the average depth ranging from 17 to 22 ft. Dam heights for alternatives 3A and 3B range from 34 to 39 ft. The maximum water depths and dam heights will occur in Cell 1 due to lower land surface elevations in that cell. The exterior and interior dams are to have a top width of 15 ft. The side slopes are 3 Horizontal to 1 Vertical (3H:1V). The exterior dams are to be constructed from existing on-site material and have a low permeability core. A graded filter is to be provided on the exterior side of the dam to direct seepage. Soil cement protection would be included on the interior side of all reservoir slope faces. A freeboard of 17 ft was used based on detailed analysis of wind and wave height run-up.

The perimeter canal, improvements to the Townsend Canal, and construction of culverts, weirs, and spillways is essentially unchanged from Alternative 2. Because this alternative has a larger storage volume yet maintains the same pumping capacity, the amount of time required to fill the reservoir is approximately 24 days longer.

Alternative 3C - 170,000 acre-foot Reservoir with 3,800 cfs Pumping Capacity

Alternative 3C is very similar to alternatives 3A and 3B, the only differences being a larger pumping capacity and the associated modified reservoir operations to optimize storage performance with greater pumping flexibility (Table 7). Alternative 3C is a two-cell reservoir with a "normal pool" storage capacity of 170,000 acre-feet. The reservoir design includes a pump station (3,800 cfs pumping capacity) to pump water from the Townsend Canal to fill the Reservoir. The water surface elevation of 42 ft (NAVD88) at "normal pool" is the same for both cells, with depths ranging from 17 to 22 ft. Other structural elements would be the same as described in the previous Alternative 3B.

The inclusion of the larger pump allows for greater operational flexibility. In particular, the reservoir can be filled approximately 34 days faster than under Alternatives 3A and 3B and 10 days faster than Alternative 2. This allows the reservoir to capture more water during the relatively short duration high flow events. See Figure 14 for additional design details.

Alternative 4A - 220,000 acre-foot Reservoir with 3,800 cfs Pumping Capacity

Alternative 4A is a two-cell Reservoir with a "normal pool" storage capacity of 220,000 acre-feet with dam heights of 39 to 44 ft and water depths of 22 to 27 ft at "normal pool." The pump station capacity is 3,800 cfs. The reservoir location and other associated features are the same as Alternative 3C.

The major difference is that by increasing the storage capacity and maintaining the same foot print normal pool elevations and levee elevations would be approximately five ft higher. In addition, by maintaining the same pump capacity as Alternative 3C approximately six additional days would be required to fill the reservoir. See Figure 14 for additional design details.

Alternative 4B - 220,000 acre-foot Reservoir on Expanded Footprint with 3,800 cfs Pumping Capacity

Alternative 4B maintains the same storage volume as Alternative 4A; however, an approximately 5,610-acre larger footprint would be utilized allowing for an approximately 8 foot lower dam height and pool elevation. Alternative 4B would also be a two-cell reservoir with 220,000 acre-feet of storage. Dam heights would range from 31 to 36 ft and water depths from 14 to 19 ft at "normal pool." The pump station location and capacity is the same as Alternative 3C and 4A. The exact locations of other culverts, weirs, and spillways would be similar to Alternative 4A. See Table 7 for design details.

Although Alternative 4B was carried into the final array of alternatives, it was screened from further consideration at this point. Alternative 4B provides the same level of ecosystem output as Alternative 4A, however, the cost estimates indicated that while construction costs would be lower, total land costs would increase by approximately $150 million resulting in a roughly $80 million higher cost. The real estate costs for the additional land area associated with

Alternative 4B were estimated to be considerably higher than previous purchases based on increasing development pressures in the area. In addition, the larger surface area of this alternative would result in greater evapotranspiration of water. Based on these findings, Alternative 4B was removed from further consideration.

C. Selected Plan: Alternative 3B

The selected plan (Figure 14) consists of two cells totaling approximately 9,220 acres providing a normal maximum storage capacity of approximately 170,000 acre-feet surrounded by a perimeter embankment and canals. Major features of the selected plan include:

- External dam embankments varying in height between 30 and 33 ft. above existing grade;
- Soil-Bentonite walls beneath the external embankments;
- An internal dam embankment separating the two cells with an approximate height of 29 ft. above existing grade;
- An inflow pump station consisting of diesel-powered pumps with a total pumping capacity of 1,500 cfs;
- A perimeter canal;
- A water supply pump station consisting of electric-powered pumps with a total pumping capacity of 150 cfs; and
- Numerous spillways, culverts, perimeter canal structures, an internal cell balancing structure, and outlet structures.

The external embankments include drainage features, and the crest width and the upper portion of the outward side will be covered with soil-cement. The internal embankment does not include drainage structures, but will be covered on both sides with soil-cement. The reservoir is designed to withstand hurricane force winds of over 160 mph, as well as a combination of hurricane force winds with a rainfall event of over 54 inches in a 72-hour period.

Operation of the selected plan is tied to conditions at S-79 approximately ten miles down-river or west of the project site. The project will be operated to improve environmental conditions in the Caloosahatchee Estuary by reducing flows over S-79 during wet periods, and helping to maintain a minimum flow of 450 cfs at S-79 during dry periods.

Project operations involve pumping inflows from the Caloosahatchee River via the existing Townsend Canal into Cell 1. An internal cell balancing structure in the internal embankment will allow water in Cell 1 to enter Cell 2. Water may be released from both cells by outlet structures into the perimeter canal for delivery back to the river via the Townsend Canal and two other direct connections, the Fort Simmons Branch and Banana Branch Canal. Other project structures help to maintain water levels in the perimeter canal and Townsend Canal, and provide water supply deliveries to adjacent lands affected by construction and operation of the reservoir.

VIII. POTENTIAL ADVERSE AND BENEFICIAL EFFECTS OF THE PROJECT

A. Construction-Related Effects

1. Existing Vegetation/Habitat

Removal or destruction of high quality native habitats was minimized through placement of the reservoir within citrus groves. Most existing plant cover within the project footprint would be removed. The project site includes approximately 1,061.3 acres of jurisdictional Waters of the United States, including 934.6 acres of man-made ditches and canals which serve as irrigation and drainage conveyances for the citrus operation and 126.7 acres of wetlands (Figure 10) as described above. In general, construction will largely replace existing vegetation communities with aquatic habitat (open-water reservoir areas) or maintained uplands (embankments, roads, berms). Water depths in the reservoir will fluctuate over time between completely dry down to depths of 15 to 25 ft, potentially impacting the survival of rooted wetland vegetation. The reservoir will lack much of a highly productive littoral zone because of the necessity to construct relatively steep sides lined with a bentonite-soil mixture to maximize water storage capacity while minimizing erosion. Floating-leaved and submergent aquatic plants will become established if conditions are suitable. Although an additional 109 acres of littoral habitat may be constructed as part of the seepage canal may, a total of 141.39 functional wetland units will be lost as a result of the C-43 West Storage Reservoir project (Table 5) consisting primarily of impacted wetlands and agricultural canals and ditches on-site. The restoration and enhancement of approximately 16,300 acres in the upper (*i.e.*, 4,130 acres) and middle and lower (*i.e.*, 12,170 acres) Caloosahatchee Estuary will provide approximately 1,139 wetland mitigation credits (Table 5) and will compensate for the loss of those functional wetland units on site.

2. Fish and Wildlife Disturbance

Construction activities will cause permanent displacement of some fish and wildlife species and could also be a temporary disturbance to wider ranging animals such as wading birds, raptors, turkey, and larger mammals. Noise, fumes, light and human presence associated with mobilization of equipment and construction activities may disturb roosting or foraging wading and waterbirds as well as breeding birds. Phasing will confine construction activities and access routes, and staging areas will likely be designated. Amphibians and reptiles may experience temporary increases in mortality associated with construction access on roadways during the wet season or the onset of dredge and fill activities after the wet season.

3. Fish and Wildlife Benefits

Wading birds will forage in standing water during and immediately after construction. Wading bird, particularly long-legged waders such as great blue herons and great egrets; wood stork; raptors; and small alligators may forage on insects, fish, amphibians, and reptiles that are trapped in depressions and canal remnants. Similar conditions would occur throughout the project site during draw-down events. The reservoir will likely be inhabited by fish and aquatic organisms that are able to enter the reservoir through the water control structures and may include:

largemouth bass, black crappie, red ear sunfish, bluegill, and mosquitofish, among others. Amphibians and aquatic retiles including frogs, turtles, snakes, and alligators will likely inhabit the deepwater reservoir. The reservoir will likely create limited foraging habitat for osprey, bald eagle, terns, cormorant, and other aquatic birds that feed on fish. Ducks may also use the reservoir, but low cover of submerged and emergent vegetation may limit the habitat value. Mammals in the reservoir will likely be limited to river otter.

4. Contaminants and Disposal/Use of Soils

Agricultural areas are typically contaminated with metals (particularly copper, arsenic, and lead), pesticides, and petroleum products. It is anticipated that all contaminated areas identified on the site will be remediated consistent with coordination with the District.

5. Exotic Vegetation

The construction of reservoir may creates the potential for the establishment of exotic and nuisance plant species in disturbed areas, along newly created dikes/levees, and within the reservoir itself. Further propagation of these species may result in a disruption of native plant communities and thus a loss of native fish and wildlife habitat.

B. Operational Effects

The C-43 West Storage Reservoir project will provide most of the storage needs for the basin, and improve estuarine health by reducing the number of damaging high and low flow events at S-79. We anticipate that the hydrologic improvements would result in significant increases in the cover and density of *Vallisneria* beds in the upper estuary by maintaining tolerable salinity levels. We expect to some increases in seagrasses but not as *Vallisneria.* Based on the model results, the proposed design and operation of the C-43 West Reservoir are more effective at augmenting flows below 450 cfs at S-79 to meet MFL criteria than at reducing extreme high flows. Daily flows frequently exceeded 3,000 cfs and in some cases exceed 10,000 cfs during extreme high flow events for all alternatives compared. When flows are that high, the ability to capture enough water to see a difference in the estuary is limited, especially with a 1,500 cfs maximum pumping capacity.

C. Oyster Reef Restoration

The Service notes that the oyster reef restoration plan included in the Draft PIR and EIS was removed from the selected plan. That plan included use of recycled and fossil oyster shell and stabilizing mesh where needed to establish 2 acres per year of suitable hard substrate for oyster recruitment over a 10-year period in the Caloosahatchee Estuary. Removal of this component reduces the likelihood of oyster expansion to 30 acres over a 10- to 15-year period and 100 acres over the project life as a direct result of the proposed project. Although the proposed project will improve salinity conditions for oysters and associated flora and fauna in the middle estuary, oyster expansion is directly tied to the availability of hard substrate for colonization. The

Service recommends that the Corps or District pursuit funding for this component under other programs.

D. Summary of Consultation under the Endangered Species Act

The Service has been an active member of the project team for the C-43 West Storage Reservoir project and has provided guidance through informal consultation during plan formulation and evaluation. The Corps Regulatory Division's January 10, 2007, and March 22, 2007, letters to the Service and the December 2006 Biological Assessment provided by the District describe the potential effects of the proposed C-43 West Storage Reservoir project on federally listed threatened and endangered species The Corps determined that the reservoir project will not affect the bald eagle, Florida scrub jay, Florida grasshopper sparrow, red cockaded woodpecker, Okeechobee gourd, or the beautiful pawpaw because they do not occur within or adjacent to reservoir footprint, nor would there be direct or indirect impacts to those species. The Corps has also determined that the proposed project may affect, but is not likely to adversely affect the wood stork, West Indian manatee, Everglade snail kite, American crocodile, piping plover, or the green, leatherback, Kemp's ridley or loggerhead sea turtles; and may adversely affect the eastern indigo snake, Audubon's crested caracara, and the Florida panther. The American crocodile, piping plover, or the green, leatherback, Kemp's ridley and loggerhead sea turtles do not occur within or adjacent to the reservoir footprint and indirect effects resulting from operation of the reservoir are expected to be negligible, discountable or beneficial to those species. Additionally, wintering piping plover critical habitat will not be adversely modified by the proposed project. Following is a summary of the effects on the remaining federally-listed species:

Wood Stork
The C-43 project area is within the CFA of three wood stork rookeries previously mentioned in the existing conditions section of the PIR. Construction of the reservoir will result in the loss of approximately 731.4 acres of potential wood stork foraging habitat within the reservoir footprint, including wetlands and secondary and tertiary drainage canals. However, the proposed project would improve salinity conditions during the dry season for 4,130 acres of *Vallisneria* beds in the upper Caloosahatchee estuary. Two of the wood stork rookeries are located on mangrove islands within the upper estuary and would directly benefit from the proposed project. Additionally, the proposed project is not expected to alter the hydroperiod of freshwater wetlands outside of the project footprint but within the wood stork CFAs as recommended in the Service' *Habitat Management Guidelines for the Wood Stork in the Southeast Region* (Service 1990). The reservoir may intermittently provide foraging habitat for wood storks during the dry season if/when water releases for the estuary are great enough to create optimal shallow-water foraging areas with concentrated prey in the reservoir. Thus, the Corps has made the determination that implementation of Alternatives 3b may affect, but is not likely to adversely affect the wood stork.

Everglade Snail Kite
No known snail kite nesting locations are documented within or adjacent to the reservoir site, and no designated critical habitat occurs within or adjacent to the project area. Construction and flooding of the proposed reservoir and seepage canals may infrequently provide wetland habitats

utilized by the snail kite on more than 10,000 acres currently under citrus production. Potential foraging habitat would be available intermittently as reservoir water levels would experience wide-ranging depth and duration fluctuations from complete dry down to 17 to 19 ft above soil surface. Citrus operations in the project area and elsewhere have routinely applied heavy copper treatments as a fungicide for many years, resulting in extensive copper contamination in the soil. Potential copper risk to the endangered snail kite may occur due to copper accumulation in the kite's primary food item, the apple snail (URS 2003). Snail kites have a specific diet comprised almost entirely of apple snails. Apple snails have been found in the larger agricultural canals adjacent to the Test Cell Project area. However, the perimeter canal may provide wetland vegetation for survival of apple snails in littoral areas created from uneven edges. The perimeter canal could potentially could attract or increase usage of snail kites, providing foraging habitat but this use would be dependent on the presence of apple snails and appropriate perching sites Thus, wetlands created as a result of the project may attract foraging snail kites.

Copper concentrations in the soils within the project area range from 13.1 to 169.0 mg/kg (URS Corporation 2003). Approximately 9 percent of the sample concentrations within the project area exceed the interim effects level of 85 mg/kg agreed upon by the Service and District until a study to evaluate that value for the snail kite is completed. Those areas will be remediated before project construction. The Corps has therefore determined the project may affect, but is not likely to adversely effect the Everglade snail kite and its critical habitat.

West Indian Manatee

Manatees are known to use major inland freshwater waterways and canals, including the Caloosahatchee River from Lake Okeechobee to the Gulf of Mexico (*i.e.,* Glades, Hendry, and Lee Counties). Additionally, there is a significant warmwater refugia for manatees located at the Florida Power and Light power generating facility on the Caloosahatchee and Orange Rivers downstream of the site. This site may support up to 600 manatees during periods of extreme cold weather. Movements of manatees to and from this facility are related to access to fresh water for drinking, the water temperatures in the Caloosahatchee and Orange Rivers and the Caloosahatchee tributaries and estuaries; and the proximity of forage resources, including *Vallisneria* in the upper estuaries and turtle and shoal grass in the middle to lower estuaries.

The manatee is known to utilize the Caloosahatchee River and the Townsend Canal on the western side of the project footprint. When water levels are high in the Caloosahatchee River, manatees are capable of passing over the existing weir or through a flap gate into the Townsend Canal and have been observed at the Berry Groves main pump station. The Townsend Canal will serve as the intake canal for the reservoir. The weir will be replaced, portions of the canal will be widened and armored, and two new pump stations will be constructed. The Service's manatee requirements for culverts *Guidelines for Culverts Located in Manatee-Accessible CERP Projects* (Service 2006), the *Standard Manatee Conditions for In-Water Work* (Florida Fish and Wildlife Conservation Commission [FWC] 2005), and *Guidelines for Manatee Conservation During Comprehensive Everglades Restoration Plan Implementation* (CERP Interagency Manatee Task Force 2006) will be followed. Therefore, the Corps has determined that the project "may affect but is not likely to adversely affect" the manatee.

Florida Panther
The proposed reservoir is within the current range of the Florida panther and will result in the conversion of approximately 10,361 acres (project footprint) of habitat suitable for use by the panther for foraging and dispersal, including wetlands and uplands, to open water habitat. The project site is adjacent to the Florida Panther Focus Area (Service 2007) and is designated as "other" lands that provide value for panthers and require consultation. In addition, the site is in the CERP Landscape Level Project Planning and Siting Map for Panther Conservation (Service and FWC 2004: Figure 15). The Corps determined that the C-43 Project "may affect" the Florida panther and requested initiation of formal consultation. The habitat loss and other project effects will be addressed during formal consultation with the Service.

Eastern Indigo Snake
Specific information on the status of this species within the project area is not available. However, indigo snakes are known to occur in the Caloosahatchee River basin in low densities and are known to occur along roads and the banks of larger ditches and canals in citrus groves, particularly if burrows (*e.g.*, tortoise, armadillo, small mammal, and land crab), debris piles, or other shelter are in close proximity. The network of ditches and canals also provide prey items. Project-related construction activities may destroy shelter and refugia sites and may cause individuals to leave the area, abandon den sites, and miss foraging and mating opportunities. The Corps assumes that eastern indigo snakes occupy the site, and are more prevalent where habitat and prey items are more plentiful.

The Service's Standard Indigo Snake Protection Conditions will be implemented during construction to minimize potential adverse effects to indigo snakes (Service 2002). Those measures include: 1) providing indigo snake educational materials to construction employees prior to project initiation; 2) if a live indigo snake is found, construction activities will cease until the snake has left the project area on its' own accord and the location of sightings will be reported to the Service; and, 3) if a dead indigo snake is found, the snake will be frozen as soon as possible and the Service will be contacted immediately for further instructions. The Corps has determined that the proposed reservoir project "may adversely affect" the eastern indigo snake. The habitat loss and other project effects will be addressed during formal consultation with the Service.

Audubon's crested caracara
The reservoir footprint occurs with the secondary (6,600-foot radius from the nest tree) protection zones of two known caracara nest sites. Caracaras were observed foraging in the southeast portion of the project footprint that overlaps with the secondary zone of one nest. However, no construction activities or habitat loss would occur within the primary (985-foot radius from the nest tree) of either nest. The Corps has determined that the proposed project "may adversely affect" the crested caracara. The habitat loss and other project effects will be addressed during formal consultation with the Service.

IX. EVALUATION OF THE PROJECT

Each alternative was evaluated against the others, and against the No Action alternative in order to identify which ones best approached the multiple goals of the project. Although Alternatives 3A and 4B were carried into the final array of alternatives, they were screened from further consideration. Operations modeled for Alternative 3A were not based on meeting the dynamic flow targets supplied by the ecological sub team (EST05) and was removed from consideration. Alternative 4B provides the same level of ecosystem output as Alternative 4A, but the additional land costs were estimated at roughly $80 million higher cost, making the project cost prohibitive.

A. Evaluation of Estuarine Habitat Benefits

The estuarine habitat benefits for each alternative were calculated using the HUCM. All the alternatives showed a net benefit to the estuary. However, Alternative 3C has the highest number of habitat units, and therefore, shows the most improvement to the estuary (Table 4).

B. Evaluation of Hydrologic Performance

The resulting flow frequency distributions from the analyses of alternatives were compared against the EST05 target distribution to determine the top performing plan. Based on the modeling results, all of the alternatives showed an increase in the number of months where flows were within the desired envelope and a decrease in the number of months flows were outside the desired flow envelope. Of the alternatives analyzed, Alternatives 3C and 4A came closest to matching the EST05 flow frequency distribution at S-79 (Table 8). When compared to the future without project condition, Alternatives 3C and 4 provide the most benefits to the estuary over the by:

- Reducing the frequency and duration of damaging high and low flows on a monthly scale.
- Increasing the frequency of times when flows to the estuary are within the desirable flow ranges.
- Achieving more of a balance in salinity patterns within the estuary.

Flows less than 450 cfs at S-79
Comparisons of alternatives using the monthly distribution of events where the flow drops below 450 cfs (especially in the middle of the dry season, between March and June) show that Alternatives 3C and 4 provide the largest decreases in damaging low-flow events during this time period when compared to the future without project condition (Figure 15).

Flows between 450 cfs and 2,800 cfs at S-79
Comparisons of alternatives based on maximizing the number of months flows from S-79 in the 450 to 800 cfs range (up to 75%) and almost all the remaining flows in the 800 to 2,800 cfs range (up to 25 percent). Alternatives 3C and 4A provided the greatest percentage of time within the desired flow envelope at 82.4% of the period of record (Table 8).

Flows Greater than 2,800 cfs at S-79
All alternatives substantially reduced the number of months and number of consecutive months with flows greater than 2,800 cfs and completely eliminated flows greater than 4,500 cfs (Table 8). Alternatives were also compared using weekly averages because short duration high flow events were dampened using monthly averages. All alternatives, even those with the additional pumping and reservoir capacity, had daily flows frequently exceeding 3,000 cfs and in some cases exceeding 10,000 cfs for these extreme events. When comparing the alternatives to the 2050 FWO condition on a weekly basis in reducing these extreme flow events, Alt 3C and Alt 4A provided decreases in the number of flow events between 2,800 cfs and 4,500 cfs and the largest decrease in the number of weeks with flows greater than 4,500 cfs.

C. Next Added Increment and Plan Selection

Originally, the Corps preferred alternative 3C (*i.e.,* 170,000 ac-ft-foot reservoir, 34 to 39 ft dam, 17 to 22 ft pool, and 3,800 cfs pumping capacity) based on an assessment of benefits (habitat units), cost effectiveness/incremental cost analysis, consideration of the four accounts, and risk and uncertainty. It provided the lowest cost per habitat unit of all the plans and provided the majority (over 97 percent) of the potential ecosystem benefits for only 90 percent of the cost compared with Alternative 4A. After a full consideration of costs and benefits, the District and Corps selected Alternative 3B. The NAI analysis and comparisons to the system formulation were made only for Alternative 3B (Table 9).

The C-43 reservoir NAI analysis demonstrates that as a stand-alone project, all of the benefits achieved in the system-wide formulation process were met or exceeded. The NAI analysis yields a greater average annual HU lift than the system-wide analysis. The reason behind the additional benefits calculated during the NAI analysis is due to different water budgets afforded to the model for both the system-wide and NAI computations, stemming from demands on Lake Okeechobee. The variables in the water budget reflect additional demands from CERP features located outside the C-43 study area. This additional water being supplied to other CERP features in the system-wide analysis leads to a lower potential benefit to the C-43 study area. This does not imply that the C-43 reservoir is operating less efficiently as part of the CERP system, but instead illustrates difficulties in comparing model results when the boundary conditions are not consistent.

Therefore, the NAI and LAI comparisons may not be valid due to different sources of data for the two analyses. The system-wide analysis utilized the MIKE-SHE model.

X. RECOMMENDATIONS/CONSERVATION MEASURES

1. The Corps and District should to consult with natural resource agencies in developing a detailed project operating manual for the reservoir to ensure restoration objectives are met. The operational plan should include the regulation schedules, operating criteria, and additional provisions as may be required to collect, analyze, and disseminate basic data. Detailed operating instructions to ensure that the project meets the restoration goals and targets should also be included in the form of a draft, interim, preliminary, and final

operational plan. The water resource allocation for the natural system as described in the PIR should be utilized and described in both documents as the project progresses. An adaptive assessment team should meet when operations begin, during interim construction operations, and after construction to review the operational plan in concert with the information obtained from the Water Quality and Ecological Monitoring Plans to assure that restoration benefits are being met and that operations are optimized for restoration (Annex D in the Draft PIR).

2. The Service recommends that the hydrologic monitoring plan in Section D.2 of Annex D in the PIR be expanded beyond the immediate footprint of the reservoir to include both existing canals and adjacent and upstream wetlands to ensure operation of the reservoir will not result in adverse impacts to the SOW and OSSF WMAs, and that the Corps formulate and incorporate related ecological hypotheses to be tested in the adaptive management protocol in Section D.4 of Annex D in the PIR. Emphasis should be placed on acquiring pre-project baseline data for existing canals (*i.e.,* Roberts Canal) that can either provide direct or indirect drainage of areas of concern such as the Spirit-of-the Wild Wildlife Management Area and the Okaloacoochee Slough State Forest and Wildlife Management Area.

3. The Corps should evaluate results of the Test Cell Water Quality Monitoring Plan and incorporate that information in the reservoir design and water management operation and maintenance plan to maximize the reduction of nutrient loads from C-43 West Reservoir outflows.

4. The Service recommends that the Corps use the results from the Test Cell Water Quality Monitoring Plan to further evaluate: the quality of water while it's retained within the reservoir; the quality of water released from the reservoir and its potential effects on water quality of flows discharged at S-79; and, the effects of the quality and volume of water released at S-79 on the estuary.

5. The Service recommends that the Corps monitor the water quality effects of the project consistent with the Water Quality portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR).

6. The Service recommends that the Corps monitor the surface water and groundwater effects of the project consistent with the Water Quality portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR) and recommendation number 2 above.

7. The Service recommends that the Corps monitor effects of the project on estuarine resources consistent with the estuarine portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR).

8. The Service recommends that the Corps implement the adaptive management protocols consistent with the Draft Project Operating Manual and Monitoring Plan.

9. If ASR wells are not constructed around the reservoir perimeter, the Service recommends that the Corps and the District expand the littoral zones created along the seepage canals.

10. The Service recommends that compatible public recreational opportunities which do not conflict with the primary function of the reservoir be provided in accordance with State Rule 40E-7.

11. The Service recommends that the Corps or District pursuit funding for oyster reef restoration by placement of hard substrate in the estuary through other programs to increase the likelihood of oyster reef expansion to 30 acres over a 10- to 15-year period and 100 acres over the project life. Although the proposed project will improve salinity conditions for oysters and associated flora and fauna in the middle estuary, oyster expansion is directly tied to the availability of hard substrate for colonization.

XI. SUMMARY OF POSITION

The Service recognizes the considerable effort that has gone into developing this plan and selecting an alternative. The proposed project could provide meaningful hydrologic, economic, and ecological improvements to the Caloosahatchee estuary. Maintenance of proper salinity regime and reductions in the volume and timing of damaging, releases to the estuary should promote the growth and spatial distribution of tape grass, oysters, and possibly seagrasses, and improve the overall health of the estuarine system. The C-43 West Storage Reservoir project also benefits lands of national interest, including the Charlotte Harbor National Estuary and the J.N. "Ding" Darling NWR.

The Service has participated in the development and review of alternatives for the C-43 West Storage Reservoir project since it was initiated. Throughout the evaluation process we have provided recommendations involving the location, refinement, and selection of project alternatives based on ecological considerations onsite and within the Caloosahatchee estuary. The Service believes that the SAP could provide meaningful hydrologic, economic, and ecological improvements to the Caloosahatchee estuary. Project operations will benefit the Caloosahatchee upper estuary by augmenting low flows during dry periods and reduce the number of times the estuary suffers from too high salinity. The Caloosahatchee will also receive fewer high flow events during wet season.

XII. LITERATURE CITED

Abrahamson, W.G., and D.C. Hartnett. 1990. Pine flatwoods and dry prairies. Pages 103-149 *in* R.L. Myers and J.J. Ewel, eds. Ecosystems of Florida. University of Central Florida Press; Orlando, Florida.

American Rivers. 2006. America's most endangered rivers of 2006 [Internet]. Available from: http://www.americanrivers.org/

Bierman, V. 1993. Performance Report for the Caloosahatchee Estuary Salinity Modeling. South Florida Water Management District expert assistance contract deliverable. Limno-Tech, Incorporated.

Bulger, A.J., B.P. Hayden, M.G. McCormick-Ray, M.E. Monaco, and D.M. Nelson. 1990. A proposed estuarine classification: analysis of species salinity ranges. ELMR Report No. 5, Strategic Assessment Branch, NOS/NOAA, Rockville, Maryland.

Comprehensive Everglades Restoration Plan [CERP] Interagency Manatee Task Force. 2006. Guidelines for Manatee Conservation During Comprehensive Everglades Restoration Plan Implementation. Fish and Wildlife Service, South Florida Ecological Services Office; Vero Beach, Florida.

Corbett, C. 2006. Seagrass Coverage Changes in Charlotte Harbor, FL. Florida Scientist. 69(00S2):7-23.

Cox, J., R. Kautz, M. Maclaughlin, and T. Gilbert. 1994. Closing the Gaps in Florida's Wildlife Habitat Conservation System. Office of Environmental Services, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

Dekshenieks, M., E. Hofmann, and E. Powell. 2000. Quantifying the Effects of Environmental Change on an Oyster Population: A Modeling Study. Estuaries Vol. 23, NO.5, p.593-610.

Doering, P.H. and R.H. Chamberlain. 1998. Water quality in the Caloosahatchee Estuary, San Carlos Bay and Pine Island sound. *In*: Proceedings of the Charlotte Harbor Public Conference and Technical Symposium, March 15-16, 1997, Punta Gorda, Florida. Pages 229-240. Charlotte Harbor National Estuary Program Technical Report No. 98-02, West Palm Beach, Florida, South Florida Water Management District.

Doering, P.H. and R.H. Chamberlain. 1999. Water quality and source of freshwater discharge to the Caloosahatchee estuary, Florida. Journal of the American Water Resources Association 35(4):793-806.

Doering, P.H. and R.H. Chamberlain. 2004. Total Nitrogen loading to the Caloosahatchee estuary at the Franklin Lock and Dam (S-79): Interim CERP water quality update. South Florida Water Management District Unpublished Report.

Duever, Michael. 2006. Hydrologic Setting of Florida Panther and Ten Thousand Islands National Wildlife Refuges. 2006 Greater Everglades Ecosystem Restoration Conference, Planning, Policy and Science. Lake Buena Vista, Florida.

Florida Department of Environmental Protection. 2004. Revised Draft List of Impaired waters for the Caloosahatchee River Basin for the Group 3 Basins, Caloosahatchee River Basin. Total Maximum Daily Load Program. http://www.dep.state.fl.us/water/tmdl/verified_gp3R.htm

Florida Department of Environmental Protection. 2002. Caloosahatchee Basin Status Report.

Florida Fish and Wildlife Conservation Commission. 2005. Standard Manatee Conditions for In-water Work. Tallahassee, Florida.

Goodwin, C.R. 1996. Simulation of the Tidal Flow, Circulation, and Flushing Characteristics of the Charlotte Harbor Estuarine System, Florida. U.S. Geological Survey Water Resources Investigations Report 93-4153. 92 pp.

Greenawalt-Boswell, J., J. Hale, K. Fuhr, and J. Ott. 2006. Seagrass Species Composition and Distribution Trends in Relation to Salinity Fluctuations in Charlotte Harbor, Florida. Florida Scientist. 69(00S2):24-35.

Janicki Environmental. 2003. Development of Critical Loads for the C-43 Basin, Caloosahatchee River. Prepared For the Florida Department of Environmental Protection, Tallahassee, Florida.

Kautz, R., R. Kawula, T. Hoctor, J. Comiskey, D. Jansen, D. Jennings, J. Kasbohm, F. Mazzotti, R. McBride, L. Richardson, and K. Root. 2006. How Much Is Enough? Landscape-scale Conservation for the Florida Panther. Biological Conservation.

Kimes, C.A. and L.C. Crocker. 1998. The Caloosahatchee River and Its Watershed. Florida Center for Environmental Studies Agreement #SR 819 FAU DSR #96-127, South Florida Water Management District, Florida.

Mazzotti, F.E., L.A. Brandt, L.G. Pearlstrine, W.M. Kitchens, T.A. Obreza, F.C. Depkin, N.E. Morris, and C.E. Arnold. 1992. An Evaluation of the Regional Effects of New Citrus Development on the Ecological Integrity of Wildlife Resources in Southwest Florida. Final Report. South Florida Water Management District, West Palm Beach, Florida.

McMahan, C.A. 1968. Biomass and salinity tolerance of shoal grass and manatee grass in Lower Laguna Madre, Texas. Journal of Wildlife Management 33:501-506.

McPherson, B.F. and R.L. Miller. 1990. Nutrient distribution and variability in the Charlotte Harbor estuarine system, Florida. Water Resources Bulletin 36:67-80.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands. Van Nostrand Reinhold. New York.

Myers, R. and Ewel, J. 1990. Ecosystems of Florida. University of Florida Press. Orlando, Florida.

Scarlatos, P.D. 1988. Caloosahatchee Estuary Hydrodynamics. South Florida Water Management District Technical Publication No. 88-7. 39 pp.

South Florida Water Management District. 2000. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary. South Florida Water Management District, Florida.

South Florida Water Management District. 2002. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary: Draft Status Update Report. South Florida Water Management District, Florida.

South Florida Water Management District. 2003. Existing legal Sources for the Caloosahatchee Estuary at the Franklin Lock and Dam (S-79). Coastal Ecosystems Division, Southern Restoration Department, South Florida Water Management District, Florida.

URS Corporation. 2003. Berry Labelle- Congen Grove Ecological Risk Assessment. Boca Raton, Florida.

South Florida Water Management District and U.S. Army Corps of Engineers (District and Corps). 2004. CERP Guidance Memorandum Number-Revision: 023.01, Water Quality considerations for the Project Implementation Report Phase.

Tomlinson, P.B. 1980. The Biology of Trees Native to Tropical Florida. Privately published. Printed by the Harvard University Printing Office.

Tomlinson, P.B. 1986. The Botany of Mangroves. Cambridge University Press, London.

Volety, A.K., S.G. Tolley, and J.T. Winstead. 2003. Effects of seasonal and water quality parameters on oysters (*Crassostrea virginica*) and associated fish populations in the Caloosahatchee River: Final contract report (C-12412) to the South Florida Water Management District. Florida Gulf Coast University; Ft. Myers, Florida.

U.S. Army Corps of Engineers and South Florida Water Management District (Corps and District). 1999. Central and Southern Florida Project Comprehensive Review Study. Final integrated feasibility report and programmatic environmental impact statement. Jacksonville District Office; Jacksonville, Florida.

U.S. Army Corps of Engineers and South Florida Water Management District (Corps and District). 2000. Comprehensive Everglades Restoration Plan (CERP), Master Program Management Plan. Volume I, Appendix A.

U.S. Army Corps of Engineers and South Florida Water Management District (Corps and District). 2002. Central and Southern Florida Project Comprehensive Everglades Restoration Plan, Project Management Plan, C-43 Basin Storage Reservoir.

U.S. Army Corps of Engineers. 1957. General Design Memorandum, Caloosahatchee River and control structures (Canal 43 and lock and spillway structures 77, 78, and 79), Part IV: Central and Southern Florida Project. U.S. Army Corps of Engineers, Serial No.36.

U.S. Fish and Wildlife Service. 1990. Habitat management guidelines for the wood stork in the southeastern region. Fish and Wildlife Service; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1999. South Florida Multi-Species Recovery Plan. Fish and Wildlife Service, Southeast Region; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 2000. Florida panther final interim standard local operating procedures (SLOPES) for endangered species. Fish and Wildlife Service; Vero Beach, Florida.

U.S. Fish and Wildlife Service. 2006. Guidelines for Culverts Located in Manatee-Accessible CERP Projects. Fish and Wildlife Service; Vero Beach, Florida.

U.S. Fish and Wildlife Service. 2007. Letter from U.S Fish and Wildlife Service dated February 19, 2007. Panther Key and Tool Recertification. Fish and Wildlife Service; Vero Beach, Florida.

Zieman, J.C. and R.T. Zieman. 1989. The ecology of the seagrass meadows of the west coast of Florida: a community profile. U.S. Fish and Wildlife Service Biological Report 85 (7.25) 155pp.

Table 3. Quality Index Calculations by Environmental Attribute.

Condition	Oyster	*Vallisneria*	Seagrass	Extreme Event	EST05
2000 Base (Existing)	.48	.16	.51	.28	.38
2050 Future Without Project	.52	.20	.54	.30	.43
Alternative 2	.60	.31	.59	.42	.64
Alternative 3b	.60	.33	.59	.43	.70
Alternative 3c	.61	.35	.59	.45	.80
Alternative 4	.61	.35	.59	.45	.79

Table 4. Average Annual Habit Units by Alternative.

Alternative	Average Annual Project Habitat Units
Alternative 2	10,628
Alternative 3b	12,809
Alternative 3c	16,397
Alternative 4	15,907

Table 5. Functional Assessment of Jurisdictional Wetlands and Waters of the United States Affected by the C-43 West Reservoir

FWS Wetland Class1	Acres	Uniform Mitigation Assessment Method			Wetland Rapid Assessment Procedure		
		Existing	With Project	Functional Value (+ or -)	Existing	With Project	Functional Value (+ or -)
Native Mixed Herbaceous	12.38	0.50	0.27	- 2.85	0.59	0.33	- 3.22
Native Tree Dominated	13.69	0.53	0.27	-3.56	0.57	0.33	- 3.29
Native Mixed Trees	13.66	0.55	0.27	- 3.82	0.60	0.33	- 3.69
Exotic/Nuisance Shrub Dominated	63.01	0.40	0.27	-8.19	0.40	0.33	- 4.41
Exotic/Nuisance Mixed Shrub	13.32	0.29	0.27	-0.27	0.35	0.33	- 0.27
Exotic/Nuisance Tree Dominated	2.63	0.31	0.27	- 0.11	0.37	0.33	- 0.11
Small reservoir/Impounded wetlands Open water or floating leave dominated	7.99	0.40	0.27	- 1.04	0.45	0.33	- 0.96
Primary Canal	88.79	0.40	0.27	- 11.54	0.57	0.33	- 21.31
Secondary Canal	209.70	0.40	0.27	- 27.26	0.45	0.33	- 25.16
Tertiary Ditch	636.14	0.40	0.27	- 82.70	0.42	0.33	- 57.25
Total Functional Wetland Loss				**-141.34**			**- 119.67**
Upper Caloosahatchee Estuary	4,130	0.33	0.60	+ 446	--	--	--
Middle and Lower Caloosahatchee Estuary	12,170	0.33	0.47	+ 693	--	--	--
Total Functional Wetland Gain				**+ 1,193**	--	--	--

[1]FWS Wetland Classifications are defined in Appendix C of this report and corresponding National Wetland Inventory codes are shown on Figure 10.

933

Table 6. EST05 Target Flow Distribution at S-79.

S-79 Freshwater Discharge (Mean monthly flow range)	Frequency -Mean Monthly Flow (36 Year Period of Record)
Number of months < 450 cfs	0.0%
Number of months between 450 cfs and 1500 cfs	74.5%
Number of months between 1500 cfs and 2800 cfs	24.8%
Number of months > 2800 cfs	0.07%
Number of months > 4500 cfs	0.0%

Table 7. Comparison and Summary of Alternatives.

	ALT 2	ALT 3A AND 3B	ALT 3C	ALT 4A	ALT 4B
Design Parameters	**Parameter Values**				
Storage Volume (acre-feet)	100,000	170,000	170,000	220,000	220,000
Storage Area / Reservoir Footprint (acres)	9,530/11,000	9,530 / 11,000	9,530 / 11,000	9,530 / 11,000	15,140 / 16,610
Project Footprint - Staging, O&M, etc. (acres)	13,300	13,300	13,300	13,300	18,910
Normal Pool Elevation/Pool Depth (ft NAVD88/ft)	35/10-15	42/17-22	42/17-22	47/22-27	39/14-19
Dam Elevation/Dam Height (ft NAVD88/ft)	52/27-32	59 /34-39	59/34-39	64/39-44	56/31-36
Total Fill Rate – Pump Capacity (cfs)	1,500	1,500	3,800	3,800	3,800
Time to Fill (days)	33	170,000	23	29	29

Table 8. Summary of Mean Monthly Flow Events AT S-79 within Different Flow Ranges.

Alternative	Number of Months <450 cfs	Number of Months 450 – 800 cfs	Number of Months 800 – 2800 cfs	Number of Months 2800 – 4500 cfs	Number of Months >4500 cfs
Target (EST05)	0	79	29	0	0
2050FWO	43	27	28	7	3
Alternative 2 (2050)	33	46	27	2	0
Alternative 3A (2050)	33	56	17	2	0
Alternative 3B (2050)	30	26	49	3	0
Alternative 3C (2050)	19	60	29	0	0
Alternative 4A (2050)	19	60	29	0	0

Table 9. Comparison of the Next-added Increment (NAI) Analysis to the System Formulation or Last-Added Increment (LAI) Analysis.

Alternative	Oyster	Vallisneria	Seagrass	Extreme Events	EST05	Total Project Average Annual Habitat Units
3B LAI	.60	.33	.59	.43	.70	12,809
3B NAI	.59	.33	.52	.24	.70	15380

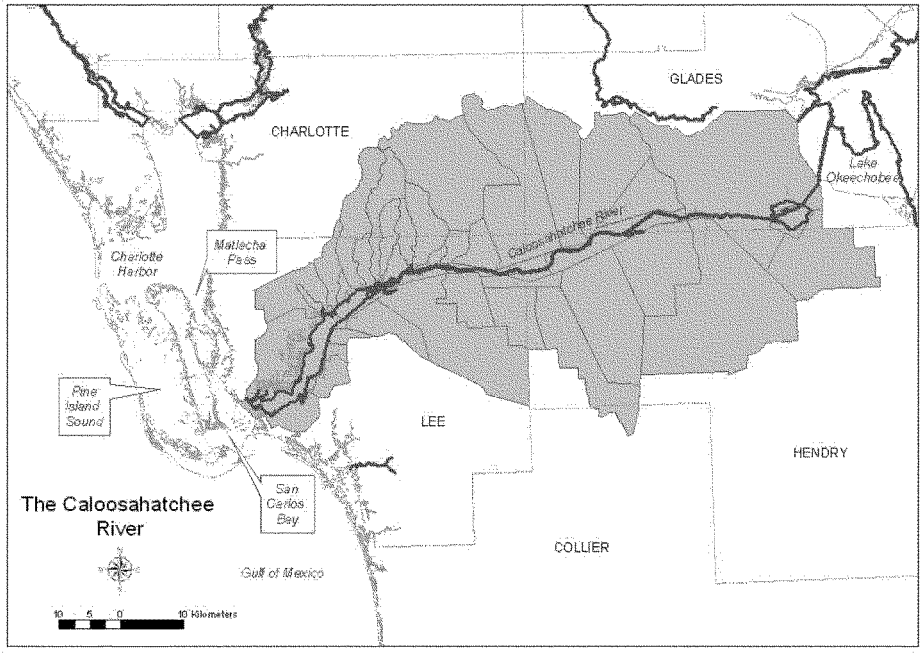


Figure 1. C-43 Basin Storage Reservoir Project Study Area (Figure adapted from Conservancy of Southwest Florida 2005).

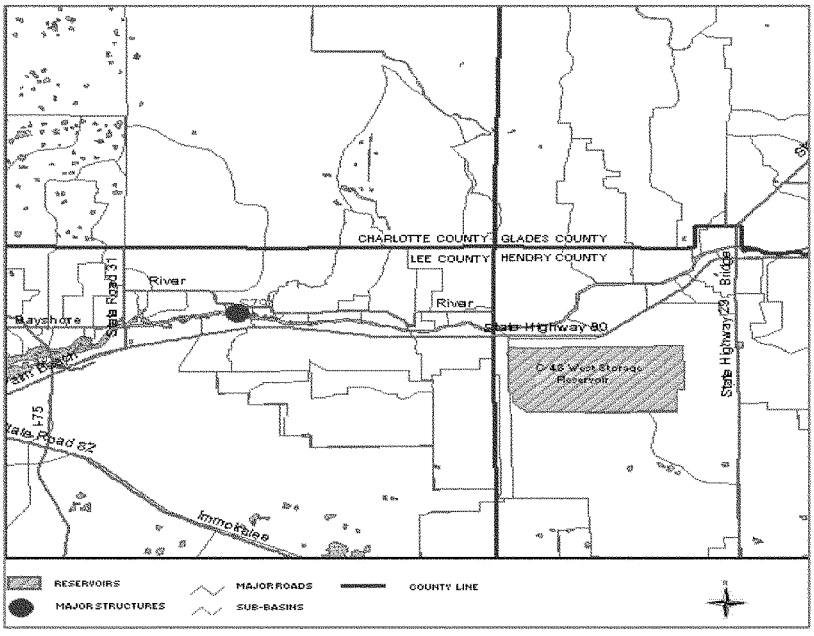


Figure 2. Proposed C-43 Basin Storage Reservoir Location.

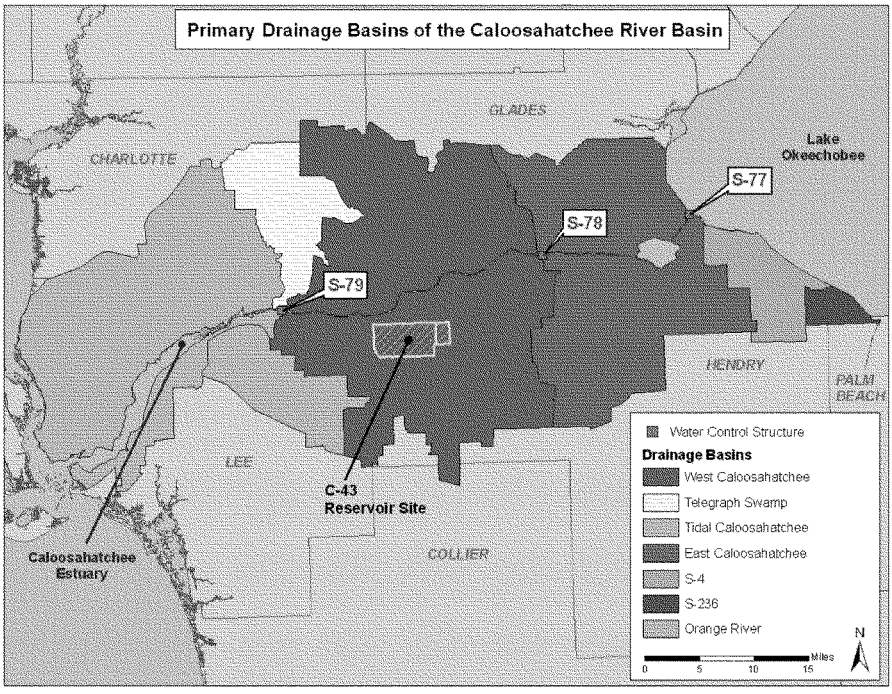
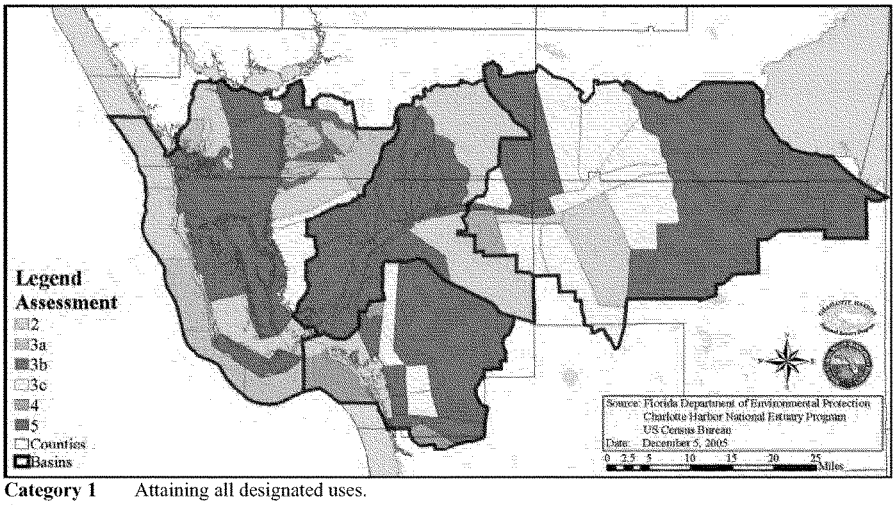


Figure 3. Primary Drainage Basins of the Caloosahatchee River Basin.



Category 1	Attaining all designated uses.
Category 2	Attaining some designated uses.
Category 3a-	No data or information to determine if any designated use is attained.
Category 3b-	Insufficient data to determine if any designated use is attained.
Category 3c-	Waterbody meets Planning List criteria and is Potentially Impaired for one or more designated uses.
Category 3d-	Waterbody meets Verified List criteria and is Potentially Impaired for one or more designated uses.
Category 4	Impaired for one or more designated uses, but does not require a TMDL because a pollutant control measure will restore a designated use, TMDL has been completed, the impairment was not caused by pollutant.
Category 5	Water quality standard not attained; water impaired and requires TMDL; Verified List and 303(d) List.

Figure 4. Florida Department of Environmental Protection Impaired Waters Rule Assessment (Figure adapted from CHNEP 2006).

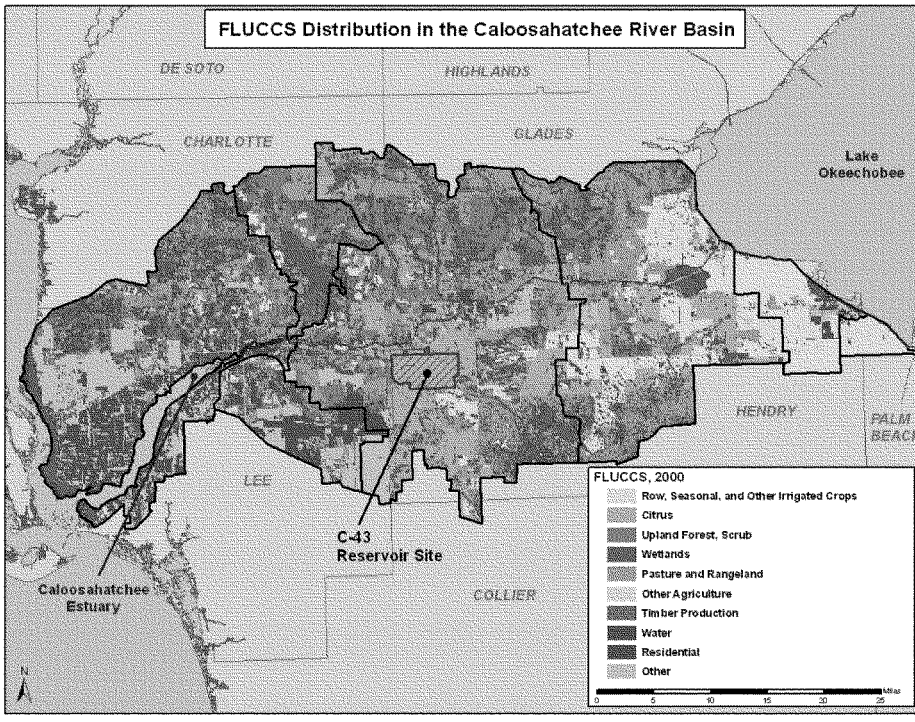


Figure 5. Florida Land Use Cover and Classification in the Caloosahatchee River Basin.

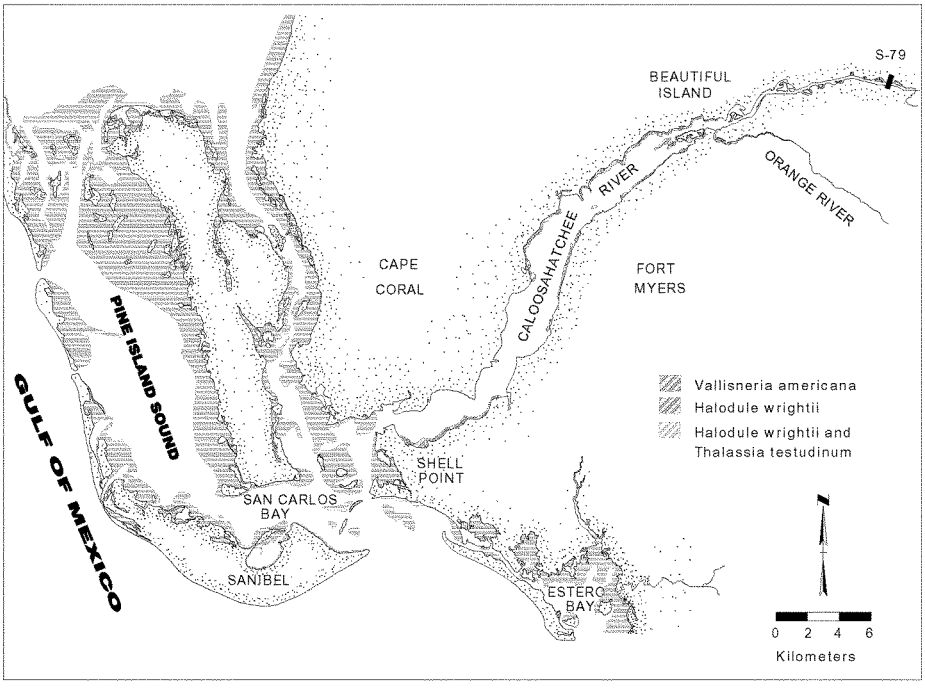


Figure 6. Current Distribution of Subermerged Aquatic Vegetation in the Caloosahatchee Estuary.

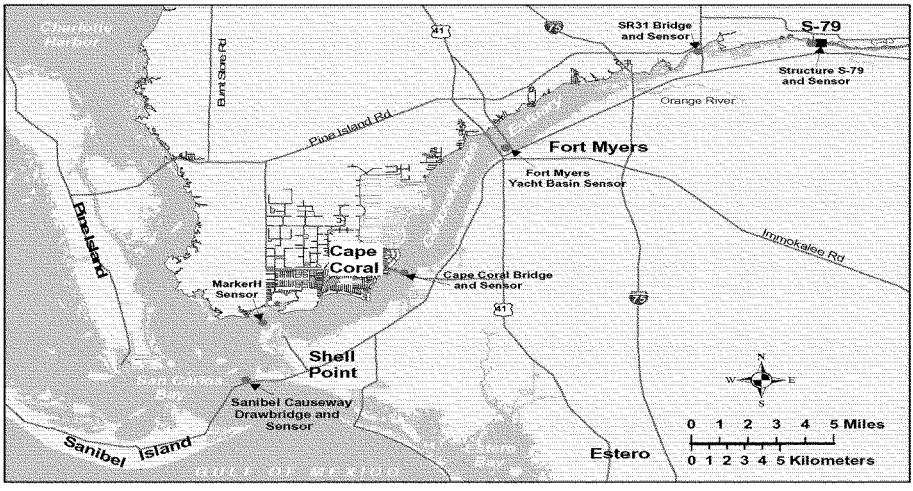
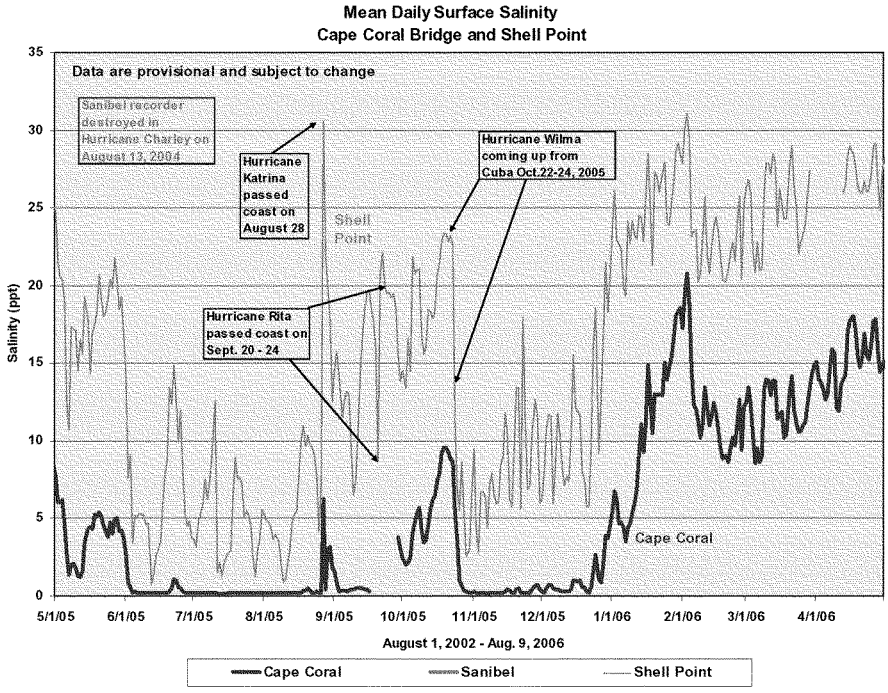
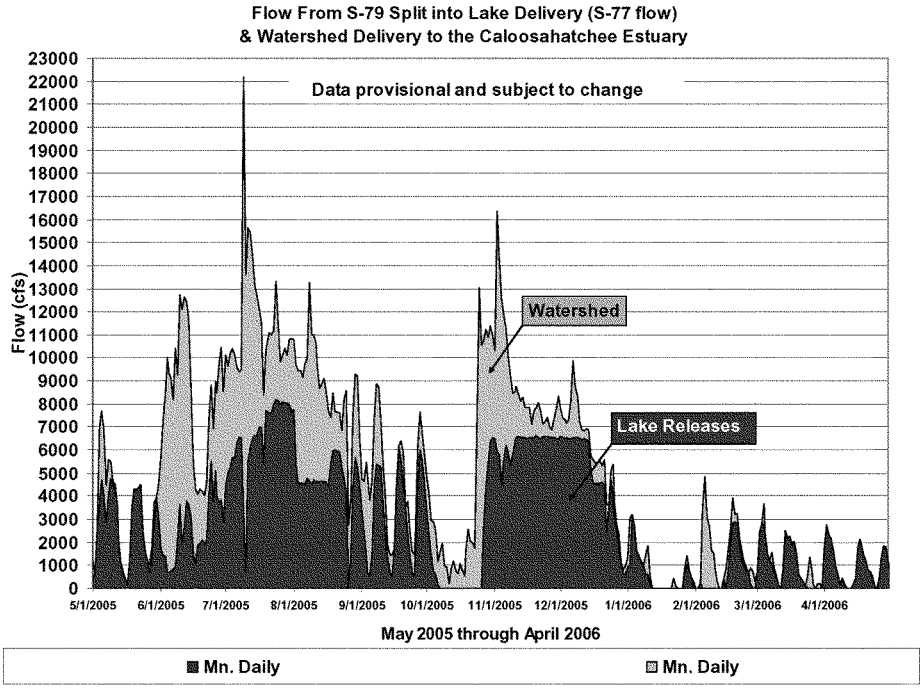


Figure 7. Caloosahatchee Estuary and Salinity Stations.



Note: The timing and influence of three hurricanes depicted.

Figure 8. Daily Average Salinity Collected by Continuous Sensors at Two Downstream Locations (Cape Coral Bridge and Shell Point at the river mouth) in the Caloosahatchee Estuary.



Note: The portion of the discharge accounted for by Lake Okeechobee releases is shown in blue.

Figure 9. Total discharge into the Caloosahatchee Estuary from Lake Okeechobee and the Caloosahatchee Watershed at S-79.

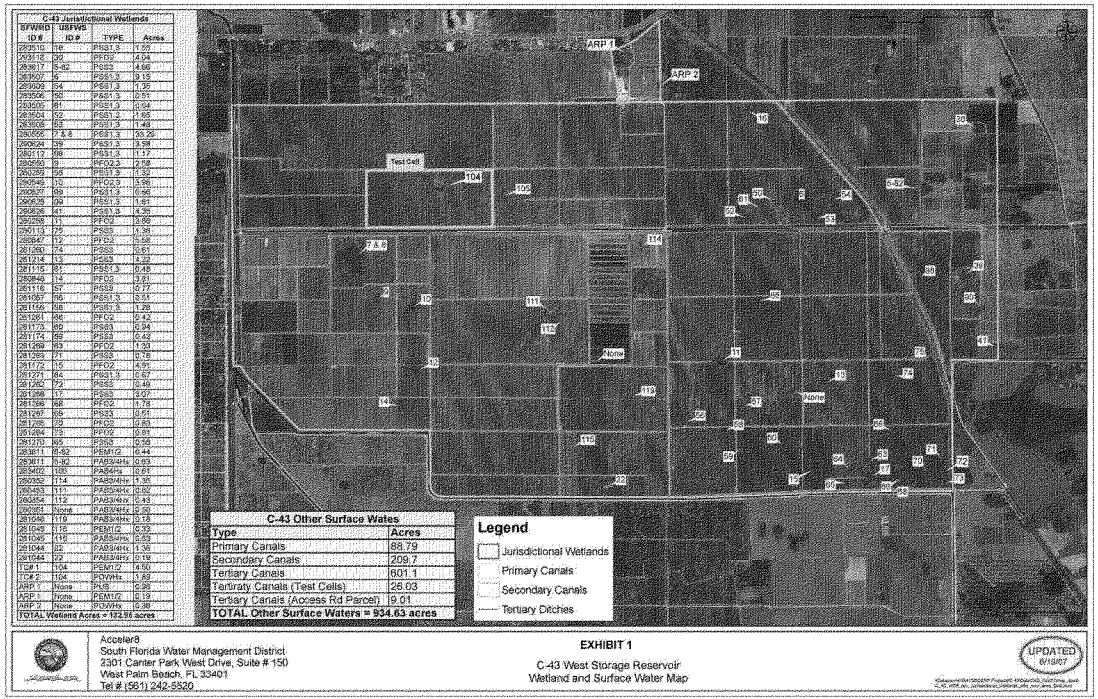


Figure 10. C-43 Basin Storage Reservoir: Jurisdictional Wetlands and Surface Waters of the United States.

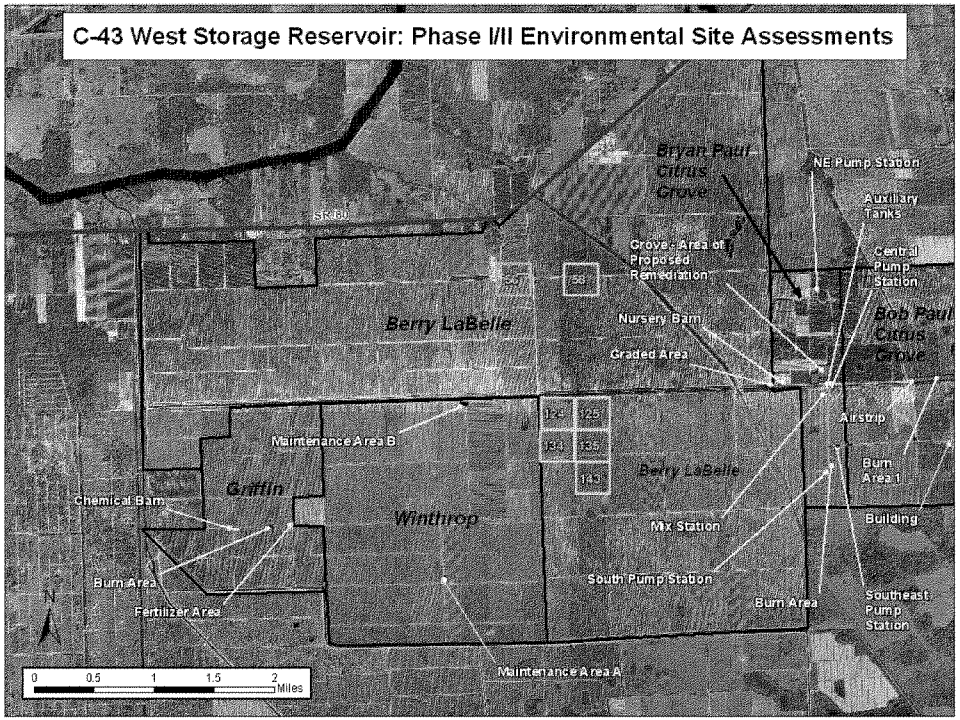
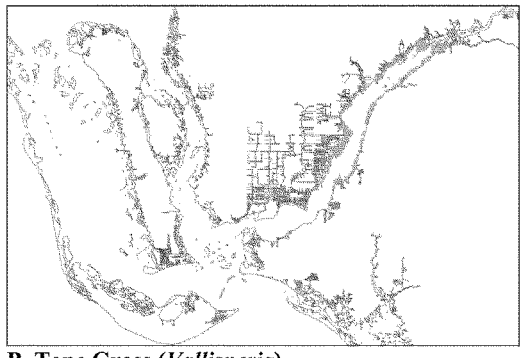


Figure 11. C-43 Basin Storage Reservoir: Phase I and II Environmental Assessments.

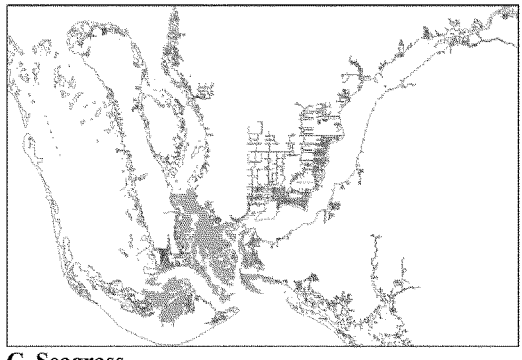
946



A. Oysters

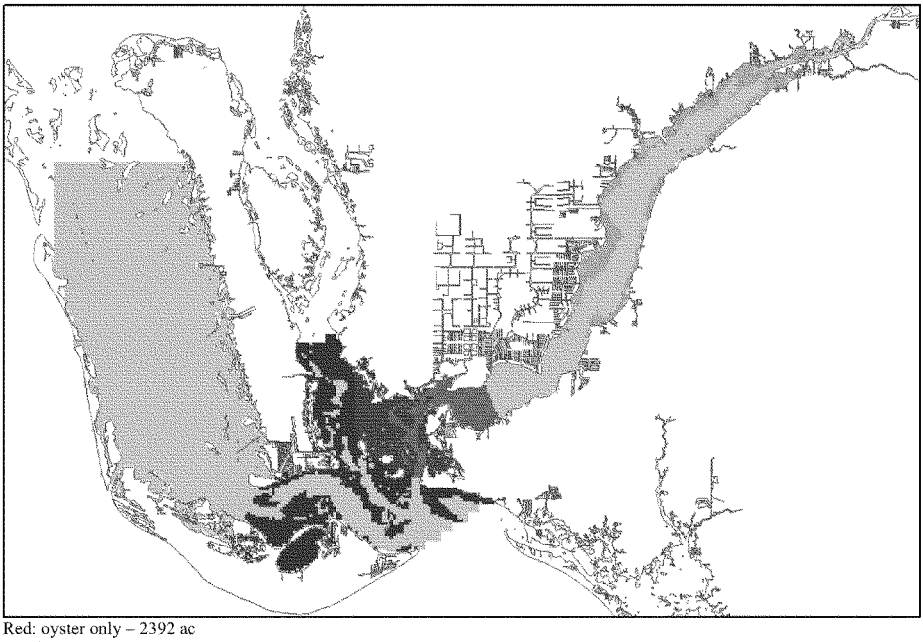


B. Tape Grass (*Vallisneria*)



C. Seagrass

Figure 12. Area of Caloosahatachee Modeled for Habitat Benefits Calculations by Species.



Red: oyster only – 2392 ac
Purple: oyster and seagrass – 3506 ac
Blue: Seagrass only – 9041 ac
Green: Vallisneria only – 4130 ac
Brown: None of these three species

Figure 13. Habitat Unit Combination Methodology.

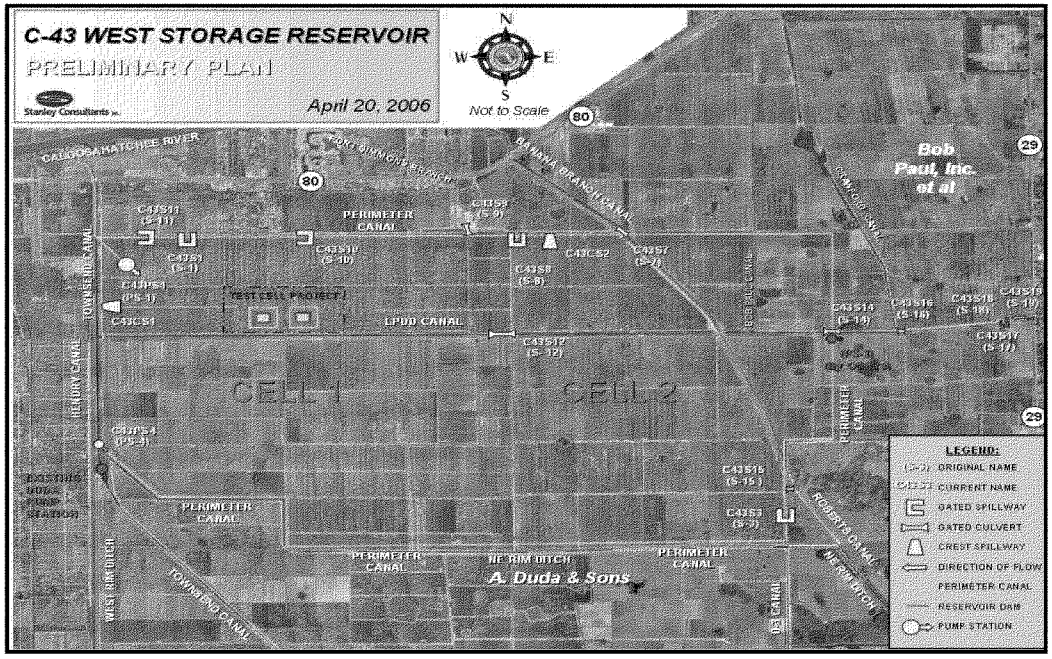


Figure 14. Typical Site Plan for Alternatives.

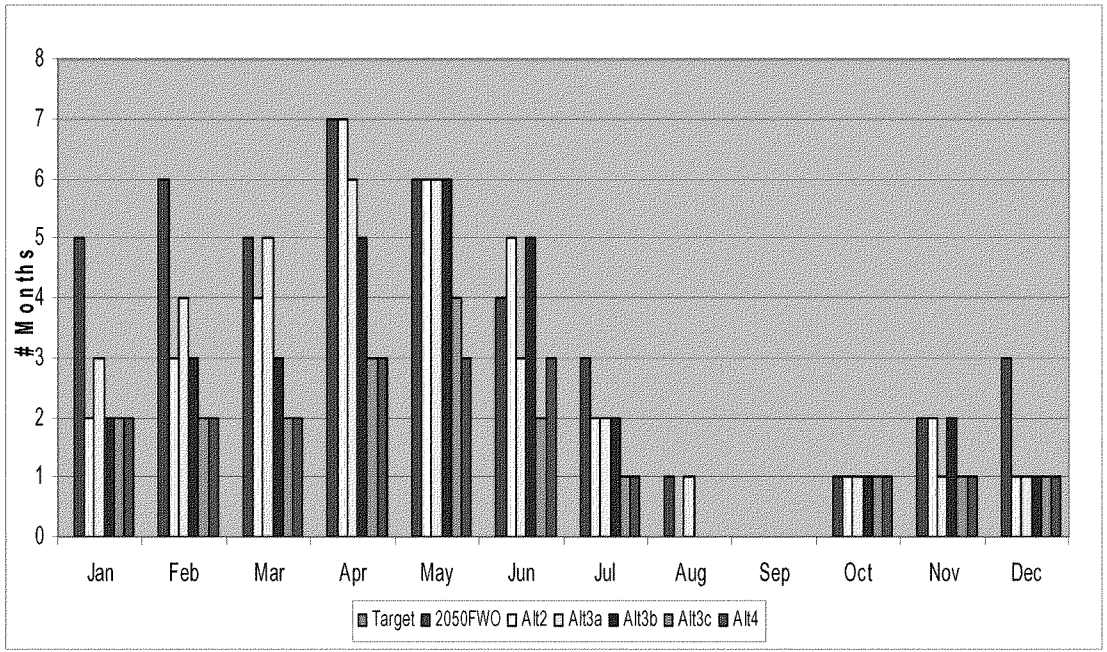


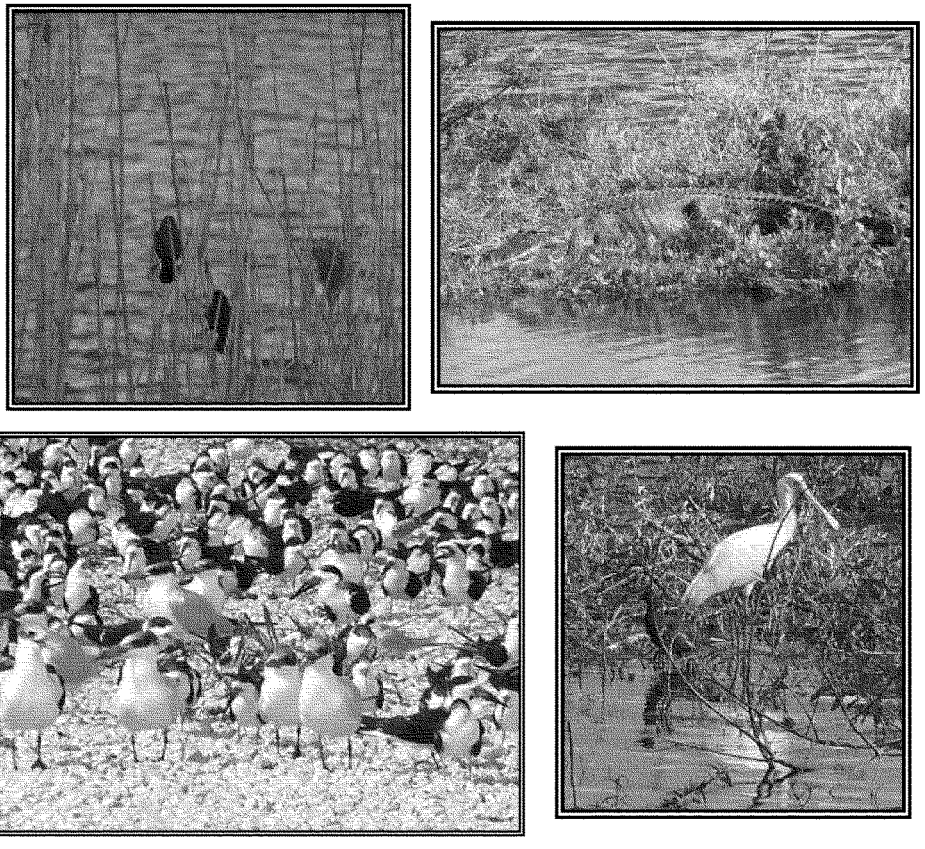
Figure 15. Distribution of Mean Monthly Flows Less than 450 cfs at S-79.

930

APPENDIX A

Fish and Wildlife Recommendations for Comprehensive Everglades Restoration Plan Stormwater Treatment Area and Reservoir Operation and Design

Fish and Wildlife Recommendations for Comprehensive Everglades Restoration Plan Stormwater Treatment Area and Reservoir Operation and Design



December 12, 2005

Prepared by
Comprehensive Everglades Restoration Project STA/R Team

Acknowledgements: We wish to thank the staff of the South Florida Water Management District (District) and St. Johns River Water Management Districts (SJRWMD) for sharing their time and expertise in contributions to this report. We also thank those who conducted field trips for the STAR Team in an effort to view existing facilities and learn from past experiences.

Site visits were conducted at:

- Deseret Ranch,
- Indian River County West Regional Wetland Treatment System,
- Orlando Easterly Wetlands,
- Blue Heron Wetland Treatment System,
- Blue Cypress and St. Johns Water Management Areas,
- St. Johns and Blue Cypress Marsh Conservation Areas,
- Blue Cypress Lake,
- Three Forks Marsh Conservation Area,
- Wakodahatchee Wetlands,
- Everglades Construction Project Stormwater Treatment Areas 1 through 6.

TABLE OF CONTENTS

Page

I. Introduction 1
II. Methods 2
III. Discussion 3
IV. Conclusions 21
V. Literature Cited 22

Appendices

Appendix A. Ecological Risk Assessment Guidance A-1
Appendix B. District Guidance in the Design of a Project-level Monitoring and Assessment Plan for Mercury, Pesticides, and Other Toxicants B-1

List of Figures

Figure 1. Location of CERP projects that include Reservoirs and STAs 5

List of Tables

Table 1. Estimated STA and reservoir acreage in CERP projects 6
Table 2. Fish and Wildlife Recommendations for Stormwater Treatment Areas and Reservoir Design and Operation 7

Executive Summary

In 1996, the Army Corps of Engineers (Corps) was directed to develop a comprehensive plan to restore, preserve and protect South Florida's natural ecosystem while providing for the water-related needs of the region, including flood control, water supply and the other objectives of the Central and Southern Florida Project. The resulting plan, authorized by Congress in 2000, is called the Comprehensive Everglades Restoration Plan (CERP), as stated in the Final Programmatic Regulations. CERP shall be implemented to ensure the protection of water quality, water supply, and environmental improvement of the South Florida ecosystem.

Because the CERP proposes the construction of more than 241 square miles of wetlands, the South Florida Federal and State fish and wildlife agencies collaborated to develop 24 recommendations consistent with Federal authorities including the Fish and Wildlife Coordination Act (FWCA), the Endangered Species Act (ESA), and the Migratory Bird Treaty Act and state authorities including the Everglades Forever Act. These recommendations are not intended to take priority over primary facility water storage and treatment functions. Many fish and wildlife recommendations compliment primary facility functions. If, however, existing contaminant levels at proposed project sites present a risk to fish and wildlife, these sites should not be considered. The South Florida Water Management District's (District) standard operation procedures (SOPs) and the U.S. Fish and Wildlife Service's (Service) protocols include environmental assessments completed during land acquisition that identify, evaluate, and recommend actions to correct existing or future contamination problems. These activities are followed by long-term monitoring to determine how facility operation and maintenance impacts fish and wildlife resources.

I. INTRODUCTION

The South Florida ecosystem is nationally and internationally unique and an important natural resource. It is also in peril, severely affected by human activities for over a hundred years. In 1948, Congress first authorized the Central and Southern Florida Project to serve the multiple objectives of flood control, prevention of salt water intrusion, water supply to Everglades National Park (ENP), preservation of fish and wildlife, recreation and navigation, and regional water supply for agriculture and urban areas. The project area extends from Orlando to the Florida Keys and is composed of a regional network of canals, levees, water storage areas and water control structures. While fulfilling these objectives, the project had unintended adverse effects on the unique natural environment that constitutes the Everglades and South Florida ecosystem.

Previous land use has severely reduced the natural water storage and cleansing capacity of South Florida wetlands through drainage, conversion, and loss of natural wetlands. Reduced natural flood storage and high nutrient levels, especially phosphorus, threaten the viability of the South Florida ecosystem. To lessen these impacts, the Central and Southern Florida Restudy (C&SF Restudy), precursor to the Central Everglades Restoration Project (CERP), incorporated stormwater treatment areas (STAs) and reservoirs to reduce pollutant levels, replace lost natural

water storage, and provide ecological benefits (Fig. 1). The large acreage involved in these constructed systems presents opportunities to include fish and wildlife features in project design, construction, operation, and maintenance after contaminant issues are addressed. The CERP includes approximately 118,000 acres of reservoirs and 36,000 acres of STAs (Table 1) for an estimated total of 154,000 acres (241 square miles, about one third the size of Lake Okeechobee). In addition, other local and system-wide non-CERP projects such as the Everglades Construction Project (58,000 acres at completion) are expected to increase the spatial extent of wetlands in South Florida.

Incorporating fish and wildlife features into CERP STAs and reservoirs is consistent with the requirements of several Federal authorities. The Fish and Wildlife Coordination Act (FWCA) establishes fish and wildlife conservation as a coequal purpose of federally-funded water resource projects such as the CERP. The Endangered Species Act (ESA) directs Federal agencies to develop proactive endangered species protection, conservation, and recovery programs. The Migratory Bird Treaty Act provides for the protection of migratory birds.

The U. S. Fish and Wildlife Service (Service) developed fish and wildlife recommendations for CERP STAs and reservoirs (Table 2) consistent with the Federal authorities cited above. Each recommendation presents expected fish and wildlife benefits and compatibility with the primary STA or reservoir functions. Due to site-specific variability and other factors, not all recommendations made in this report are practicable at all facilities. These recommendations are not constraints, but should be considered as opportunities to improve on-site fish and wildlife habitat, provided their implementation does not reduce project benefits to the South Florida ecosystem. The Service and the Florida Fish and Wildlife Conservation Commission (FWC) developed these recommendations through review of existing literature, field visits to STAs and reservoirs, as well as interviews and discussions with facility scientists, designers, and managers. An interagency meeting helped refine agency concerns and recommendations.

II. METHODS

A Service team of biologists and ecologists (STAR team) considered recommendations that support fish and wildlife resources and supports STA and reservoir functions. The FWC, U.S. Environmental Protection Agency (EPA), Arthur R. Marshall (A.R.M.) Loxahatchee National Wildlife Refuge (NWR), Dr. Robert Knight and the Department of the Interior's (DOI) consultant, Dr. Robert Kadlec, participated in STAR team deliberations. The STAR team conducted a literature search on STAs and reservoirs with emphasis on fish and wildlife features, phosphorus treatment, water quality, contaminants, design, and operation. Team members visited eight constructed wetlands in South Florida, and interviewed scientists, designers, and managers to draft a list of design and management recommendations.

The Service sent the draft recommendations to the South Florida Water Management District (District), U.S. Army Corps of Engineers (Corps), EPA, ENP, A.R.M. Loxahatchee NWR, DOI consultants, FWC, Florida Department of Environmental Protection (DEP), St. John's River Water Management District (SJRWMD), and other interested parties. In June 2004, a workshop

was conducted which included a presentation of draft recommendations to two working groups, (design and morphology, water quality and operations). Based on the input from these working groups, STA site visits, and additional interagency coordination, the Service further refined these recommendations.

III. DISCUSSION

It is essential that contaminant levels do not present a risk to fish and wildlife resources. Sites with contaminant levels that clearly present a risk in their current or future project condition are not suitable for CERP STAs and reservoirs or for incorporation of fish and wildlife features without effective remediation. If unexpected contaminant levels become a problem following project construction, the site should be remediated or abandoned.

There are a number of activities which respond to contamination issues prior to and during land acquisition, construction, and operations. For example, the District conducts pre-transactional environmental assessments as part of their routine real estate acquisition process. The Service and the District use these assessments to identify, evaluate, and correct environmental concerns or contaminant issues associated with the properties intended for STA or reservoir use. An example of the environmental assessment process was completed by the District for STA 3/4. This assessment identified concentrations of pesticides, petroleum, and metals ("compounds of concern") related to former agricultural application and operations (*e.g.*, pump stations, mix/load areas, storage facilities, and airstrips). Various contaminants were present at concentrations of potential ecological and/or human concern. Subsequently, corrective or remedial actions were taken, and additional monitoring was completed that addressed contamination conditions prior to land acquisition and construction. Environmental assessments such as these are standard operating procedures (SOPs) completed during all District land acquisitions.

After the initial environmental assessment process, the District routinely implements on-going monitoring and assessment programs to measure potential impacts from historical land use, and the effectiveness of their corrective actions. For example, after construction of STA 3/4 but prior to its operation, an intensive one-time surface water/sediment monitoring program was completed to insure the STA would not initially be a net exporter of contaminants. After STA 3/4 start-up, an additional long-term monitoring and assessment program was initiated to determine if operations cause the release of detrimental sediment compounds into the water column.

The Service and District also evaluate food chain models, bioassays, bioaccumulation studies, and soil desorption studies prior to construction to determine potential contaminant risk to fish and wildlife. At times, soil concentrations of contaminants can be orders of magnitude higher that those in the water column and can pose greater risk to fish and wildlife resources. In addition, there are concerns regarding the accumulation of contaminated sediment in any given reservoir or STA as the facility operates over time. The monitoring and assessment programs described above address these concerns. Presently, information on long-term effects is being collected (*e.g.*, the STA-3/4 monitoring program described above) that will determine if

accumulation of contaminant levels in reservoirs or STAs will pose an unacceptable risk to fish and wildlife resources. In some STAs, risk from contaminant accumulation within the entire facility is reduced by initial treatment cells designed for deposition of suspended particulate-bound contaminants; for example STA 1-East, eastern and western distribution cells. Experience obtained from the operation and monitoring of existing and future STAs will supply valuable information to address these concerns. A scientific advisory committee may be useful in providing guidance for developing research needs associated with STA and reservoir operation and maintenance.

Extensive wetland losses can degrade landscape-scale, natural systems. Such degraded systems can reflect decreases in: (1) genetically viable numbers, distribution, and reproduction of native fish and wildlife, particularly among habitat-specialist and wetland obligate or dependent species; (2) habitat diversity of native flora and fauna; and (3) the ability of species and ecosystems to recover from disturbances (Corps 1999). While STAs and reservoirs do not replace natural systems, they can be designed to supplement ecological systems and processes on local and landscape scales. Davis (*et al.* 1994) identified the loss of original wetland spatial extent, type, diversity, quality, distribution, and pattern in the south Florida ecosystem as key issues. In most cases, Project Delivery Teams discourage the location of STA and reservoir projects in natural areas. However, in some cases, the facility footprint may unavoidably fragment or otherwise impact rare or unique habitats (*e.g.*, wetlands, scrub habitats). Incidental take of federally listed species (as defined in the ESA) may occur if these species use habitats within the project footprint. In other cases, well-designed and operated facilities may provide features attractive to federally listed species, offsetting potential adverse effects. The Service continues to work with CERP partners to achieve system-wide CERP goals and to meet ESA obligations. The Service supported DOI funding to purchase lands because STAs and reservoirs will meet CERP system-wide restoration goals by benefiting downstream fish and wildlife resources and habitats.

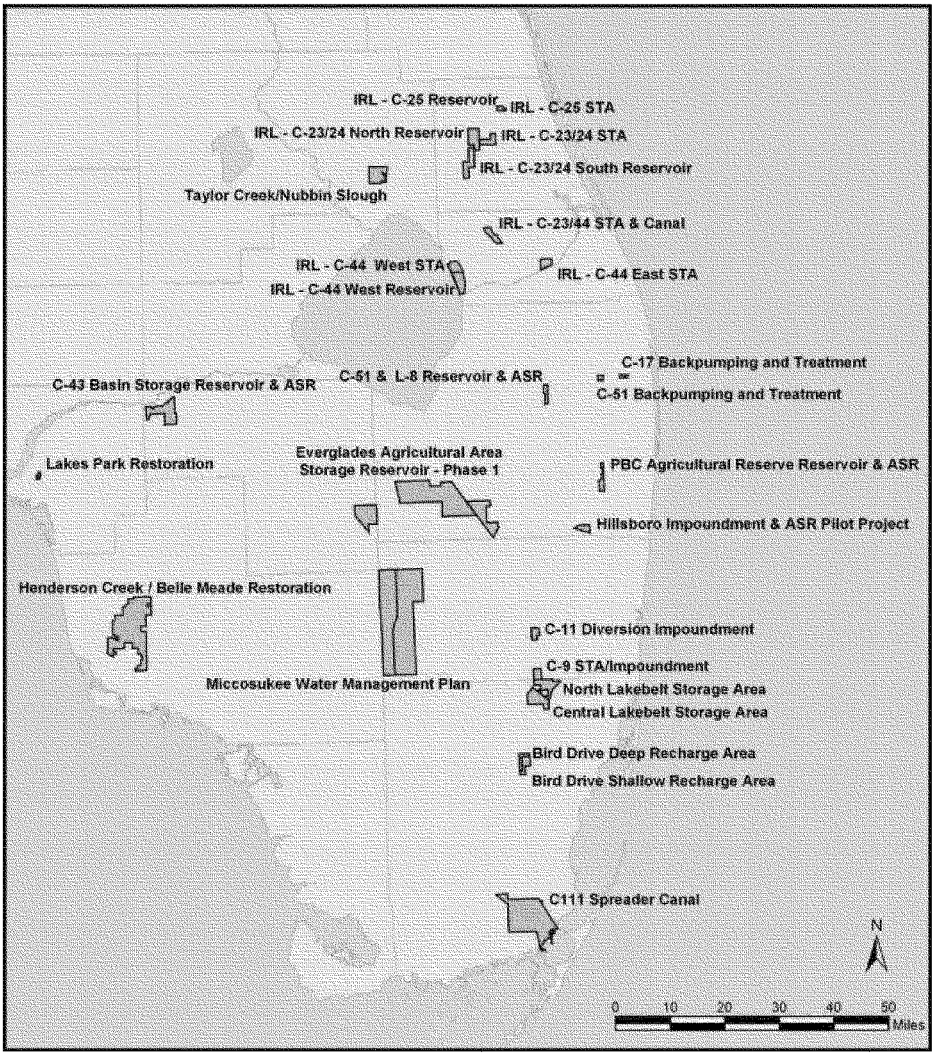


Figure 1. Location of several proposed CERP reservoirs and STAs (Corps 1999).

Table 1. Estimated STA and reservoir acreage in CERP projects.

Estimated STA and Reservoir Acreage in CERP Projects (12/2004)		
Project	**Reservoir**	**STA**
Lake Okeechobee Watershed:		
North of Lake Storage	20,000	
Taylor Creek/Nubbin Slough Storage and Treatment Area	5,000	5,000
Lake Okeechobee Water Quality Treatment Facility		4,375
Caloosahatchee (C-43) Basin:	25,000	5,000
Indian River Lagoon:		
C-44 West	3,315	3,000
C-44 East		3,000
C-23/24 North	4,398	2,568
C-23/24 South	4,155	
C-23/24 STA and diversion canal		2,300
C-25	741	163
Everglades Agricultural Area:	36,000	
Big Cypress/ L-28 Interceptor:		1,100
		800
North Palm Beach County:		
C-51 and L-8 Reservoir	1,250	
C-17 Backpumping and Treatment		550
C-51 Backpumping and Treatment		600
Palm Beach County Agricultural Reserve Reservoir	1,660	
North Lakebelt Storage Area	4,500	
Central Lakebelt Storage Area	5,200	640
Biscayne Bay Coastal Wetlands	TBD	TBD
C-111 Spreader Canal		3,200
Lakebelt Inground Reservoir Technology Pilot	102	
Site 1 Impoundment	1,660	
Bird Drive Recharge Area	1,493	2,243
Broward County Water Preserve Areas		
C-11	1,695	205
C-9	1,850	
Miccosukee Water Management Plan		900
Henderson Creek/ Belle Mead Restoration		4
Lakes Park Restoration		40
Total	**118,019**	**35,688**

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

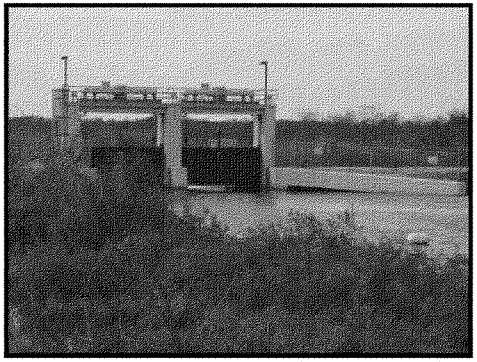
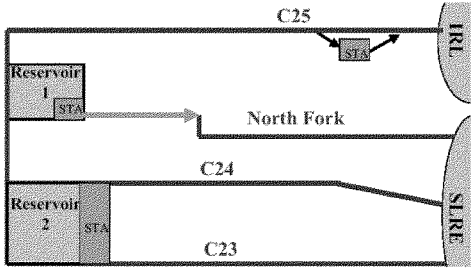
	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Contaminants			
1	Evaluate and Remediate Contaminants. Evaluate sites prior to acquisition in accordance with District SOPs and Service protocols (Appendices). Site remediation will occur prior to construction in areas where contaminant concentrations could compromise fish and wildlife health.	Evaluation and remediation of contaminants prior to acquisition and construction: • eliminates or reduces contaminant remobilization; • eliminates or reduces exposure risks to fish and wildlife.	Evaluating and remediating contaminants prior to acquisition and facility construction: • reduces long-term treatment and remediation cost; • optimizes STA and reservoir function by eliminating potential contaminant remobilization; • improves public health.	SJRWMD 1999. District 2005. Appendix B. Service 2001 Appendix A
2	Clean Construction Materials. Evaluate construction materials for contaminants prior to use for levees, berms, islands, etc. Do not use materials from contaminated areas.	Use of clean construction materials used for levees, berms, islands, etc.: • prevents mobilization of contaminants; • reduces exposure risk to fish and wildlife.	The District's SOP requires environmental assessment and remediation on all materials used for construction purposes.	District 2005. Appendix B
	 Evaluate and remediate contaminants.		 Clean construction materials.	

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
3	Contaminant Monitoring. Implement a post-construction monitoring and contingency plan for mercury, pesticides, and other toxicants as described in the draft Contaminants of Concern CERP Guidance Memorandum (Appendix B).	Contaminant monitoring and contingency plan implementation will: • alert mangers to potential exposure risks to fish and wildlife; • prevent contaminant remobilization.	Contamination monitoring is consistent with District remediation and monitoring programs at Everglades Construction Project STAs (Appendix B, *District Guidance in the Design of a Project-level Monitoring and Assessment Plan for Mercury, Pesticides and other Toxicants, DRAFT 2005*)	SJRWMD 1999. District and Corps 2003. District 2005. Appendix B
				

Monitor contaminants.

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Design and Location			
4	Facilities Location. Locate facilities in the watershed where water volumes will: • optimize water treatment (by placing them adjacent to reservoirs or canals) • minimize "dry-outs" (water below bed surface) • avoid ecologically sensitive area, which is a CERP goal.	Locate facilities to: • maximize water treatment and management to benefit fish and wildlife resources and habitats; • reduce direct (footprint) and indirect (*e.g.*, hydrological modifications, fragmentation) impacts to fish and wildlife resources and habitats.	When practicable, locate facilities to: • maximize water supply, treatment, and storage functions; • minimize potential remobilization of pollutants (*i.e.*, contaminants and nutrients).	Kadlec and Knight 1996.
	 G-302 delivers water to STA 1-W from the L-7 Canal.		 Proposed Indian River Lagoon-South reservoirs adjacent to canals and STAs.	

963

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

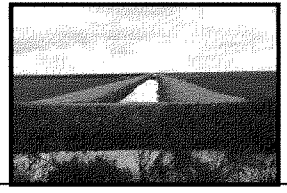
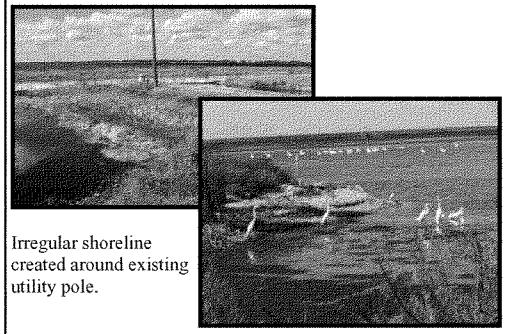
	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Design and Location			
5	Heterogeneous Topography. Preserve and maximize heterogeneous topography, such as berms, ditches, farms roads and emergent vegetated rows. Preserve or create features that reduce the potential for hydrologic short-circuiting.	Preserving heterogeneous topography: • supports habitat diversity; • enhances biochemical processes over a wide range of water elevations; • provides refugia for aquatic/forage species during critical periods (*e.g.*, winter or drawdown).	Heterogeneous topography has the potential to: • increase hydraulic residence time and treatment efficiency; • reduce design, construction, and maintenance costs; • reduce the potential for hydrologic short-circuiting when perpendicular to flow direction.	Mitch and Gosselink 2000.
6	Sloping Vegetated Zones. Include gradually sloping/stepped vegetated littoral zones in STAs, reservoirs, and seepage canals. Provide organic soil over hard substrates where soil is lacking, and manage for native vegetation.	• Sloping/stepped vegetated zones provide habitat for plant diversity, fish spawning, and wading bird foraging during water level manipulation. • Organic soil provides for aquatic vegetation which promotes viable aquatic ecosystems.	Sloping/stepped vegetated zones: • maintain bank stability; • resist erosion; • assist in turbidity reduction.	Honke 1993. Anderson and Brown 1991.
	Heterogeneous topography preserved in STA-5 Ditch prior to flooding  Ditch after flooding 		Sloping littoral zones included in STA 1W. 	

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Design and Location (continued)			
7	Shallow Pools/Interior Perimeter Canal. Preserve or create shallow pools (some at least 3 feet deep), such as distribution and collection canals, and/or an interior perimeter canal. Extent (acres) should be proportional to the facility size.	Shallow pools, such as distribution and collection canals, and interior perimeter canals provide aquatic plant, and fish habitat, and refugia for other aquatic resources during critical periods (*e.g.*, low water events.	Shallow pools: • improve hydrologic mixing; • increase hydraulic residence time; • reduce resuspension of sediment-bound pollutants.	Kobza, *et al. In review.* Kadlec and Knight 1996. Walker 1987.
8	Irregular Shorelines. Preserve irregular shoreline features such as peninsulas and submerged bars.	Irregular shorelines: • provide visual cover; • increase habitat edge; • support biologically rich and diverse zones.	Irregular shorelines may provide for design and construction cost savings (example: maintenance access for existing utilities, see photo below).	Kadlec and Knight 1996. Mitch and Gosselink 2000. USEPA 2000.
	 Shallow pool created from borrow canal.		 Irregular shoreline created around existing utility pole.	

965

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

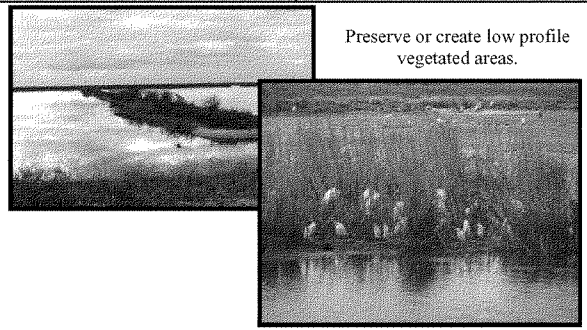
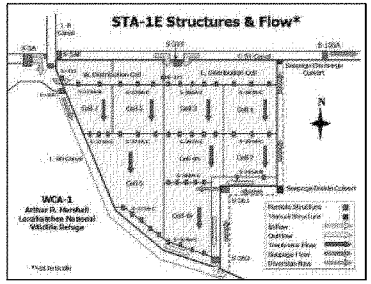
	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Design and Location (continued)			
9	Low-profile Vegetated Areas. Preserve low-profile vegetated areas in appropriate locations. Establish and maintain native plants.	Low-profile vegetated areas: • increase habitat diversity; • support fish and wildlife activities such as loafing, feeding, and sheltering.	Low-profile vegetated areas may: • prevent hydrologic short-circuiting; • enhance retention time; • improve hydrologic mixing.	White *et al.* 2002. Files 2003.
10	Multi-cell Flow ways. Design cell sequence to minimize wildlife use in downstream portions of polishing cells.	Multi-cell flow ways increase: • habitat diversity; • structure; • composition (*e.g.* , more edge, vertical structure).	Multi-cells: • increase operational flexibility; • increase treatment efficiency; • reduce short-circuiting.	Kadlec and Knight 1996. Swindell 2002.
		Preserve or create low profile vegetated areas.	Create multi-celled facilities. 	

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
Design and Location (continued)				
11	Vegetated Buffers. Create or maintain vegetated buffers (*e.g.*, 100 to 500 meters wide) adjacent to STA and reservoir levees, and seepage collection canals. Manage buffers to control invasive exotic vegetation.	Vegetated buffers adjacent to STA/reservoir levees and seepage collection canals provide habitat for amphibians, reptiles, neotropical migrant birds, and other wildlife.	Vegetated buffers: • create natural aesthetic and safety barriers between constructed facilities and developed areas; • provide wildlife travel corridors; • reduce seepage impacts to neighboring property.	USEPA 2000. Sees 2002. Tiner 2002.

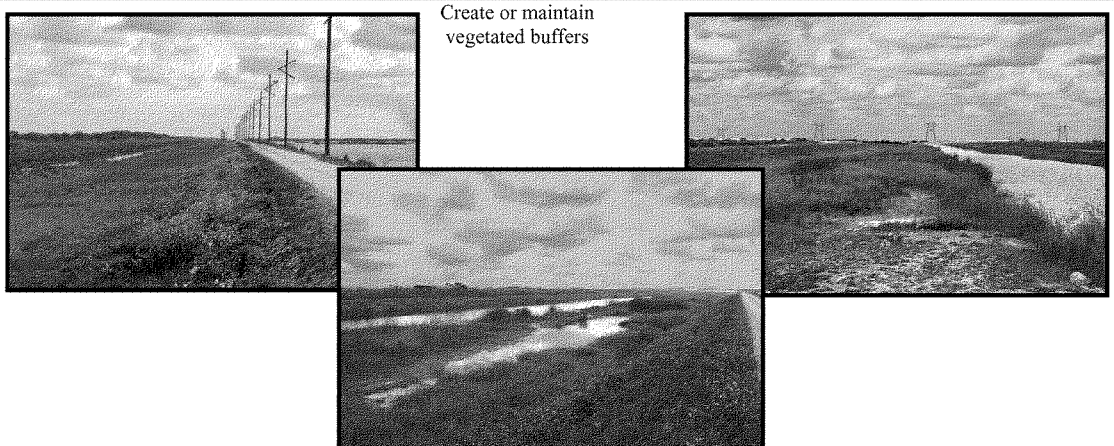


Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Design and Location (continued)			
12	Wading Bird Foraging Conditions. When flood control and water supply requirements are met, maintain water depths in STAs/reservoir between 6 and 14 inches (15 to 35 cm) for a minimum 90-day period from January through May. This may be achieved by heterogeneous topography and/or water management.	The maintenance of shallow water conditions would maximize wading bird foraging opportunities during the nesting season (January through May).	Maintaining wetted cells (within the constraints of weather conditions and competing water demands: • enhances phosphate removal; • reduces pollutant remobilization; • reduces mercury methylation.	Service 1999. ATLSS 2003.
	Biological Diversity			
13	Long-hydroperiod Marsh. When water supply needs are met, maintain long-hydroperiod marsh cells that are inundated 3- 5 years between dry-outs, to the maximum extent practicable.	Long-hydroperiod marsh ecosystems support natural communities, resulting in a stable food web.	Long-hydroperiod marsh ecosystems: • improve water treatment; • minimize maintenance, such as rehydration. (However, this is subject to water availability and competing water demands.)	Service 1999.
		Maintain wading bird foraging conditions.	 Maintain long hydroperiod marsh cell.	

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Biological Diversity (continued)			
14	Delayed Cell dry-outs. In reservoir-assisted STAs, delay scheduled dry-outs until after May 15, or as late as possible, by holding water in reservoirs.	Delayed dry-outs in cells containing water during late dry season (Jan thru May) increases survival of offspring (*e.g.* apple snails and other aquatic organisms) to the following wet season.	Delayed dry-outs reduce maintenance costs associated with rehydration. (However, this is subject to water availability and competing water demands.)	R. Bennetts, USGS, personal communication, July 23, 2003.
15	Recession Rates and Reversals. Manage reservoir/STA water levels to gradually recede, and minimize rapid reversals during the dry season (Oct through Apr), when possible.	Slowing recession rates and reversals will: • concentrate wading bird prey in a manner similar to natural water recessions; • protect low-lying nests from flooding.	Slowing recession rates and reversals can: • increase retention time; • increase water treatment efficiency. (However, managing recession rates is subject to weather and competing water demands.)	Lorenz *et al.* 2001. Ogden 1994. Bancroft *et al.* 1994. Bjork and Powell 1994, 1996.

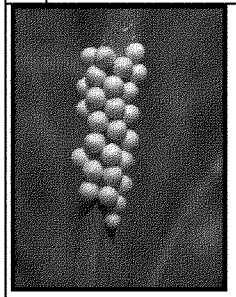
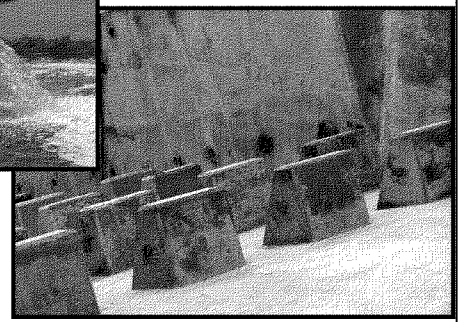






Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Water Quality			
16	Passive Flow Technology. Use best available, passive flow technology (baffles, distribution and collection canals, etc.), to evenly distribute inflows and aerate water at inflow and outflow points.	Passive flow technologies that distribute and aerate inflows/outflows can; • increase DO concentrations • reduce pockets of stagnation.	Passive flow technologies that distribute and aerate inflows/outflows increase water treatment efficacy by: • reducing short-circuiting; • distributing water evenly; • improving hydrologic mixing; • increasing DO levels.	Examples - City of Titusville, Blue Heron Wetland Treatment System, December 16, 2002. - Distribution and collection canals at ECP STAs
	  			

16

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

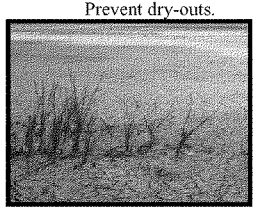
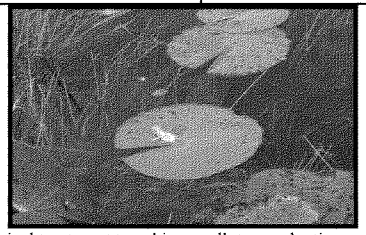
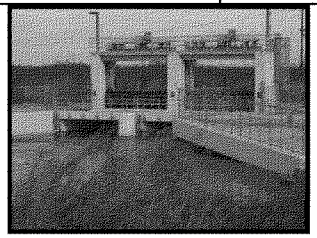
	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Water Quality (continued)			
17	Prevent Reservoir/STA Dry-outs. Maintain a 6-inch water depth to reduce mercury methylation and pollutant release.	Preventing dry-outs: • sustains aquatic communities in STAs and reservoirs; • protects aquatic resources from contaminant exposure; • protects and enhance downstream ecosystems.	Preventing dry-outs: • increases treatment efficiency; • impedes mercury methylation; • prevents release of sequestered nutrients.	Walker 1995. District 2005. Appendix B
18	Water Retention after Dry-outs. At facility start-up and after dry-outs, raise water levels in reservoir and/or STA quickly to a depth greater than 35 cm. Retain water levels until water quality is acceptable for discharge to the receiving water body pursuant to applicable federal and state regulations and legally binding documents.	Water retention after dry-outs will reduce the release of methylmercury and high nutrient pulses. Methylmercury is toxic to wildlife. High nutrient pulses can negatively impact downstream plant and animal communities.	Water retention after dry-outs improves water quality treatment efficiency.	District and Corps 2003.
	Prevent dry-outs. 			

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Water Quality (continued)			
19	Chemical Treatment. Avoid applying chemical treatments in STAs and reservoirs to achieve phosphorus reduction targets.	Chemical treatments for pollutant reduction expose wildlife and their habitat to unknown risks.	Chemical treatments for pollutants incur continuous operation costs which are avoided with natural treatment methods.	Everglades Program Team 2001. Chimney *et al.* 2004.
	Iterative Process			
20	Hydrologic Operating Plans. Develop and implement hydrologic operating plans to maintain water levels for desired plant communities. These plans should include iterative monitoring and adaptive assessment. Coordinate STA operating issues with the District's STA Communication Team.	Hydrologic operating plans sustain vegetation for fish and wildlife survival and reproduction by planning for beneficial water management. Coordinated monitoring and communication between state/federal agencies can improve management for fish and wildlife benefits.	Hydrologic operating plans enhance; • water treatment; • storage functions. Coordinated monitoring and communication between state/federal agencies can: • improve system management; • decrease time between operational adjustments.	Miller et al. 1998. District 2005. Appendix B.
	 Avoid chemical treatment to achieve pollutant reduction targets.		 Develop and implement hydrologic operating plans.	

975

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

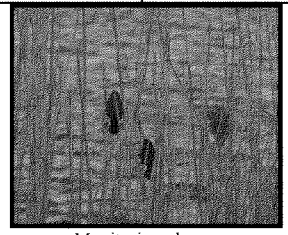
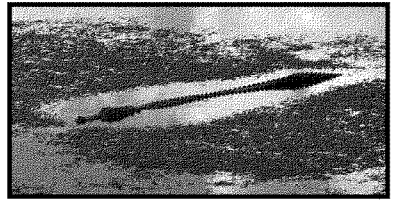
	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Iterative Process			
21	Monitoring Plan. Design and implement a monitoring plan for water and sediment quality to trigger the adaptive management process. Include standards for operation contained in the Hydrologic Operating Plan (See #20).	Monitoring provides knowledge of: • fish and wildlife habitat; • water and sediment quality; • response to STA and reservoir operations. • early detection and resolution of potential problematic wildlife issues.	Monitoring assesses water treatment and storage efficiency. (Environmental permits issued to the District include compliance criteria which necessitate routine monitoring, reporting, and adaptive management responses.)	
22	Adaptive Assessment and Management. Develop and implement a facility monitoring plan with adaptive management. Include annual evaluation of compliance with targets for adaptive assessment.	Adaptive assessment and management improves facility operations that benefit fish and wildlife.	Adaptive assessment and management improves facility operation for water treatment and storage functions. (Environmental permits issued to the District include compliance criteria which necessitate routine monitoring, reporting, and adaptive management responses.)	
	 Monitoring plans.		 Implement adaptive assessment and management.	

Table 2. Fish and wildlife recommendations for CERP stormwater treatment areas and reservoirs.

	Wildlife Recommendations	Fish And Wildlife Benefit	Compatibility/Benefit To Primary Function	Reference
	Iterative Process - continued			
23	Avian Protection Plan . Develop and implement an avian protection plan based, in part, on lessons learned from the management of existing projects.	An avian protection plan: • supports avian diversity and listed species recovery; • maintains/enhances avian populations.	An avian protection plan improves operational flexibility by defining operation and management options concerning wildlife issues.	
	Public Use			
24	Recreational Use. Provide compatible public recreational opportunities as identified in the CERP Master Recreation Plan.	Compatible recreational use: • promotes public awareness of fish and wildlife conservation; • provides multi-purpose facilities for public benefit.	Recreational uses generate public support for STA and reservoir projects. Recreational uses must be compatible and not conflict with the primary function of the STA or reservoir.	Corps *In progress.*
		Develop and implement avian protection plans.		Provide compatible recreational uses such as bird watching.

IV. CONCLUSIONS

There is an opportunity to include a number of fish and wildlife enhancement features in the design and operation of STAs and reservoirs. Features that mimic natural ecological processes, functions, and habitat diversity would promote stable wetland communities, and may be compatible with primary design functions. The Service does not suggest all recommendations presented in Table 2 are applicable or practicable for all project sites. However, these recommendations should be considered in STA and reservoir design and operation when and if they are compatible with the primary design functions of a project. It is important that all operational plans be developed with the participation and review of all appropriate state/federal agencies and disciplines, including biologists.

V. LITERATURE CITED

Anderson, R.C. and L.E. Brown. 1991. Establishment of a wetland plant community in a limestone quarry. Castanea, 56(3):168-175.

ATLSS, 2003. http://www.atlss.org.

Bancroft, G.T., A.M. Strong, R.J. Sawicki, W. Hoffman, and S.D. Jewell. 1994. Relationships among wading bird foraging patterns, colony locations, and hydrology in the Everglades. Ogden (Eds.) 1994. St. Lucie Press, Delray Beach, Florida.

Bjork, R.D. and G.V.N. Powell. 1994. Relationships between hydrologic conditions and quality and quantity of foraging habitat for roseate spoonbills and other wading birds in the C-111 Basin, final report to the South /Florida Research Center, Everglades National Park, Homestead, Florida.

Bjork, R.D. and G.V.N. Powell. 1996. Roseate spoonbill, pp. 295-308, In: Rare and Endangered Biota of Florida. Vol 5: Birds. Rodgers, J.A

Chimney, M.J., M.K. Nungesser, C. Combs, B. Gu, E. Fogarty-Kellis, J.M. Newman, W. Wagner and L. Wenkert. 2004. STA Optimization and Advanced Treatment Technologies. Chapter 4B in: 2004 Everglades Consolidated Report, South Florida Water Management District, January 1, 2004. West Palm Beach, Florida.

City of Titusville. 2002. Blue Heron Wetland Treatment System site visit, December 16, 2002.

Davis, S.M., L.H. Gunderson, J.R. Richardson, J.E. Mattson. 1994. Landscape dimension, composition, and function in a changing Everglades ecosystem. Chapter 17 in: Everglades: The Ecosystem and It's Restoration, S.M. Davis and J.C. Ogden (Eds.) 1994. St. Lucie Press, Delray Beach, Florida.

Everglades Program Team. 2001. Marsh readiness concept paper. U.S. Department of the Interior, Loxahatchee, Florida.

Files, Brian. 2003. U.S. Army Corps of Engineers, personal communication, PowerPoint presentation, April 1, 2003.

Honke, J.S. 1993. Water quality of abandoned limestone quarry pits in the east central Nebraska region, a survey. Geological Society of America. Abstracts with Programs, 25(3):26.

Kadlec, R.H. and R.L. Knight. 1996. Treatment Wetlands. CRC Press, Boca Raton, FL.

Kobza, R.M., J.C. Trexler, W.F. Loftus, and S.A. Perry. In review. Community structure of fishes inhabiting aquatic refuges in a threatened karst wetland and implications for ecosystem management.

Lorenz, J.J., J.C. Ogden, R.D. Bjork and B.V.N. Powell. 2001. Nesting patterns of roseate spoonbills in Florida Bay 1935-1999: implications of landscape scale anthropogenic impacts. In: J.W. Porter and D.G. Porter, eds. The Everglades, Florida Bay and Coral Reefs of the Florida Keys, an Ecosystem Sourcebook. CRC Press, Boca Raton. FL: 555-598.

Miller, S.J., M.A. Lee and E.F. Lowe. 1998. The Upper St. Johns River Basin Project: Merging flood control with aquatic ecosystem restoration and preservation. Trans.63rd No. Am Wldl. and Natur. Resour. Conf.

Mitch, W.J. and J.G. Gosselink. 2000. Wetlands, 3rd ed. John Wiley and Sons, Inc. New York, New York.

Ogden, J.C. 1990. Habitat management guidelines for the wood stork in the Southeast Region. U.S. Fish & Wildlife Service. 9pp.

Ogden, J.C. 1994. A comparison of wading bird nesting colony dynamics (1931-1946 and 1974-1989) as an indication of ecosystem conditions in the Southern Everglades. Chapter 22 in: Everglades: The Ecosystem and It's Restoration, S.M. Davis and J.C. Ogden (Eds.) 1994. St. Lucie Press, Delray Beach, Florida.

Sees, Mark. 2002. City of Orlando, Public Works Dept, personal communication, Orlando Easterly Wetlands STA field visit, December 16, 2002.

St. Johns River Water Management District (SJRWMD). 1999. Lake Apopka Restoration Project: Wildlife Impacts and Progress Toward Remediation. 11pp.

South Florida Water Management District (District). 2004. Operational Plan, Stormwater Treatment Area 1 West. West Palm Beach, Florida.

South Florida Water Management District (District) and U.S. Army Corps of Engineers (Corps). 2003. Draft CERP Guidance Memorandum. Toxic substances Screening Process - Mercury and Pesticides.

Swindell, Jr., C.E. 2002. Ecotech Consultants, Mgr - Vero Beach treatment plant, personal communication, site visit, November 12, 2002.

Tiner, Ralph, W. 2002. Remotely-sensed Natural Habitat Integrity Indices for Assessing the General Ecological Condition of Watersheds. In: R.W. Tiner (compiler) Watershed-based Wetland Planning and Evaluation. A Collection of Papers from the Wetland Millennium Event (August 6 to 12, 2000; Quebec City, Quebec, Canada). Distributed by the Association of State Wetland Managers, Inc., Berne, New York. pp.125-141.

U.S. Army Corps of Engineers (Corps). In progress. Draft Master Recreation Plan.

U.S. Army Corps of Engineers (Corps). 1999. Central and south Florida project comprehensive review study. Final integrated feasibility report and programmatic Environmental Impact Statement. Jacksonville District Office, Jacksonville, Florida.

U.S. Environmental Protection Agency (USEPA). 2000. Guiding principles for constructed treatment wetlands: providing for water quality and wildlife habitat. EPA 843-00-003. 41pp.

U.S. Fish and Wildlife Service (Service). 1999. South Florida multi-species recovery plan. Atlanta, Georgia. 2,172 pp.

U.S. Fish and Wildlife Service (Service). 2001 Ecological Risk Assessment Guidance for Wetland Restoration on Agricultural Lands in South Florida. 13 pp.

Walker, W.W. 1995. Design basis for Everglades Stormwater Treatment Areas. Water Resources Bull. 31(4):671-685.

Walker, W.W. 1987. Phosphorus removal by urban runoff detention basins. Lake & Reservoir Management III:314-326.

White, J.R., K.R. Reddy, W.F. Debusk, W.R. Wise and T. Crisman. 2002. Phosphorus removal capacity of the Orlando Easterly Wetland Treatment System, Final Report Wetland Biogeochemistry Laboratory, Soil and Water Science Department, UF-IFAS and Environmental Engineering Sciences Department, UF, Center for Wetlands, University of Florida.

DRAFT

Appendix A

Ecological Risk Assessment Guidance

DRAFT

Draft

Ecological Risk Assessment Guidance for Wetland Restoration on Agricultural Lands in South Florida

U.S. Fish and Wildlife Service
South Florida Ecological Services Office
Vero Beach, Florida

November 2001
(Revised 8/30/04)

I. Contaminant Issues

Construction and implementation of the Comprehensive Everglades Restoration Plan (CERP) will require thousands of acres of publicly owned land (State and Federal) for the purpose of maintaining hydrologic buffer areas and the operation of regional water storage and conveyance systems. Lands determined to be feasible for incorporation into CERP projects in south Florida are limited and expensive, as increasing demands for commercial and residential development compete with the need for viable and functioning Everglades wetlands and adjacent scrub and forested uplands. A large portion of these lands are presently, or were at some time, in active agricultural production. Historical management practices, especially those associated with row crop farming, typically involved the frequent application of organochlorine (OC) pesticides for insect control. Most of these pesticides are no longer registered for use in the U.S. due to environmental concerns. However, from the 1940s to the mid 1980s, frequent applications of DDT, chlordane, toxaphene, and other OCs were common in agricultural areas of south Florida, leaving significant residual concentrations of these toxic substances and their degradation by-products bound to and sequestered in the top soil. Conversion of these soils from a dry and frequently disturbed aerobic environment to inundated (perennially or intermittent) relatively undisturbed anaerobic sediments, supporting native submergent and emergent vegetation and periphyton, will likely promote the release of these residual pesticides (along with other common contaminants such as mercury, selenium, and copper) into surface waters. More recent agricultural practices employ a different suite of pesticides, including organophosphates, carbamates, and a variety of herbicides and fungicides. Although generally not as persistent as OCs, many of these modern pesticides are highly toxic to wildlife.

Many of these lands proposed for acquisition will support functioning water reservoirs (storm water treatment areas, Aquifer Storage and Recovery detention reservoirs, and storage reservoirs) designed to impound a wide range of water capacities and depths over long periods of time. Additionally, many of these reservoirs will cover large expanses of several thousand acres, establishing local and regional aquatic ecosystems as well as providing foraging habitat for waterfowl and other aquatic wildlife. Without appropriate risk management and attention to design alternatives, the subsequent release of these pesticides and trace metals into CERP wetlands, reservoirs, and conveyances will provide exposure pathways to the regional fish and wildlife communities in south Florida.

Although the need for this guidance was prompted by the CERP land acquisition program, its use is encouraged for wetland restoration projects under other programs such as the Service's Partners for Fish and Wildlife Program, the Natural Resources Conservation Service's Wetland Reserve Program, or other water management districts in Florida.

II. Phase I Environmental Site Assessment

The Phase I Environmental Site Assessment (Phase I) is performed in accordance with the American Society of Testing and Materials (ASTM) Standard Practice E1527-00, "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process."

DRAFT

The purpose of the Phase I is to identify the presence or likely presence of any hazardous substance or petroleum product on the property. This includes conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substance or petroleum product into structures on the property or into the ground, groundwater, or surface water of the property. The Phase I should provide all available information on current and past land use, and consists of the following elements:

A. Site inspection

The site inspection usually consists of walking, driving and/or flying over the property to visually ascertain the presence of features or indicators of past land uses and possible environmental contaminants. A checklist of such indicators includes, but is not limited to, dumps, drums, construction debris, fills, unusual chemical odors, above ground and underground storage tanks, chemical storage buildings, asbestos evidence, "stressed" vegetation or bare ground, "sterile" water bodies, oiled roads, stained or discolored ground or stream banks, oil slicks, air strips, maintenance areas, pipelines, transformers or other electrical equipment, oil and gas drilling, and mining activities.

B. Historical considerations

The historical review should include interviews with owners, previous owners, and neighbors to obtain an accurate picture of past land uses, farming practices, pesticide usage, etc. Aerial photographs should be reviewed for evidence of row crops and other agricultural, commercial or industrial activities. At a minimum, the historical review should include reliable information on (1) farming practices (e.g., row crops, sugarcane, citrus, sod farm, ornamentals, grazing), (2) exact location of these practices on the property, and (3) farming chronology. For example, row cropping on a portion of the property during the period from the 1940s to the mid-1980s is strong suggestive evidence for the presence of OC pesticides at that location.

C. Review of environmental databases

An extensive review of environmental databases (Comprehensive Environmental Response, Compensation, and Liability Information System; Resource Conservation and Recovery Information System; National Priorities List; Emergency Response Notification System; state Above Ground and Underground Storage Tank records; Solid Waste Facility and Landfill Report; Florida State Hazardous Waste Site list; Facility Index System/Identification Initiative Program Summary Report; Formerly Used Defense Sites; and local mosquito control districts) should be conducted.

Information gleaned from the Phase I assessment is used to determine the necessity of a Phase II assessment.

III. Phase II Environmental Site Assessment

DRAFT

Should information gleaned from the Phase I or other credible sources (i.e., previous investigations) indicate the presence of contamination or that the potential for contamination exists, a Phase II Environmental Site Assessment (Phase II) should be initiated. Coordination between the Service and the agency performing the assessment is important starting at this point and throughout the rest of the process. Coordination will be facilitated by providing the Service with a Phase II Scope of Work (SOW) or proposal for review. The proposal should describe in detail the sampling plan (number, media, and location of samples), sample collection methods, analytical parameters, quality control/quality assurance (QA/QC) plan, standards and/or ecological screening criteria to be used for comparison, contingency for expanded sampling, and screening level risk assessment procedures, if applicable. The environmental laboratory to perform chemical analyses should be EPA certified, maintain a rigorous QA/QC program, and achieve laboratory detection limits consistent with state and federally approved ecological screening values and water/soil quality standards. More detail on sampling procedures and analytical requirements is provided in the following section. The selection of a credible laboratory is one of the highest priorities in the site assessment process.

The purpose of the Phase II is to identify sources and locations of contamination, specify contaminants of potential concern (both human health and ecological), and provide recommendations for additional sampling, testing, or risk assessment; and corresponding corrective actions. The focus of the Phase II is generally on facilities and potential point sources on the property, which includes:

1. Mixing/loading areas
2. Storage sheds
3. Vehicle turn-arounds
4. Airstrips
5. Cattle dip tanks
6. Pumping stations
7. Burn areas

In addition, limited sampling may be conducted in other areas, such as canals and agricultural fields, in order to identify contaminants that have a more widespread distribution or to establish background levels of contaminants. Media sampled may include soils, sediments, groundwater and occasionally surface water. The most commonly encountered types of contaminants at agricultural sites include pesticides, petroleum hydrocarbons, and various metals.

Chemical concentrations in the various sampled media should be compared with the appropriate ecological screening values to determine if remediation and/or additional sampling is required. Ecological screening values to be used include the following:

1. Soils and sediments: Florida Department of Environmental Protection (FDEP) Sediment Quality Assessment Guidelines (SQAGs)

2. Surface water: Florida Surface Water Quality Standards, or USEPA Ambient Water Quality Criteria for protection of aquatic life

Ecological screening values are discussed in more detail in the next section.

Generally, any point sources identified can be remediated based on the results of the Phase II, with some additional delineation work. If remediation of the point source(s) removes all ecological concerns (i.e., all contaminant concentrations are reduced below screening values), no further assessment work is required on the site. However, if the results of the Phase I and/or Phase II indicate that widespread contamination at levels of ecological concern may be present, then more extensive sampling in the agricultural fields may be required (see next section).

IV. Agricultural Field Sampling and Screening

Generally, contaminant information obtained during a standard Phase I/Phase II Environmental Site Assessment (Phase I/II) is not detailed or comprehensive enough to be suitable for use in an ecological risk assessment (ERA). The methods described in this section are designed to provide detailed information on the distribution and concentrations of contaminants of concern (COCs) identified in the Phase I/II, for use in the food chain model to predict risks to Fish and Wildlife Service trust resources. A major purpose of this section is to determine whether concentrations of contaminants in the farmed areas are uniformly distributed in the fields, or are present as "hotspots" that can be remediated. The method allows for sampling coverage of a large area while attempting to hold down analytical costs. If there is sufficient evidence to expect that pesticide contamination is likely at a site, it may be advantageous to conduct this sampling protocol concurrently with the Phase II assessment.

Sample site selection should be biased in order to maximize detection of agrochemicals in cultivated soils by sampling the entire cultivated area when possible. Random sampling on properties characterized by a mixed land use is not likely to provide the greatest degree of representation regarding contamination commonly associated with agricultural production (*i.e.*, insecticides, herbicides, fungicides, fertilizers, etc.). Prior to developing a sampling strategy, each property's land use should be reviewed in terms of spatial and temporal variables, placing the greatest sampling priority on those areas which were intensively managed for agricultural production (e.g., cultivated fields). Conversely, a lesser priority should be given to rangelands and abandoned or vacant lots which have limited or no historical agricultural land uses. Some exceptions to this rationale would include commercial and industrial land uses which are sparsely distributed within the geographic areas currently under consideration for incorporation into CERP projects. In most cases, the use of random sampling is limited to those properties demonstrating homogeneous land use across the majority of the property.

DRAFT

A. Sample collection

Soil samples will be collected using a stainless steel spoon or hand auger from 0-6 inches below land surface. This interval represents the biologically relevant depth for interaction with surface water and biological receptors. It is important that care is taken not to include sample material from more than 6 inches deep, as this may result in dilution and underestimation of contaminant concentrations. Between samples, sampling equipment should be decontaminated using standard procedures to prevent cross-contamination between samples. (Decontamination between subsamples (see below) will not be necessary because subsamples will be mixed together to form a composite.) Immediately following collection, samples should be placed on ice and submitted as soon as possible to the laboratory for analysis.

Before being placed in the sample jar, all soil samples (discreets and composites) should be thoroughly homogenized until they appear completely uniform in texture and color. Analytical laboratories should be instructed that samples received from the field should be thoroughly homogenized again in the jar before an aliquot is removed for extraction.

B. Analytical parameters

If it has been determined during the Phase I/II that a property has a history of agricultural activity prior to 1985, then each soil analysis should include, at a minimum, organochlorine pesticides (EPA Method 8081), metals (including mercury and copper), and total organic carbon (TOC). If the history of the property or more recent uses suggest that other contaminants may be present, then the list of analytes should be expanded as appropriate. The best available detection limits should be requested of the analytical laboratory, but at a minimum, detection limits (practical quantitation limits) for each chemical should be as low as the corresponding screening value (see below). As a general rule, TOC analysis should be done for all soil and sediment samples. TOC is essential for food chain modeling and interpretation of individual sample results, bioassay results, etc.

C. Discreet sampling for small properties (<500 acres)

Discreet sampling will be required for agricultural areas less than 500 acres in size. Discreet sample sites should be established at regular intervals across the property, at a density of at least one sample per 10-20 acres. The actual sampling density will depend on the size of the property, analytical cost per sample, likelihood of contamination, and other factors, and will be specified in the proposed sampling plan and agreed to by consensus between the District and the Service. A minimum of 10 samples will be necessary for most properties. Some exceptions to this minimum sample size will occur where parcels are small (<100 acres) or demonstrate a combination of land uses (i.e., residential "ranchettes", small scale livestock/garden/nursery properties, rock mining pits, etc.) where only a small percentage of the overall area was cultivated. Careful consideration should be given prior to using a sample size smaller than 10. As sample size decreases, statistical variation tends to increase, thereby increasing the size of confidence intervals used to determine the 95 percent UCL of the mean for any given analyte.

Higher UCL values may increase the probability that samples will exceed ecological screening values, thereby necessitating expanded sampling, risk assessment, and subsequent clean up. Also, higher UCL values will generate correspondingly higher Hazard Quotients (HQ) in food chain modeling exercises associated with Ecological Risk Assessments (ERA).

Within this framework, actual sample location is at the discretion of the project manager. This agricultural field sampling is in addition to, and separate from, Phase II sampling that may be focusing on facilities with a high likelihood of contamination, such as pump stations, storage sheds, mixing/loading areas, airstrips, vehicle turn-arounds, cattle dip tanks, etc. The exact location of each sample should be recorded using GPS.

D. Composite sampling for large properties (>500 acres)

The large size of some of the properties being acquired (up to 20,000 acres) makes it difficult to characterize contaminant distribution and concentrations with confidence while staying within a reasonable cost. In order to address this problem, the following sampling strategy has been developed jointly by the Service and South Florida Water Management District (District).

Using aerial photographs, a 50-acre grid pattern will be established on each property or agricultural area greater than 500 acres in size. The grids should be located and confirmed in the field using GPS. Using a random number generator, specific 50-acre grids will be selected for sampling. The number of grids selected will depend on the size of the property. Obviously, the most desirable situation would be complete coverage of all present and former agricultural areas. For example, for a 1000-acre parcel, all 20 of the 50-acre grids would be sampled. For a very large property where complete coverage is not possible due to budget constraints, a pre-arranged fraction of the 50-acre grids should be selected. For example, a 5000-acre parcel would be divided into 100, 50-acre grids. Perhaps half (50) of these grids would then be randomly selected for sampling. The number of grids to be selected will be pre-determined for each site by consensus between the District and the Service, based on site-specific factors.

Each of the 50-acre areas will be subdivided into ten 5-acre plots. One soil sample will be collected from each of the 5-acre plots in the 50-acre grid. The location of each subsample should be exactly determined using GPS. The 10 subsamples are then composited into one sample and thoroughly mixed. This composite sample, representing the entire 50-acre grid, is then submitted to the laboratory for analysis and/or testing.

E. Ecological screening values

Ecological screening values are used to identify areas that may require further attention. The Florida Department of Environmental Protection's (FDEP) Sediment Quality Assessment Guidelines (SQAGs) for Florida Inland Waters (MacDonald et al. 2003) should be used as screening values whenever possible. The SQAGs were developed for assessing sediment quality in Florida waters, based on the probability of effects on aquatic organisms. For each contaminant there are two SQAGs: Threshold Effect Concentration (TEC) and Probable Effect

Concentration (PEC). TECs were formulated to define concentrations of contaminants below which biological effects are not expected. PECs were developed to define ranges of concentrations above which biological effects are likely.

In most cases the TEC will serve as the initial screening value, especially when using the composite-random sampling design. Use of PECs as screening values may be justified under some circumstances for certain contaminants. For some contaminants, SQAGs have not yet been developed. The U.S. Environmental Protection Agency's Ecotox Thresholds (USEPA, 1996), the National Oceanic and Atmospheric Administration's ER-Ls and ER-Ms (Long and Morgan, 1990), or other ecologically-based guidelines should be used when SQAGs are not available. For some chemicals such as metals, information on natural background levels may have to be considered. Human health-based guidelines for cleanup of contaminated sites, such as FDEP's Soil Cleanup Target Levels, should not be used for this purpose.

F. Sites which exceed the PEC

Sediments with concentrations of contaminants above the PEC are considered to represent significant and immediate hazards to exposed organisms. If any of the 50-acre composite samples, described above, exceeds the PEC or other appropriate probable effect-level screening value, it will be necessary to return to that 50-acre grid and obtain individual samples from each of the ten 5-acre sub-areas, which together formed the original composite. These samples should be taken as close as possible to the original sample locations. These discreet samples should then be submitted to the laboratory for analysis. The purpose of this follow-up sampling is to determine the distribution of contaminants within the 50-acre grid; i.e, do the data indicate the presence of one or more "hotspots," or is the contaminant(s) more or less evenly distributed over the site. If only one or two of the individual (5-acre) samples are elevated, the District may choose to remediate these areas in order to reduce the contaminant levels of the 50-acre grid to below PEC. Conversely, follow-up sampling may indicate that most or all of the 50-acre grids contain elevated levels of contaminants. Remediation of widespread contamination over such a large area may not be practical. In such a case, further testing and completion of an ecological risk assessment (ERA) will be necessary in order to refine our understanding of the hazards to federal trust resources associated with contaminants on the site. These tests and assessments should include: (1) elutriate studies, (2) sediment bioassays, and (3) ERA with food chain modeling. In addition, if any of the contaminants have a tendency to accumulate in aquatic organisms or biomagnify in the food chain, such as organochlorine pesticides, PCBs, PCDDs/PCDFs, and some metals, bioaccumulation studies are recommended. Specific tests and methods to be used are discussed in the following sections.

As stated above, follow-up sampling of discreet locations within a 50-acre grid is intended to determine the distribution of contaminants within the grid, and should not constitute an attempt to confirm or refute the original composite result. If widely disparate results are obtained upon follow-up (discreet) sampling compared with the original composite, this suggests that some error has occurred in sampling, homogenization, or laboratory analysis. In these cases, the original composite result will represent the 50-acre grid in question, barring some evidence to the

contrary suggesting that the follow-up result is actually more representative of contaminant concentrations in the grid.

In order to avoid the above situation, it is strongly recommended that discreet samples collected in the field, following homogenization, be split into two jars. One sample jar will be used for producing the composite by mixing with the other samples representing a particular 50-acre grid; the other jar of each pair would be stored at 4 degrees centigrade for possible future analyses. If screening levels for any analytes of interest are exceeded in the composite sample analyses, then all 10 of the subsample aliquots used to make that sample will be reanalyzed for the observed compounds to identify more precisely the location of the observed contaminant(s). Of course, use of this methodolgy may be problematic for very large properties due to limited storage space.

G. Sites which exceed only the TEC

In general, a few scattered exceedances of a TEC by an individual contaminant at a site, when there are no PECs exceeded, is not considered to be a significant cause for concern. However, if enough samples exceed the TEC, such that the mean (estimated by the 95 percent upper confidence limit (UCL) of the mean) for the entire site (i.e., the mean of all discreet samples for a small site, or the mean of all 50-acre composites for a large site) is above the TEC, serious widespread ecological effects are possible. To evaluate this, the mean and the 95 percent UCL of the mean should be calculated for each contaminant of concern. In most cases, if the 95 percent UCL for all contaminants is below the TEC, no further action will be necessary. However, if the 95 percent UCL for any contaminant exceeds the TEC, then the additional testing and an ERA (as described above for PEC exceedances) will be necessary. These tests and assessments should include: (1) elutriate studies, (2) sediment bioassays, (3) ERA with food chain modeling, and (4) bioaccumulation studies for lipophilic contaminants. In addition, if TECs are exceeded by more than one contaminant in the same grid(s), further testing and studies will be necessary to address possible synergistic or additive effects of these co-contaminants. Bioassays will be useful in this case to identify potential toxicity from multiple contaminants that would not be predicted by using individual screening values. Specific tests and methods to be used are discussed in the following sections.

V. Desorption Studies

Contaminated soils inundated during the process of wetland restoration may release soil bound pollutants into the pore and surface waters. Soil or sediment characteristics governing pollutant desorption (e.g., total organic carbon, grain size, pH) will vary among locations. In addition, weathering or aging of some contaminants may alter their bioavailability from that predicted in the published literature. This necessitates site-specific desorption studies to accurately assess pollutant availability to aquatic organisms. Pollutant desorption is assessed on soils from the location using ASTM method E-1195-01, "Method for Determining a Sorption Constant (Koc) for an Organic Chemical in Soil and Sediments." This method simulates flooding of site soils and measures release of contaminants from the soil over time. Filtered pore water samples are

collected and analyzed for COCs after 3, 7, 14, and 21 days contact time. These results are used to determine a site-specific organic carbon partitioning coefficient (Koc), an estimate of pollutant partitioning between sediments and water. This value can be used in food chain models for predicting aquatic and terrestrial organism exposure to pollutants.

Soils used in the desorption study should represent, as near as possible, the maximum detected concentration of the contaminant on the site, in order to ensure that measurable levels of the particular COC are released into the water. Bulk soil samples collected for this purpose must be thoroughly mixed. To ensure uniform contaminant concentrations, samples should be collected and analyzed from several locations within the bulk soil sample (e.g., top, middle, and bottom of the container). In order to be useful, the water analysis results must show evidence that steady-state concentrations have been reached within the 21-day duration of the test. Contaminant concentrations in water obtained during the desorption study may be compared with Florida Surface Water Quality Standards.

VI. Sediment Toxicity Testing

Toxicity testing with representative aquatic invertebrates and vertebrates allows prediction of soil bound pollutant toxicity to aquatic organisms if the location is converted to a wetland. For properties requiring an ecological risk assessment, the following sediment toxicity tests should be conducted:

1. Amphipod (*Hyalella azteca*) 10-day sediment bioassay (flow-through)
2. Midge (*Chironomus tentans*) 10-day sediment bioassay (flow-through)
3. Fathead minnow (*Pimephales promelas*) 7-day sediment bioassay (static renewal)

"Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates (ASTM E-1706-95)," "Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates (USEPA/600-R-99/064)," and "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms (USEPA/600/4-91/002)" provide standard methods to assess soil-associated pollutant effects upon aquatic organisms.

Endpoints measured in these tests are survival and growth. Any statistically significant impacts upon these endpoints in any test are considered direct evidence of potential impairment of the prospective benthic/aquatic community in the restored wetland.

As with the other sediment studies, bulk soil samples collected for this purpose must be thoroughly mixed, and uniformity of contaminant concentrations should be confirmed by sampling from several locations within the bulk soil sample. Soils used in the sediment toxicity tests should represent, as near as possible, the maximum detected concentration of the contaminant on the site.

DRAFT

VII. Bioaccumulation Studies

Factors affecting pollutant accumulation by aquatic organisms can vary among locations. Accurate prediction of pollutant bioaccumulation at a location requires site-specific bioaccumulation studies, using species representative of those that may exist on the location once flooded. For properties requiring an ecological risk assessment, the following bioaccumulation studies should be conducted:

1. Oligochaete (*Lumbriculus variegatus*) 28-day bioaccumulation study
2. Fathead minnow (*Pimephales promelas*) 28-day bioaccumulation study

Methods described in "Great Lakes Dredged Material Testing and Evaluation Manual (USEPA and Army Corps of Engineers, 1998)" and "Standard Guide for Determination of the Bioaccumulation of Sediment-Associated Contaminants by Benthic Invertebrates (ASTM E-1688)" should be used to determine the bioaccumulation potential of soil-associated pollutants. These results are used to determine a site-specific octanol-water partitioning coefficient (Kow), an estimate of pollutant partitioning (bioconcentration) between water and the body fat of the exposed organism. This information is utilized in food chain models for estimating contaminant uptake from water and accumulation in various trophic levels.

Soils used in the bioaccumulation studies should represent, as near as possible, the maximum detected concentration of the contaminant on the site, in order to ensure that measurable levels of the particular COC are released into the water and taken up by the organisms. Bulk soil samples collected for this purpose must be thoroughly mixed. To ensure uniform contaminant concentrations, samples should be collected and analyzed from several locations within the bulk soil sample (e.g., top, middle, and bottom of the container). In order to be useful, the concentration of contaminant(s) in the test organisms must show evidence that steady-state conditions have been reached within the 28-day duration of the test.

VIII. Aquatic Food Chain Modeling

In the absence of direct measures of effects, it becomes necessary to estimate or predict potential pollutant effects upon the Service's trust resources and other organisms that may utilize the created wetland, reservoir, or STA. Testing that directly assesses soil bound pollutant toxicity to organisms, other than benthic invertebrates and fish, is relatively time consuming and costly. Food chain models allow prediction of effects on higher level organisms by combining data from the site-specific desorption and bioaccumulation studies with information on dietary composition, consumption rates, body weights, etc. and literature toxicity data.

The Service's trust resources include migratory birds and Federally listed threatened or endangered species. The bald eagle (*Haliaeetus leucocephalus*), white pelican (*Pelecanus erythrorhynchos*), snail kite (*Rostrhamus sociabilis*), osprey (*Pandion haliaetus*), clapper rail (*Rallus longirostris*), and wood stork (*Mycteria americana*) are federal trust species that should be considered as representative target organisms. Where bioaccumulating pollutants are present,

a maximally exposed piscivorous bird must always be included. Generic fish species (omnivorous and higher level predatory fish) may be used as aquatic focal species. At a minimum, the food chain model should assess risk to the following groups (trophic levels) of target organisms:

1. Benthic invertebrates (detritivores)
2. Omnivorous fish
3. 1st order carnivorous fish (trophic level 3)
4. 2nd order carnivorous fish (trophic level 4)
5. Omnivorous bird
6. 1st order carnivorous bird
7. 2nd order carnivorous bird
8. Threatened and endangered species

The following potential routes of exposure should be included in the model:

1. Direct exposure to contaminated water/sediments
2. Sediment ingestion
3. Water ingestion
4. Food ingestion

The following transfer mechanisms and processes should be included:

1. Desorption from sediment to water
2. Bioconcentration from water
3. Bioaccumulation through ingestion of contaminated prey
4. Biomagnification with increasing trophic level

Once the target species' exposure to pollutants has been modeled, the potential risk to the species needs to be assessed by comparing the modeled exposure to a toxicity reference value (TRV). Perhaps the most relevant endpoints for assessing risk are effects upon (1) survival and (2) reproduction. In the absence of toxicity tests performed with the specific target species, TRVs for the pollutant(s) of interest must be obtained from the literature. Where possible, the ideal TRV will have been generated using a similar exposure route for a taxonomically related species. Uncertainties arising from the use of TRVs based on different exposure routes or unrelated species should be discussed in the risk assessment. In general, the most sensitive TRV should be utilized to assess risk to the target species.

Risk is expressed by calculating a hazard quotient (HQ), which is simply the ratio of the modeled exposure (numerator) and TRV (denominator). HQs above one indicate a potential for adverse effects to occur in a species under a given exposure scenario. The higher the HQ above one, the greater the risk that adverse effects will occur. HQs below one generally indicate that adverse effects are unlikely. HQs that are greatly different from one provide the greatest level of

certainty in their interpretation.

IX. Final Report

Upon completion of all sampling, chemical analyses, laboratory studies, and food chain modeling, a draft Phase I/II Environmental Site Assessment and Ecological Risk Assessment report should be prepared which identifies all potential hazards to ecological receptors and provides recommendations for corrective actions and/or management of the project that will reduce the hazards to acceptable levels. The Service will review the draft report and provide concurrence or make recommendations for changes or additions. The final report will incorporate Service recommendations, providing an accurate and complete report which can be used as a planning tool to optimize wetland restoration efforts and minimize adverse affects to fish and wildlife resources.

DRAFT

Literature Cited

Long, E.R. and L.G. Morgan. 1990. The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. Seattle, Washington.

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, G. Sloan and T. Biernacki. 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Technical Report. Florida Department of Environmental Protection, Tallahassee, Florida.

USEPA. 1996. ECO Update: Ecotox Thresholds. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C. EPA 540/F-95/038. 12 pp

Appendix B

District Guidance in the Design of a Project-level Monitoring and Assessment Plan for Mercury, Pesticides and Other Toxicants

Guidance in the Design of a Project-level Monitoring and Assessment District Plan for Mercury, Pesticides and Other Toxicants

INTRODUCTION 2
Mercury 3
Pesticides and Other Toxicants 5
MONITORING AND ASSESSMENT FRAMEWORK 6
1. Phase 1 - Baseline Collection and Assessment 6
1. 1 Phase 1 - Tier 1: Compilation and Review of Available Data 6
1. 2. Phase 1 - Tier 2: Field Sampling 7
1. 2.a Soil/Sediment 7
1. 2.b Fish Tissues 9
1. 3. Phase 1 - Tier 3: Bioaccumulation Tests and Dynamic Modeling 10
1.3.a Bioaccumulation Tests 10
1.3.b Modeling 11
2. Phase 2 - Monitoring During Three-Year Stabilization Period 12
2.1 Phase 2 - Tier 1: Routine Monitoring During Stabilization Period 12
2.1.a Water 12
2.1.b Soil / Sediment 12
2.1.c Fish Tissues 13
2.2 Phase 2 - Tier 2: Expanded Monitoring and Risk Assessment 14
3. Phase 3 - Routine Operational Monitoring (Post-Stabilization) 16
3.1 Phase 3 - Tier 1: Routine Operational Monitoring 16
CONTRACTOR SELECTION CRITERIA 17
REPORTING REQUIREMENTS 17
CONTACTS 17
REFERENCES 18

South Florida Water Management District DRAFT, January 6, 2005

INTRODUCTION

This document is intended to guide in the design of monitoring and assessment plans for mercury (Hg), pesticides, and other toxicants for South Florida Water Management District (District or SFWMD) projects. Because Hg is a regional problem in South Florida, it should be a consideration in all plans. As discussed below, although pesticides or other toxicants are often found dispersed in various media throughout South Florida (e.g., water, sediment, biota), concentrations do not frequently exceed critical levels that are thought to result in toxicity. Therefore, risk from exposure to pesticides or other toxicants tends to be a more localized concern than for mercury. More importantly in this context, the risk from changes related to the Comprehensive Everglades Restoration Plan (CERP) increasing the likelihood that wildlife will be exposed to these constituents, to a level that is toxic, also tends to be a localized concern. Accordingly, monitoring pesticides or other toxicants should be considered on a case-by-case basis.

It is not the intent of this plan to substitute for environmental site assessments (ESA) that are conducted on acquisition tracts. The District has an excellent record in conducting ESAs, site-specific environmental risk assessments (ERA), and implementation of corrective actions, where appropriate. This guidance has been prepared in consultation with and, where possible, will be implemented in coordination with the District's program for assessing the environmental liabilities associated with land transfer. However, the potential for anomalous methylmercury (MeHg) production is not considered during the ESA and thus must be assessed separately. With regard to other toxicants, the guidance provided here should prove useful in cases where either:

- an ESA identified dispersed low-level contamination of toxicants and there is a need to reduce uncertainties, i.e., better define spatial or vertical distribution,
- where lands were purchased by other public / private entities, but may not have been subjected to the same level of ESA as current transfers,
- there has been a lengthy interval between the time of assessment and start of construction (with interim usage by a lessee), or
- where pesticides or other toxicants have previously been identified as a concern on public lands (i.e., possibly as a result of stormwater runoff).

Results from the monitoring and assessment plan, in combination with information generated during land transfers, is intended to provide state and federal regulatory and trust oversight agencies with reasonable assurance that the project will not cause or contribute to an unacceptable increase in the risk of toxic effects to aquatic or terrestrial resources. As discussed below, the current numerical water quality standard (WQS) for total mercury (THg) is not protective of human or wildlife health. Consequently, assessments will need to place greater weight on protecting designated beneficial uses, i.e., recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. This will also be true for other toxicants that can be released suddenly from flooded soils and/or that have the potential to biomagnify. In addition to numerical water quality standards, assessments will need to consider Line 62 of 62-

302.530, Florida Administrative Code (F.A.C.), which states that substances in concentrations which injure, are chronically toxic to, or produce adverse physiological or behavioral response in humans, plants, or animals shall not be present. In addition to state requirements, federal legislation that may be pertinent include the Comprehensive Environmental Response, Compensation and Liability Act, the Endangered Species Act, and/or, the Migratory Bird Treaty Act.

This guidance uses a phased, multi-tiered approach that is intended to commit information gathering, assessment, and remedial resources in proportion to the likelihood of harm by following a logical and cost-effective procedure. The plan covers three phases of a project: (1) Baseline Collection and Assessment, (2) Monitoring during the Three-Year Stabilization Period, and (3) Routine Operational Monitoring (Post-Stabilization). The plan includes decision points and adaptive management recommendations if preconstruction or operational monitoring reveals conditions of immediate concern. If an identified threshold of concern (i.e., action level) is crossed, then Tier 2 expanded monitoring and risk assessment would be triggered to determine the cause and guide appropriate adaptive management decision making regarding short-term corrective actions and long-term operational optimization. The intent of this approach is to allow monitoring efforts to smoothly ramp down or up, as appropriate.

This general plan is intended to accommodate diverse projects by providing a framework that can be tailored to a project's specific design. For example, a monitoring and assessment plan for a wetland restoration project would likely differ substantially from a plan for a Stormwater Treatment Area (STA) or reservoir. While it is anticipated that this guidance will serve as a frame of reference for future permit-mandated monitoring, incorporation of all, some, or none of its elements into a permit is at the discretion of the responsible authorities.

Mercury

Although atmospheric loading is often the dominant proximate source of inorganic mercury to many water bodies, the complication lies in the relationship between influx of inorganic mercury and the amount that is methylated by sulfate-reducing bacteria (SRB) following deposition. The latter process is of fundamental concern because MeHg is the more toxic and bioaccumulative form that can build up in the food chain to levels harmful to humans and other fish-eating animals, particularly in ecosystems with complex, lengthy food chains. Accordingly, a monitoring and assessment plan must be able to detect increased amounts of MeHg in the project area or downstream waters, either through sedimentary release of THg or MeHg, or through increased net Hg methylation. Although there are some constraints in predicting outcomes, the following factors are thought to be associated with increased MeHg production, particularly when in combination with certain site conditions (i.e., sediment biogeochemistry that is, as yet, less well-defined):

- Increased proportion of source water from direct rainfall relative to surface water runoff (explanatory note: rain contains elevated levels of bioavailable inorganic Hg, particularly

during summer; whereas, surface water runoff has already lost Hg through evasion back to atmosphere, sorption and deposition, and biological uptake);

- Elevated levels of oxidized sulfur compounds (e.g., sulfate, etc.) in inflows or sediments (explanatory note: used as electron acceptor by SRBs);
- Drawdown – drying followed by rewetting (explanatory note: allows constituents in the sediments/soils to oxidize); or
- Large bioavailable carbon source (explanatory note: feeds SRBs).

The goal is to prevent these factors from combining to produce a mercury methylation hot spot both in the short term (known as the "first-flush effect") and the long term (known as the "reservoir effect"). For additional details, see evolving conceptual model presented in the Fink et al., 1999; Stober et al., 2001; Harris et al., 2003; Atkeson and Axelrad, 2004.

The Florida Department of Environmental Protection (FDEP) has recognized that the current Florida numerical water quality criterion of 12 nanograms of total mercury (THg) per liter (ng/L) in water is of limited use, because fish consumption advisories have proven necessary for waters meeting the state criterion (Atkeson and Parks, 2002). Likewise, the U.S. Environmental Protection Agency (USEPA), also recognizing the limited utility of its recommended water quality criterion for the protection of human health, recently published guidance on a new criterion expressed not as a water-column concentration of mercury, but as a concentration of mercury in fish tissue (0.3 milligrams per kilogram, or mg/kg in fish tissue; USEPA, 2001). Biomonitoring mercury provides several advantages. First, MeHg occurs at much greater concentrations in fish tissues relative to surrounding water, making chemical analysis more accurate, precise, and cost-effective. Second, organisms integrate exposure to MeHg over space and time, while corresponding water concentrations may vary by a factor of two or more over a period of hours. Finally, the tissue Hg concentration in fish is a true measure of its bioavailability and provides a much better indicator of possible exposure to fish-eating wildlife and humans than the concentration in water.

In anticipation of the state adopting a new WQS based on tissue concentration and because it is cost-effective, this generic plan has a biomonitoring program as a key component. The long-term goal is to reduce tissue Hg concentrations in predatory fish to levels that do not exceed USEPA guidance values for the protection of both human health and wildlife (for guidance values to protect wildlife, see USEPA, 1997). However, it should be recognized that the Everglades has a preexisting, widespread mercury problem (i.e., fish from most areas currently exceed one or more predatory protection criteria) and that many of the influential factors controlling MeHg production are beyond the scope of individual projects. Accordingly, use of USEPA's guidance criterion as a "risk-based" action levels is not appropriate in the short term. Instead, monitoring and assessment plans will track the status and trends of mercury bioaccumulation to ensure that it does not significantly increase over baseline levels. This monitoring and assessment plan incorporates action levels or triggers for decision points based on existing reference or baseline conditions (i.e., annual basin-wide arithmetic average or percentile concentration for all basins

pooled). For purposes of pooling related data, the basin will be operationally defined based on the physiography and land uses of the watershed, category of water body (e.g., wetland, slough, open lake, etc.), and the data set available at that time. Ideally, the data set would allow for comparisons between similar habitat or sediment types. However, near-term projects may not have this option and may need to collect reference samples (especially where data on similar sediment types are unavailable) or use surrogate data collected at Stormwater Treatment Areas or Water Conservation Areas under the Everglades Forever Act Permits for comparative purposes.

Pesticides and Other Toxicants

Potential impacts to wildlife from exposure to toxicants other than mercury (e.g., organic pesticides or trace metals) continues to be a problem. This is of particular concern in Florida because of its complex stormwater management system from both urban (e.g., lawns, golf courses, "street dust") and agriculture, high groundwater table, and significant usage of a wide variety of pesticides and fertilizers. Fertilizers (including organic and biosolids) are a concern because several studies have measured heavy metals (e.g., cadmium, lead, nickel, and copper) in mineral ores and the resulting fertilizers (USEPA, 1999). Like mercury, many other toxicants, including relic (e.g., DDT, DDE, toxaphene, etc.) and new (e.g., atrazine, alachlor) pesticides, have been found to be atmospherically deposited from both local and global sources (for details, see Eisenreich et al., 1981; Goolsby et al., 1993). Consequently, source identification can be challenging.

Owing to their absorptive capacity, soils and sediments typically act as a sink for these contaminants. As long as these soils/sediments maintain the capacity to store and thus immobilize the potential toxicant, the effects are significantly reduced. However, any alteration in the environment (e.g., flooding, anoxia and redox, microbial processes, pH changes) can suddenly reduce the sediment's storage capacity, which in turn can result in serious environmental damage (see "Chemical Time Bomb" concept in Stigliani et al., 1991).

Pesticides have been detected in sediments and surface water at District structures at various times (Miles and Pfeuffer, 1997; Pfeuffer and Matson, 2003; Pfeuffer and Rand, 2004). Likewise, pesticide residues have been found in fish and wildlife from certain locations in the central and southern Everglades (USGS National Water Quality Assessment Program at http://fl.water.usgs.gov/Abstracts/fs110_97_haag.html; Rumbold et al. 1996, Spalding et al. 1997, Rodgers 1997, Fernandez et al. 2003). Recently, a bird kill in excess of 800 birds occurred on Lake Apopka, possibly as a result of pesticide poisoning, after former farmlands were flooded (see Memorandum of Understanding between U.S. Department of Justice and St. John's River Water Management District, available at http://sjr.state.fl.us/programs/acq_restoration/s_water/lapopka/MOU.html).

The monitoring and assessment plan for other toxicants often takes advantage of the mercury monitoring program, as in many cases, additional work simply involves splitting samples.

South Florida Water Management District DRAFT, January 6, 2005
MONITORING AND ASSESSMENT FRAMEWORK

1. Phase 1 - Baseline Collection and Assessment

This section describes activities conducted during the initial stages of a project. In some cases, a Project Manager may opt to carry out these activities prior to site selection (i.e., on short-listed sites) to provide additional information to guide in the selection process. If site selection has already occurred, then a Project Manager may elect to carry out these tests to assist in selecting the final design (e.g., footprint or operational features). As previously stated, it is not the intent of this plan to substitute for ESAs that are conducted on acquisition tracts. Results of those assessments are routinely reviewed and receive necessary approvals from the FDEP and the U.S. Fish and Wildlife Service. Accordingly, where an ESA has recently been completed, baseline collection and assessment of toxicants other than Hg is not a general recommendation beyond the Phase 1 - Tier 1 task of compiling and reviewing existing data. Although these tests are a general recommendation for mercury, it should be understood that due to current limitations in predicting methylation potential, results of these tests should not be the sole factor in making site or design selection. Nonetheless, information gathered during this phase of the project will be crucial in developing the final monitoring plan and as baseline for future, post-construction cause-and-effect assessments.

1. 1 Phase 1 - Tier 1: Compilation and Review of Available Data

The first step in any project is to compile and review all available data (e.g., ESA, DBHYDRO, Battelle Monitoring Data Inventory) collected from the project footprint and surrounding area. With regard to other toxicants, data should be reviewed to answer the following questions:

- If land transfer, responsible agency and level of ESA preformed (i.e., Phase 1 or 2)?
- Did the ESA identify contaminants of concern?
- Were any corrective actions taken and was there follow-up sampling?
- Was there dispersed low-level contamination of toxicants (i.e., that did not exceed the requirements for corrective action)?
- Has there been a lengthy interval between the time of assessment and start of construction (with interim usage by a lessee) and, if so, what chemicals may have been used in the interim?
- If public lands, have toxicants been previously identified based on surface water, sediment or fish monitoring?

Answers to these questions will guide in developing an abbreviated analyte list for subsequent monitoring.

In areas that have been extensively studied, projects may have adequate baseline datasets and thus may not be required to collect any additional data before developing the Phase 2 monitoring and assessment plan. Alternatively, where datagaps exist or where the preponderance of the

baseline data demonstrate a potential problem, additional sampling (i.e., under Phase 1 - Tier 2 or Tier 3) may be necessary.

1. 2. Phase 1 - Tier 2: Field Sampling

1. 2.a Soil/Sediment

To describe conditions within each project, it is recommended that soil/sediment cores be collected from five locations within each operable unit (i.e., OU - each independently operated treatment train of an STA or reservoir) or each 1,000-acre parcel, whichever is smaller. At each location or site, three cores from the 0-to-4 cm horizon are to be collected and composited as a single soil sample. To conserve resources at large projects, sub-samples or aliquots from each of the soil samples from the five different locations can be pooled to form a single supercomposite sample for each OU or 1,000 acres. In this two-staged sampling approach, the analyses of the supercomposite representing the entire OU or 1,000 acres can be used as a screening mechanism to identify if additional, individual analysis are need to be performed (on each of the individual soil/sediment samples). Accordingly, remaining material from each soil sample will be archived separately for up to one year to allow for possible future analysis.

If the site was flooded and sediments had been saturated for some period of time (i.e., in excess of a month) with water comparable to future source water, then sediments may be immediately analyzed for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe). Alternatively, if soils were collected from a dry site (i.e., orange grove, range land, etc.), then baseline concentrations will not reflect future flooded conditions (i.e., potential for MeHg production or first flush). Accordingly, soil/sediment must first be incubated with source water (i.e., surface water containing ambient concentrations of sulfate and dissolved organic carbon mixed with rainwater containing bioavailable inorganic Hg) for a period to evaluate this potential for first flush and future MeHg production. This test (i.e., beaker-scale microcosm test) will use fresh soils (i.e., the supercomposite from above) and ambient water from the anticipated inflows (i.e., appropriate mixture of surface water and rainfall, which have been subsampled for analysis for THg and MeHg), and will be run under static conditions, with frequent renewal. Upon completion of the test, sediments will be collected and analyzed for THg, MeHg, moisture content, TOC, TS, and TFe.

If deemed necessary, based on the discussion above, soil/sediment samples (wet or dry) could also be split and analyzed for toxicants of concern identified either through an ESA, available water quality (WQ) database or, if these were unavailable, previous land uses (both upstream and within the footprint). Although this course sampling would likely miss possible "hot spots" (e.g., fuel loading or pesticide mixing zones), which should have been detected during the ESA (when cores were collected from 5-acre subparcels and composited for randomly selected 50-acre parcels), this level of detail should be sufficient to characterize dispersed contaminants.

The objective of screening for toxicants is (1) to prevent direct toxicity, either acute or chronic, and (2) to prevent the biomagnification of toxicants from reaching unacceptable levels that

would pose a threat to upper trophic level wildlife. To achieve the first objective, toxicants would be evaluated against effects-based, numerical sediment quality assessment guidelines (SQAGs for sediment dwelling organisms, MacDonald Environmental Sciences Ltd.; USGS, 2003). In cases where the effects-based SQAG did not assess the potential for adverse effects on aquatic organisms due to the resuspension of sediments or partitioning of contaminants into water (i.e., using elutriates or pore water), soils may be subjected to a synthetic precipitate leaching procedure (SPLP; USEPA Method 1312, also see Brannon et al., 1994) using ambient source water to elute the column and the resulting elutriate assessed based on Chapter 62-302, F.A.C. (and other references contained in Pfeuffer and Matson, 2003); exceedances would trigger
Tier 3 assessments. To achieve the second objective, bioaccumulative toxicants would also be evaluated against established bioaccumulative-based SQAGs, if available (MacDonald Environmental Sciences Ltd.; USGS, 2003).

A project would stop and reevaluate the ESA (if completed) and/or proceed to Phase 1 - Tier 3 bioaccumulation tests and dynamic modeling if:

- concentrations in sediments exceeded the appropriate SQAG,
- concentrations in sediments exceeded a value reported in the ESA or a level that was determined to be critical in a site-specific risk assessment, or
- the concentration in the elutriate exceeded a WQS in Chapter 62-302, F.A.C.

Although bioaccumulation-based SQAGs have been developed for a limited number of toxicants, there is no chemical-specific SQAG for mercury. Consequently, there is no screening-level benchmark sediment THg or MeHg concentration that can be used to confidently predict whether a site will become a "MeHg" hotspot. However, data collected over the last nine years by various agencies working in the Everglades offer some limited capability as a reference (or baseline) to predict the potential for excessive MeHg production. Accordingly, as one of several potential tools for alternatives analysis, it is recommended that soil/sediment conditions of the site be assessed for MeHg production potential through comparisons with this reference database. If absolute concentrations of MeHg, or percent MeHg (i.e., percentage of THg that is in the MeHg form) in soils/sediment from an OU exceeds the 90% upper confidence interval for within basin sediments or, if not available, the 90^{th} percentile concentration (or %MeHg) for all basins, then the potential exists for excessive MeHg production and, accordingly, it is recommended that the project proceed to Phase 1 - Tier 3.

As previously discussed, a great deal of uncertainty remains surrounding the use of soil/sediment concentrations as a predictive tool to forecast future MeHg potential. Accordingly, as discussed in the following section, it is recommended that resident fish also be collected to assess current MeHg production and bioaccumulation.

1. 2.b Fish Tissues

At a minimum, fish samples from multiple trophic levels should be collected upstream and downstream of each project. Specifically, a sample of at least 100 mosquitofish (*Gambusia spp.*) should be collected from each location and composited into a single sample for THg analysis. Additionally, individual sunfish [sample size (n) should be greater than or equal to 5; whole-body] should be collected from each location and analyzed for THg. Where habitat will support largemouth bass (*Micropterus salmiodes*) and there is a possibility of future recreational harvesting, bass should also be collected and individually analyzed for THg (n should be greater than or equal to 5; fillets). Becasue virtually all (> 85 percent) of the mercury in fish muscle tissues is in the methylated form (Grieb et al., 1990; Bloom, 1992; SFWMD, unpublished data), the analysis of fish tissue for THg, which is a more straightforward and less-costly procedure than for MeHg, can be interpreted as being equivalent to the analysis of MeHg.

To reduce variance (i.e., due to species related differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections should target bluegill (*Lepomis macrochirus*) ranging in size from 102 to 178 mm (i.e., 4-7 inches) and largemouth bass ranging in size from 280 to 330 mm (i.e., 11 to 13 inches); however, other lepomids (first priority being given to spotted sunfish, *L. punctatus*, due to similar trophic status) or sizes are to be collected if efforts fail to locate targeted fish. If neither sunfish nor bass are present, then consideration should be given to sampling other species.

In addition, if possible (i.e., if flooded), mosquitofish should also be collected randomly from multiple locations from each OU or 1,000 acres (total should exceed 100 mosquitofish) and physically composited to form a single mosquitofish sample representative of the entire OU.

Body burdens in upstream and downstream fish do not provide predictive capabilities for alternatives analysis; however, this data set will be a crucial baseline for trend analyses following initiation of flow-through operation. Alternatively, ambient fish from the interior or footprint do provide some predictive capabilities for alternatives analysis. If these mosquitofish demonstrate excessive levels of MeHg bioaccumulation that exceed the 90% upper confidence level of the basin-wide annual average (reference basin will be defined for each specific project) or the 90th percentile concentration for the period of record for all basins, then it is recommended that the project proceed to Phase 1 - Tier 3: Bioaccumulation Tests and Dynamic Modeling.

If deemed necessary, based on the discussion above, fish samples could also be split and analyzed for bioaccumulative toxicants identified either through an ESA, available WQ database or, if these were unavailable, previous land uses (both upstream and within the footprint). Although, it is recognized that under certain circumstances a taxa other than fish may be more

appropriate biological sentinels depending on toxicant and risk assessment endpoint, this will require a thorough justification.

If levels of other toxicants in tissues exceed recognized background tissue concentrations (USGS National Water Quality Assessment Program, etc.) or benchmarks established in ecological risk assessments completed as part of the ESA, then the project would stop and reevaluate the ESA or proceed to Tier 3 Bioaccumulation Tests and Dynamic Modeling.

1. 3. Phase 1 - Tier 3: Bioaccumulation Tests and Dynamic Modeling

Tier 3 assessments during Phase 1 Baseline Collection and Assessment are triggered if one of the following action levels are exceeded:

- If absolute concentrations of MeHg, or average percent MeHg (i.e., percentage of THg that is in the MeHg form) in soils/sediments from an OU exceeds the 90% upper confidence level of within the basin average, or if not available, the 90th percentile concentration (or %MeHg) for all basins;
- If concentrations of other toxicants in soils/sediments exceeded benchmarks established in ecological risk assessments completed as part of the ESA, or exceeded an appropriate SQAG, or the concentrations in the elutriate exceeds Chapter 62-302, F.A.C.; or
- If ambient fish collected within the project boundary demonstrate excessive bioaccumulation that exceeds the critical tissue benchmark used to establish SQAGs or in site-specific risk assessments exceeds the 90% confidence level of within the basin average, or if not available, the 90th percentile concentration for all basins.

Before proceeding to full Tier 3 sampling or modeling, the following steps are recommended to better define spatial extent of problem (i.e., to focus future efforts and thus conserve resources).

Step 1. Run analytical chemistry on the five individual soil samples that comprise the supercomposite that exceeded the trigger.

Step 2. Resample mosquitofish at a finer scale (i.e., 1 sample per 200 acres) within the OU or 1,000 acres for which the Tier 1 composite sample exceeded the trigger.

1.3.a Bioaccumulation Tests

As previously discussed, uncertainties remain surrounding the use of soil/sediment concentrations as a predictive tool to forecast future MeHg potential. Depending on soil conditions (e.g., concentration of TOC, TS, or TFe) bulk concentrations could substantially overestimate the fraction of MeHg actually bioavailable to aquatic animals living on or in surficial soils and thus the short-term MeHg bioaccumulation potential.

To reduce this uncertainty, a standardized laboratory determination of MeHg bioaccumulation (ASTM 1688-00a, E1706-00e1, or equivalent; also see Ingersoll et al., 1998; Nuutinen and Kukkonen, 1998) may be carried out using soils collected from multiple locations within the footprint of the proposed component; supercomposite from above or individual composites (if area has been defined by sediment concentrations). Because most of the cost of this test is associated with the collection of soil/sediments, a Project Manager may opt to collect sufficient soil/sediments for this test during Tier 1 sampling.

The bioaccumulation test will use soils/sediments, ambient water from the anticipated inflows (i.e., appropriate mixture of surface water and rainfall, which have been subsampled for analysis for THg and MeHg) and will be run under static conditions with frequent renewal. Current standard protocols utilize infaunal invertebrates (e.g., *Lumbriculus variegatus*, a freshwater benthic worm) and are non-feeding exposures. Therefore, assessment of food chain transfers (biomagnification) require modeling (i.e., in this case to mosquitofish or sunfish) using biomagnification factors (BMFs) from the peer-reviewed literature, if basin-specific data are unavailable. A probabilistic bioenergetics-based food chain model may be used if a valid, applicable BMF cannot be obtained (e.g., Norstrom et al., 1976; Rodgers, 1994; Korhonen et al., 1995; Schultz et al., 1995).

If Tier 3 Bioaccumulation Tests and Modeling is triggered by toxicants other than Hg on a site that has recently undergone an ESA or ERA, then the Project Manager should reevaluate early model runs and rerun with additional data. Where an SQAG (either effects-based or bioaccumulation-based) has not been identified, or in cases where an exceeded SQAG is thought to be overly conservative, it is recommended that a standardized laboratory bioaccumulation test (ASTM 1688-00a, E1706-00e1, or equivalent; also see Ingersoll et al., 1998) be performed.

1.3.b Modeling

If Phase 1 - Tier 2 evaluations or Tier 3 bioaccumulation tests demonstrate the potential for excessive MeHg production and bioaccumulation over a substantial portion of the project footprint (hence, the need to define spatial extent, as discussed above), then it is recommended that the Everglades Mercury Cycling Model (E-MCM) or comparable model be used during alternatives analysis. Preferably, model output should be considered both in terms of site selection and operational design. However, due to the current limitations in the predictive strength of the E-MCM, results of the management scenarios simulated must be considered as possible, rather than probable outcomes (Harris et al., 2004), and should not be the sole factor in site selection.

Consultants under contract to the District's Land Acquisition Department have developed and routinely use several different models for evaluating biomagnification and ecological risk from exposure to other toxicants. If resulting risk estimates (either based on uptake or critical tissue concentrations) are deemed acceptable, the project would proceed and initiate Phase 2 - Tier 1 monitoring. On the other hand, if risk is deemed to be unacceptable, then the Project Manager would proceed to determine potential remedial actions/alternatives to reduce exposure and risk.

2. Phase 2 - Monitoring During Three-Year Stabilization Period

This section describes a general monitoring and assessment plan to be conducted on projects after initial flooding and through the first three years of operation.

2.1 Phase 2 - Tier 1: Routine Monitoring During Stabilization Period

2.1.a Water

At a minimum, an unfiltered surface water sample (n = 1) should be collected in accordance with Chapter 62-160, F.A.C., at the inflows and immediately upstream of the outflows of each project on a quarterly basis and analyzed for THg, MeHg, and if not included under routine WQ monitoring, sulfate. In addition, flow will be monitored at the inflow and outflow to allow for load estimation to and from the project (it should be recognized that quarterly sampling would allow for only rough estimation of loads).

This data set will provide crucial information regarding assessment measures, i.e., annual outflow loads of THg and MeHg should not be significantly greater than inflow loads, including atmospheric loading; load estimates should include confidence intervals that describe uncertainty in measures of flow and concentration (e.g., field and analytical precision) and resulting from interpolation (note: assessment protocol to be negotiated with permitting authority). Failure to satisfy this assessment measure would trigger Tier 2 Expanded Monitoring and Risk Assessment.

Until a new criterion based on tissue concentrations is promulgated, monitoring THg in surface water will likely also be necessary to demonstrate compliance with Chapter 62-302, F.A.C. (i.e., WQS of 12 ng THg/L); however, this would trigger Tier 2 Expanded Monitoring and Risk Assessment only if the loading assessment measure was also exceeded.

It is recommended that other toxicants identified during Phase 1 - Tier 1 data review (i.e., based on ESA, DBHYDRO, Battelle Monitoring Data Inventory) be included on the analyte list for quarterly water-column sampling. Because of the concern for potential acute toxicity, the initial sample collection should occur prior to flow-through operation. Subsequent sampling would occur at the same frequency as mercury monitoring and be assessed using a similar performance measure, i.e., outflow load should not be significantly > inflow load (including atmospheric load). Because of differences in the anticipated time frames under which sedimentary release are thought to occur (i.e., relative to MeHg that may have time lag associated with changes in biogeochemistry and microbial methylation driven by water quality), monitoring for other toxicants would cease after one year, if action levels are not exceeded within that time. Exceedance of WQS in Ch.62-302 would trigger Tier 2 Expanded Monitoring and Risk Assessment.

2.1.b Soil / Sediment

Soil / sediments will not be collected under Phase 2 - Tier 1 monitoring.

2.1.c Fish Tissues

At a minimum, samples of fish from multiple trophic levels should be collected from each OU and from a single downstream site for each project. Specifically, within one month following initial flooding and quarterly thereafter, mosquitofish should be collected from multiple locations within each OU (to total at least 100 fish) and physically composited into one (spatially-averaged) sample and analyzed for THg (note, a single aliquot should be analyzed per composite). Mosquitofish were selected as a primary sentinel species because of their widespread occurrence in the Everglades, ability to invade newly flooded areas, and because of their relatively small home range and short life span. Mosquitofish are known to bioaccumulate MeHg as well as, other metals, such as lead, zinc, selenium and cadmium and organochlorine pesticides including but not limited to DDT, endosulfan, and toxaphene. These characteristics make the mosquitofish an excellent indicator of short-term, localized changes in a toxicant's bioavailablity.

On an annual basis, sunfish (n should be greater than or equal to 5) should be collected and individually analyzed (whole-fish) for THg. Sunfish were selected because of their widespread occurrence (especially bluegill) and because they are a preferred prey for a number of fish-eating species. Where habitat supports largemouth bass and there is a possibility of future recreational harvesting, bass should also be collected (n should be greater than or equal to 5) and individually analyzed (fillets) for THg. Largemouth bass can be used as an indicator of potential human exposure to mercury. To reduce variance (i.e., due to species differences in diet, ontological shifts in diet, exposure duration) and improve spatial and temporal comparisons of tissue levels within trophic levels, collections should target bluegill ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 280 to 330 mm (i.e., 11 to 13 inches); however, other lepomids (due to similar trophic status, first priority being given to spotted sunfish) or sizes are to be collected if efforts fail to locate targeted fish.

Due to their relatively longer life spans and larger home ranges, sunfish and largemouth bass integrate their exposure over a larger spatial area and longer time frame. Accordingly, caution should be exercised when assessing levels in these fish in recently flooded (or intermittingly flooded) marshes. Under those circumstances, more weight should be placed on levels in mosquitofish which, as stated previously, integrate exposure over a shorter period of time.

If after one year of monitoring, sufficient data are collected to demonstrate that conditions within the different OUs are equivalent, collection of large-bodied fish can be reduced to one OU and one downstream site. Alternatively, if OUs are shown to differ in terms of average concentration in mosquitofish, project managers may elect to sample large-bodied fish from the OU with the highest observed concentration and assess results as "worst case". However, in either case, mosquitofish collections would continue from all OUs.

This data will then be used to evaluate the following assessment measure: annual average THg levels in fishes should not increase progressively over time or become elevated to the point of

exceeding the 90% upper confidence level of the annual basin-wide average, or if basin-specific data are lacking, exceeding the 90th percentile concentration for the period of record for all basins. Exceedance of any of these action levels would trigger Phase 2 - Tier 2 Expanded Monitoring and Risk Assessment.

It is recommended that bioaccumulative toxicants identified during the Phase 1 - Tier 1 data review (i.e., based on information contained in the ESA, available WQ database, or previous land uses) be included on the analyte list for fish tissues collected during the first year of the stabilization period, if analytical procedures exist. For toxicants other than mercury, more weight may need to be placed on whole-body residues in mosquitofish and sunfish (that will include organs that may preferentially accumulate other toxicants) to assess ecological risk than levels in fillets of largemouth bass. Furthermore, it should also be recognized that under certain circumstances taxa other than fish may be more appropriate biological sentinels depending on the toxicant and the risk assessment endpoint. For example, preliminary discussions have taken place regarding the possible use of the apple snail (*Pomacea paludosa*) to biomonitor potential copper exposure to the endangered snail kite (*Rostrhamus sociabilis plumbeus*). However, a thorough justification will be required in any plan that targets species other than mosquitofish, sunfish, or bass.

Tissue levels of other toxicants should not increase significantly over time or become elevated to the point of exceeding the critical tissue benchmark used to establish SQAGs or in risk assessments, exceeding the 90% upper confidence level of the annual basin-wide average, or if not available, exceeding the 90th percentile concentration for all basins. Exceedance of these action levels would trigger Phase 2 - Tier 2 Expanded Monitoring and Risk Assessment.

2.2 Phase 2 - Tier 2: Expanded Monitoring and Risk Assessment

Phase 2 - Tier 2 is triggered if one of the following action levels is exceeded:

- If annual outflow loads of THg or MeHg are significantly greater than inflow loads (i.e., based on an uncertainty analysis of loading estimates);
- If a WQS (in Chapter 62-302, F.A.C.) for a toxicant other than mercury is exceeded;
- If annual average levels of a residue in a given fish species increases progressively over time (i.e., two or more years) ($p < 0.1$);
- If annual average Hg levels in a given fish species become elevated to the point of exceeding the 90% upper confidence level of the basin-wide average, or if basin-specific data are lacking, exceeding the 90th percentile concentration for the period of record for all basins; or
- If residue levels of other toxicants in fish become elevated to the point of exceeding the critical tissue benchmark used to establish SQAGs or developed in risk assessments.

The following steps will be taken if any action level in Phase 2 - Tier 2 is triggered:

Step 1: Resample media (e.g., water or fish) that triggered Tier 2.

If results of Step 1 (i.e., re-sampling of media that triggered Tier 2) demonstrate that the anomalous condition was an isolated event, the project will revert back and continue with Phase 2 - Tier 1 monitoring. Alternatively, if results of Step 1 reveal anomalous condition was not an isolated event, proceed to Step 2.

Step 2 involves expanding the monitoring program as follows:

- Increase frequency of mosquitofish collection from quarterly to monthly.
- If Tier 2 was triggered by excessive loading or exceedance of a WQS at common outflow, then begin sampling discharges at outflows of each OU or independent treatment train to better define spatial extent of problem. If necessary (i.e., if loading uncertainty is high), increase frequency of surface water collection to monthly (reducing temporal interpolation), or as appropriate for hydraulic retention time (HRT).
- To further define spatial extent of problem, collect multiple mosquitofish composites from within the OU or treatment train exhibiting anomalous conditions.
- If Tier 2 was triggered by tissue levels in large-bodied fish, increase sample size of large-bodied fish to n = 20, i.e., 20 each of sunfish (collect various species and sizes) and/or bass (collect various sizes and extract otolith from bass for age determination).
- To evaluate possible trends in methylation rates in sediments (i.e., to determine if problem is improving or worsening), replicate sediment cores (0-4 cm) can be collected from the suspected methylation "hot spot" and reference locations within the component (for THg, MeHg, moisture content, TOC, TS, and TFe) over a given period of time (i.e., 2 to 4 months). At these same locations and times, collect pore water samples and analyze for THg, MeHg, and sulfides, or if no acceptable pore water protocol has been developed, acid-volatile sulfide (AVS) on solids.

Projects shown to have (spatially) large or multiple MeHg "hotspots" should consider use of the E-MCM or comparable model as an assessment tool (i.e., to synthesize results of expanded monitoring).

Step 2 will also include the notification of the permitting authority that anomalous conditions are continuing. The permitting authority and the permittee may then develop an adaptive management plan using the data generated from the expanded monitoring program. This plan will evaluate the potential risks from continued operation under existing conditions (i.e., through a risk assessment for appropriate ecological receptors). If risk under existing operational conditions is deemed acceptable, then project monitoring would continue under a modified Tier 2 scheme to monitor exposure. On the other hand, if risk under existing operational conditions is deemed unacceptable, then the adaptive management plan would then proceed to determine potential remedial actions to (1) reduce exposure and risk (e.g., signage for human health concerns, reduce fish populations,

reduce forage habitat suitability); if risk of acute toxicity - immediate drawdown of OU and reevaluation of ESA [Note that assessment of potential human health impacts and corrective actions (i.e., signage) will require the involvement of the Florida Department of Health]; and (2) affect mercury biogeochemistry to reduce net methylation (e.g., modify hydroperiod or stage, water quality).

In developing this adaptive management plan, the permitting authority may conduct a publicly noticed workshop to solicit comments from the permittee, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Park Service, the Florida Fish and Wildlife Conservation Commission, and other interested persons.

The next step would then be to carry out such remedial or corrective action. If the remedial or corrective action is demonstrated to be successful, then the project would revert back to Phase 2 - Tier 1 monitoring. Alternatively, if monitoring data indicate that the remedial action was unsuccessful in reducing fish tissue concentrations or downstream loading, the permitting authority and the permittee would then initiate a peer-reviewed, scientific assessment of the benefits and risks of the project.

3. Phase 3 - Routine Operational Monitoring (Post-Stabilization)

This section describes assessment measures, action levels and monitoring efforts for the project following the period of stabilization, i.e., during operation in years 4 through 9. Because of differences in the anticipated time frames under which sedimentary release and bioaccumulation are thought to occur, monitoring toxicants other than mercury in water or biological tissues is not a general recommendation past the first year of stabilization.

3.1 Phase 3 - Tier 1: Routine Operational Monitoring

If after the first three years of monitoring neither downstream loading nor residue levels in fishes exceed action levels, then (1) surface water sampling would be discontinued, (2) frequency of mosquitofish collection would be reduced to semiannually, and (3) frequency of large-bodied fish collection reduced to one collection event every three years.

Phase 2 - Tier 2 Monitoring and Risk Assessment during operation is triggered if one of the following action levels is exceeded:

- If annual average THg levels in mosquitofish progressively increased over time (i.e., two or more years) or become elevated to the point of exceeding the 90% upper confidence level of the basin-wide annual average or, if basin-specific data are lacking, exceed the 90^{th} percentile concentration for the period of record for all basins; or
- If triennial monitoring of large-bodied fish (i.e., in years 6 and 9) reveals tissue Hg levels in fishes has statistically increased, progressively over time (i.e., two or more years) or has become elevated to the point of exceeding the 90% upper confidence level of the

basin-wide annual average or, if basin-specific data are lacking, exceeded the 90th percentile concentration for the period of record for all basins.

On the other hand, if fishes collected under Phase 3 Operational Monitoring have not exceeded action levels by year 9, project-specific monitoring would be discontinued; future assessments would be based on regional monitoring under RECOVER. However, Project Managers are cautioned that action levels may be revised at a future date, owing to the likelihood that a tissue-based WQS will be adopted by the state within in next 9 to 10 years.

CONTRACTOR SELECTION CRITERIA

Given the inherent difficulties of ultra-trace monitoring, it is crucial that any contractor selected to carry out field collection has demonstrated prior performance or be trained by District staff and has a stringent quality assurance/quality control (QA/QC) program in place. Likewise, the analytical lab must also demonstrate prior performance in ultra-trace analysis, have a stringent QA/QC program (including inter-laboratory comparisons) and be capable of achieving desired method detection limits.

REPORTING REQUIREMENTS

The District shall submit an annual report to the permitting authority that summarizes the most recent data and compares them with the cumulative results from previous years. This report shall also evaluate assessment performance measures (i.e., action levels) outlined above.

CONTACTS

For assistance using this guidance document the reader should contact the following:

- Darren Rumbold (drumbol@District.gov)
- Richard Pfeuffer (rpfeuff@District.gov)

REFERENCES

ASTM. 1997a. E1706-00e1 test method for measuring the toxicity of sediment-associated contaminants with fresh water invertebrates. In ASTM annual book of standards, Vol. 11.05, American Society for Testing and Materials, Philadelphia, PA, pp.1138-1220.

ASTM. 1997b. E1688-00a standard guide for determination of the bioaccumulation of sediment-associated contaminants by benthic invertebrates. In ASTM annual book of standards, Vol. 11.05, American Society for Testing and Materials, Philadelphia, PA, pp.1072-1121.

Atkeson, T. and D. Axelrad. 2004. Chapter 2B: Mercury Monitoring, Research and Environmental Assessment. G. Redfield, ed. In: *2004 Everglades Consolidated Report*, South Florida Water Management District, West Palm Beach, FL.

Bloom, N.S. 1992. On the Chemical Form of Mercury in Edible Fish and Marine Invertebrates. *Can. J. Fish. Aquat. Sci.*, 49: 1010-1017.

Brannon, J.M., T.E. Myers and B.A. Tardy. 1994. Leachate Testing and Evaluation for Freshwater Sediments, U.S. Army Corps of Engineers, Waterways Experiment Station, Miscellaneous Paper D-94-1, 64 pp.

Eisenreich, S.J., B.B. Looney and J.D. Thornton. 1981b. Airborne organic contaminants in the Great Lakes ecosystem. *Environmental Science and Technology*, 15: 30-38.

Fernandez, A., R. Jaffe, P. Gardinali, G. Rand, Y. Cai, M. Cejas and W. Perry. 2003. Regional distribution of organic contaminants and trace metals in fish tissues from Everglades National Park. Abstracts form the 24th Annual Meeting of the Society of Environmental Toxicology and Chemistry.

Fink, L.E., D.G. Rumbold and P. Rawlik. 1999. Chapter 7: The Everglades Mercury Problem. G. Redfield, ed. In: *1999 Everglades Interim Report*, South Florida Water Management District, West Palm Beach, FL.

Grieb, T.M., C.T. Driscoll, S.P. Gloss, C.L. Schofield, G.L. Bowie and D.B. Porcella. 1990. Factors Affecting Mercury Accumulation in Fish in the Upper Michigan Peninsula. *Environ. Toxicol. Chem.*, 9: 919-930.

Goolsby, D.A., E.M. Thurman, M.L. Pomes and W.A. Battaglin. 1993. Occurrence, deposition, and long range transport of herbicides in precipitation in the midwestern and northeastern United States, in Selected Papers on Agricultural Chemicals in Water Resources of the Midcontinental United States. U.S. Geological Survey, Open-File Report 93-418, pp. 75-89.

Harris, R., D. Beals, D. Hutchinson and C.D. Pollman. 2004. Appendix 2B-2: Modeling Mercury Cycling and Bioaccumulation in Everglades Marshes with the Everglades Mercury Cycling Model (E-MCM). G. Redfield, ed. In: *2004 Everglades Consolidated Report*, South Florida Water Management District, West Palm Beach, FL.

Ingersoll, C.G., E.L. Brunson and F.J. Dwyer. 1998. Methods for assessing bioaccumulation of sediment-associated contaminants with freshwater invertebrates. National Sediment

Bioaccumulation Conference. U.S. Environmental Protection Agency, Office of Water. EPA 823-R-98-002.

Korhonen, P., M. Virtanen and T. Schultz. 1995. Bioenergetic calculation of methylmercury accumulation in fish. *Water, Air and Soil Pollution*, 80: 901-904.

MacDonald Environmental Sciences, LTD., and United States Geological Survey (2003). Development and evaluation of numerical sediment quality assessment guidelines for Florida Inland Waters. Report to Florida Department of Environmental Protection, Tallahassee, FL.

Miles, C.J. and R.J. Pfeuffer. 1997. Pesticides in canals of South Florida. Archives *Environmental Contamination and Toxicology*, 32: 337-345.

Norstrom, R. J., A.E. McKinnon and A.S.W. DeFreitas. 1976. A bioenergetics-based model for pollutant accumulation by fish. Simulation of PCB and MeHg residue levels in Ottawa River yellow perch (*Perca flavescens*). *J. Fish Res. Board Can.*, 33: 248-267.

Nuutinen, S. and J.V.K. Kukkonen. 1998. The effect of selenium and organic material in lake sediments on the bioaccumulation of methylmercury by *Lumbriculus variegatus* (Oligochaeta). *Biogeochemistry*, 40: 267-278.

Pfeuffer, R. and F. Matson. 20023. Pesticide Surface Water and Sediment Quality Report: October 2003 Sampling Event. South Florida Water Management District, West Palm Beach, FL. Available online at www.District.gov/curre/pest/pestindex.htm.

Pfeufer, R.J. and G.M. Rand. 2004. South Florida Ambient Pesticide Monitoring Program. *Ecotoxicology*, 13: 195-205.

Rodgers, D.W. 1994. You are what you eat and a little bit more: bioenergetics-based models of MeHg accumulation in fish revisited. C.J. Watras and J.W. Huckabee, eds. pp. 427-439. In: *Mercury Pollution Integration and Synthesis*, Lewis Publishers, Boca Raton, FL.

Rodgers, J.A., Jr., 1997. Pesticide and heavy metal levels of waterbirds in the Everglades agricultural area of south Florida. *Florida Field Naturalist*, 25: 33-41.

Rumbold, D.G., M.C. Bruner, M.B. Mihalik, E.A. Marti and L.L White. 1996. Organochlorine pesticides in anhingas, white ibises and apple snails collected in Florida, 1989-1991. *Archives of Environmental Contamination and Toxicology*, 30: 379-83.

Schultz T., P. Korhonen and M. Virtanen. 1995. A mercury model used for assessment of dredging impacts. *Water Air Soil Pollut.*, 80: 1171-1180.

Spalding, M.G., C.K. Steible, S.F. Sundlof and D.J. Forrester. 1997. Metal and organochlorine toxicants in tissues of nestling wading birds (Ciconiformes) from southern Florida. *Florida Field Naturalist*, 25: 42-50.

Stigliani, W.M., P. Doelman, W. Salomons, R. Schulin, G.R.B. Smidt and S. van der Zee. 1991. Chemical time bombs: Predicting the unpredictable. *Environment*, 33(4): 4-9; 26-30.

Stober, Q.J., K. Thornton, R. Jones, J. Richards, C. Ivey, R. Welch, M. Madden, J. Trexler, E. Gaiser, D. Scheidt and S. Rathbun. 2001. South Florida Ecosystem Assessment: - Everglades

Stressors Interaction: Hydropatterns, Eutrophication, Habitat Alteration, and Mercury Contamination. U.S. Environmental Protection Agency, Atlanta, GA. EPA 904-R-01-002.

USEPA. 1997. Mercury study Report to Congress. Volume VI: An Ecological Assessment for Anthropogenic Mercury Emissions in the United States. U.S. Environmental Protection Agency. EPA 452/R-97-008.

USEPA. 1999. Background Report on Fertilizer Use, Contaminants and Regulations. U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Washington D.C. EPA 747-R-98-003.

USEPA. 2001. Water Quality Criterion for the Protection of Human Health: Methylmercury. U.S. Environmental Protection Agency, Office of Science and Technology. EPA 823-R-01-001.

APPENDIX B

Wetland Classification, Wetland Rapid Assessment Procedure Data Sheets and Uniform Mitigation Assessment Method Data Sheets for the C-43 West Reservoir Project

Wetland Classification based on the percentage of woody, herbaceous, native, and exotic/nuisance vegetation within wetland.

Category	Vegetation
1	Native Herbaceous Dominated (<20% Shrub)
2	Native Mixed Herbaceous (20% to 49% Shrub)
3	Native Shrub Dominated (<20% Herbaceous or Trees)
4	Native Mixed Shrub (>50% shrub) with at least 20% Herbaceous or Trees
5	Native Tree Dominated (<20% Herbaceous or Shrubs)
6	Native Mixed Trees (>50% trees) with at least 20% Herbaceous or Shrubs
7	Exotic/Nuisance Herbaceous Dominated (<20% Shrub) Exotic/Nuisance >50 % Exotic/Nuisance present
8	Exotic/Nuisance Mixed Herbaceous (20% to 49% Shrub) >50 % Exotic/Nuisance present
9	Exotic/Nuisance Shrub Dominated (<20% Herbaceous) >50 % Exotic/Nuisance present
10	Exotic/Nuisance Mixed Shrub (20% to 49% Herbaceous) >50 % Exotic/Nuisance present
11	Exotic/Nuisance Tree Dominated (<20% Herbaceous or Shrub) >50 % Exotic/Nuisance present
12	Exotic/Nuisance Mixed Tree (20% to 49% Herbaceous or Shrub) >50 % Exotic/Nuisance present
13	Open Water

Example using Herbaceous and Shrub mixes:

0-19% Shrub = Herb Dominated
20 – 49% Shrub = Mixed Herb/Shrub Dominated
50% – 79% Shrub = Mixed Shrub/Herb Dominated
80 – 100% Shrub = Shrub Dominated

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator	Wetland Type
6/8/2004	6	FWS,SFWMD,USACE	9 - Exotic Shrub

Land Use	FLUUCS Code		Wetland Acreage
citrus	619	Description: exotic hardwood	9.15

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
0.5	0	0.5

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
1	1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE
0.22

Wildlife Utilization (WU)
common ground dove

Wetland Canopy (O/S)
Brazilian pepper, Salix caroliniana

Wetland Ground Cover (GC)
ferns, lantana

Habitat Support/Buffer

Field Hydrology (HYD)

WQ Input & Treatment (WQ)
surrounded by citrus; 3 ditches cut through the wetland

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/10/2004	7	FWS,SFWMD,USACE		2-Native Herb. Mixed

Land Use	FLUUCS Code		Wetland Acreage
citrus	641	Description: freshwater marsh	4.78

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	2	2.75

Field Hydrology (HYD): 2.5

WQ Input & Treatment (WQ): 2.2

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
citrus	2	0.4	0.8	
natural	3	0.6	1.8	
			0	
			0	
			0	Total
			0	2.6

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		0.4	0.8
natural	3		0.6	1.8
				0
				0
				0
		LU Total		2.6

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0.4	0
natural	3		0.6	1.8
				0
				0
				0
		PT Total		1.8

WRAP SCORE: 0.81

Wildlife Utilization (WU)
apple snails, various water insects, viceroy butterfly

Wetland Canopy (O/S)
Buttonbush, wax myrtle, willow, saltbush, corkwood

Wetland Ground Cover (GC)
fleabane, Sagittaria, sawgrass, beak rush, Bacopa, hydrocotyle, Centella, willow, camphorweed, maindencane, E. celluosa

Habitat Support/Buffer

Field Hydrology (HYD)
standing water in marsh area

WQ Input & Treatment (WQ)
surrounding land use is citrus

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
7/13/2004	9	FWS,SFWMD,USACE		6 - Native mixed tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	6240	Description: cypress and pine	2.58

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	2	2.5

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
2.25	2.75

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
Citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE
0.69

Wildlife Utilization (WU)
red-shouldered hawk

Wetland Canopy (O/S)
Southern willow, Cypress, cabbage palm, wax myrtle, button bush, Brazilian pepper, primrose willow

Wetland Ground Cover (GC)
smartweed, cattail, day flower, shield fern, royal fern, bacopa, pickeral weed, white vine, ceasar weed, lycopus, virgina creeper

Habitat Support/Buffer

Field Hydrology (HYD)
standing water

WQ Input & Treatment (WQ)
Ringed all the way around by berm and ditch = 2.75

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator	Wetland Type
7/13/2004	10	FWS,SFWMD,USACE	5 - Native tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	621	Description: cypress	3.98

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	1.75	2.25

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
2	1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE
0.58

Wildlife Utilization (WU)

Wetland Canopy (O/S)
pond cypress, brazilian pepper, cabbage palm, ficus, buttonbush, elderberry,

Wetland Ground Cover (GC)
saw fern, chain fern, bog hemp, polypoid fern, muscadine, poke week, seasar weed

Habitat Support/Buffer
ring of young B. pepper surrounding cypress

Field Hydrology (HYD)
water marks on base of trees

WQ Input & Treatment (WQ)
surrounded by citrus; no obvious ditching/berms

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator	Wetland Type
7/15/2004	11	FWS,SFWMD,USACE	10 - Exotic mixed shrub

Land Use	FLUUCS Code		Wetland Acreage
	619	Description: exotic hardwoods	3.86

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	1.5	2

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
2.75	1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE
0.57

Wildlife Utilization (WU)
turtles, zebra longwing butterflies

Wetland Canopy (O/S)
Cypress, brazilian pepper, elderberry

Wetland Ground Cover (GC)
saw fern, muscadine, leather fern, ficus, guava, ligodium, virginia creeper, beauty berry

Habitat Support/Buffer

Field Hydrology (HYD)
standing waterfrom overflow of middle ditch - no spoil adjacent to ditch

WQ Input & Treatment (WQ)
surrounded by citrus; ditch runs all around and through middle

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/8/2004	15	FWS,SFWMD,USACE		6 - Native mixed tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	621	Description: cypress	4.91

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1.5	1.5	2

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
2	1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE
0.50

Wildlife Utilization (WU)
Carolina wren, parula, cardinal, red-shouldered hawk, flicker, blue jay, white eyed vireo, dove, southern broken dash giant and black swallowtails, buckeye, white peacock, zebra long wing, viceroy, great southern white, Gulf fritillary

Wetland Canopy (O/S)
pond cypress, strangler fig, carolina willow
braziian pepper midstory

Wetland Ground Cover (GC)
leather fern, chain fern, saw fern, shield fern, boston fern, swamp fern, royal fern, muscadine, duckweed, pennywort, salvinia, Ludwigia repens

Habitat Support/Buffer

Field Hydrology (HYD)
hydric soil, watermark on trees indicating water depth

WQ Input & Treatment (WQ)
ditched around the entire wetland and through the middle

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/9/2004	18	FWS,SFWMD,USACE		9 - Exotic shrub

Land Use	FLUUCS Code		Wetland Acreage
citrus	619	Description: exotic hardwood	3.07

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	1.25	2

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
2.25	1.8

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
	1.5	0.6	0.9	
	1.5	0.4	0.6	
			0	
			0	
			0	Total
			0	1.5

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		0.6	1.2
natural	3		0.4	1.2
				0
				0
				0
			LU Total	2.4

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
no treatment	0	1	0.6	0
Natural	3		0.4	1.2
				0
				0
				0
			PT Total	1.2

WRAP SCORE
0.60

Wildlife Utilization (WU)
great egret, northern flicker, green tree frogs, tadpoles, crayfish, various waterbugs, apple snails

Wetland Canopy (O/S)
Baccharis, cabbage palm, pond cypress, willow, Brazilian pepper, wax myrtle, red bay

Wetland Ground Cover (GC)
fleabane, stinkweed, muscadine, leather and shield fern, saw grass, Sagittaria lancifolia, Pharagmites, pennywort, St. John's wort, smartweed, Virginia creeper, loose striff, widgen grass, pickeral weed, Mycaenea, sedges

Habitat Support/Buffer

Field Hydrology (HYD)

WQ Input & Treatment (WQ)
No obvious ditching within or adjacent to wetland; surrounded by citrus and marsh

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/9/2004	32 South	FWS,SFWMD,USACE		5 - Native tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	621	Description:	

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1.5	2.5	2.5

Field Hydrology (HYD): 1.75

WQ Input & Treatment (WQ): 1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
citrus	1	0.7	0.7	
road	1	0.3	0.3	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		0.7	1.4
road	2		0.3	0.6
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0	1	0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE: 0.57

Wildlife Utilization (WU)
white-eyed vireo, blue jay, ground dove, red-bellied woodpecker, cardinal, giant swallowtail

Wetland Canopy (O/S)
pond cypress, cabbage palm, red bay, laurel oak, wax myrtle, strangler fig, pond apple

Wetland Ground Cover (GC)
saw fern, string fern, royal fern, boston fern, chain fern, bromeliads, muscadine, Virginia creeper, leather fern, white vine

Habitat Support/Buffer

Field Hydrology (HYD)

WQ Input & Treatment (WQ)
shallow ditch around perimeter; dirt road along south side and then Header canal; citrus around remainder

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator	Wetland Type
6/9/2004	38	FWS,SFWMD,USACE	10 - Exotic mixed shrub

Land Use	FLUUCS Code		Wetland Acreage
citrus	619	Description: exotic hardwoods	

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
0.5	0.5	0.5

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
0.5	1.4

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
citrus	1	0.8	0.8	
natural	1	0.2	0.2	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		0.8	1.6
natural	3		0.2	0.6
				0
				0
				0
			LU Total	2.2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
natural	3	1	0.2	0.6
	0		0.8	0
				0
				0
				0
			PT Total	0.6

WRAP SCORE
0.24

Wildlife Utilization (WU)
queen & white peacock butterflies, ground dove, red bellied woodpecker
Wetland Canopy (O/S)
baccharis, wax myrtle
Wetland Ground Cover (GC)
Bidens palosa, pokeweed, dog fennel, lantana, cattail, solidago, fleabane, Andropogon
Habitat Support/Buffer
Field Hydrology (HYD)
sandy soil
WQ Input & Treatment (WQ)
ring entirely by ditch; citrus

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/9/2004	44	FWS,SFWMD,USACE		9 - Exotic shrub

Land Use	FLUUCS Code		Wetland Acreage
citrus	619	Description: exotic hardwoods	

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1	1	1

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
0.5	1.8

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
citrus	1.5	0.6	0.9	
natural	1.5	0.4	0.6	
			0	
			0	
			0	Total
			0	1.5

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		0.6	1.2
natural	3		0.4	1.2
				0
				0
				0
			LU Total	2.4

Pretreatment Category (PT)

PT Category	(Score)	X		% of area	Subtotals
	0		1	0.6	0
Natural	3			0.4	1.2
					0
					0
					0
				PT Total	1.2

WRAP SCORE
0.38

Wildlife Utilization (WU)
Red-bellied woodpecker, common yellow throat, blue jay, zebra longwing, buckeye, giant swallowtail, viceroy, white-eyed vireo, green treefrog, snake, rabbit signs

Wetland Canopy (O/S)
Baccharis, cabbage palm, pond cypress. dahoon holly, Brazilian pepper, white vine, wax myrtle, elder berry

Wetland Ground Cover (GC)
fleabane, foxtail, soda apple, Andropogon, muscadine, Boston fern, Royal fern, Saw fern, Sagittaria lancifolia, juncus, 3 species primrose (repens, peruvian,?) bog hemp, balsam apple, sweet broom, cattail, Bacopa, Salix 2 spp.

Habitat Support/Buffer

Field Hydrology (HYD)
dry soil

WQ Input & Treatment (WQ)
No aparent ditches

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/9/2004	45	FWS,SFWMD,USACE		5 - Native tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	621	Description: cypress	3.11

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1.5	2.5	2.5

Field Hydrology (HYD): 1.5

WQ Input & Treatment (WQ): 1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
citrus	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0	1	0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE: 0.56

Wildlife Utilization (WU)	white checkered skipper, common ground dove, red-bellied woodpecker, cardinal, blue jay, great-crested flycatcher, caroloina wren, downy woodpecker, ground skink, great southern white, giant and palamedes and black swallowtail, white peacock
Wetland Canopy (O/S)	pond cypress, strangkler fig, Carolina willow, cabbage palm, red bay, laurel oak
Wetland Ground Cover (GC)	ludwigia, ferns, pennywort, sagitaria,muscadine, elderberry, wax myrtle, pokeweed, fireweed, parietaria sp, wild cucumber, butterfly orchid, bog hemp, bromeiliad
Habitat Support/Buffer	
Field Hydrology (HYD)	
WQ Input & Treatment (WQ)	ditch and dirt road along one side; surrounded by citrus

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/8/2004	58	FWS,SFWMD,USACE		11 - Exotic tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	619	Description: exotic wetland hardoods	1.28

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1	0.5	2

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
1.5	2.75

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
citrus	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE
0.49

Wildlife Utilization (WU)
armadillo, white eyed vireo, blue jay, red-shouldered hawk, catbird, dove

Wetland Canopy (O/S)
willow, minimal pond cypress, Brazilian pepper

Wetland Ground Cover (GC)
Virginia creeper, chain fern, saw fern

Habitat Support/Buffer

Field Hydrology (HYD)
hydric soil

WQ Input & Treatment (WQ)

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
7/14/2004	59	FWS,SFWMD,USACE		11 - Exotic tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	619	Description: exotic wetland hardoods	1.32

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1.5	0.5	1

Field Hydrology (HYD): 0.5

WQ Input & Treatment (WQ): 1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

LU Category	Land Use Category (LU) (Score)	X	% of area	Subtotals
	2		1	2
				0
				0
				0
				0
			LU Total	2

PT Category	Pretreatment Category (PT) (Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE: 0.31

Wildlife Utilization (WU)

Wetland Canopy (O/S)
Cypress, Sabal palm, Brazilian Pepper, Southern Willow, primrose willow

Wetland Ground Cover (GC)
duckweed, shield fern

Habitat Support/Buffer

Field Hydrology (HYD)

WQ Input & Treatment (WQ)
surrounded by citrus; ditch runs along one side

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
7/15/2004	60	FWS,SFWMD,USACE		11 - Exotic tree

Land Use	FLUUCS Code		Wetland Acreage
citrus	619	Description: exotic wetland hardoods	0.64

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1.5	0.5	1

Field Hydrology (HYD): 0.5

WQ Input & Treatment (WQ): 1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE: 0.31

Wildlife Utilization (WU)
Hogs; lots of bird activity: cardinals, blue jays, herons

Wetland Canopy (O/S)
Brazilian Pepper, Southern willow

Wetland Ground Cover (GC)
leather fern

Habitat Support/Buffer

Field Hydrology (HYD)

WQ Input & Treatment (WQ)
surrounded by citrus; ditched through middle

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
7/13/2004	61	FWS,SFWMD,USACE		2 - native herb mixed

Land Use	FLUUCS Code		Wetland Acreage
citrus	641	Description: freshwater marsh	0.64 acres

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1	1	2

Field Hydrology (HYD): 0.5

WQ Input & Treatment (WQ): 1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

LU Category	Land Use Category (LU) (Score)	X	% of area	Subtotals
	2	1	2	
			0	
			0	
			0	
			0	
		LU Total	2	

PT Category	Pretreatment Category (PT) (Score)	X	% of area	Subtotals
	0	0	0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE: 0.36

Wildlife Utilization (WU)

Wetland Canopy (O/S)
southern willow, elderberry, primrose willow

Wetland Ground Cover (GC)
night shade, poke weed, phragmites, balsam apple

Habitat Support/Buffer

Field Hydrology (HYD)

WQ Input & Treatment (WQ)
surrounded by citrus; no evident ditches

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
6/9/2004	87	FWS,SFWMD,USACE		10

Land Use	FLUUCS Code		Wetland Acreage
citrus	618/631	Description: Exotic mixed Shrub	

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1	0.5	0.5

Field Hydrology (HYD): 0.5

WQ Input & Treatment (WQ): 1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
citrus	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0	1	0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE: 0.25

Wildlife Utilization (WU)
common ground dove

Wetland Canopy (O/S)
Ludwigia peruviana, elderberry, brazilian pepper, pond cypress,

Wetland Ground Cover (GC)
ceasar weed, swamp fern, chain fern, smilax, sagitaria/habenaria

Habitat Support/Buffer

Field Hydrology (HYD)

WQ Input & Treatment (WQ)
No evident ditch connected to it; citrus surrounding

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
7/13/2004	114	FWS,SFWMD,USACE		13

Land Use	FLUUCS Code		Wetland Acreage
citrus	534	Description: reservoir, detention pond	

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	N/A	0.75

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ): 1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
Citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		0	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE: 0.45

Wildlife Utilization (WU)
bull frog, purple gallinule, common grackle, black swallowtail and white peacock butterflies

Wetland Canopy (O/S)
southern willow, primrose willow, baccharis

Wetland Ground Cover (GC)
water lettuce, smart weed, cattail, torpedo grass

Habitat Support/Buffer

Field Hydrology (HYD)
standing water - detention pond

WQ Input & Treatment (WQ)
ditched along one side

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
7/13/2004	Header Canal	FWS,SFWMD,USACE		Primary canal

Land Use	FLUUCS Code		Wetland Acreage
citrus	510	Description: primary irrigation canal	88.79

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2.5	N/A	1

Field Hydrology (HYD): 2.5

WQ Input & Treatment (WQ): 1.5

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
citrus	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	1		1	1
				0
				0
				0
				0
			PT Total	1

WRAP SCORE: 0.57

Wildlife Utilization (WU)
white and glossy Ibis, green heron, little blue heron, snowy egret, great egret, grackles, swallow tailed kites

Wetland Canopy (O/S)
along slope/border of canal: button bush, wild rice, nuphar

Wetland Ground Cover (GC)
alligator weed, duckweed, water hyacinth, water lettuce, wild taro, torpedo grass

Habitat Support/Buffer

Field Hydrology (HYD)
standing water- main water supply for irrigation/pumps

WQ Input & Treatment (WQ)

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator		Wetland Type
7/15/2004	Secondary canal	FWS,SFWMD,USACE		Secondary canal

Land Use	FLUUCS Code		Wetland Acreage
citrus	510	Description: secondar irrigation canal	209.7

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
2	N/A	0.25

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ): 1.5

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Habitat Support/Buffer

Buffer Type	(Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	1		1	1
				0
				0
				0
				0
			PT Total	1

WRAP SCORE: 0.45

Wildlife Utilization (WU)
wading birds, fish, alligator

Wetland Canopy (O/S)
N/A

Wetland Ground Cover (GC)
alligatorweed, hydrilla, coontail, duckweed, torpedo grass

Habitat Support/Buffer

Field Hydrology (HYD)
standing water

WQ Input & Treatment (WQ)

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator	Wetland Type
7/28/2005	tertiary ditch	FWS,SFWMD, USACE, EPA, FDACS, SEA	Tertiary ditch

Land Use	FLUUCS Code		Wetland Acreage
citrus	500	Description: tertiary irrigation canal	636.14

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1.5	N/A	0.5

Field Hydrology (HYD): 2

WQ Input & Treatment (WQ): 1.25

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

LU Category	Land Use Category (LU) (Score)	X	% of area	Subtotals
	2		1	2
				0
				0
				0
				0
			LU Total	2

PT Category	Pretreatment Category (PT) (Score)	X	% of area	Subtotals
	0.5		1	0.5
				0
				0
				0
				0
			PT Total	0.5

WRAP SCORE: 0.42

Wildlife Utilization (WU)
Apple snails, fish, alligator, wading birds.

Wetland Canopy (O/S)
N/A

Wetland Ground Cover (GC)
alligatorweed, hydrilla, coontail, duckweed, torpedo grass

Habitat Support/Buffer
Generally surrounded by maintenance roads and citrus groves

Field Hydrology (HYD)
ditch system within a citrus grove

WQ Input & Treatment (WQ)
untreated water enter wetland through ditch matrix

Wetland Rapid Assessment Procedure
C-43 Storage Reservoir Project Data Collection Sheet

Date	Wetland ID	Evaluator	Wetland Type
7/28/2005	C-43 West Reservoir	FWS,SFWMD, USACE, EPA, FDACS, SEA	C-43 West Reservoir

Land Use	FLUUCS Code		Wetland Acreage
citrus	531	Description: open water	10,492

Wildlife Utilization(WU)	Wetland Canopy (O/S)	Wetland Ground Cover (GC)
1.5	N/A	0.5

Field Hydrology (HYD)	WQ Input & Treatment (WQ)
N/A	1

The value of WQ is obtained by adding the TOTAL scores of LU and pre-treatment categories and dividing by 2

Buffer Type	Habitat Support/Buffer (Score)	X (% of area)	Subtotals	
	1	1	1	
			0	
			0	
			0	
			0	Total
			0	1

Land Use Category (LU)

LU Category	(Score)	X	% of area	Subtotals
	2		1	2
				0
				0
				0
				0
			LU Total	2

Pretreatment Category (PT)

PT Category	(Score)	X	% of area	Subtotals
	0		1	0
				0
				0
				0
				0
			PT Total	0

WRAP SCORE
0.33

Wildlife Utilization (WU)
anticipated that fish, reptiles, and wading birds will utilize the reservoir

Wetland Canopy (O/S)
N/A

Wetland Ground Cover (GC)
minimal ground cover

Habitat Support/Buffer

Field Hydrology (HYD)
N/A

WQ Input & Treatment (WQ)
no anticipated pre-treatment

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		10
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/13/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

	w/o pres or current	with	
.500(6)(a) Location and Landscape Support	4		Located within actively maintained citrus grove with frequent human presence.
.500(6)(b)Water Environment (n/a for uplands)	6		No agricultural ditch or berm.
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	6		Primrily Brazilian pepper with 30% Cypress canopy cover. See WRAP datasheet for details.

Score = sum of above scores/30 (if uplands, divide by 20)	current or w/o pres	with
	0.53	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation) (See Sections 62-345.500 and .600, F.A.C.)** Fish and Wildlife

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		11
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/14/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence	4	
.500(6)(b)Water Environment (n/a for uplands)	Agricultural ditch and berm surrounds the wetland and another cuts through the middle.	4	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Approximately 60% Brazilian pepper and 40% Cypress. See WRAP datasheet for detail.	4	

Score = sum of above scores/30 (if uplands, divide by 20)	current or w/o pres	with
	0.40	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		15
Impact or Mitigation	Assessment conducted by:	Assessment date:
impact	FWS, USACE, SFWMD	6/8/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	Evidence water levels are lower than appropriate but water level indicators distinct. Hydric soils.	7	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Cypress dominated. Other species include Carolina willow; leather, chain, and swamp fern; salvinia duck weed, penny wort, Brazilian pepper.	4	

Score = sum of above scores/30 (if uplands, divide by 20)	current or w/o pres	with
	0.5	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Fish and Wildlife

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		18
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	6/10/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	5	
.500(6)(b)Water Environment (n/a for uplands)	No agricultural ditches surrounding or bisecting the wetland. Standing water present.	8	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Willow dominated wetland with Cypress, cabbage palm, saw grass, sagittaria, mermaid weed, Bacopa sp., wax myrtle, loose strife, wigeon grass, phragmites, red bay, leather fern,	6	

Score = sum of above scores/30 (if uplands, divide by 20)	current or w/o pres	with
	0.63333	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		32
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS,USACE, SFWMD	6/9/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence. Adjacent to agricultural road and canal.	4	
.500(6)(b)Water Environment (n/a for uplands)	Shallow ditch bisecting wetland.	7	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Cypress dominated wetland with approximately 10 % cabbage palm. Understory includes: saw fern, string fern, royal fern, boston fern, chain fern, bromeliads, muscadine, Virginia creeper, leather fern, white vine.	7	

Score = sum of above scores/30 (if uplands, divide by 20)		If preservation as mitigation,	For impact assessment areas
current or w/o pres	with	Preservation adjustment factor =	FL = delta x acres =
0.6		Adjusted mitigation delta =	

Delta = [with-current]	If mitigation	For mitigation assessment areas
	Time lag (t-factor) =	RFG = delta/(t-factor x risk) =
	Risk factor =	

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		38
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS,USACE, SFWMD	6/9/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	Wetland completely surrounded/ringed by berm and ditch.	1	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Shrub community dominated by primrose willow, baccharis, and wax myrtle. 20% canopy cover includes willow and cypress. Ground cover includes: Bidens palosa, pokeweed, dog fennel, lantana, cattail, solidago, fleabane, Andropogon	1	

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
	0.2	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		44
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	6/9/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	5	
.500(6)(b)Water Environment (n/a for uplands)	Wetland not ringed or ditched.	2	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Shrub community dominated by baccharus with cattail. See WRAP datasheet for detail.	3	

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
	0.33	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		45
Impact or Mitigation	**Assessment conducted by:**	**Assessment date:**
Impact	FWS, USACE, SFWMD	6/9/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

.500(6)(a) Location and Landscape Support w/o pres or current: 4 with:	Located within actively maintained citrus grove with frequent human presence.
.500(6)(b)Water Environment (n/a for uplands) w/o pres or current: 4 with:	Agricultural ditch and berm borders one side of wetland.
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community w/o pres or current: 6 with:	Remnant cypress dome. See WRAP data sheet for details.

Score = sum of above scores/30 (if uplands, divide by 20)	If preservation as mitigation,	For impact assessment areas
current or w/o pres: 0.47 with:	Preservation adjustment factor =	FL = delta x acres =
	Adjusted mitigation delta =	

Delta = [with-current]	If mitigation	For mitigation assessment areas
	Time lag (t-factor) =	RFG = delta/(t-factor x risk) =
	Risk factor =	

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		58
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	6/8/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	No agricultural ditch or berm present	5	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Brazilian pepper and willow dominated. See WRAP data sheets for detail.	3	

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
	0.4	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Fish and Wildlife

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		59
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/14/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

	w/o pres or current	with	
.500(6)(a) Location and Landscape Support	4		Located within actively maintained citrus grove with frequent human presence.
.500(6)(b)Water Environment (n/a for uplands)	2		Agricultural ditch borders one side of the wetland.
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	2		Vegetation community is primarily dominated by Brazilian pepper with some Cypress. See WRAP datasheet for detail.

Score = sum of above scores/30 (if uplands, divide by 20)		
current or w/o pres	with	
0.27		

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Storage Reservoir		6
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/13/2004

Scoring Guidance: The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface water functions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

	w/o proj or current	with
500(6)(a) Location and Landscape Support: Located within actively maintained citrus grove with frequent human presence	4	
500(6)(b)Water Environment (n/a for uplands): Hydrology altered by three agricultural ditches cutting through the wetland	2	
500(6)(c)Community structure: 1. Vegetation and/or 2. Benthic Community: Atypical vegetation community dominated by the exotic Brazilian Pepper	1	

Score = sum of above scores/30 of uplands, divide by 20	w/o proj current	with
	0.233	

If preservation as mitigation:	For impact assessment areas:
Preservation adjustment factor =	FL = delta x acres =
Adjusted mitigation delta =	

Delta = [with-current]	If mitigation:	For mitigation assessment areas:
	Time lag (T-factor) =	RFG = delta/(1-factor x risk) =
	Risk factor =	

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
Berry Groves		A7
Impact or Mitigation	Assessment conducted by	Assessment date
		6/10/2004

Scoring Guidance: The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface water functions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

	w/o proj or current	with
500(6)(a) Location and Landscape Support	5	
500(6)(b)Water Environment (n/a for uplands)	9	
500(6)(c)Community structure: 1. Vegetation and/or 2. Benthic Community	6	

Score = sum of above scores/30 of uplands, divide by 20	w/o proj current	with
	0.73333	

If preservation as mitigation:	For impact assessment areas:
Preservation adjustment factor =	FL = delta x acres =
Adjusted mitigation delta =	

Delta = [with-current]	If mitigation:	For mitigation assessment areas:
	Time lag (T-factor) =	RFG = delta/(1-factor x risk) =
	Risk factor =	

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		Berry Groves - 60
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/14/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	Agricultural ditch bisects wetland.	2	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Vegetation dominated by Brazilian pepper. See WRAP datasheet for detail.	2	

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
	0.27	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		61
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/14/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	No agricultural ditch or berm. Dryer than normal.	2	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Phragmites and elderberry dominated. See WRAP datasheet for detail.	2	

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
	0.27	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		7
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS,USACE, SFWMD	6/10/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence. Relatively large wetland complex adjacent to freshwater marsh. Standing water present.	5	
.500(6)(b)Water Environment (n/a for uplands)	Water levles were apprpriate for the wetland community. Standing water present.	9	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Buttonbush swamp with Eleocharis spp., sawgrass, sagittaria, bacopa, maidencane, willow, wax myrtle	8	

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
	0.73333	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		87
Impact or Mitigation	**Assessment conducted by:**	**Assessment date:**
Impact	FWS, USACE, SFWMD	6/9/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

.500(6)(a) Location and Landscape Support w/o pres or current: 4 with:	Located within actively maintained citrus grove with frequent human presence.
.500(6)(b)Water Environment (n/a for uplands) w/o pres or current: 2 with:	No agricultural ditches or berms present.
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community w/o pres or current: 2 with:	primrose willow dominated wetland with approximately 20% cypress canopy cover. See WRAP datasheet.

Score = sum of above scores/30 (if uplands, divide by 20)	If preservation as mitigation,	For impact assessment areas
current or w/o pres: 0.27 with:	Preservation adjustment factor = Adjusted mitigation delta =	FL = delta x acres =

Delta = [with-current]	If mitigation	For mitigation assessment areas
	Time lag (t-factor) = Risk factor =	RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Fish and Wildlife

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		9
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/13/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence. Surrounded/ringed by agricultural ditch and berm limiting wildlife assessibility and altered hydrology.	4	
.500(6)(b)Water Environment (n/a for uplands)	Standing water present. Hydrology slightly altered by berm and ditch surrounding wetland.	7	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Majority of species present apprpriate/desirable, minimal exotics. Vegetation included: Southern willow, Cypress, cabbage palm, wax myrtle, button bush, Brazilian pepper, primrose willow, smartweed, cattail, day flower, shield fern, royal fern, bacopa, pickeral weed, white vine, ceasar weed,lycopus, virgina creeper	7	

Score = sum of above scores/30 (if uplands, divide by 20)		
current or w/o pres	with	
0.60		

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Fish and Wildlife

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		Primary Canal (header canal)
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/13/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	Water present, levels vary due to rainfall, pumping and water control structures.	4	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Vegetation present included wild rice buttonbush, water lettuce, torpedo grass, elephant ear, alligator weed, water hyacinth. See WRAP datasheet for detail.	4	

Score = sum of above scores/30 (if uplands, divide by 20)	current or w/o pres	with
	0.40	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		Secondary Canal
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/13/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	Water present, levels vary due to rainfall, pumping and water control structures.	4	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Vegetation included hydrilla, coontail, duck weed, torpedo grass, alligator weed, water hyacinth. See WRAP datasheet for detail.	4	

Score = sum of above scores/30 (if uplands, divide by 20)	current or w/o pres	with
	0.40	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation)** Fish and Wildlife
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		Teritary Canal
Impact or Mitigation	Assessment conducted by:	Assessment date:
Impact	FWS, USACE, SFWMD	7/13/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.	4	
.500(6)(b)Water Environment (n/a for uplands)	Water generally present, levels vary due to rainfall, pumping and water control structures.	4	
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Vegetation included torpedo grass, alligator weed, coontail, duck weed. See WRAP datasheet for detail.	4	

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
	0.40	

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

Annex A **PART II – Quantification of Assessment Area (impact or mitigation) (See Sections 62-345.500 and .600, F.A.C.)** Fish and Wildlife

Site/Project Name	Application Number	Assessment Area Name or Number
C-43 West Reservoir		Reservoir
Impact or Mitigation	Assessment conducted by:	Assessment date:
Mitigation	FWS, USACE, SFWMD	7/13/2004

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

		w/o pres or current	with
.500(6)(a) Location and Landscape Support	Located within actively maintained citrus grove with frequent human presence.		4
.500(6)(b)Water Environment (n/a for uplands)	Water generally present. Levels will vary based on rainfall and downstream needs for freshwater releases.		2
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	Vegetation minimal. Anticipated that floating-leaved and submergent plants may become established depending on frequency and duration of drawdowns. Emergent wetland vegetation could become established during extend drawdowns but won't persist after reservoir rehydrated.		2

Score = sum of above scores/30 (if uplands, divide by 20)		
	current or w/o pres	with
		0.27

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]

If mitigation
Time lag (t-factor) =
Risk factor =

For mitigation assessment areas
RFG = delta/(t-factor x risk) =

Form 62-345.900(2), F.A.C. [effective date 02-04-2004]

PART I – Qualitative Description
(See Section 62-345.400, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
Acceler8 Projects		Caloosahatchee Estuary- Tapegrass beds

FLUCCs code	Further classification (optional)	Impact or Mitigation Site?	Assessment Area Size
645 - Submerged aquaitc vegetation		mitigation	4,130 acres

Basin/Watershed Name/Number	Affected Waterbody (Class)	Special Classification (i.e OFW, AP, other local/state/federal designation of importance)
Caloosahatchee Estuary	Class III	OFW

Geographic relationship to and hydrologic connection with wetlands, other surface water, uplands

The Caloosahatchee Estuary is hydrologically connected to upsteam wetlands by the Caloosahatchee River (C-43) then Lake Okeechobee in which flows are regulated by the S235 (Lake O), the S-78 and S-79 pumping structures along the C-43 and to downstream wetlands through flows from the river into a delta type system then flowing primarily west to San Carlos Bay, Matlacha Pass and Pine Island Sound and south along the coast to Estero Bay and the Gulf of Mexico.

Assessment area description

The Caloosahatchee Estuary is a delta type system receiving freshwater inflows from the Caloosahatchee River (C-43). Due to regulatory releases in Lake Okeechobee, the increase in freshwat water flows and the lack of MFL attainment have severly affected the overall health of the estuarine system through extreme fluctuations in salinity levels between the wet and dry seasons, and thus, the reducing the spatial extent of seagrasses (*Halodule* sp. and *Thalassia* sp.) and oysters in the middle and lower estuary and tapegrass (*Vallisneria* sp.) in the upper estuary. Extreme flows are also associated with high nutrient loading to the estuary and have contributed to poor water quality conditions in the estuary.

Significant nearby features	Uniqueness (considering the relative rarity in relation to the regional landscape.)
Urban development along the north and south borders of the estuary, increases in urban runoff flowing into the estuary due to a lack of mangrove and upland buffers.	Tapegrass is a salt tolerant, freshwater, submerged plant that has limited distribution in the upper estuary. Tapegrass beds provide food and habitat for many other species and are considered an indicator of estuarine health where they occur.

Functions	Mitigation for previous permit/other historic use
Tapegrass beds in the upper estuary provide foraging habitat for wood storks and manatees and provide feeding, breeding, and escape cover for commercial and sport fisheries and shellfish, aquatic birds, invertebrates, and other estuarine species.	None

Anticipated Wildlife Utilization Based on Literature Review (List of species that are representative of the assessment area and reasonably expected to be found)	Anticipated Utilization by Listed Species (List species, their legal classification (E, T, SSC), type of use, and intensity of use of the assessment area)
Aquatic dependant birds (native and migratory), fish, benthic macroinvertebrates, manatees, small mammals, shellfish, phytoplankton, zooplankton	Wood Stork, Bald Eagle, West Indiatn manatee, Smalltooth Sawfish

Observed Evidence of Wildlife Utilization (List species directly observed, or other signs such as tracks, droppings, casings, nests, etc.):

Fish, shellfish, Smalltooth Sawfish, Wood Storks, Bald Eagles, Manatees, birds, invertebrates

Additional relevant factors:

The estuaries overall health is considered poor due to the high volume freshwater inflow decreasing salinity levels, lack of seagrasses and quality of the water.

Assessment conducted by:	Assessment date(s):
SFWMD, USACE, USEPA, USFWS	6/13/2007

Form 62-345.900(1), F.A.C. [effective date of 2/2/04]

Annex A

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
Accelerit Projects		Caloosahatchee Estuary-Tapegrass beds
Impact or Mitigation	Assessment conducted by:	Assessment date:
Mitigation	SFWMD, USACE, USEPA, USFWS	6/13/2007

Scoring Guidance: The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface water functions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

500(6)(a) Location and Landscape Support

w/o proj or current: 6 | with: 6

Existing Conditions: Assessment area extends from the Franklin Lock and Dam structure (i.e., S-79) west to the Cape Coral Bridge which is the existing and predicted expansion area for tapegrass(*Vallisneria* sp.). **With Project** The C-43 West Reservoir project will construct an above-ground reservoir on an existing 10,400-acre parcel primarily consisting of citrus operations.

500(6)(b)Water Environment (n/a for uplands)

w/o proj or current: 2 | with: 6

Existing Conditions: Assessment area receives basin runoff, which is primarily agricultural in the upper basin and urban in the lower basin, as well as a damaging regulatory releases from Lake Okeechobee. This results in poor water quality and too much fresh water during the wet season and not enough water during the dry season. **With project:** Wet season basin runoff and regulatory releases from Lake Okeechobee will be captured by and stored in the C-43 Reservoir to be released during the dry season to improve salinity conditions in the upper estuary. Augmenting dry season flows will directly benefit the tapegrass beds by maintaining flows at S-79 at a minimum of 450 cfs and preventing salinity levels to increase above the tolerance tapegrass for prolonged periods. No water quality concern is associated with the reservoir

500(6)(c)Community structure

1. Vegetation and/or
2. Benthic Community

w/o proj or current: 2 | with: 6

Existing Conditions: Reduced extent or even complete loss of existing tapegrass beds due to lack of freshwater releases at S-79 during drought conditions. **With project:** Tapegrass beds are expected to recover to 2000 conditions and expand as minimum flows of 450 cfs are maintained at S-79 and salinity conditions improve. Associated invertebrate and fish communities are also expected to return.

Score = sum of above scores/30 (if uplands, divide by 20)
current: 0.33 | w/o proj: | with: 0.60

Delta = [with-current]: 0.27

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

If mitigation
Time lag (-factor) = 1.25
Risk factor = 2

For impact assessment areas
FL = delta x acres =

For mitigation assessment areas
RFG = delta/(1-factor x risk)*init acres =
446

Form 62-345.900(2), F.A.C. (effective date 2/2/04)

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
Accelerit Projects		Caloosahatchee Estuary-Tapegrass beds
Impact or Mitigation	Assessment conducted by:	Assessment date:
Mitigation	SFWMD, USACE, USEPA, USFWS	6/13/2007

Scoring Guidance: The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface water functions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

500(6)(a) Location and Landscape Support

w/o proj or current: 6 | with: 6

Existing Conditions: Assessment area extends from the Franklin Lock and Dam structure (i.e., S-79) west to the Cape Coral Bridge which is the existing and predicted expansion area for tapegrass(*Vallisneria* sp.). **With Project** The C-43 West Reservoir

500(6)(b)Water Environment (n/a for uplands)

w/o proj or current: 2 | with: 6

Existing Conditions: Assessment area receives basin runoff, which is primarily agricultural in the upper basin and urban in the lower basin, as well as a damaging regulatory releases from Lake Okeechobee. This results in poor water quality and too much fr

500(6)(c)Community structure

1. Vegetation and/or
2. Benthic Community

w/o proj or current: 2 | with: 6

Existing Conditions: Reduced extent or even complete loss of existing tapegrass beds due to lack of freshwater releases at S-79 during drought conditions. **With project:** Tapegrass beds are expected to recover to 2000 conditions and expand as minimum flows

Score = sum of above scores/30 (if uplands, divide by 20)
current: 0.33 | w/o proj: | with: 0.60

Delta = [with-current]: 0.27

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

If mitigation
Time lag (-factor) = 1.25
Risk factor = 2

For impact assessment areas
FL = delta x acres =

For mitigation assessment areas
RFG = delta/(1-factor x risk)*init acres =
446

Form 62-345.900(2), F.A.C. (effective date 2/2/04)

PART I – Qualitative Description
(See Section 62-345.400, F.A.C.)

Site/Project Name	Application Number	Assessment Area Name or Number
Acceler8 Projects		Caloosahatchee Estuary

FLUCCs code	Further classification (optional)	Impact or Mitigation Site?	Assessment Area Size
612, 651, 654			12,170 acres

Basin/Watershed Name/Number	Affected Waterbody (Class)	Special Classification (i.e. OFW, AP, other local/state/federal designation of importance)
Caloosahatchee Estuary	Class III	OFW

Geographic relationship to and hydrologic connection with wetlands, other surface water, uplands

The Caloosahatchee Estuary is hydrologically connected to upsteam wetlands by the Caloosahatchee River (C-43) then Lake Okeechobee in which flows are regulated by the S235 (Lake O), the S-78 and S-79 pumping structures along the C-43 and to downstream wetlands through flows from the river into a delta type system then flowing primary south along the coast to Caloosahatchee Estuary, San Carlos Bay, Matlache Pass,

Assessment area description

The Caloosahatchee Estuary is a delta type system receiving freshwater inflows from the Caloosahatchee River (C-43). Due to regulatory releases in Lake Okeechobee, the increase in freshwater water flows and the lack of MFL attainment have severly affected the overall health of the estuarine system through decreases in salinity levels, the spatial extent of seagrasses (Halodule and Thallassia), water quality and depressed oyster numbers.

Significant nearby features	Uniqueness (considering the relative rarity in relation to the regional landscape.)
Urban development along the north and south borders of the estuary, increases in urban runoff flowing into the estuary due to a lack of mangrove and upland buffers.	Estuarine system supporting native populations of oysters, manatees, some remaining mangrove areas

Functions	Mitigation for previous permit/other historic use
Provides habitat and foraging for aquatic dependent birds, fish assemblages, manatees, oysters. Provides breeding, feeding, escape, and cover for commercial fisheries and shellfish	None

Anticipated Wildlife Utilization Based on Literature Review (List of species that are representative of the assessment area and reasonably expected to be found)	Anticipated Utilization by Listed Species (List species, their legal classification (E, T, SSC), type of use, and intensity of use of the assessment area)
Aquatic dependant birds (native and migratory), fish, benthic macroinvertebrates, manatees, small mammals, shellfish, wood storks, phytoplankton/zooplankton	Wood Stork, Bald Eagle, Manatee, Smalltooth Sawfish

Observed Evidence of Wildlife Utilization (List species directly observed, or other signs such as tracks, droppings, casings, nests, etc.):

Fish, Smalltooth Sawfish, Wood Storks, Bald Eagles, Manatees, birds, invertebrates, shellfish

Additional relevant factors:

The estuaries overall health is considered poor due to the high volume freshwater inflow decreasing salinity levels, lack of seagrasses and quality of the water.

Assessment conducted by:	Assessment date(s):
SFWMD, USACE, USFWS, USEPA	6/13/2007

Form 62-345.900(1), F.A.C. [effective date of 2/2/04]

Annex A

PART II – Quantification of Assessment Area (impact or mitigation)
(See Sections 62-345.500 and .600, F.A.C.)

Fish and Wildlife

Site/Project Name	Application Number	Assessment Area Name or Number
EAA A-1, C-43 WSR, C-44 RSTA		Middle & Lower Caloosahatchee Estuary
Impact or Mitigation	**Assessment conducted by:**	**Assessment date:**
Mitigation	USACE, SFWMD, USEPA, USFWS	6/13/2007

Scoring Guidance	Optimal (10)	Moderate(7)	Minimal (4)	Not Present (0)
The scoring of each indicator is based on what would be suitable for the type of wetland or surface water assessed	Condition is optimal and fully supports wetland/surface water functions	Condition is less than optimal, but sufficient to maintain most wetland/surface waterfunctions	Minimal level of support of wetland/surface water functions	Condition is insufficient to provide wetland/surface water functions

.500(6)(a) Location and Landscape Support	w/o pres or current: 6	with: 6	**Existing Conditions:** Assessment area extends from Lake Okeechobee to the east to the Gulf of Mexico to the west. **With Project:** Berry Groves will be replaced with above-ground reservoir rather than remaining as agriculture.
.500(6)(b)Water Environment (n/a for uplands)	w/o pres or current: 2	with: 4	**Existing Conditions: Assessment area** receives basin runoff, primarily agricultural, as well as a damaging pulse discharges from Lake Okeechobee. This results in poor water quality and too much fresh water during the wet season. **With project:** Basin runoff will be captured by C-43 Reservoir to moderate releases and return salinity levels to more natural conditions. There is no water quality component associated with the C-43 Reservoir. EAA A-1 Reservoir will storage water from Lake Okeechobee reducing damaging pulse releases. Reductions in blue green algae and improved salinity envelope.
.500(6)(c)Community structure 1. Vegetation and/or 2. Benthic Community	w/o pres or current: 2	with: 4	**Existing Conditions:** Loss of SAV and oysters due to damaging freshwater releases. **With project:** Estuarine species will return as salinity levels return to normal resulting in return of SAV and oysters.

Score = sum of above scores/30 (if uplands, divide by 20)	
current or w/o pres: 0.33	with: 0.47

If preservation as mitigation,
Preservation adjustment factor =
Adjusted mitigation delta =

For impact assessment areas
FL = delta x acres =

Delta = [with-current]
0.14

If mitigation
Time lag (t-factor) = 1.23
Risk factor = 2

For mitigation assessment areas
RFG = delta/(t-factor x risk) = 693

Form 62-345.900(2), F.A.C. [effective date 2/2/04]

APPENDIX C

Comment Letter from the Florida Fish and Wildlife Commission on the Draft Fish and Wildlife Coordination Act Report

Annex A

June 27, 2007

Hopkins

RECEIVED
Fish and Wildlife
JUL 02 2007
South Florida ES Office
Vero Beach, FL

Ms. Joyce Mazourek
U.S. Fish and Wildlife Service
J.N. "Ding" Darling NWR
1 Wildlife Drive
Sanibel, Florida 33957

Florida Fish and Wildlife Conservation Commission

Commissioners
Rodney Barreto
Chair
Miami
David K. Meehan
Vice-Chair
St. Petersburg
Kathy Barco
Jacksonville
Richard A. Corbett
Tampa
H. A. "Herky" Huffman
Enterprise
Dwight Stephenson
Fort Lauderdale
Brian S. Yablonski
Tallahassee

Executive Staff
Kenneth D. Haddad
Executive Director
Victor J. Heller
Assistant Executive Director
Darlyn A. Stockfisch
Deputy Chief of Staff

Office of Policy and Stakeholder Coordination
Mary Ann Poole
Director
(850)410-5272
(850)922-5679 FAX

Managing fish and wildlife resources for their long-term well-being and the benefit of people.

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850)488-4676
Hearing/speech impaired:
(800)955-8771 (T)
(800)955-8770 (V)
MyFWC.com

Re: Fish and Wildlife Coordination Act (FWCA) Report comments for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Draft Integrated Project Implementation Report and Environmental Impact Statement, Hendry County

Dear Ms. Mazourek:

The Division of Habitat and Species Conservation (HSC) of the Florida Fish and Wildlife Conservation Commission (FWC) has coordinated an agency review of the U.S. Fish and Wildlife Service's draft Fish and Wildlife Coordination Act (FWCA) Report for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Draft Integrated Project Implementation Report. The following comments and recommendations are being provided in accordance with § 662(b) of the Fish and Wildlife Coordination Act, and is not intended as a determination of consistency or inconsistency for purposes of the Coastal Zone Management Act.

The FWC concurs with the findings of the draft FWCA Report, and adds recommendations regarding the use of the facility for recreational activities that are consistent with the primary goals and intent of the project.

Project Description

The proposed project is the first of two phases of a larger project to better manage water deliveries to the Caloosahatchee River (C-43) and estuary. This phase is limited to an above-ground reservoir that would discharge to the river, and would later be supplemented by aquifer storage recovery (ASR) wells. The project is located west of Lake Okeechobee and south of the Caloosahatchee Waterway in western Hendry County near the city of LaBelle. The proposed C-43 reservoir would contain approximately 160,000 acre-feet of water storage capacity on 10,492 acres of land. The reservoir would be divided into two cells contained by an embankment ranging between 27 and 38 feet above grade. An internal embankment 31 feet high would divide the cells of the reservoir, while a perimeter canal would encompass the entire reservoir. Numerous water-control structures would be constructed in conjunction with this project. The water-control structures would include an inflow pump station, a perimeter canal pump station, and multiple spillways and culverts.

Although a boat ramp is proposed, we understand that the South Florida Water Management District plans on monitoring the performance of the reservoir for 18 months before deciding on which forms of recreation will be allowed within the reservoir.

The proposed construction of the C-43 basin storage reservoir project is to provide an overall benefit to the Caloosahatchee River by providing additional control of the timing

and quantity of water releases from watershed runoff and Lake Okeechobee water releases. The reduction of large freshwater discharges into the Caloosahatchee River, especially during the seasonal dry periods, would assist in imitating historical water flow patterns and would reduce nutrient influx and moderate salinity regimes associated with flood waters. In addition, the C-43 basin reservoir would provide the potential to reduce flooding and potentially provide water supply storage.

Potentially Affected Resources

Project Site:

The South Florida Water Management District owns the majority of the property and currently leases it for citrus farming. Of the 10,492 acres, approximately 1,024 are jurisdictional wetlands, 899.59 acres of which are canals and ditches and 125 acres are pre-existing wetlands. The uplands that would be flooded currently provide marginal wildlife habitat, while the downstream freshwater and estuarine habitats could benefit greatly from the retention of freshwater that would otherwise flow to the river and estuary, often in large pulses that are seasonally ill timed. In addition, there may be opportunities within the completed reservoir to manage for freshwater fisheries, and improving habitats for many other wildlife species including songbirds, wading birds, waterfowl, and alligators.

Caloosahatchee River and Estuary:

Major changes resulting from this project should be beneficial to most existing Florida habitats within this project's influence. The primary beneficiary will be the estuarine communities associated with the Caloosahatchee River, including submerged aquatic vegetation and oyster (*Crassostrea virginica*) populations. Improvements in water quality and more appropriate salinity regimes should provide improved conditions for associated habitats and the wildlife resources dependent upon them.

West Indian (Florida) manatee:

Improved riverine and estuarine habitats as a result of this project would benefit the endangered West Indian (Florida) manatee (*Trichechus manatus*) through increases of stable submerged aquatic vegetation. Potential adverse affects could occur to the manatee during construction and operation of numerous water-control structures associated with the proposed reservoir. Reservoir waters have the potential to retain daily solar heating due to their deep depths. Discharge of reservoir waters that are warmer than the ambient waters of the C-43 canal could create conditions similar to manatee warm-water aggregation sites; however, suitable warm-water sites require consistent flows that create refuge areas with temperatures greater than 20°C during the winter months. If the water temperatures do not remain near 20°C or are inconsistent in their availability, the site becomes an attractive nuisance that increases the risk of cold season death for manatees that locate and use them.

Concerns and Recommendations

Caloosahatchee River and Estuary:

The Caloosahatchee estuary stands to be the primary beneficiary of this project. Storing water from Lake Okeechobee and runoff from the basin's watershed for future releases that are measured and seasonally appropriate could provide a boon to estuarine habitats. Riverine and estuarine habitats in this system have long suffered due to large freshwater releases that have caused significant shifts in salinity, large influxes of nutrients and increases in turbidity (Chamberlain and Doering 1998). Habitats most likely to benefit from this project include eelgrass (*Vallisneria americana*) beds located in the upper Caloosahatchee River, shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), turtle grass (*Thalassia testudinum*) and oyster reefs all located in the estuarine waters. The increased viability of these habitats should enhance the animal communities that use them as nursery and foraging habitat. While we understand that this will remain the primary objective of this project, we add our support that measured and seasonally appropriate freshwater releases from the C-43 basin storage reservoir remain the primary goal of this project while other worthy purposes for the reservoir (flood control, agriculture, and drinking water supply) remain secondary except for emergency purposes.

West Indian (Florida) Manatee:

The numerous water-control structures associated with this project could entrap, injure, or kill manatees that may encounter them. Manatees are frequent travelers of the Caloosahatchee waterway, traversing the entire waterway through Lake Okeechobee. Water-control structures have been responsible for hundreds of manatee deaths (Fish and Wildlife Research Institute's manatee mortality database); however, with the appropriate safeguards, these structures can be rendered relatively benign. The most efficient way to achieve this goal is to prevent manatee ingress and egress to the C-43 reservoir by constructing manatee barriers at all access points to the perimeter canal and reservoir.

During the winter months manatees are dependent on warm-water refuges to survive during periods of cold air and water temperatures (O'Shea et al. 1985; Hartman 1974). Water temperatures greater than 20°C are needed for survival; however, water temperatures that inconsistently reach 20°C can create an attractive nuisance that may jeopardize the health of manatees (Worthy et al. 2000; Laist and Reynolds 2005).

Recommendations:

- Barriers should be used at all ingress structures to the perimeter canal to eliminate manatee access to the perimeter canal and reservoir.
- Standard manatee construction conditions should be used in all waters accessible by manatees during the construction of this project.
- We highly recommend using the information provided in the document entitled "Guidelines for Manatee Conservation during Comprehensive Everglades Restoration Plan Implementation."

- We recommend that manatee access to the Towsend Canal be eliminated to reduce the potential for manatees to be attracted to the warm-water discharge that may be created by water releases from the reservoir into the Towsend Canal.
- If manatee access to the Towsend Canal is not eliminated, then during the winter season (November 1 through March 31) we recommend that: 1) water releases from the C-43 reservoir be monitored hourly for temperature near the point of discharge (S-11) with data retrieved daily; 2) manatee visual surveys should be conducted daily in the Townsend canal to detect any shifts in manatee winter-use patterns and movements into the area. Observations should be conducted in four 10-minute intervals over a 2-hour period each morning; 3) during the winter season, if water released from the reservoir creates a thermal plume that is greater than 20°C, or if manatees are observed using the site of the reservoir discharge on two or more consecutive days, then we request that the FWC-Imperiled Species Management section (850-922-4330) work with the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and South Florida Water Management District to resolve the issue of potential adverse impacts to manatees from intermittent warm-water releases from the C-43 reservoir.

Although not part of this portion of the C-43 Basin Storage Reservoir project, aquifer storage recovery (ASR) wells are a proposed component of the overall project in a subsequent phase. We believe that the ASR component could present similar issues related to thermal effects. ASR wells at this site have a projected capacity to store an additional 220 million gallons of water. Limited information is available at this time but monitoring suggests that water from some ASR wells has been retrieved at temperatures greater than 20°C. Reservoir waters discharged at greater than ambient water temperature that are near 20°C could be attractive to manatees during the winter months. Discharge waters that are inconsistent or insufficient in temperature could result in cold stress-related manatee mortality.

Recommendation:

- FWC requests that the U.S. Army Corps of Engineers and the South Florida Water Management District keep FWC apprised of the results of ongoing ASR studies and monitoring efforts so future manatee-related issues can be identified, refined, and resolved proactively prior to the implementation of ASR technology.

Recreation:

The proposed C-43 reservoir project would create over 10,000 acres of open water with depths reaching 25 feet. Although this project's primary purpose is water storage for the benefit of the downstream estuary, some form of recreation is contemplated by the proposed project. The FWC encourages public access to areas that can allow opportunities for recreational pursuits, whenever compatible. The C-43 reservoir has the potential to be managed for public activities that include alligator and waterfowl hunting, fishing, hiking, and wildlife observation.

Specifically, we support allowing waterfowl hunting and fishing as recreational opportunities that should be allowed on the C-43 reservoir. There is a very high public

demand for waterfowl hunting and angling in the southern portion of peninsular Florida, and we believe that use of this area for these recreational purposes would meet all criteria of recreational features proposed on CERP projects:

1. Compatible with the authorized project purposes
2. Affordable within project limits
3. Easily operated and maintained

Allowing the above opportunities on the reservoir should add little to no extra cost to the project, as a boat ramp is currently a proposed Acceler8 component of the project. We recommend that the South Florida Water Management District work with our staff during the assessment period to refine what types of activities could be accommodated. We would like to operate and maintain waterfowl hunting cooperatively with the South Florida Water Management District and others, as appropriate.

Recommendations:

- The use of soil cement for construction of the reservoir embankments is not conducive to the establishment and growth of submerged aquatic vegetation, an attractant for waterfowl. We recommend the placement of a natural substrate within the interior of the reservoir to allow for vegetation growth, which will increase the wildlife habitat value and assist with improvements in water quality through the reduction of nutrients.
- We recommend planning for recreational alligator hunting on the C-43 Reservoir in the future.
- Project plans should provide roads and boat ramps allowing adequate public access.
- Portions of the reservoir footprint have been in citrus production. We recommend that these areas not be cleared prior to reservoir flooding. Citrus is fairly durable wood and should not degrade rapidly, thereby creating long-lasting fish and wildlife habitat. A similar recommendation provided a cost savings during the construction planning of the Site 1 impoundment.
- Minimizing dry outs would benefit wildlife habitat through the reduction of nutrients and re-suspension of contaminants while providing for a stable aquatic community.

Conclusion

The FWC concurs with the findings of the draft FWCA Report, and we fully support the construction and operation of the proposed reservoir for the benefit of the Caloosahatchee River and estuarine habitats. Recognizing this priority, we also recommend that completed public works projects be made available to the public for recreational opportunities that are compatible with the primary intended purposes. The C-43 reservoir project appears to offer a variety of potential recreational pursuits including waterfowl and alligator hunting, fishing, hiking and wildlife observation. The FWC is willing to assist in achieving these multiple-use goals.

If you or your staff would like to coordinate further on the recommendations contained in this report, please contact me at 850-410-5272 or email me at MaryAnn.Poole@MyFWC.com, and I will be glade to help make the necessary

arrangements. If your staff has any specific technical questions regarding our comments, please contact Ron Mezich at 850-922-4330; email ron.mezich@myfwc.com.

Sincerely,

Mary Ann Poole

Mary Ann Poole, Director
Office of Policy and Stakeholder Coordination

map/rrm
ENV 1-3-2
C-43 Basin_838_841_842 FWCA
cc: Col. Paul L. Grosskruger, USACE, Jacksonville
Dennis Duke, USACE, Jacksonville
Paul Souza, USFWS, Vero Beach
Greg Knecht, DEP, Tallahassee
Janet Starne, SFWMD, West Palm Beach
J. Feiertag, FWC, Tallahassee
J. Fury, FWC, West Palm Beach

Referenced Cited:

Chamberlain, R.H., and P.H. Doering. 1998. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach. South Florida Water Management District Report. West Palm Beach, Florida. 21 pp.

Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute Manatee Mortality database. http://myfwc.com/manatee/

Hartman, D.S. 1974. Distribution, status, and conservation of the manatee in the United States. U.S. Fish and Wildlife Service, National Fish and Wildlife Laboratory contract report No. 14-16-0008-748. NTIS publication No. PB81-140725, pp.1-246.

Laist, D.W. and Reynolds, J.E., III. 2005b. Florida manatees, warm-water refuges, and an uncertain future. *Coastal Management* 33:279-295.

O'Shea, T.J., C.A. Beck, R.K. Bonde, H.I. Kochman and D.K. Odell. 1985. An analysis of manatee mortality patterns in Florida, 1976-81. *Journal of Wildlife Management*, 49(1): 1-11.

U.S. Fish and Wildlife Service, CERP Interagency Manatee Task Force. 2006. Guidelines for manatee conservation during Comprehensive Everglades Restoration Plan implementation.

Worthy, G.A.J., T.A. Miculka, and S.D. Wright. 2000. Manatee response to cold: how cold is too cold? Pages 16-22 *in* U.S. Fish and Wildlife Service. Florida Manatees and Warm Water: Proceedings of the Warm-Water Workshop, Jupiter, Florida, August 24–25, 1999.



US Army Corps
of Engineers®

Jacksonville District

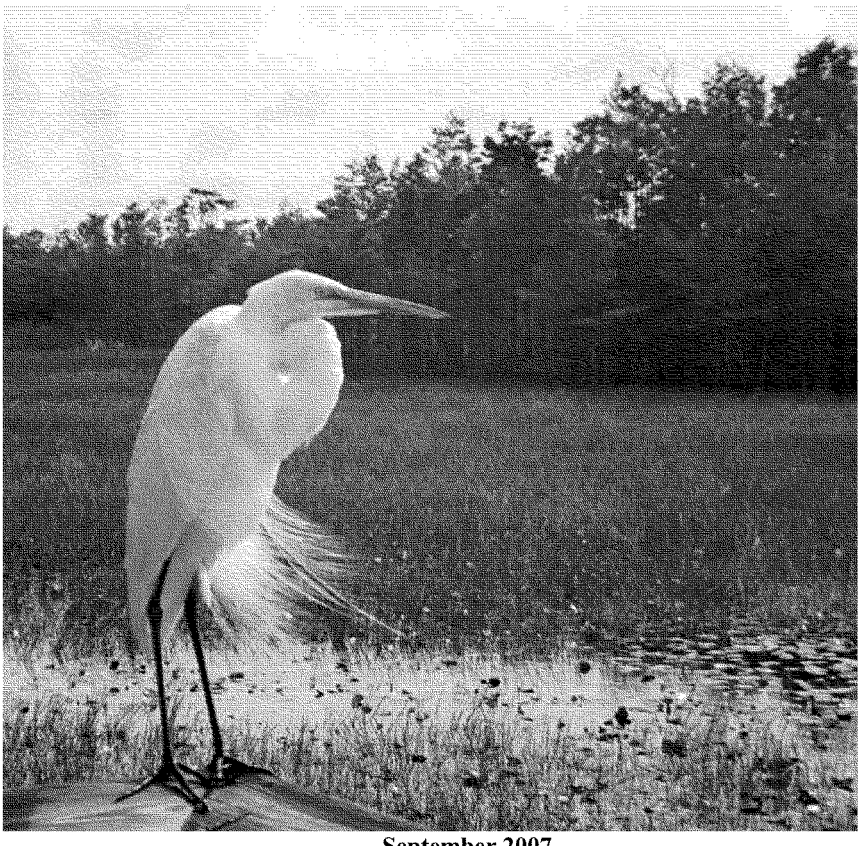


South Florida Water
Management District

CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE EVERGLADES RESTORATION PLAN
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
FINAL PROJECT IMPLEMENTATION REPORT

FINAL ANNEXES

NEPA INFORMATION – ANNEX B
ANALYSES REQUIRED BY WRDA 2000 AND STATE LAW – ANNEX C
DRAFT PROJECT OPERATING MANUAL AND MONITORING PLAN – ANNEX D
REPORTS PROVIDED BY RECOVER TO SUPPORT THE PIR – ANNEX E
CZM CONSISTENCY AND 404(B)(1) EVALUATIONS – ANNEX F



September 2007

This Report Contains [5] Volumes

You Are Here

Volume 1 – Main Report – November 2010
- Addendum A
- Addendum B
- Executive Summary
- Section 1 – Introduction
- Section 2 – Existing Conditions/Affected Environment
- Section 3 – Future "Without Project" Condition
- Section 4 – Identification of Problems and Opportunities
- Section 5 – Formulation of Alternative Plans
- Section 6 – Environmental Effects of the Selected Alternative Plan
- Section 7 – The Selected Alternative Plan
- Section 8 – Plan Implementation
- Section 9 – Summary of Coordination, Public Views, and Comments
- Section 10 – Recommendations
- List of Report Preparers
- Index
- Glossary of Terms
- Acronyms
- References

Volume 2- Annex – September 2007
- Annex A – FWCA and Endangered Species Act Compliance

Volume 3 – Annexes – September 2007
- Annex B – NEPA Information
- Annex C – Analyses Required by WRDA 2000 and State Law
- Annex D – Draft Project Operating Manual and Monitoring Plan
- Annex E – Reports Provided by RECOVER to Support the PIR
- Annex F – CZM Consistency and 404(b)(1) Evaluations

Volume 4 – Appendices – November 2010
- Appendix A – Engineering

Volume 5 – Appendices – November 2010
- Appendix B – Cost Estimates
- Appendix C – Environmental Information
- Appendix D – Real Estate
- Appendix E – Agency / Public Coordination
- Appendix F – Plan Formulation
- Appendix G – Economic and Social Considerations
- Appendix H – Recreation

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR

FINAL ANNEXES

NEPA Information – Annex B
Analyses Required by WRDA 2000 and State Law – Annex C
Draft Project Operating Manual and Monitoring Plan – Annex D
Reports Provided by RECOVER to Support the PIR – Annex E
CZM Consistency and 404(b)(1) Evaluations – Annex F

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

SOUTH FLORIDA WATER
MANAGEMENT DISTRICT

September 2007

This page intentionally left blank.

ANNEX B
NEPA INFORMATION

This page intentionally left blank

TABLE OF CONTENTS

B.0 NEPA INFORMATION B-1
B.1 INVENTORY OF PUBLIC CONCERNS FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR B-2
B.2 FISH AND WILDLIFE COORDINATION B-6
B.3 OTHER AGENCY COORDINATION B-6
B.3.1 Outgoing Correspondence B-8
B.3.2 SHPO Coordination B-24
B.3.3 Agency Correspondence B-37
B.3.4 Public Correspondence B-67
B.4 DRAFT PIR COMMENT MATRIX B-70
B.4.1 Written Correspondence B-131
B.4.2 Public Meeting Transcript B-187

LIST OF TABLES

Table B-1: Public Comments and How They Were Addressed B-4

This page intentionally left blank

B.0 NEPA INFORMATION

The National Environmental Policy Act (NEPA) of 1969, as amended, 42 U.S.C. 4321, et seq. P.L. 91-109 establishes the process requirement for this project. NEPA establishes the Federal decision making process and requires documentation of a comprehensive evaluation of all potential impacts on the human environment. The NEPA process is fully integrated with the six-step planning process in accordance with USACE planning guidelines.

In compliance with the National Environmental Policy Act (NEPA), the Caloosahatchee River (C-43) West Basin Storage Reservoir project initiated a scoping process in early 2002. An initial scoping meeting was held in February/ March of 2002, with a follow-up scoping meeting held on May 1, 2003. Following this meeting, a letter was sent to federal, state, and local stakeholders requesting their assistance in identifying the extent of significant issues to be addressed in this study. A public meeting was held on February 28, 2002 to specifically identify critical fish and wildlife habitat and any threatened or endangered species that may be within the project area or affected by the activities of the project.

Once it was determined that an Environmental Impact Statement (EIS) would be necessary for this project, a Notice of Intent (NOI) to prepare a draft Environmental Impact Statement (EIS) was published in the Federal Register in March 2003. A NEPA scoping letter was sent to federal, state, and local stakeholders, including those who had earlier expressed an interest in this project. A public meeting, identified in the scoping letter, was held on May 1, 2003 to ensure continued public involvement. This meeting was recorded and all issues identified were noted and reviewed. Comments on the scoping letter received from the federal, state, and local entities were collected and shared with the Study team. Those comments are included in this Annex.

Outreach efforts have continued throughout the project. A fact sheet was created for the project to make the information easily presentable to many members of the public. Because of the large study area, as well as the significant potential size of the project, a concerted effort was made to ensure continued public involvement throughout the planning process. The project team members held stakeholder meetings with interest groups including environmental, recreation, and agriculture. Elected officials in the project area were also given a presentation and asked to submit issues and suggestions. The issues raised in all of these meetings were recorded and considered during the planning process. Environmental justice issues were examined to ascertain that negative effects will be avoided or minimized.

B.1 INVENTORY OF PUBLIC CONCERNS FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR

An integral component of the identification of problems and opportunities is an understanding of the public's concerns (USACE 1999). Public workshops were conducted early in the planning process for this project in order to gather public input and to document public concerns related to the problems, needs, and opportunities within the Caloosahatchee River watershed. Numerous presentations to public groups were conducted, including Lee, Collier, Hendry and Glades Counties, the Cities of LaBelle, Moore Haven, and Clewiston, local agencies, agricultural organizations, civic groups, business groups, clubs and neighborhood organizations.

In February of 2001 and 2002, representatives from the Corps and the SFWMD conducted two workshops/public meetings with various groups and individuals to provide a brief overview of the process for development of a Project Implementation Report (PIR) for the Caloosahatchee (C-43) West Basin Storage Reservoir project and to obtain an understanding of the public's concerns and issues. The public meetings were held in LaBelle, Florida at the Hendry County Extension Service Building on February 26, 2001 and at the LaBelle Civic Center on February 28, 2002. Approximately 35 people attend the meeting on the 26th of February 2001 and approximately 35 people attended the meeting on the 28th of February 2002. Information collected at these meetings was used to help inform the plan formulation process.

In addition to the earlier meetings, a NEPA scoping letter was sent out in March of 2003. A public scoping meeting was subsequently held in LaBelle on May 1, 2003. By this time the team had already completed some potential site identification and screening. The public was updated on the progress and status of the project to that point. Meetings were also held in the spring of 2003 with various stakeholders including recreational interests, agricultural interests, and local policy makers.

A NOI to prepare a draft EIS for the Caloosahatchee River (C-43) West Basin Storage Reservoir project was published in the Federal Register on March 28, 2003. A scoping letter describing the project objectives and array of alternatives was mailed on 18 March 2003, to Federal, State, and local agencies, Native American Tribes, private organizations, and other interested parties to solicit their views, comments, and information about resources, study objectives, alternatives, and important features within the study area. Comments received were reviewed and incorporated in project planning. A Notice of Availability of the draft PIR/EIS was published in the Federal Register on 27 April 2007 when this document was released for public and agency review. Comments received were addressed and are summarized along with responses in a matrix in section B.4 of this Annex.

Table B-1 outlines the public concerns that were brought to our attention through written correspondence, phone calls, and public meetings. The right hand column lists the responses to the comments.

TABLE B-1: PUBLIC COMMENTS AND HOW THEY WERE ADDRESSED

Public Comment - Issue, Problem, or Opportunity	Action taken
Health of the estuary	Main purpose/objective of study
Fish health and abundance for commercial and recreational uses	Estuarine indicators used to identify benefits and impacts of project
Water quality	Water quality analysis performed on final alternatives
Economic impacts	Socioeconomic analysis
Tourism	Healthier estuary will promote tourism
Water supply	Water reservation studies as part of project assurances analyses
Flood control	Modeling of alternatives to ensure no harm
Wildlife health and abundance	Ecological performance measures
Cost of project	Cost estimates in PIR; part of alternative screening; addressed through cost effectiveness and incremental cost analyses
Questions on ASR	Separate study – see ASR pilot project Draft PIR/EIS
Dredging of oxbows	Being accomplished by other projects
Use of water stored in reservoir	Water reservations study as part of project assurances analyses; Draft operating manual will accompany PIR
Drainage problems in basin	Not a project purpose – will recommend to SWFFS
Recreational opportunities	Recreation plan included in PIR
Loss of tax base in Hendry County	A large number of sites were considered for the study – an objective screening process was used to narrow these sites
Concern that cost will outweigh benefits	Cost effectiveness/ incremental cost analyses will be performed to justify costs
Water allocation concerns	Water reservation studies will be completed
Water level on the river	Project objective to deliver a more consistent water flow to estuary, which would result in a more consistent water level

Public Comment - Issue, Problem, or Opportunity	Action taken
Littoral zone around reservoir to promote fishing and fish habitat	There may be some secondary benefits due to littoral zone, but reservoir is not designed for littoral benefits due to extreme fluctuations in water depth
Loss of Highway 80 property for development	The reservoir was sited a significant distance from Highway 80 so that development will not be hindered.
Suggest deeper reservoir	Geotechnical studies were conducted to determine appropriate maximum depths
Visual aesthetics –high levee is not conducive to visual enjoyment	Due to the soils, aquifers, and topography, high levees were not able to be avoided
Water loss due to evaporation	ASRs are envisioned to complement the reservoir(s), and they will decrease total loss to evaporation
Lake Hicpochee for natural area restoration	Lake Hicpochee is being considered as an alternative for natural area restoration in Part II of the project which is scheduled to begin in mid-late 2007.
Hurricane evacuation route/safety issues	A meeting was held to come up with safety standards for all CERP projects
Exotic/invasive plant control	Other CERP projects are addressing this issue; proper procedures will be used to minimize this problem during construction
Active recreation opportunities (baseball fields, playgrounds, etc.)	Recreation opportunities are outlined in the Recreation Plan
"Watchable" wildlife areas	These are part of the Recreation Plan.
Recreation and restoration as opposing uses	Restoration is the main purpose of this study, so restoration will not be sacrificed for recreational opportunities. However, recreation will be considered wherever it is viable and applicable trade-offs displayed.

B.2 FISH AND WILDLIFE COORDINATION

The central objective of the Fish and Wildlife Coordination Act (FWCA) is to allow for equal consideration of wildlife resources. Transfer funds have been made available to the USFWS in order to participate in team meetings and workshops scheduled in conjunction with the Corps' planning, implementation, and evaluation process. Funding has also been provided for the USFWS to conduct surveys and investigations necessary to determine impacts of the Caloosahatchee River (C-43) West Basin Storage Reservoir project on wildlife resources and to make recommendations to the Corps on measures to prevent loss of or damage to wildlife resources. Recommendations for optimizing opportunities related to the conservation and enhancement of fish and wildlife resources have been provided through the submittal of Planning Aid Letters dated 13 August 2003 and 29 March 2005. The USFWS also identified critical fish and wildlife habitat and threatened and endangered species in a letter dated 11 April 2002, and provided scoping comments in a letter dated 10 June 2003.

There has been verbal coordination with the USFWS in 2004, 2005, and 2006. The Corps asked for formal consultation with the USFWS due to potential adverse impacts to the endangered Florida panther (*Felis concolor coryi*), threatened Audubon's crested caracara (*Polyborus plancus audubonii*), and threatened eastern indigo snake (*Drymarchon corais couperi*). This letter was sent by the Corps on January 10, 2007. The USFWS requested some additional information which was provided. .

A Final Fish and Wildlife Coordination Act Report (FCAR) report dated July 2007 has been prepared and is included in Annex A. A Biological Opinion (BO) dated July 2007 is also included in Annex A. Details of the Section 7 ESA consultation can be found in the BO.

Florida Fish and Wildlife Conservation Commission (FFWCC) has also taken part in project meetings and has been an important part of the technical sub-team process of evaluating components, determining benefits and producing performance measures for the alternatives. Additionally, FWC provided a Scoping Letter dated 10 June 2003 and comments on the dPIR dated June 8, 2007 .

B.3 OTHER AGENCY COORDINATION

The Caloosahatchee River (C-43) West Basin Storage Reservoir project team has been an interdisciplinary, multi-agency group of local, state, and Federal agency representatives (USACE, USFWS, USEPA, USGS, FFWCC, FDEP, Hendry county, and Lee county). Coordination was achieved through staff member participation on the PDT and sub-teams as necessary. The Corps, SFWMD, Natural Resource Conservation Service, U.S. Fish and Wildlife Service, Florida

Department of Environmental Protection, National Marine Fisheries Service, Florida Fish and Wildlife Conservation Commission, and Lee and Hendry counties have all been involved in the project as it has developed. The issues and concerns of these agencies and governments were continually a consideration of the project team. A compilation of all agency correspondence is included in this Annex.

B.3.1 Outgoing Correspondence

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
SOUTH FLORIDA RESTORATION PROGRAM OFFICE
1400 CENTREPARK, SUITE 750
WEST PALM BEACH, FLORIDA 33401

REPLY TO ATTENTION OF

January 10, 2007

Special Project/Enforcement Branch
SAJ-2005-5958(IP-TKW)

David Bernhart
Assistant Regional Administrator
Protected Resources
National Marine Fisheries Service
263 13th Avenue South
St. Petersburg, FL 33701

Dear Mr. Bernhart:

Pursuant to the Endangered Species Act (ESA), below is our determination of effects for potentially affected federally threatened and endangered species for the C-43 West Storage Reservoir Project located in Hendry County, Florida.

Scheda Ecological Associates, Inc. has prepared a Biological Assessment (BA) for the project on behalf of the South Florida Water Management District (SFWMD). The BA includes the information described in 50 CFR §402.12. This letter serves to transmit the BA and effects determination for the project. Also included with this letter is a copy of the permit application which further describes the project. The U.S. Army Corps of Engineers (Corps) has determined that the proposed project would cause the following effects on federally listed species:

No affect: The Corps has determined the proposed project will not affect threatened bald eagle (*Haliaeetus leucocephalus*), threatened Florida scrub jay (*Aphelocoma coerulescens*), endangered Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), endangered red cockaded woodpecker (*Picoides borealis*), endangered Okeechobee gourd (*Cucurbita okeechobeensis*) or threatened Florida scrub-jay (*Aphelocoma coerulescens*).

May affect not likely to adversely affect: The Corps has determined the project may affect but is not likely to adversely affect the endangered smalltooth sawfish (*Pristis pectinata*), endangered American crocodile (*Crocodylus acutus*), endangered green sea turtle (*Chelonia mydas*), endangered leatherback sea turtle (*Dermochelys coriacea*), endangered Kemp's ridley sea turtle (*Lepiodchelys kempii*), endangered hawksbill turtle

-2-

(*Eretmochelys imbricata*), threatened loggerhead sea turtle (*Caretta caretta*), endangered Everglade snail kite (*Rostrhamus sociabilis*), threatened piping plover (*Charadrius melodus*), endangered wood stork (*Mycteria Americana*), and endangered West Indian manatee (*Trichechus manatus latirostris*).

May adversely affect: The Corps has determined the project may adversely affect the endangered Florida panther (*Felis concolor coryi*), threatened Audubon's crested caracara (*Polyborus plancus audubonii*), and threatened eastern indigo snake (*Drymarchon corais couperi*).

It should be noted that the SFWMD has restricted the use of copper on the site and plans to conduct all required corrective actions as recommended by the U.S. Fish and Wildlife Service prior to commencement of construction. Therefore, the Corps' determination for the snail kite in this cover letter supersedes the determination for the snail kite as specified in the BA.

The Corps has requested the U.S. Fish and Wildlife Service initiate formal consultation for the Florida panther, Audubon's crested caracara, and eastern indigo snake. Additionally, we request your written concurrence with our "may affect not likely to adversely affect" determination for those species that are within the purview of the National Marine Fisheries Service. If you need additional information or have any questions, please Tori White at the letterhead address, at 561-472-8888 or by e-mail at tori.white@saj02.usace.army.mil.

Sincerely,

for David S. Hobbie
Chief, Regulatory Division

Enclosures

Identical Letter Sent to:
Mr. Paul Souza, Field Supervisor, South Florida Ecological Services Office, USFWS, 1339 20th St., Vero Beach, FL 32960

Copy Furnished w/o Enclosures:
Susan Conner, Corps, PO Box 4970, Jacksonville, FL 32232
John Mitnik, SFWMD, 3301 Gun Club Rd., W. Palm Beach, FL 33410

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P.O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF
Planning Division
Environmental Branch

SEP 0 1 2006

Mr. Jerry Brooks
Florida Dept. of Environmental Protection
Division of Water Resource Management
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Dear Mr. Brooks:

In accordance with regulations pertaining to the National Environmental Policy Act (Title 40 of the Code of Federal Regulations, part 1501.6), I am formally inviting your agency to become a cooperating agency for an Environmental Impact Statement (EIS) on the C-43 Basin Storage Reservoir project. The goal of the C-43 Basin Storage Reservoir Project is to improve the quality, quantity, timing and distribution of flows in the Caloosahatchee River and Estuary to restore ecosystem function. The plan formulation for this project focused on reaffirming that above-ground storage reservoirs in the C-43 Basin continue to meet the goals, objectives, and purposes for the project as described in the Restudy. Please see the enclosed figures of the Caloosahatchee basin as well as the proposed site of the Part I-Phase I portion of this project (C-43 West Storage Reservoir).

Please note that cooperating agency status involves actions and responsibilities beyond that normally associated with a commenting or permitting agency. We appreciate and acknowledge your participation and cooperation in the project formulation to this point, and look forward to your continued cooperation in the preparation of the Draft Project Implementation Report / Environmental Impact Statement.

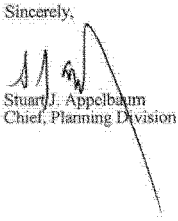
The formulation of the project, alternatives, and mitigation have been in accordance with Engineer Regulation ER 1105-2-100 and have fully considered a range of environmental, economic, and social factors. As a cooperating agency, you must fully consider the views, needs, and benefits of competing interests.

No cooperating agency will have "veto" over the selection of the project plan, alternatives, or mitigation measures. Under your status as a commenting agency, you may recommend actions not ultimately adopted or implemented by the lead agency. You may also impose requirements to the extent allowed under your legal authority as a permitting agency. Conflict with the lead agency may be resolved through mediation, placing a dissenting opinion in the EIS, withdrawing your cooperating agency status, or the Lead agency pursuing an EIS without you as a cooperating agency. For additional information see the enclosed "Rights and Responsibilities of Lead and Cooperating Agencies" (Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, Council on Environmental Quality, 1981).

-2-

Please indicate whether you accept this invitation to become a cooperating agency (as described above) within 30 days of the date of this letter. If you have any questions, please contact Susan Conner at 904-232-1782.

Sincerely,



Stuart J. Appelbaum
Chief, Planning Division

Enclosure

Excerpt: Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations (Council on Environmental Quality, 1981)

14a. **Rights and Responsibilities of Lead and Cooperating Agencies.** What are the respective rights and responsibilities of lead and cooperating agencies? What letters and memoranda must be prepared?
A. After a lead agency has been designated (Sec. 1501.5), that agency has the responsibility to solicit cooperation from other federal agencies that have jurisdiction by law or special expertise on any environmental issue that should be addressed in the EIS being prepared. Where appropriate, the lead agency should seek the cooperation of state or local agencies of similar qualifications. When the proposal may affect an Indian reservation, the agency should consult with the Indian tribe. Section 1508.5. The request for cooperation should come at the earliest possible time in the NEPA process. After discussions with the candidate cooperating agencies, the lead agency and the cooperating agencies are to determine by letter or by memorandum which agencies will undertake cooperating responsibilities. To the extent possible at this stage, responsibilities for specific issues should be assigned. The allocation of responsibilities will be completed during scoping. Section 1501.7(a)(4).
Cooperating agencies must assume responsibility for the development of information and the preparation of environmental analyses at the request of the lead agency. Section 1501.6(b)(3). Cooperating agencies are now required by Section 1501.6 to devote staff resources that were normally primarily used to critique or comment on the Draft EIS after its preparation, much earlier in the NEPA process -- primarily at the scoping and Draft EIS preparation stages. If a cooperating agency determines that its resource limitations preclude any involvement, or the degree of involvement (amount of work) requested by the lead agency, it must so inform the lead agency in writing and submit a copy of this correspondence to the Council. Section 1501.6(c).
In other words, the potential cooperating agency must decide early if it is able to devote any of its resources to a particular proposal. For this reason the regulation states that an agency may reply to a request for cooperation that "other program commitments preclude any involvement or the degree of involvement requested in the action that is the subject of the environmental impact statement." (Emphasis added). The regulation refers to the "action," rather than to the EIS, to clarify that the agency is taking itself out of all phases of the federal action, not just draft EIS preparation. This means that the agency has determined that it cannot be involved in the later stages of EIS review and comment, as well as decisionmaking on the proposed action. For this reason, cooperating agencies with jurisdiction by law (those which have permitting or other approval authority) cannot opt out entirely of the duty to cooperate on the EIS. See also Question 15, relating specifically to the responsibility of EPA.

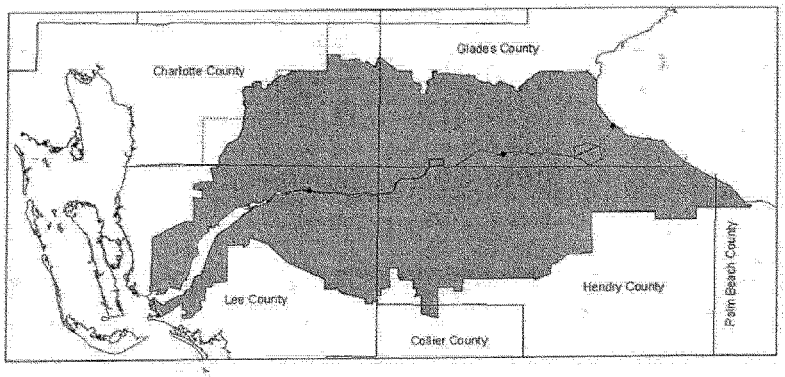
14b. How are **disputes resolved between lead and cooperating agencies** concerning the scope and level of detail of analysis and the quality of data in impact statements?
A. Such disputes are resolved by the agencies themselves. A lead agency, of course, has the ultimate responsibility for the content of an EIS. But it is supposed to use the environmental analysis and recommendations of cooperating agencies with jurisdiction by law or special expertise to the maximum extent possible, consistent with its own responsibilities as lead agency. Section 1501.6(a)(2).
If the lead agency leaves out a significant issue or ignores the advice and expertise of the cooperating agency, the EIS may be found later to be inadequate. Similarly, where cooperating agencies have their own decisions to make and they intend to adopt the environmental impact statement and base their decisions on it, one document should include all of the information necessary for the decisions by the cooperating agencies.

Otherwise they may be forced to duplicate the EIS process by issuing a new, more complete EIS or Supplemental EIS, even though the original EIS could have sufficed if it had been properly done at the outset. Thus, both lead and cooperating agencies have a stake in producing a document of good quality. Cooperating agencies also have a duty to participate fully in the scoping process to ensure that the appropriate range of issues is determined early in the EIS process.
Because the EIS is not the Record of Decision, but instead constitutes the information and analysis on which to base a decision, disagreements about conclusions to be drawn from the EIS need not inhibit agencies from issuing a joint document, or adopting another agency's EIS, if the analysis is adequate. Thus, if each agency has its own "preferred alternative," both can be identified in the EIS. Similarly, a cooperating agency with jurisdiction by law may determine in its own ROD that alternative A is the environmentally preferable action, even though the lead agency has decided in its separate ROD that Alternative B is environmentally preferable.

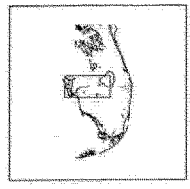
14c. What are the specific responsibilities of federal and state **cooperating agencies to review draft EISs**?
A. Cooperating agencies (i.e., agencies with jurisdiction by law or special expertise) and agencies that are authorized to develop or enforce environmental standards, must comment on environmental impact statements within their jurisdiction, expertise or authority. Sections 1503.2, 1508.5. If a cooperating agency is satisfied that its views are adequately reflected in the environmental impact statement, it should simply comment accordingly. Conversely, if the cooperating agency determines that a draft EIS is incomplete, inadequate or inaccurate, or it has other comments, it should promptly make such comments, conforming to the requirements of specificity in section 1503.3.

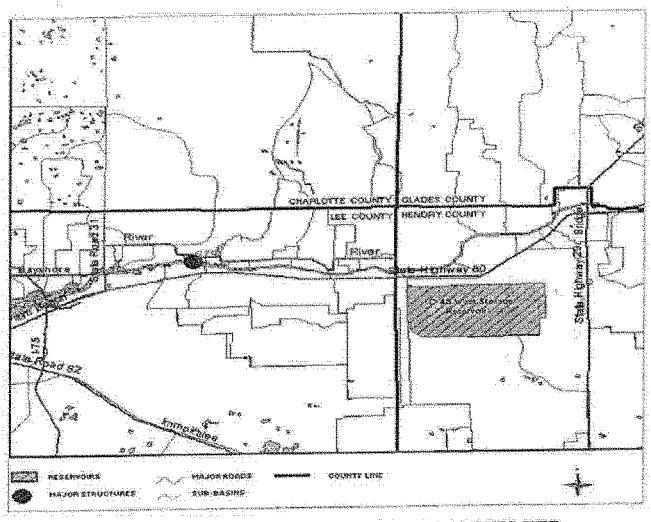
14d. How is the lead agency to treat the comments of another agency with jurisdiction by law or special expertise which has **failed or refused to cooperate or participate in scoping or EIS preparation**?
A. A lead agency has the responsibility to respond to all substantive comments raising significant issues regarding a draft EIS. Section 1503.4. However, cooperating agencies are generally under an obligation to raise issues or otherwise participate in the EIS process during scoping and EIS preparation if they reasonably can do so. In practical terms, if a cooperating agency fails to cooperate at the outset, such as during scoping, it will find that its comments at a later stage will not be as persuasive to the lead agency.

-DRAFT-



Caloosahatchee Basin





LOCATION OF THE BERRY GROVES SITE

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

Planning Division
Environmental Branch

MAR 18 2003

TO WHOM IT MAY CONCERN:

The U.S. Army Corps of Engineers (Corps), Jacksonville District, is requesting your assistance in gathering information that will help define issues and concerns to be addressed in a National Environmental Policy Act (NEPA) document being prepared for the C-43 Basin Storage Reservoir adjacent to the Caloosahatchee River in Hendry, Lee, Charlotte, or Glades County. The project is part of the Comprehensive Everglades Restoration Project (CERP) authorized by the Water Resources Development Act of 2000. The Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS), which includes detailed project information, is enclosed.

This letter initiates the public scoping process under the NEPA. We welcome your views, comments, concerns and information about resources and important features within the area. An initial scoping letter was sent in February 2002, to help gather general issues related to this project. A public meeting was held following that letter. Because it is a long process, continued public participation is a normal part of the NEPA schedule. Therefore, we will be holding a public meeting to take additional questions and suggestions on significant issues and alternative plans. The meeting will be held as follows:

DATE/TIME: Thursday, May 1, 2003, 7:00 p.m.

PLACE: Dallas B. Townsend Agricultural Center
Hendry County Agriculture Extension Service
1085 Pratt Boulevard
LaBelle, Florida

If you know others who may wish to comment on this activity, please advise them of this request for public comments. Letters of comment or inquiry should be directed to the letterhead

-2-

address to the attention of Planning Division, Environmental Branch, South Florida Section, and be received by this office within 30 days of the date of this letter. If you have any questions, please contact Mrs. Susan Conner by telephone at 904-232-1782, or by electronic mail at susan.l.conner@usace.army.mil.

Sincerely,

James C. Duck
Chief, Planning Division

Enclosures

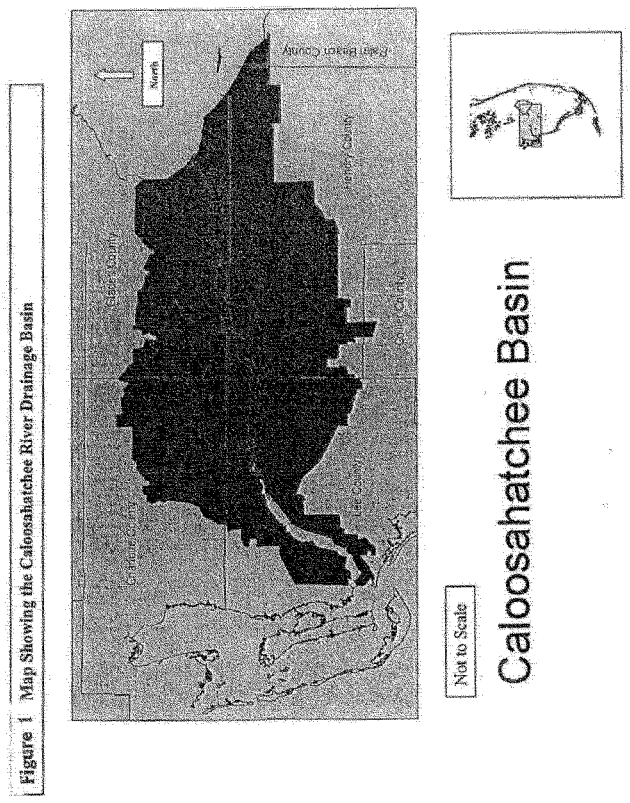


Figure 1 Map Showing the Caloosahatchee River Drainage Basin

BILLING CODE: 3710-AJ

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Intent to Prepare a Draft Environmental Impact Statement for the C-43 Basin Storage Reservoir Project adjacent to the Caloosahatchee River, Hendry, Glades, Charlotte, or Lee County, FL

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DOD.

ACTION: Notice of intent.

SUMMARY: The Jacksonville District, U.S. Army Corps of Engineers (Corps), intends to prepare an integrated Project Implementation Report and Draft Environmental Impact Statement (DEIS) for the C-43 Basin Storage Reservoir Project, Part 1. The study is a cooperative effort between the Corps and the South Florida Water Management District (SFWMD), which is also a cooperating agency for this DEIS. One of the recommendations of the final report of the Central & South Florida (C&SF) Comprehensive Review Study (Restudy) was the C-43 Basin Storage Reservoir Project. This project includes the construction of an approximately 160,000 acre-feet storage area within the Caloosahatchee Basin to capture and store stormwater runoff and water releases from Lake Okeechobee. Stored water would be used to meet the environmental demands of the Caloosahatchee River and Estuary and urban and agricultural demand as able.

1

DATES: A public meeting is scheduled for May 1, 2003, 7 p.m. in Hendry County at the Dallas B. Townsend Agricultural Center, 1085 Pratt Boulevard, LaBelle, FL.

FOR FURTHER INFORMATION CONTACT: Mrs. Susan Conner, U.S. Army Corps of Engineers, Planning Division, Environmental Branch, P.O. Box 4970, Jacksonville, FL, 32232-0019, or by telephone at 904-232-1782.

SUPPLEMENTARY INFORMATION:

a. Authorization: Section 601 of the Water Resources Development Act of 2000 authorized a framework and guide for modifications to the C&SF Project to restore the south Florida ecosystem and to provide for the other water-related needs of the region, including the C-43 Basin Storage Reservoir Project.

b. Project Scope: The purpose of this project is to capture C-43 Basin runoff and releases from Lake Okeechobee. These facilities will be designed for water supply benefits, some flood attenuation, to provide environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. It is assumed that, depending upon the location of the facility and pollutant loading conditions in the watershed, the facility could be designed to achieve significant water quality improvements, consistent with appropriate pollution load reduction targets. The project as proposed will include the construction of an above-ground reservoir(s) with a total capacity of approximately 160,000 acre-feet, located in the C-43 Basin in Hendry, Glades, Charlotte, or Lee Counties. Water levels could fluctuate up to 8 feet above grade.

c. Preliminary Alternatives: Formulation of alternative plans will involve the selection of the most suitable site or sites for a reservoir, depth and configurations of the

impoundment(s), investigation of intake and discharge sites, and investigation of opportunities in configuration designs to provide significant water quality improvements for the project.

The Environmental Impact Statement (EIS) evaluation of the project will include an evaluation of adverse environmental impacts, including but not limited to, water quality, socio-economic, archeological and biological. In addition to adverse impacts, the evaluation will also focus on how well the plans perform with regard to specific ecological and other performance measures.

d. Issues: The EIS will consider impacts on water quality, ecosystem habitat, threatened and endangered species, health and safety, aesthetics and recreation, fish and wildlife resources, cultural resources, water availability, flood protection, and other potential impacts identified through scoping, public involvement, and interagency coordination.

e. Scoping: Initial project scoping began in February 2002 at a public meeting in Hendry County. A scoping letter was issued in February 2002 to interested parties inviting all interested parties and government agencies to participate in the scoping process by identifying any additional concerns on issues, studies needed, alternatives, procedures, and other matters related to the scoping process. A NEPA scoping letter will be issued in March 2003, along with this notice. A public meeting is scheduled for May 1, 2003 (see DATES above).

f. Public Involvement: We invite the participation of affected Federal, state and local agencies, affected Indian tribes, and other interested private organizations and parties.

3

g. Coordination: The proposed action is being coordinated with the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service under Section 7 of the Endangered Species Act, with the FWS under the Fish and Wildlife Coordination Act, and with the State Historic Preservation Officer.

h. Other Environmental Review and Consultation: The proposed action would involve evaluation for compliance with guidelines pursuant to Section 404 (b) of the Clean Water Act; application (to the State of Florida) for Water Quality Certification pursuant to Section 401 of the Clean Water Act; certification of state lands, easements and right of ways, and determination of Coastal Zone Management Act consistency.

i. Agency Role: As cooperation agency, non-Federal sponsor, and leading local expert, SFWMD will provide information and assistance on the resources to be impacted and alternatives.

j. DEIS Preparation: The integrated Project Implementation Report (PIR) including a DEIS, is currently estimated for publication in September 2004.

3-17-03
Date

James C. Duck
JAMES C. DUCK
Chief, Planning Division

4

B.3.2 SHPO Coordination

RECEIVED
11 Oct 06

FLORIDA DEPARTMENT OF STATE
Sue M. Cobb
Secretary of State
DIVISION OF HISTORICAL RESOURCES

Marie G. Burns, Chief
Department of the Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

October 5, 2006

Re: DHR Project File No. 2006-07757 / Received by DHR: August 30, 2006
Cultural Resource Assessment Survey of the C-43 Reservoir Addition Project Area, Hendry County, Florida

Dear Chief Burns:

Our office received and reviewed the above referenced mitigation report in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992, and *36 C.F.R., Part 800: Protection of Historic Properties*, and Chapters 267 and 373, *Florida Statutes*, for assessment of possible adverse impact to cultural resources (any prehistoric or historic district, site, building, structure, or object) listed, or eligible for listing, in the *National Register of Historic Places (NRHP)*, or otherwise of historical, architectural or archaeological value.

In April 2006, Janus Research conducted an archaeological and historical survey of the C-43 Reservoir Project on behalf of South Florida Water Management District. Janus Research located one archaeological site (8HN129) during the course of the investigation and found the site to be potentially eligible for listing in the *NRHP*.

It is the opinion of Janus Research that since site 8HN129 is located well outside of the proposed project footprint, the activities will have no adverse effect on the potentially eligible site. Janus Research recommended no further archaeological or historical investigation of the project area.

Based on the information provided, this office concurs with these determinations and finds the submitted report complete and sufficient under 1A-46, *Florida Administrative Code*.

If you have any questions concerning our comments, please contact Scott Sorset, Historic Sites Specialist, by phone at (850) 245-6333, or by electronic mail at srsorset@dos.state.fl.us. Your continued interest in protecting Florida's historic properties is appreciated.

Sincerely,

Frederick P. Gaske, Director, and
State Historic Preservation Officer

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6436
☐ Archaeological Research (850) 245-6444 • FAX: 245-6452
■ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Southeast Regional Office (954) 467-4990 • FAX: 467-4991
☐ Northeast Regional Office (904) 825-5045 • FAX: 825-5044
☐ Central Florida Regional Office (813) 272-3843 • FAX: 272-2340

FLORIDA DEPARTMENT OF STATE
Glenda E. Hood
Secretary of State
DIVISION OF HISTORICAL RESOURCES

Mr. James C. Duck
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

September 27, 2004

Re: DHR Project File No. 2004-8676 (2002-1944, 2003-2300)/ Received by DHR: August 30, 2004
Cultural Resources Survey of the C-43 Berry Groves Storage Reservoir, Hendry County, Florida

Dear Mr. Duck:

Our office received and reviewed the above referenced survey report in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992; *36 C.F.R., Part 800: Protection of Historic Properties*; and Chapter 267, *Florida Statutes*, for assessment of possible adverse impact to historic properties listed, or eligible for listing, in the *National Register of Historic Places (NRHP)*.

In August to October 2003, New South Associates conducted an archaeological and historical survey of the C-43 Berry Groves Storage Reservoir project area in Hendry County on behalf of the U.S. Army Corps of Engineers, Jacksonville District. Four previously unrecorded historic structures were identified within the project area during the investigation.

The Ted Wells House (8HN102), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN102 does not appear eligible for listing in the *NRHP*.

The Berry Groves House (8HN103), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN103 does not appear eligible for listing in the *NRHP*.

The Berry Groves Bunkhouse (8HN104), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN104 does not appear eligible for listing in the *NRHP*.

The Jeff Jones House (8HN105), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN105 does not appear eligible for listing in the *NRHP*.

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6435
☐ Archaeological Research (850) 245-6444 • FAX: 245-6436
☒ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Palm Beach Regional Office (561) 279-1475 • FAX: 279-1476
☐ St. Augustine Regional Office (904) 825-5045 • FAX: 825-5044
☐ Tampa Regional Office (813) 272-3843 • FAX: 272-2340

Mr. Duck
September 27, 2004
Page 2

It is the opinion of New South Associates that proposed development will have no effect on historical properties listed or eligible for listing in the *NRHP*, or otherwise of historical, architectural or archaeological value. New South Associates recommends no further investigation of the subject parcel.

Based on the information provided, our office concurs with these determinations and finds the submitted report complete and sufficient in accordance with Chapter 1A-46, *Florida Administrative Code*.

If you have any questions concerning our comments, please contact Ron Grayson, Historic Sites Specialist, by phone at (850) 245-6333, or by electronic mail at rgrayson@dos.state.fl.us. Your continued interest in protecting Florida's historic properties is appreciated.

Sincerely,

Laura A. Kammerer, Deputy SHPO

for Frederick Gaske, Director, and
State Historic Preservation Officer

FLORIDA DEPARTMENT OF STATE
Glenda E. Hood
Secretary of State
DIVISION OF HISTORICAL RESOURCES

Mr. James C. Duck
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

September 27, 2004

Re: DHR Project File No. 2004-8676 (2002-1944, 2003-2300)/ Received by DHR: August 30, 2004
Cultural Resources Survey of the C-43 Berry Groves Storage Reservoir, Hendry County, Florida

Dear Mr. Duck:

Our office received and reviewed the above referenced survey report in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992; *36 C.F.R., Part 800: Protection of Historic Properties*; and Chapter 267, *Florida Statutes*, for assessment of possible adverse impact to historic properties listed, or eligible for listing, in the *National Register of Historic Places (NRHP)*.

In August to October 2003, New South Associates conducted an archaeological and historical survey of the C-43 Berry Groves Storage Reservoir project area in Hendry County on behalf of the U.S. Army Corps of Engineers, Jacksonville District. Four previously unrecorded historic structures were identified within the project area during the investigation.

The Ted Wells House (8HN102), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN102 does not appear eligible for listing in the *NRHP*.

The Berry Groves House (8HN103), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN103 does not appear eligible for listing in the *NRHP*.

The Berry Groves Bunkhouse (8HN104), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN104 does not appear eligible for listing in the *NRHP*.

The Jeff Jones House (8HN105), a frame vernacular residence built in 1950, was identified within the project area. Due to lack of significant architectural characteristics, and a lack of historical associations, it is the opinion of New South Associates that 8HN105 does not appear eligible for listing in the *NRHP*.

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6435
☐ Archaeological Research (850) 245-6444 • FAX: 245-6436
☑ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Palm Beach Regional Office (561) 279-1475 • FAX: 279-1476
☐ St. Augustine Regional Office (904) 825-5045 • FAX: 825-5044
☐ Tampa Regional Office (813) 272-3843 • FAX: 272-2340

Mr. Duck
September 27, 2004
Page 2

It is the opinion of New South Associates that proposed development will have no effect on historical properties listed or eligible for listing in the *NRHP*, or otherwise of historical, architectural or archaeological value. New South Associates recommends no further investigation of the subject parcel.

Based on the information provided, our office concurs with these determinations and finds the submitted report complete and sufficient in accordance with Chapter 1A-46, *Florida Administrative Code*.

If you have any questions concerning our comments, please contact Ron Grayson, Historic Sites Specialist, by phone at (850) 245-6333, or by electronic mail at rigrayson@dos.state.fl.us. Your continued interest in protecting Florida's historic properties is appreciated.

Sincerely,

Laura A. Kammerer, Deputy SHPO

for Frederick Gaske, Director, and
State Historic Preservation Officer

FLORIDA DEPARTMENT OF STATE
Glenda E. Hood
Secretary of State
DIVISION OF HISTORICAL RESOURCES

Mr. James Duck, Chief
Planning Division, Environmental Branch
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

April 23, 2003

RE: DHR No. 2003-2300
Date Received by DHR: March 20, 2003
Scoping Notice – C-43 Basin Storage Reservoir
Hendry, Lee, Charlotte, or Glades Counties, Florida

Dear Mr. Duck:

Our office received and reviewed the above referenced project in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992, and *36 C.F.R., Part 800: Protection of Historic Properties*. The State Historic Preservation Officer is to advise and assist federal agencies when identifying cultural resources (listed or eligible for listing, in the National Register of Historic Places), assessing the project's effects, and considering alternatives to avoid or reduce the project's adverse effects.

We have reviewed the Scoping Letter for the C-43 Basin Storage Reservoir. The referenced project is part of the Comprehensive Everglades Restoration Project. We note that the Jacksonville District Army Corps of Engineers is preparing a Draft Environmental Impact Statement (DEIS). In the DEIS, environmental considerations will include effects on historic properties and archaeological sites. We look forward to receiving the DEIS, and coordinating with the Jacksonville District Army Corps of Engineers regarding cultural resources that may be impacted by this project.

If there are any questions concerning our comments, please contact Janice Maddox, Historic Sites Specialist, by electronic mail at jmaddox@mail.dos.state.fl.us, or by telephone at 850/245-6333 or 800/847-7278. Thank you for your interest in protecting Florida's cultural resources.

Sincerely,

Janet Snyder Matthews, Ph.D., Director, and
State Historic Preservation Officer

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6435
☐ Archaeological Research (850) 245-6444 • FAX: 245-6436
☑ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Palm Beach Regional Office (561) 279-1475 • FAX: 279-1476
☐ St. Augustine Regional Office (904) 825-5045 • FAX: 825-5044
☐ Tampa Regional Office (813) 272-3843 • FAX: 272-2340

04/16/03 WED 16:18 FAX 727 570 5300 NMFS SERO 002

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, FL 33702
http://caldera.sero.nmfs.gov/

April 16, 2003 F/SER43:MS/DD

Mr. James C. Duck,
Chief, Planning Division
Department of the Army, Corps of Engineers
Environmental Branch
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Duck:

The National Marine Fisheries Service (NOAA Fisheries) has reviewed the public scoping letter, dated March 18, 2003, requesting comments regarding the development of a Draft Environmental Impact Statement (EIS) for the feasibility phase of the C-43 Basin Storage Reservoir Project, Part 1, adjacent to the Caloosahatchee River in either Hendry, Lee, Charlotte, or Glades County, Florida. The project is part of the Comprehensive Everglades Restoration Project (CERP), and the scope of the project includes the construction of an approximately 160,000 acre-foot storage area within the Caloosahatchee Basin to capture and store stormwater runoff and water releases from Lake Okeechobee. According to the public scoping letter, anticipated benefit of the C-43 Basin Storage Reservoir Project is to capture C-43 Basin runoff and releases from Lake Okeechobee. The facilities will be designed to provide water supply benefits, some flood attenuation; environmental water supply deliveries to the Caloosahatchee Estuary; and, water quality benefits by reducing salinity and nutrient impacts of runoff on the downstream estuary.

It is our understanding that detailed information regarding the environmental and biological analyses for the C-43 Basin Storage Reservoir Project will be provided in an forthcoming EIS. Pursuant to the 1996 amendment to the Magnuson-Stevens Fishery Conservation and Management Act, it appears that an Essential Fish Habitat (EFH) Assessment should be incorporated in National Environmental Policy Act documents necessary for the project. To ensure adequate consideration of EFH and fishery resources and measures to conserve those resources, NOAA Fisheries recommends the following issues be addressed in the EIS:

1. Identify Federally managed fisheries and EFH which may be affected by project construction or operation. For example, EFH affected by the project may include submerged aquatic vegetation, estuarine emergent wetlands, mangrove wetlands, estuarine water column, oyster reefs and shell banks, and palustrine emergent and forested wetlands.

2. Include an extensive review of project impacts on EFH, including cumulative effects, an evaluation of those effects, and any proposed mitigation. Additionally, the

04/16/03 WED 16:20 FAX 727 570 5300 NMFS SERO 003

EFH Assessment should include your agency's views regarding EFH impacts.

If we can be of further assistance, please advise. Related comments, questions or correspondence should be directed to Mark Sramek in St. Petersburg, Florida, at (727) 570-5311.

Sincerely,

Rickey N. Ruebsamen

Rickey N. Ruebsamen
Acting Assistant Regional Administrator
Habitat Conservation Division

Cc:
EPA, WPB
DEP, WPB
FFWCC, Tallahassee
FWS, Vero Beach
F/SER3
F/SER4
F/SER43

DIVISIONS OF FLORIDA DEPARTMENT OF STATE
Office of the Secretary
Office of International Relations
Division of Elections
Division of Corporations
Division of Cultural Affairs
Division of Historical Resources
Division of Library and Information Services
Division of Licensing
Division of Administrative Services

FLORIDA DEPARTMENT OF STATE
Katherine Harris
Secretary of State
DIVISION OF HISTORICAL RESOURCES

MEMBER OF THE FLORIDA CABINET
State Board of Education
Trustees of the Internal Improvement Trust Fund
Administration Commission
Florida Land and Water Adjudicatory Commission
Siting Board
Division of Bond Finance
Department of Revenue
Department of Law Enforcement
Department of Highway Safety and Motor Vehicles
Department of Veterans' Affairs

March 19, 2002

Department of Community Affairs
Florida Coastal Management Program
Mr. Mike Murray, State Clearinghouse Coordinator
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

RE: DHR No. 2002-01944 / Received by DHR: February 26, 2002
SAI #: 200202251575C
NEPA Scooping Notice for the C-43 Basin Storage Reservoir
Hendry County, Florida

Dear Mr. Murray:

Our office has received and reviewed the above referenced project in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992, and *36 C.F.R., Part 800: Protection of Historic Properties*, Chapters 267, *Florida Statutes*, Florida's Coastal Management Program, and implementing state regulations, for possible impact to historic properties listed, or eligible for listing, in the *National Register of Historic Places*, or otherwise of historical, architectural or archaeological value. The State Historic Preservation Officer is to advise and assist state and federal agencies when identifying historic properties, assessing effects upon them, and considering alternatives to avoid or minimize adverse effects.

Our review of the Florida Master Site File indicates that there are no archaeological or historic sites currently recorded within the project area. However, the lack of recorded historic properties is not considered significant because the area has never been subjected to a systematic, professional survey to locate such properties. Data from environmentally similar areas indicate that archaeological and historic sites, especially the former, are likely to occur in the study area. It is, therefore, the opinion of this office that there is a reasonable probability of project activities impacting historic properties potentially eligible for listing in the *National Register of Historic Places*, or otherwise of historical, architectural or archaeological value.

Since potentially significant archaeological and historic sites may be present, it is our recommendation that when the final area has been determined, it should be subjected to a systematic, professional archaeological and historical survey. The purpose of this survey will be to locate and assess the significance of historic properties present. The resultant survey report shall conform to the specifications set forth in Chapter 1A-46, *Florida Administrative Code*, and will need to be forwarded to this agency in order to complete the process of reviewing the impact of this proposed project on historic properties.

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6435
☐ Archaeological Research (850) 245-6444 • FAX: 245-6436
☒ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Palm Beach Regional Office (561) 279-1475 • FAX: 279-1476
☐ St. Augustine Regional Office (904) 825-5045 • FAX: 825-5044
☐ Tampa Regional Office (813) 272-3843 • FAX: 272-2340

Mr. Murray
March 19, 2002
Page 2

The results of the investigations will determine if significant historic properties would be disturbed by this project. In addition, if significant remains are located, the data described in the report and the consultant's conclusions will assist this office in determining measures that must be taken to avoid, minimize, or mitigate adverse impacts to historic properties listed, or eligible for listing in the *National Register of Historic Places*, or otherwise of historical, architectural, or archaeological significance.

Based on the information provided, consistency with Section 307 of the *Coastal Zone Management Act*, Chapter 373.414 *Florida Statutes*, 16 U.S.C. Sections 1456 (c) and (d) and implementing regulations, and 15 CFR Part 930 can not be determined by this agency at this time. Under provisions of Chapter 267.061 *Florida Statutes*, it must be determined if the proposed activity will adversely affect or will enhance significant historical or archaeological resources. Meeting these consistency criteria is conditioned upon a thorough cultural resource evaluation to determine if any properties of archaeological or historical significance are present within the area of potential effect for the proposed project.

It is the opinion of this agency that until the required survey described above has been conducted, and any cultural resources identified determined to be significant or potentially significant scheduled for avoidance or mitigation, the proposed project will not be consistent with the *Coastal Zone Management Act* and implementing regulations.

Because this letter and its contents are a matter of public record, consultants who have knowledge of our recommendations may contact the project applicant. This should in no way be interpreted as an endorsement by this agency. The *Registry of Professional Archaeologists* (RPA) is the national certifying organization for archaeologists. A listing of archaeologists who are RPA members living or working in Florida can be accessed at http://dhr.dos.state.fl.us /bhp/compliance. In addition, the complete RPA Directory of Certified Professional Archaeologists is available at www.rpanet.org. Otherwise, upon request, we will forward our RPA list to the applicant.

If you have any questions concerning our comments, please contact Sarah Jalving, Historic Sites Specialist, by electronic mail at sjalving@mail.dos.state.fl.us or at 850-245-6333 or 800-847-7278. Thank you for your interest in protecting Florida's historic properties.

Sincerely,

Janet Snyder Matthews, Ph.D., Director, and
State Historic Preservation Officer

DIVISIONS OF FLORIDA DEPARTMENT OF STATE
Office of the Secretary
Office of International Relations
Division of Elections
Division of Corporations
Division of Cultural Affairs
Division of Historical Resources
Division of Library and Information Services
Division of Licensing
Division of Administrative Services

FLORIDA DEPARTMENT OF STATE
Katherine Harris
Secretary of State
DIVISION OF HISTORICAL RESOURCES

MEMBER OF THE FLORIDA CABINET
State Board of Education
Trustees of the Internal Improvement Trust Fund
Administration Commission
Florida Land and Water Adjudicatory Commission
Siting Board
Division of Bond Finance
Department of Revenue
Department of Law Enforcement
Department of Highway Safety and Motor Vehicles
Department of Veterans' Affairs

March 18, 2002

Mr. James C. Duck
Planning Division, Environmental Branch
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32399-0250

RE: DHR Project File Number: 2002-1584
Received by DHR: February 20, 2002
Project Name: C-43 Basin Storage Reservoir – Berry Groves Property
Hendry County

Dear Mr. Duck:

Our office has received and reviewed the above referenced project in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992, and *36 C.F.R., Part 800: Protection of Historic Properties*. The State Historic Preservation Officer is to advise and assist federal agencies when identifying historic properties (listed or eligible for listing, in the National Register of Historic Places), assessing effects upon them, and considering alternatives to avoid or reduce the project's effect on them.

Our review of the Florida Master Site File indicates that there are no archaeological or historic sites currently recorded within the project area. However, the lack of recorded historic properties is not considered significant because the area has never been subjected to a systematic, professional survey to locate such properties. Data from environmentally similar areas indicate that archaeological and historic sites, especially the former, are likely to occur in the study area. It is, therefore, the opinion of this office that there is a reasonable probability of project activities impacting historic properties potentially eligible for listing in the *National Register of Historic Places*, or otherwise of historical, architectural or archaeological value.

Since potentially significant archaeological and historic sites may be present, it is our recommendation that the area should be subjected to a systematic, professional archaeological and historical survey. The purpose of this survey will be to locate and assess the significance of historic properties present. The resultant survey report shall conform to the specifications set forth in Chapter 1A-46, *Florida Administrative Code*, and will need to be forwarded to this agency in order to complete the process of reviewing the impact of this proposed project on historic properties

The results of the investigations will determine if significant historic properties would be disturbed by this project. In addition, if significant remains are located, the data described in the report and the consultant's conclusions will assist this office in determining measures that must be taken to avoid, minimize, or mitigate adverse impacts to historic properties listed, or eligible for listing in the *National Register of Historic Places*, or otherwise of historical or architectural significance.

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6435
☐ Archaeological Research (850) 245-6444 • FAX: 245-6436
☑ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Palm Beach Regional Office (561) 279-1475 • FAX: 279-1476
☐ St. Augustine Regional Office (904) 825-5045 • FAX: 825-5044
☐ Tampa Regional Office (813) 272-3843 • FAX: 272-2340

Mr. Hall
March 18, 2002
Page 2

Because this letter and its contents are a matter of public record, consultants who have knowledge of our recommendations may contact the project applicant. This should in no way be interpreted as an endorsement by this agency. The *Registry of Professional Archaeologists* (RPA) is the national certifying organization for archaeologists. A listing of archaeologists who are RPA members living or working in Florida can be accessed at http://dhr.dos.state.fl.us/bhp/compliance. In addition, the complete RPA Directory of Certified Professional Archaeologists is available at www.rpanet.org.

If there are any questions concerning our comments, please contact Allison McCarthy, Historic Sites Specialist, by electronic mail at amccarthy@mail.dos.state.fl.us or at 850-245-6333 or 800-847-7278. Thank you for your interest in protecting Florida's historic properties.

Sincerely,

Janet Snyder Matthews

Janet Snyder Matthews, Ph.D., Director, and
State Historic Preservation Officer

B.3.3 Agency Correspondence

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P.O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

Planning Division
Environmental Branch

2 MAR 2007

Mr. Warren Henderson
Natural Resources Conservation Service
Soils Section
2614 NW 43rd Street
Gainesville, FL 32606-6611

Dear Mr. Henderson:

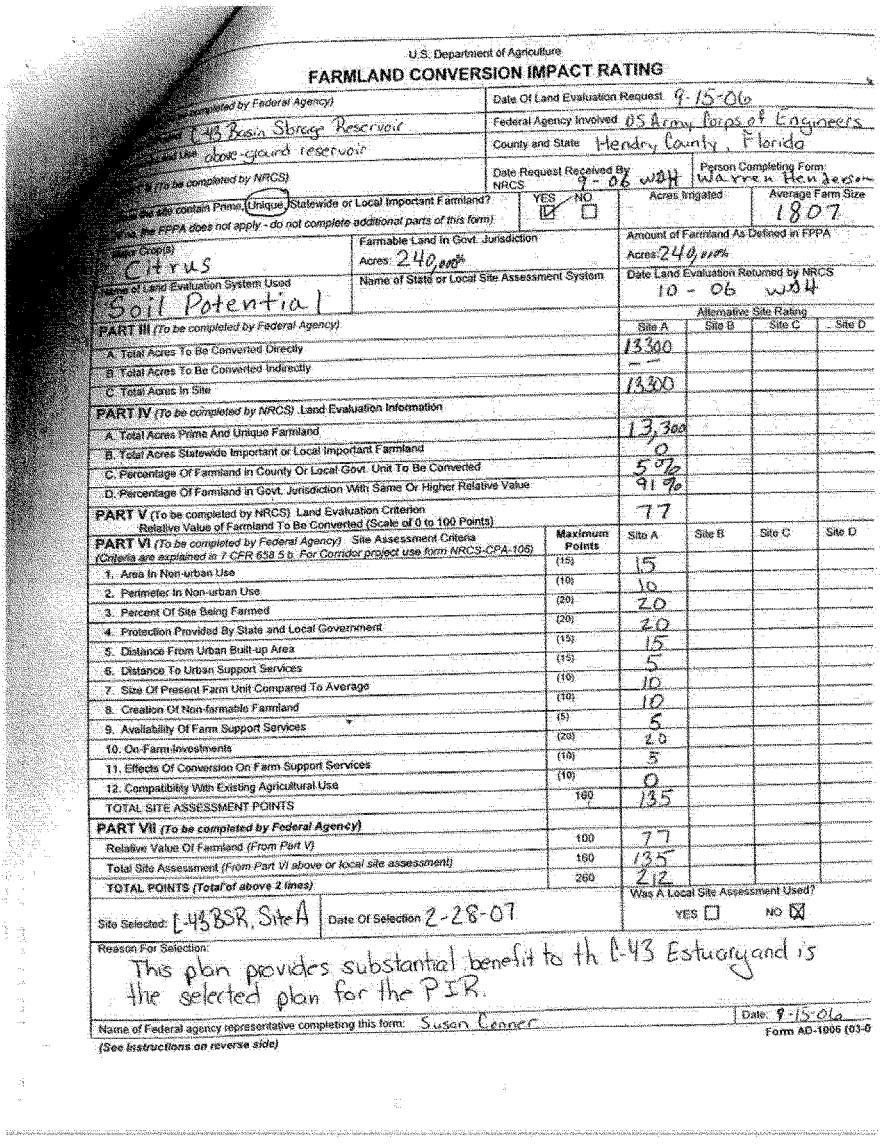
The U.S. Army Corps of Engineers, Jacksonville District, is resubmitting the Farmland Conversion Impact Rating form (Form AD-1006) for C-43 Basin Storage Reservoir. We have completed Parts VI and VII as requested. The form is enclosed.

If you have any questions, please contact Ms. Susan Conner at 904-232-1782 or by email at Susan.L.Conner@usace.army.mil. Thank you for your assistance on this matter.

Sincerely,

Marie G. Burns
Chief, Environmental Branch

Enclosure



U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

(To be completed by Federal Agency)	Date Of Land Evaluation Request: 9-15-06
L-43 Basin Storage Reservoir	Federal Agency Involved: US Army Corps of Engineers
above ground reservoir	County and State: Hendry County, Florida
(To be completed by NRCS)	Date Request Received By NRCS: 9-06 WSH
	Person Completing Form: Warren Henderson

Does the site contain Prime, Unique, Statewide or Local Important Farmland? YES ☑ NO ☐ — Acres Irrigated: — — Average Farm Size: 1807

(If the FPPA does not apply - do not complete additional parts of this form)

Major Crop(s): Citrus	Farmable Land in Govt. Jurisdiction Acres: 240,000
Name of Land Evaluation System Used: Soil Potential	Name of State or Local Site Assessment System
	Amount of Farmland As Defined in FPPA Acres: 240,000
	Date Land Evaluation Returned by NRCS: 10-06 WSH

PART III (To be completed by Federal Agency)

	Alternative Site Rating			
	Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	13300			
B. Total Acres To Be Converted Indirectly	—			
C. Total Acres In Site	13300			

PART IV (To be completed by NRCS) Land Evaluation Information

A. Total Acres Prime And Unique Farmland	13,300			
B. Total Acres Statewide Important or Local Important Farmland	0			
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted	5%			
D. Percentage Of Farmland in Govt. Jurisdiction With Same Or Higher Relative Value	91%			
PART V (To be completed by NRCS) Land Evaluation Criterion Relative Value of Farmland To Be Converted (Scale of 0 to 100 Points)	77			

PART VI (To be completed by Federal Agency) Site Assessment Criteria (Criteria are explained in 7 CFR 658.5 b. For Corridor project use form NRCS-CPA-106)

	Maximum Points	Site A	Site B	Site C	Site D
1. Area In Non-urban Use	(15)	15			
2. Perimeter In Non-urban Use	(10)	10			
3. Percent Of Site Being Farmed	(20)	20			
4. Protection Provided By State and Local Government	(20)	20			
5. Distance From Urban Built-up Area	(15)	15			
6. Distance To Urban Support Services	(15)	5			
7. Size Of Present Farm Unit Compared To Average	(10)	10			
8. Creation Of Non-farmable Farmland	(10)	10			
9. Availability Of Farm Support Services	(5)	5			
10. On-Farm Investments	(20)	20			
11. Effects Of Conversion On Farm Support Services	(10)	5			
12. Compatibility With Existing Agricultural Use	(10)	0			
TOTAL SITE ASSESSMENT POINTS	160	135			
PART VII (To be completed by Federal Agency)					
Relative Value Of Farmland (From Part V)	100	77			
Total Site Assessment (From Part VI above or local site assessment)	160	135			
TOTAL POINTS (Total of above 2 lines)	260	212			

Site Selected: L-43BSR, Site A — Date Of Selection: 2-28-07 — Was A Local Site Assessment Used? YES ☐ NO ☒

Reason For Selection:

This plan provides substantial benefit to th L-43 Estuary and is the selected plan for the PIR.

Name of Federal agency representative completing this form: Susan Cenner — Date: 9-15-06

(See instructions on reverse side) — Form AD-1006 (03-0

United States Department of Agriculture



Natural Resources Conservation Service
Florida State Office
2614 NW 43rd Street
Gainesville, FL 32606

PH 352-338-9500
FX 352-338-9574
www.fl.nrcs.usda.gov

October 30, 2006

Ms. Susan Conner
Research Biologist
Environmental Branch
Planning Division
701 San Marco Boulevard
PO Box 4970
Jacksonville, Florida 32232-0019

RE: Farmland Conversion Impact Rating
Form AD-1006
C-43 Basin Storage Reservoir

Dear Ms. Conner:

Enclosed is form AD 1006 with Parts II, IV, and V completed for the referenced project. The citrus groves are considered unique farmland, which is defined by the Farmland Protection Policy Act (FPPA). Completion of the project would take this farmland out of production. According to the FPPA, if the Federal Agency involved decides to fund the project, Parts VI and VII of the form should be competed and returned to this office.

If there are additional questions, please feel free to contact me at 352-338-9535.

Sincerely,

Warren Henderson

Warren Henderson
State Soil Scientist

Enclosure

cc: Dan Rutlege, District Conservationist, LaBelle

Helping People Help the Land

An Equal Opportunity Provider and Employer

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*

Name of Project: C-43 Basin Storage Reservoir	Date Of Land Evaluation Request: 9-15-06
Proposed Land Use: above-ground reservoir	Federal Agency Involved: US Army Corps of Engineers
	County and State: Hendry County, Florida
	Date Request Received By NRCS: 9-06 WAH
	Person Completing Form: Warren Henderson

Does the site contain Prime, Unique, Statewide or Local Important Farmland? (If no, the FPPA does not apply - do not complete additional parts of this form)	YES ☑	NO ☐	Acres Irrigated	Average Farm Size
				1807

Major Crop(s)	Farmable Land In Govt. Jurisdiction	Amount of Farmland As Defined in FPPA
Citrus	Acres: 240,000	Acres: 240,000
Name of Land Evaluation System Used	**Name of State or Local Site Assessment System**	**Date Land Evaluation Returned by NRCS**
Soil Potential		10-06 WAH

PART III *(To be completed by Federal Agency)*

	Alternative Site Rating			
	Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	13300			
B. Total Acres To Be Converted Indirectly	—			
C. Total Acres In Site	13300			

PART IV *(To be completed by NRCS)* Land Evaluation Information

A. Total Acres Prime And Unique Farmland	13,300			
B. Total Acres Statewide Important or Local Important Farmland	0			
C. Percentage Of Farmland in County Or Local Govt. Unit To Be Converted	5%			
D. Percentage Of Farmland in Govt. Jurisdiction With Same Or Higher Relative Value	91%			

PART V (To be completed by NRCS) Land Evaluation Criterion
Relative Value of Farmland To Be Converted (Scale of 0 to 100 Points): 77

PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(Criteria are explained in 7 CFR 658.5 b. For Corridor project use form NRCS-CPA-106)*

	Maximum Points	Site A	Site B	Site C	Site D
1. Area In Non-urban Use	(15)	15			
2. Perimeter In Non-urban Use	(10)	10			
3. Percent Of Site Being Farmed	(20)	20			
4. Protection Provided By State and Local Government	(20)	20			
5. Distance From Urban Built-up Area	(15)	15			
6. Distance To Urban Support Services	(15)	5			
7. Size Of Present Farm Unit Compared To Average	(10)	10			
8. Creation Of Non-farmable Farmland	(10)	10			
9. Availability Of Farm Support Services	(5)	5			
10. On-Farm Investments	(20)	20			
11. Effects Of Conversion On Farm Support Services	(10)	5			
12. Compatibility With Existing Agricultural Use	(10)	0			
TOTAL SITE ASSESSMENT POINTS	160	135			
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	77			
Total Site Assessment *(From Part VI above or local site assessment)*	160	135			
TOTAL POINTS *(Total of above 2 lines)*	260	212			

Site Selected: C-43SR, Site A	Date Of Selection: 2-28-07	Was A Local Site Assessment Used? YES ☐ NO ☒

Reason For Selection:
This plan provides substantial benefit to the C-43 Estuary and is the selected plan for the PIR.

Name of Federal agency representative completing this form: Susan Connec — Date: 9-15-06

(See instructions on reverse side)

Form AD-1006 (03-02)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
WATER MANAGEMENT DIVISION
SOUTH FLORIDA OFFICE
400 NORTH CONGRESS AVE., SUITE 120
WEST PALM BEACH, FLORIDA 33401

MAR 1 4 2005

Mr. Lawrence Skaggs
C-43 Basin Storage Reservoir Project Manager
US Army Corps of Engineers
701 San Marco Blvd.
PO Box 4970
Jacksonville, Florida 32232

SUBJECT: C-43 Basin Storage Reservoir Project

Dear Mr. Skaggs,

This letter provides comments from the U.S. Environmental Protection Agency's (EPA) on the ongoing development of the Project Implementation Report (PIR) for the C-43 (Caloosahatchee River) Basin Storage Reservoir. According to the 1999 Restudy Final Environmental Impact Statement (FEIS) and Integrated Feasibility Report, the C-43 Basin Storage Reservoir (BSR) will have water supply benefits, and provide environmental water supply deliveries to the Caloosahatchee estuary. The Project Scope is to "provide environmental, urban and agricultural water supply needs, flood attenuation and improvements to water quality and timing of releases to the Caloosahatchee Basin, River and Estuary". Specifically, "nutrient impacts of runoff into the estuary" are to be addressed by the project (C-43 Basin Draft Feasibility Scoping Meeting (FSM), page 127). The C-43 Basin Storage Reservoir Draft FSM document states that excessive nutrients, depressed levels of dissolved oxygen, and elevated coliform bacteria levels are problematic in the estuary. Reducing nutrient loads would result in substantial ecological improvement in the Caloosahatchee estuary.

Because the C-43 Basin Storage Reservoir is a "Category B" project according to CERP Guidance Memorandum number 23, it is not required that water quality improvement features be included in the project. However, Category B projects must be designed to achieve water quality (WQ) improvement during project formulation and design by:

1) Characterizing existing WQ conditions, including a baseline sampling program, if necessary;
2) Forecasting base-year WQ conditions;
3) Forecasting future without project WQ conditions;
4) Developing evaluation criteria to determine the extent of WQ improvement associated with alternative plans;
5) Identify WQ constraints;
6) Developing evaluation criteria associated with WQ constraints;

Recycled/Recyclable • Printed with Vegetable Oil Based Inks on 100% Recycled Paper (40% Postconsumer)

7) Selecting the least cost plan that meets the WQ restoration objectives; and,
8) Optimizing the design of the selected plan to maximize WQ improvement if optimization does not conflict with the purpose and objectives for the project.

We understand that the C-43 project PIR is not being formulated for water quality improvements, and that the Tentatively Selected Plan (TSP) will not make water quality worse in the basin. The CGM 23 also requires that evaluation criteria be developed for "alternative plan evaluation, comparison, and selection purposes, as well as for **maximizing the water quality improvement efficiency**" (number 4 above and CGM 23 page 11). The Water Quality Evaluation Criteria Matrix that is included in the C-43 Draft FSM report (appendix D) does address the potential for degrading water quality with the construction of the reservoir. However, the matrix does not include a method for evaluating the efficiency of project alternatives at *improving* water quality, as is required by CGM 23.

The EPA has had conversations with the U. S. Army Corps of Engineers, Jacksonville District, regarding this issue, and was informed that the Water Quality Evaluation Criteria Matrix that is included in the Draft FSM document is being revised. Evaluation Criteria that address the ability of plan alternatives to improve water quality should be added.

If you need any assistance, please feel free to contact Eric Hughes or Melanie Edwards, of my staff.

Sincerely,

Richard M. Harvey, P.E.
Director, South Florida Office

Florida Department of Agriculture & Consumer Services
CHARLES H. BRONSON, Commissioner

Please Respond to:
Office of Agricultural Water Policy
3301 Gun Club Rd
P.O. Box 24680
West Palm Beach, FL 33406-4680

January 26, 2005

Ms. Kim Brooks-Hall
Chief, South Florida Restoration Branch
Department of the Army
Jacksonville District Corps of Engineers
701 San Marco Blvd.
Jacksonville, FL 32207-8175

Dear Ms. Brooks-Hall:

During development of the conceptual plan for the Restudy, one of the main concepts of the regional storage components was to provide additional storage for water supply in the Caloosahatchee, St. Lucie and Kissimmee Basins which should ultimately reduce irrigation demands on Lake Okeechobee. Water could then be conserved in the lake and would be "...available for sustaining the health of lake and downstream natural areas ..." (Sections 6.4.2 and 6.4.1.2). The source for agricultural irrigation demands would be "switched" to the reservoirs as much as possible and be supplemented as needed by the lake. More lake water would be available for natural system needs.

Currently the C-43 BSR FSM Draft does not address this function of the C-43 BSR project. Instead, the introduction on page one of the FSM draft states: "Once the demands of the estuary are met, additional water resource benefits could be achieved by providing supplemental water resources for agriculture and urban users resulting in a reduction of demands placed on existing surface water and ground water resources such as the C-43 canal and Lake Okeechobee." Agricultural water supply from this project is treated as being supplemental, not as a "source switch" for current demands. This introductory approach is maintained throughout the C-43 BSR FSM Draft.

Our concerns are not that agricultural irrigation demands will not be addressed in the state planning and permitting processes. They are about changing the original concepts on how the CERP storage reservoirs would be operated. If the primary purpose of the C-43 reservoir is now to meet estuary demands, and not to "switch sources" for local irrigation demands, that change from the Yellowbook concept needs to be made after a public debate.

A second issue with the C-43 BSR FSM Draft is one that FDACS has previously raised at the August 24, 2004 Regional PDT meeting. The socioeconomic section contains a lot of

information on recreation and fisheries and very little on agriculture in the region. The economic impacts of removing large acreages of viable agricultural land out of production for project components needs to be better addressed in order to adequately consider the feasibility of the alternatives being considered.

If you have any questions or I can assist in any way, please feel free to call me at 561- 682-2845 or Rebecca Elliott at 561-682-6040. We would be happy to participate in any future modifications to the draft document.

Sincerely,

CHARLES H. BRONSON
COMMISSIONER OF AGRICULTURE

Linda J. McCarthy
Water Policy Liaison

cc: Chuck Aller, FDACS
Ray Scott, FDACS
Dennis Duke, USACE

Department of
Environmental Protection

Jeb Bush
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

David B. Struhs
Secretary

May 23, 2003

Mr. James C. Duck, Chief
Planning Division, Jacksonville District
U. S. Army Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

Re: Department of the Army, Jacksonville District Corps of Engineers, Scoping Notice, Draft Environmental Impact Statement, C-43 Basin Storage Reservoir Project, Caloosahatchee Basin, Hendry, Glades, Charlotte, or Lee County, Florida

SAI: FL200303261382C

Dear Mr. Duck:

The Florida State Clearinghouse, pursuant to Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated the review of the above-referenced Draft Environmental Impact Statement (DEIS) for the proposed project.

The Southwest Florida Regional Planning Council (SWFRPC) indicates that the project is regionally significant and consistent with its Strategic Regional Policy Plan. Please see the enclosed letter form the SWFRPC.

The Florida Department of Transportation (FDOT) indicated that it has no comments for this project; however, FDOT's initial issues and concerns, expressed in its April 5, 2002 response to the scoping notice need to be addressed. Please see FDOT comments in the enclosed Clearinghouse tracking system page.

The Department of Environmental Protection (DEP) states that additional evaluation of the properties and reservoir capacities is necessary to provide assurances that the proposed project will meet safety standards for the residential area in which it will be located. Additional properties should be considered and evaluated in the DEIS. Please see the enclosed memorandum from DEP.

Based on the information contained in the above-referenced DEIS and the comments provided by our reviewing agencies, as summarized above and enclosed, the state has determined that, at this stage, the proposed project is consistent with the Florida Coastal Management

Printed on recycled paper.

Mr. James C. Duck
May 23, 2003
Page 2

Program (FCMP). All subsequent environmental documents prepared for this project must be reviewed to determine the project's continued consistency with the FCMP. The state's consistency concurrence with the project will be based, in part, on the adequate resolution of issues identified during this and subsequent reviews. The state's final concurrence on the project's consistency with the FCMP will be determined during the environmental permitting stage.

Thank you for the opportunity to review this project. If you have any questions regarding this letter, please contact Mr. Bob Hall at 850/245-2163.

Sincerely,

Sally B. Mann, Director
Office of Intergovernmental Programs

SBM/rwh
Enclosures
cc: Marisa Erika Morr, SWFRPC
Sandra Whitmire, DOT, Tallahassee
Gordon Romeis, DEP Ft. Myers
Greg Knecht, MS 3560

04/16/03 WED 16:19 FAX 727 570 5300 NMFS SERO 002

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, FL 33702
http://caldera.sero.nmfs.gov/

April 16, 2003 F/SER43:MS/DD

Mr. James C. Duck,
Chief, Planning Division
Department of the Army, Corps of Engineers
Environmental Branch
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Duck:

The National Marine Fisheries Service (NOAA Fisheries) has reviewed the public scoping letter, dated March 18, 2003, requesting comments regarding the development of a Draft Environmental Impact Statement (EIS) for the feasibility phase of the C-43 Basin Storage Reservoir Project, Part 1, adjacent to the Caloosahatchee River in either Hendry, Lee, Charlotte, or Glades County, Florida. The project is part of the Comprehensive Everglades Restoration Project (CERP), and the scope of the project includes the construction of an approximately 160,000 acre-foot storage area within the Caloosahatchee Basin to capture and store stormwater runoff and water releases from Lake Okeechobee. According to the public scoping letter, anticipated benefit of the C-43 Basin Storage Reservoir Project is to capture C-43 Basin runoff and releases from Lake Okeechobee. The facilities will be designed to provide water supply benefits; some flood attenuation; environmental water supply deliveries to the Caloosahatchee Estuary; and, water quality benefits by reducing salinity and nutrient impacts of runoff on the downstream estuary.

It is our understanding that detailed information regarding the environmental and biological analyses for the C-43 Basin Storage Reservoir Project will be provided in an forthcoming EIS. Pursuant to the 1996 amendment to the Magnuson-Stevens Fishery Conservation and Management Act, it appears that an Essential Fish Habitat (EFH) Assessment should be incorporated in National Environmental Policy Act documents necessary for the project. To ensure adequate consideration of EFH and fishery resources and measures to conserve those resources, NOAA Fisheries recommends the following issues be addressed in the EIS:

1. Identify Federally managed fisheries and EFH which may be affected by project construction or operation. For example, EFH affected by the project may include submerged aquatic vegetation, estuarine emergent wetlands, mangrove wetlands, estuarine water column, oyster reefs and shell banks, and palustrine emergent and forested wetlands.

2. Include an extensive review of project impacts on EFH, including cumulative effects, an evaluation of those effects, and any proposed mitigation. Additionally, the

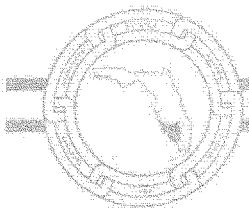
EFH Assessment should include your agency's views regarding EFH impacts.

If we can be of further assistance, please advise. Related comments, questions or correspondence should be directed to Mark Sramek in St. Petersburg, Florida, at (727) 570-5311.

Sincerely,

Rickey N. Ruebsamen
Acting Assistant Regional Administrator
Habitat Conservation Division

Cc:
EPA, WPB
DEP, WPB
FFWCC, Tallahassee
FWS, Vero Beach
F/SER3
F/SER4
F/SER43



Southwest Florida Regional Planning Council

April 15, 2003

James C. Duck
Attention: Planning Division, Environmental Studies Section
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

RE: ICR Project #: 2003-068
Project Comments for Scoping Notice for Draft Programmatic EIS for C-43 Basin Storage Reservoir Project, Caloosahatchee Basin
Applicant: Department of the Army – Jacksonville District Corps of Engineers

Dear Mr. Duck:

The staff of the Southwest Florida Regional Planning Council reviews various proposals, Notifications of Intent, Preapplications, permit applications, and Environmental Impact Statements for compliance with regional goals, objectives, and policies, as determined by the Strategic Regional Policy Plan. The staff reviews such items in accordance with the Florida Intergovernmental Coordination and Review Process (Chapter 29I-5, F.A.C.), and adopted regional clearinghouse procedures.

The Southwest Florida Regional Planning Council recognizes the importance of clean, renewable water resources for the health, survival, and well being of area residents. The C-43 Basin Storage Reservoir Project is a good way to utilize stored water to help meet the regional environmental demands of the Caloosahatchee River and Estuary.

Enclosed is a copy of the Natural Resources Element Section of the Strategic Regional Policy Plan for the Southwest Florida Regional Planning Council. This section discusses the adopted goals, objectives, and actions which outline issues that need to be addressed in the draft EIS for this project.

Please contact Nichole L. Gwinnett, IC&R Coordinator, with any questions concerning staff review of this item.

Sincerely,

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL

Marisa Erika Morr
Regional Planner

MEM/NLG

Enclosures

7

STATE OF FLORIDA

DEPARTMENT OF COMMUNITY AFFAIRS

"Dedicated to making Florida a better place to call home"

JEB BUSH
Governor

STEVEN M. SEIBERT
Secretary

May 16, 2002

Mr. James C. Duck
Department of the Army
Jacksonville District Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

RE: Department of the Army - District Corps of Engineers - Scoping Notice - Gathering Information to Help Define Issues and Concerns to be Addressed in a National Environmental Policy Act Document Being Prepared for the C-43 Basin Storage Reservoir - Hendry, Glades or Lee Counties, Florida
SAI: FL200202251575C

Dear Mr. Duck:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4231, 4331-4335, 4341-4347, as amended, has coordinated a review of the above-referenced project.

The Department of Environmental Protection (DEP) notes that the project will require permits from DEP. This includes a Comprehensive Everglades Restoration Plan Regulation permit and a National Pollutant Discharge Elimination System permit. These permits will cover the construction and operation of the reservoir and discharges to surface waters. A consumptive use permit will also be required pursuant to South Florida Water Management District regulations, although this permit will probably be reviewed by DEP because the SFWMD is a co-applicant on this project. The Corps should contact these agencies regarding permitting requirements. Please refer to the enclosed DEP comments for further details.

The Florida State Historic Preservation Officer (SHPO) is concerned that project activities could disturb significant archaeological or historic sites. Therefore, the SHPO recommends that a systematic archaeological and historical survey be conducted within the project area. The Corps should contact the SHPO office early in the process for information regarding the recommended survey. Please refer to the enclosed SHPO comments for further details.

2555 SHUMARD OAK BOULEVARD • TALLAHASSEE, FLORIDA 32399-2100
Phone: 850.488.8466/Suncom 278.8466 FAX: 850.921.0781/Suncom 291.0781
Internet address: http://www.dca.state.fl.us

CRITICAL STATE CONCERN FIELD OFFICE
2796 Overseas Highway, Suite 212
Marathon, FL 33050-2227
(305) 289-2402

COMMUNITY PLANNING EMERGENCY MANAGEMENT
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 488-2356

HOUSING & COMMUNITY DEVELOPMENT
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 488-7956

The Florida Fish and Wildlife Conservation Commission (FWC) notes that the C-43 Basin is documented for the occurrence of many species classified by the FWC as endangered, threatened, or species of special concern. The proposed project has the potential for direct and indirect effects that could benefit or adversely impact many of these species, depending on the location, design, and operation of the proposed reservoirs. Protection and restoration of the native habitats in the region, and restoration of optimal base flows to the Caloosahatchee River and estuary can benefit general fish and wildlife resources, and assist in recovery of listed species. Please refer to the enclosed FWC comments for further details.

The Florida Department of Transportation has identified two areas of immediate concern which should be addressed as soon as possible. Currently, a section of SR 80 within the project area is being multi-laned under an expedited construction schedule. To ensure that the drainage requirements and structural integrity of this SR 80 project are maintained, the applicant must provide adequate documentation to DOT that provides assurance that the water table will not be elevated to such an extent that SR 80 roadway sub grades will be negatively impacted. Also, DOT understands that the Townsend Canal will be utilized as the main conduit for alternating hydraulic flows between the proposed reservoir and the Caloosahatchee River and will need to be widened to accommodate the extra flow. DOT has scheduled two bridge projects over the Townsend Canal which will begin this spring/summer. In order to avoid having to replace or retrofit these two soon-to-be constructed SR 80 bridges over Townsend Canal, the applicant should address this issue as soon as possible. Please refer to the enclosed DOT comments for further details.

The Southwest Florida Regional Planning Council (SWFRPC) notes that SR 80 is a critical hurricane evacuation route for Lee County. SWFRPC is concerned that an above ground reservoir along this route creates additional danger and exposure should the above ground berm fail during a hurricane event. Please refer to the enclosed SWFRPC comments for further details.

Based on the information contained in the scoping notice and the enclosed comments provided by our reviewing agencies, the state has determined that, at this stage, the above-referenced action is consistent with the Florida Coastal Management Program (FCMP). All subsequent environmental documents prepared for this project must be reviewed to determine the project's continued consistency with the FCMP. The state's continued concurrence with the project will be based, in part, on the adequate resolution of issues identified during this and subsequent reviews.

Mr. James C. Duck
May 16, 2002
Page Three

Thank you for the opportunity to review this project. If you have any questions regarding this letter, please contact Ms. Jasmin Raffington at (850) 922-5438.

Sincerely,

Shirley W. Collins, Acting Administrator
Florida Coastal Management Program

SWC/dc

Enclosures

cc: Robert W. Hall, Florida Department of Environmental Protection
Janet Snyder Matthews, SHPO, Division of Historical Resources
James J. Golden, South Florida Water Management District
Larry G. Slayback, Florida Department of Transportation
Wayne E. Daltry, Southwest Florida Regional Planning Council

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

DAVID K. MEEHAN, St. Petersburg
H.A. "HERKY" HUFFMAN, Deltona
JOHN D. ROOD, Jacksonville
QUINTON L. HEDGEPETH, DDS, Miami
EDWIN P. ROBERTS, DC, Pensacola
RODNEY BARRETO, Miami
SANDRA T. KAUPE, Palm Beach

ALLAN L. EGBERT, Ph.D., Executive Director
VICTOR J. HELLER, Assistant Executive Director

BRADLEY J. HARTMAN, DIRECTOR
OFFICE OF ENVIRONMENTAL SERVICES
(850)488-6661 TDD (850)488-9542
FAX (850)922-5679

April 24, 2002

Ms. Cindy Cranick
Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

Re: FL200202251575C, Hendry County, C-43 Basin Storage Reservoir

Dear Ms. Cranick:

The Office of Environmental Services of the Florida Fish and Wildlife Conservation Commission (FWC) has reviewed this document, and has the following comments and requests for additional information.

The C-43 Basin Storage Reservoir feature of the Comprehensive Everglades Restoration Plan (CERP) includes aboveground reservoirs, with a total storage capacity of approximately 160,000 acre-feet. The initial design assumed 20,000 reservoir acres, with water levels fluctuating up to eight feet above grade. An initial site proposed for an 8,000-acre reservoir is the Berry Groves property, located in Hendry County. The property is currently in agricultural production, with citrus as the primary crop. There are two adjacent canals that adjoin the property, the Townsend Canal to the west and the Roberts Canal to the east. The area is primarily citrus groves, with strips of shrubs along irrigation/drainage ditches in the grove. The primary vegetation in the ditches is Brazilian pepper, with some grasses and other herbaceous plants. Currently, the Berry Groves operation obtains water from the Townsend Canal through a pump, with a system of secondary ditches providing conveyance of water to, and drainage from, the citrus groves.

Other potential sites are to be identified within the C-43 Basin in Hendry, Glades, and/or Lee counties. Our understanding is that the U.S. Army Corps of Engineers (USACOE) is looking for sites throughout the Caloosahatchee Basin, and elevation contours are being used to make initial rough determinations of site suitability. The final size, depth, and configuration of these facilities will be determined through more detailed planning and design. The purpose of this project is to capture C-43 Basin runoff and releases from Lake Okeechobee. Upon implementation, the C-43 Basin Storage Reservoir project is intended to provide environmental, urban, and agricultural water supply needs, "flood attenuation," and improved timing of releases

620 South Meridian Street - Tallahassee - FL - 32399-1600
www.floridaconservation.org

to the Caloosahatchee Basin, River and Estuary. It is assumed that, depending upon the location of the facility and pollutant loading conditions in the watershed, the facility could be designed to achieve significant water quality improvements.

The C-43 Basin is documented for the occurrence of many species classified by the FWC as endangered, threatened, or species of special concern. The proposed total project has the potential for direct and indirect effects that would potentially benefit or adversely impact many of these species, depending upon the location, design, and operation of the proposed reservoirs. To date, no comprehensive surveys have been completed for fish and wildlife species within the Berry Groves property, but because of its highly altered habitat conditions, we expect that it has limited use by listed species. We assisted in coordination of the selection of the Berry Groves site with the South Florida Water Management District (SFWMD) and USACOE. In contrast, the site review of other potential sites has not been coordinated with the FWC.

We recommend that the USACOE and SFWMD consult with the FWC in the early planning stages of reservoir siting. Protection and restoration of the native habitats in the region, and restoration of optimal base flows to the Caloosahatchee River and estuary can benefit general fish and wildlife resources, and assist in recovery of listed species.

We recommend minimizing the impact of the C-43 reservoirs on native habitats. This would include native range areas that retain habitat value for species such as the Florida grasshopper sparrow, Audubon' s crested caracara, Florida sandhill crane, Florida burrowing owl, gopher tortoise, eastern indigo snake, and gopher frog. Therefore, we recommend that if siting of reservoirs allows a choice of lands with different agricultural land use histories, that areas supporting citrus and sugarcane be selected in preference to unimproved or improved pastures, and that improved pastures be selected in preference to unimproved pastures.

The Caloosahatchee Basin plays an important role in the recovery of the Florida panther. The USFWS has organized a multi-agency subgroup of the Multi-species/Ecosystem Recovery Implementation Team to produce a Florida panther landscape conservation strategy. In addition to protection of habitat for adult home ranges, the strategy includes a provision of corridors for dispersal of juveniles between larger areas of contiguous habitat. Dispersal across the Caloosahatchee River, between existing primary habitat south of the river and habitat that is used by panthers north of the river, is considered essential for recovery of the species. The dispersal habitat coincides with the proposed public land acquisition area known as the Caloosahatchee Ecoscape. Facilities proposed as part of the C-43 reservoir project should not be located in the Caloosahatchee Ecoscape.

The proposed total project is located within the feeding radius of several colonies of wood storks and other colonially nesting wading birds. The maintenance of natural hydro-periods in foraging grounds around nesting areas is vital to the recovery of these birds in south

Florida. The intended operation of the reservoirs can provide foraging opportunities, or loss of short hydroperiod shallow foraging areas. The project should address this issue and the potential for conflicts of the operation schedule with listed wading bird nesting and foraging in a wading and water bird management plan for the reservoirs. We offer our assistance in the development of such a plan. Mitigation may be needed to offset the loss of seasonal wetlands for woodstork and other listed wading bird foraging.

Since funding for this project is coming from CERP, a restoration project, the water in the reservoirs should be used to meet environmental needs before the water is allocated to urban or agricultural use. The FWC plans to participate in efforts to establish specific ecological targets for the Caloosahatchee River and the estuary, with optimal seasonal base flows and flow regimes. This will depend in part on water from the C-43 reservoirs to meet those needs. The C-43 Project Delivery Team should work closely with the Southwest Florida Feasibility Study Team to establish these goals and to ensure that the design and operation of the C-43 reservoirs are compatible with those targets.

We will continue interagency coordination on these issues. Please contact me, or Mr. Jim Beever at (941)575-5765, if you have any questions.

Sincerely,

Bradley J. Hartman, Director
Office of Environmental Services

BJH/JWB
ENV 1-3-2
a:\C43basinstroagesii.doc

CC: Mr. Dave Burr, DRI Coordinator
Southwest Florida Regional Planning Council
4980 Bayline Drive, 4th Floor
North Ft. Myers, Florida 33917-3909

Ms. Kim Dryden
U.S. Fish and Wildlife Service
Office of Ecological Services
Southwest Florida Suboffice
3860 Tollgate Boulevard, Suite 300
Naples, Florida 34114

MAY-14-02 01:12 PM F D O T 19413382311 P.02

Florida Department of Transportation

JEB BUSH
GOVERNOR

THOMAS F. BARRY, JR.
SECRETARY

April 5, 2002

Ms. Jasmin Raffington
State Clearinghouse
Florida Coastal Management Program
Department of Community Affairs
2555 Shumard Oak Boulevard, Suite 325
Tallahassee, Florida 32399-2100

RE: ICAR REVIEW (SAI# FL200202251575C)
USACOE C-43 BASIN STORAGE RESERVOIR (HENDRY COUNTY)

Dear Ms. Raffington:

District One, Florida Department of Transportation, has reviewed the above-referenced Intergovernmental Coordination and Review (ICAR) document, and offers the following comments:

1. The Applicant is undertaking development of a National Environmental Policy Act (NEPA) document for the proposed C-43 Basin Storage Reservoir, which is an element of the Comprehensive Everglades Restoration Project (CERP), authorized by the Federal Water Resources Development Act of 2000. The proposal calls for the construction of an above-ground reservoir with total storage capacity tentatively estimated at approximately 160,000 acre-feet; that is to say, 20,000 acres with water levels fluctuating up to eight feet above grade. Final design will be contingent, in part, upon issues and concerns raised in the NEPA document.

   Preliminary plans are to locate the proposed reservoir adjacent to State Road 80 on the south side, from Townsend Canal east for a distance of approximately seven (7) miles, in northwestern Hendry County. Half of this segment of SR 80, a Florida Intrastate Highway System (FIHS) facility, is currently being multi-laned (FM# 1941961) under an expedited construction schedule.

2. The Applicant's notification package does not provide sufficient information or engineering detail to definitively determine whether the proposed reservoir and acceptable roadway drainage mechanics for SR 80 could coexist. To ensure that the drainage requirements and structural integrity of the upcoming SR 80 multi-laning investments are maintained, the Applicant is required to provide adequate documentation to the District Drainage Engineer's Office for review and assurance that the water table will not be elevated to such extent that SR 80 roadway sub grades will be detrimentally impacted. Assurances will also be needed that tail water

District One Planning Office, Modal Development Department
District One Southwest Area Office * Post Office Box 1030 * Fort Myers, FL 33902-1030
(941) 461-4300 * (941) 338-2353 (Fax) * MS 1-98

elevations assumed for roadway drainage will not be increased as a result of the close proximity of the proposed reservoir.

The Applicant will need to contact Mr. John Previte, P.E., of the District Drainage Engineer's Office in Bartow at (863) 519-2676, in order to provide the necessary documentation, assurances and coordination, before proceeding with this project.

3. Of particular *urgent* concern to the Department is an impending design/construction conflict between a reservoir-associated flow way and two State Road 80 bridge construction projects (FM# 1941821) scheduled for letting this spring/summer. According to C-43 Basin Storage Reservoir concept plans, Townsend Canal is to be utilized as the main conduit for alternating hydraulic flows between the proposed reservoir and the Caloosahatchee River. While future capacity needs of the canal are not yet known, and thus no ultimate typical cross-section developed as yet, South Florida Water Management District hydraulic engineers have confirmed that Townsend Canal will need to be widened, and that the two SR 80 bridges soon to be constructed over the canal by the Department, will not be large enough spans to accommodate the anticipated increase in canal capacity.

   In order to avoid having to replace (or retrofit) these two soon-to-be-constructed SR 80 bridges over Townsend Canal, to the financial and operational detriment of the Department, the SR 80 projects, and motoring public, the Applicant is requested to address Department concerns with the utmost of speed, professional dialogue, and spirit of interagency cooperation. The Applicant will need to closely coordinate this critical issue with Sarah Clarke, Project Manager, of the FDOT Southwest Area Office in Fort Myers at (941) 461-4300; and Amy Shafer, SR 80 Project Manager in Bartow, at (863) 519-2276.

4. The Department finds the Applicant's project proposal to be consistent with Florida Department of Transportation policies, plans, programs, standards, rules and regulations *conditional* upon the Applicant's timely attention to, and satisfactory remediation of, Florida Department of Transportation comments No. 2 and No. 3 above, as deemed acceptable by the Department.

Thank you for allowing us the opportunity to review this document. Should you have any questions, please contact Larry Slayback, District ICAR Coordinator, at Suncom 741-4300 or (941) 461-4300.

Sincerely,

Larry G. Slayback
District ICAR Coordinator

District One Planning Office, Modal Development Department
District One Southwest Area Office * Post Office Box 1030 * Fort Myers, FL 33902-1030
(941) 461-4300 * (941) 338-2353 (Fax) * MS 1-98

Jasmin Raffington, State Clearinghouse
April 5, 2002
Page 3

LGS/ls
LS-L27-02

Attachment

cc: Sandra Whitmire, MS 28
Ricky Langley, MS 1-3
Mike Rippe, MS 1-98
Dick Combs, MS 1-40
Bernie Masing, MS 1-29
Amy Shafer, MS 1-29
Dan Foss, MS 1-6
Eduardo Ponce, MS 1-29
Frank Chupka, MS 1-14
John Previte, MS 1-14
Joe Philips, MS 1-98
Sarah Clarke, MS 1-98
Mike Tako, MS 1-36
John Limbaugh, MS 1-98

District One Planning Office, Modal Development Department
District One Southwest Area Office * Post Office Box 1030 * Fort Myers, FL 33902-1030
(941) 461-4300 * (941)338-2353 (Fax) * MS 1-98



Department of Environmental Protection

Jeb Bush
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

David B. Struhs
Secretary

March 26, 2002

Ms. Jasmin Raffington
Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

Re: Department of the Army, COE, Scoping Notice to Gather Information to Define Issues and Concerns to be Addressed in an Environmental Assessment for the C-43 Basin Storage Reservoir, Hendry, Glades or Lee Counties

SAI: FL 200202251575C

Dear Ms. Raffington:

We have reviewed the above-referenced Clearinghouse project and offer the following comments.

The final site location(s), project design, and other facets of the project are not yet defined, as they are continually being developed with the Project Implementation Report (PIR) phase of development just beginning. Assigned teams will evaluate designs, locations, alternatives, costs, and others factors as part of preparing the PIR, and it is our intent to ensure that the final project design will meet our rule requirements. A consistency review of the final proposal will be made prior to approval of actual construction by the Corps and the SFWMD. This review is part of the Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) regulations.

The project will need permits from the Department in the form of a CERPRA permit and a National Pollutant Discharge Elimination System permit. These permits will cover the construction and operation of the reservoir and discharges to surface waters, respectively. A consumptive use permit will also be required under the SFWMD regulations. The Department will probably be reviewing this permit because the WMD is the co-applicant with the Corps. Details are still being developed.

Project managers from both the Corps and the WMD have been advised and are continually being advised of required permits as their status evolves.

If you have questions regarding this letter, or if we may be of further assistance, please give me a call at (850) 487-2231.

Sincerely,

Robert W. Hall
Office of Intergovernmental Programs

cc: Gordon Romeis

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive North
St. Petersburg, FL 33702
(727) 570-5312; FAX 570-5517
http://caldera.sero.nmfs.gov

F/SER3:EH

MAR 18 2002

Mr. James C. Duck
Chief, Planning Division
Jacksonville District Corps of Engineers
Department of the Army
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Mr. Duck:

This responds to your February 15, 2002, notice received by the National Marine Fisheries Service (NMFS) Protected Resources Division (PRD) on February 21, 2002, requesting information to help define environmental issues and concerns to be addressed in a National Environmental Policy Act (NEPA) document being prepared for the C-43 Basin Storage Reservoir. The project is part of the Comprehensive Everglades Restoration Project (CERP) authorized by the Water Resources Development Act of 2000. We have assigned consultation number I/SER/2002/00107 to this action. Our comments are rendered pursuant to the section 7 requirements of the Endangered Species Act of 1973.

The project as proposed includes an above-ground reservoir(s) with a total storage capacity of approximately 160,000 acre-feet located in the C-43 Basin in Hendry, Glades, or Lee Counties. It is anticipated that the proposed reservoir would capture excess storm runoff and releases from Lake Okeechobee. The captured water could then be released into the Caloosahatchee River during times of need or drought.

Of all federally listed species under NMFS purview, NMFS considers that only the Gulf sturgeon could potentially be affected by the proposed action. The Gulf sturgeon could be present in the Caloosahatchee estuary, since it has been reported from the nearby Charlotte Harbor estuary. However, NMFS PRD believes that the release of captured stormwater runoff into the Caloosahatchee River will not adversely affect Gulf sturgeon, if present, since Gulf sturgeon spend part of their lives in freshwater and part in the marine environment and are well adapted to euryhaline conditions.

This concludes consultation responsibilities under section 7 of the ESA. Consultation should be reinitiated if there is a take, new information reveals impacts of the identified activity that may affect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified or critical habitat designted that may be affected by the identified activity. If you have any question, please call Eric Hawk, fishery biologist, of my Protected Resources staff.

Pursuant to the essential fish habitat consultation requirements of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)(2) and 50 CFR 600.905-.930, Subpart K), the NMFS Habitat Conservation Division (HCD) is being copied with this letter. The HCD

biologist for this region is Mark Thompson. If you have any questions about consultation regarding essential fish habitat for this project, please contact Mr. Thompson at (850)234-5061.

Sincerely,

for, Joseph E. Powers, Ph.D.
Acting Regional Administrator

cc: F/PR3
File: 1514-22.f.1 FL
o:\section7\informal\C43-CERP.jax

2

Southwest Florida Regional Planning Council
4980 Bayline Drive, 4th Floor, N. Ft. Myers, FL 33917-3909 (941) 656-7720
P.O. Box 3455, N. Ft. Myers, FL 33918-3455 SUNCOM 749-7720
FAX 941-656-7724

March 1, 2002

Mr. James C. Duck, Chief
Planning Division
USACOE - Jacksonville District
Environmental Branch
P.O. Box 4970
JACKSONVILLE, FL 32232-0019

SUBJECT: C-43 Basin Storage Reservoir Project Description

Dear Mr. Duck:

These comments are preliminary, based solely upon the Berry Grove site, or any other site above grade along SR80. Other comments will be forthcoming.

General Comment #1: SR 80 is a critical evacuation route for Lee County in the event a hurricane evacuation is declared. Any successful evacuation depends upon all routes being open. An above ground reservoir located along this route provides additional danger and exposure should the above ground berm fail. A lake the size you have proposed will have additional forces posed by wind which will need to be modeled and brought into consideration.

General Comment #2: The Southwest Florida Feasibility Study is a component of CERP The study scope was to include an assessment of the other CERP projects, in conjunction with the detailed evaluation Southwest Florida did not get through the development of CERP. Expediting this proposal is contrary to the SWFFS, and the proposal approved by Congress. This proposal should not be expedited until the SWFFS is completed.

General Comment #3: What was the site selection and evaluation process used to designate the site in the public notice.

Comments pertinent to the Berry Grove site:

1. The original discussion included options of "above" and "below" grade. Below grade seems to have been rejected. In light of General Comment #1, why?

TO: Mr. James C. Duck
DATE: March 1, 2002
PAGE: Two
RE: C-43 Basin Storage Reservoir Project Description

2. The Berry Grove site is up to 10 feet higher in elevation than the nearby community of LaBelle. The water storage would be up to 8 feet higher than that. Has any thought been given to increasing the hazard to this community?

3. The Berry Grove site is directly adjacent to SR80, and its accompanying drainage works. Is it appropriate to locate a reservoir adjacent to a public works (SR 80) that depends upon good drainage?

4. What sort of cost evaluation has been performed to place this reservoir, above ground, at this location in comparison to any other site reviewed? What was the cost evaluation for the site being used as a below ground reservoir.

5. A workshop held on February 28th stated a different purpose for the site than that stated in the public notice. It was stated at the workshop that the site was to provide water for ASR wells. Since the ASR test well is only now being sited, and it is hoped that the test at least goes through a scientifically sound process, why is this reservoir being promoted before the test results are in, verified, and lead to this conclusion?

Additional comments will be forthcoming.

Sincerely,

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL

Wayne E. Daltry
Executive Director

WED/nlg

TO: Mr. James C. Duck
DATE: March 1, 2002
PAGE: Three
RE: C-43 Basin Storage Reservoir Project Description

cc: Rick Cantrell, FDEP-Fort Myers Office
Carol Senne, SFWMD-Fort Myers Service Center
Donald Stillwell, Lee County Administration
Thomas Olliff, Collier County Administration
Cliff Miller, Glades County Administration
Lester Baird, Hendry County Administration
Porter Goss, US House of Representatives
Mark Foley, US House of Representatives
Dan Miller, US House of Representatives
Bob Graham, US Senate

B.3.4 Public Correspondence



LYKES BROS. INC.

TELEPHONE
(863) 763 3041
(863) 763 3545
FAX (863) 467 4651

SOUTHERN OPERATING DIVISION
166 SW CR 721
OKEECHOBEE, FL 34974-9613

FLORIDA RANCH
TEXAS RANCH
CATTLE
FORESTRY
SUGAR CANE

22 October 2002

Trent Ferguson, PE
US Army Corps of Engineers
PO Box 4970
Jacksonville, FL 32232-0019

RE: C-43 Basin Water Storage Reservoirs

Dear Trent:

As we have discussed, Lykes Bros. Inc. is interested in discussing the potential for developing a public/private partnership for water storage for the C-43 Basin. I have enclosed a map showing 2 locations that we believe have a great deal of potential for such a project. I have sent this to Dave Apple with the COE and Agnes Ramsey with the SFWMD. I wanted to make sure you had a copy as well.

The Ortona site is approximately 14,000 acres with its southern boundary generally being State Road 78. This location is close to the river and could receive and discharge water either upstream or downstream (or both) of structure S-78.

The Nicodemus site is approximately 10,000 acres in size and located just west of Lake Okeechobee. This site already has a very large levee along the entire northern boundary of the site. The site also has a large canal that is connected directly to Lake Okeechobee and comes to the northeast corner of the site. The southeast corner of this site is very near C-19, which connects to C-43. It is easy to envision collecting excess water from Lake Okeechobee and storing it at this site and releasing it down C-19 to C-43 when appropriate.

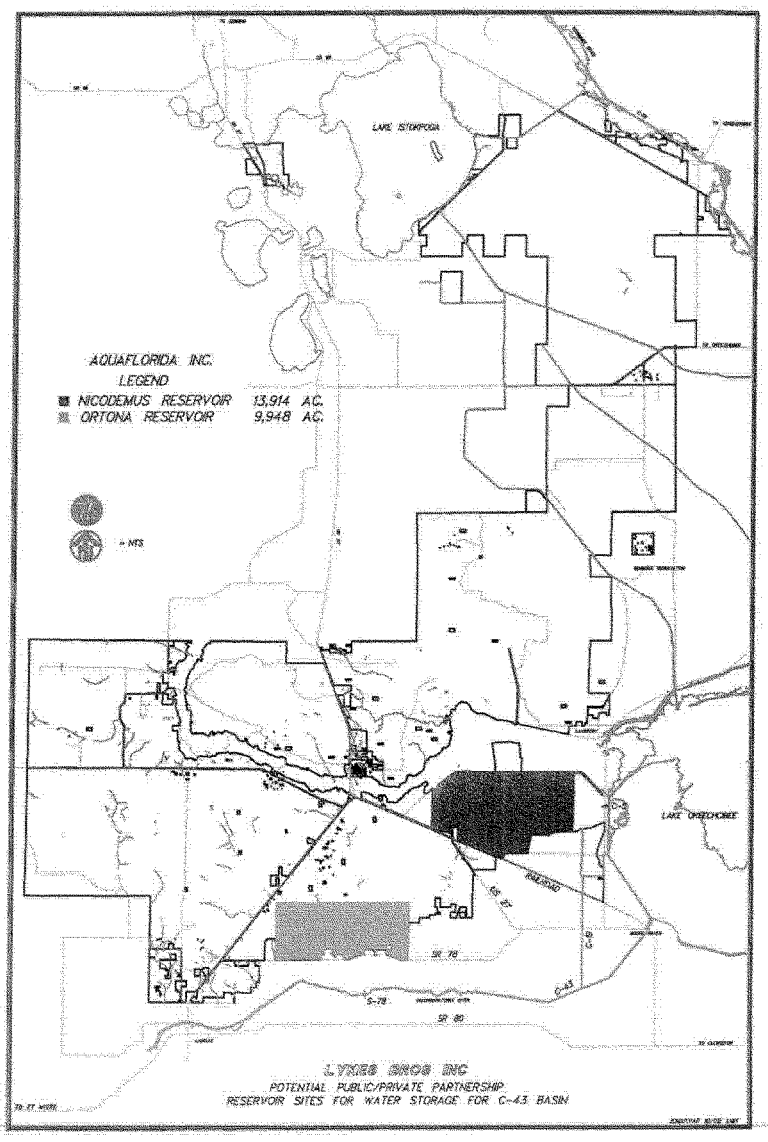
If you have any questions please give me a call at 863-763-3041. I look forward to discussing this with you further.

Sincerely,

Joe Collins, PE
General Manager
AquaFlorida, Inc.

863-763-3041 (call)
863-673-2169 (call)

Enc.


LAKE ISTOKPOGA
AQUAFLORIDA INC.
LEGEND
NICODEMUS RESERVOIR 13,914 AC.
ORTONA RESERVOIR 9,948 AC.
LAKE OKEECHOBEE
SR 78
SR 80
LYKES BROS INC
POTENTIAL PUBLIC/PRIVATE PARTNERSHIP
RESERVOIR SITES FOR WATER STORAGE FOR C-43 BASIN

B.4 DRAFT PIR COMMENT MATRIX

Name of Commenter	Comment	Response
US DOI June 11, 2007		
Letter dated June 11, 2007	1. The Department of the Interior (Department) supports the TSP for the project.	Noted.
Final FWS Coordination Act Report Recommendations July 2007	1. The Corps and District should consult with natural resource agencies in developing a detailed project operating manual for the reservoir to ensure restoration objectives are met. The operational plan should include the regulation schedules, operating criteria, and additional provisions as may be required to collect, analyze, and disseminate basic data. Detailed operating instructions to ensure that the project meets the restoration goals and targets should also be included in the form of a draft, interim, preliminary, and final operational plan. The water resource allocation for the natural system as described in the Project Implementation Report (PIR) should be utilized and described in both documents as the project progresses. An adaptive assessment team should meet when operations begin, during interim construction operations, and after construction to review the operational plan in concert with the information obtained from the Water Quality and Ecological Monitoring Plans to assure that restoration benefits are being met and that operations are optimized for restoration (Annex D in the Draft PIR).	The development of the project operating manual (POM) is an iterative process that will continue throughout the life of the project. The operational plan as presented in the draft Operating Manual is appropriate for the level of design and modeling performed for this project, as required in a PIR. The draft POM will be updated during design, construction and operational testing and monitoring phases. During these intervals of updates/refinements the Corps will be in consultation with the public, state and other federal agencies (including natural resource agencies). Though we would like to be more absolute in our operations plan, it would require a much greater effort that would still not be the final plan. It is well known and accepted by the public that initial operations after construction will be monitored and assessed comprehensively to ensure no significant impacts are caused to existing level of service flood protection, surrounding land owners, or downstream estuaries.

1148

	2. The Service recommends that the hydrologic monitoring plan in Section D.2 of Annex D in the PIR be expanded beyond the immediate footprint of the reservoir to include both existing canals and adjacent and upstream wetlands to ensure operation of the reservoir will not result in adverse impacts to the Spirit-of-the Wild (SOW) Wildlife Management Area (WMA) and the Okaloacoochee Slough State Forest (OSSF) WMA, and that the Corps formulate and incorporate related ecological hypotheses to be tested in the adaptive management protocol in Section D.4 of Annex D in the PIR. Emphasis should be placed on acquiring pre-project baseline data for existing canals (i.e., Roberts Canal) that can either provide direct or indirect drainage of areas of concern such as the SOW and the OSSF WMAs.	Groundwater and surface water modeling conducted by the SFWMD predicts that no impacts will occur to these areas. The reservoir and perimeter canal control structures will be operated to ensure that existing levels of water in the canals and upstream areas are not significantly impacted, based on project operations. No adverse impacts to the SOW, WMA and OSSF are expected.
	3. The Corps should evaluate results of the Test Cell Water Quality Monitoring Plan and incorporate that information in the reservoir design and water management operation and maintenance plan to maximize the reduction of nutrient loads from C-43 West Reservoir outflows.	The Test Cell Study Contractor is scheduled to provide the final evaluation of the test cell water quality data by the end of July. This evaluation will not be available in time for the FINAL PIR . The Corps will review the information when received and make any appropriate recommendations.
	4. The Service recommends that the Corps use the results from the Test Cell Water Quality Monitoring Plan to further evaluate: the quality of water while it is retained within the reservoir; the quality of water released from the reservoir and its potential effects on water quality of flows discharged at S-79; and, the effects of the quality and volume of water released at S-79 on the estuary.	The PIR includes a conservative assessment of water quality conditions both in the reservoir and downstream of it. The test cell contractor will provide another version of most of the requested analyses in July; however, given the relatively small size of the test cells and the short duration of the water quality study, caution should be used when interpreting the results as an indication of water quality conditions and impacts from the full size reservoir.

1149

	5. The Service recommends that the Corps monitor the water quality effects of the project consistent with the Water Quality portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR).	Concur
	6. The Service recommends that the Corps monitor the surface water and groundwater effects of the project consistent with the Water Quality portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR) and recommendation number 2 above.	Concur with the first part of the comment. See response to recommendation number 2 above.
	7. The Service recommends that the Corps monitor effects of the project on estuarine resources consistent with the estuarine portion of the Draft Project Operating Manual and Monitoring Plan (Annex D in the Draft PIR).	This type of ecological response monitoring within CERP is the responsibility of RECOVER. This project will not be able to determine what monitoring is funded for the estuarine resources.
	8. The Service recommends that the Corps implement the adaptive management protocols consistent with the Draft Project Operating Manual and Monitoring Plan.	Concur.
	9. If ASR wells are not constructed around the reservoir perimeter, the Service recommends that the Corps and the District expand the littoral zones created along the seepage canals.	This will be considered in the future when a determination is made on the feasibility of ASR wells at this site.
	10. The Service recommends that compatible public recreational opportunities which do not conflict with the primary function of the reservoir be provided in accordance with State Rule 40E-7.	The PIR includes a recreation plan which is the draft plan for implementation of recreation at the reservoir. However, after approximately a year of operations, the reservoir will be reevaluated to determine appropriate recreational activities.
	11. The Service recommends that the Corps or District pursuit funding for oyster reef restoration by placement of hard substrate in the estuary through other programs to increase the likelihood of oyster reef expansion to 30 acres over a 10- to 15-year period and 100 acres over the project life. Although the proposed project will improve salinity conditions for oysters and associated flora and fauna in the	The oyster reef restoration plan will not be a part of this project. Oyster reef restoration in the Caloosahatchee estuary has been initiated by various organizations in the past and a description of the program is included in this PIR as a recommendation

1150

	middle estuary, oyster expansion is directly tied to the availability of hard substrate for colonization.	for other organizations to pursue this restoration.
USEPA NEPA Program Office June 2007		
	1. As suggested in the DEIS, the water quality of the water released from the C-43 impoundment to the Caloosahatchee River should be no worse than the inflow water. We agree. Consistent with the purpose of the reservoir to improve estuarine health, water quality management should complement water quality management as an important project goal. As such, we recommend that the algal growth potential (AGP) of the impounded waters be assessed to minimize algal blooms and associated toxins in the water column. Intuitively, reservoir conditions are conducive for algal blooms due to the impounded water's warm temperature, high nutrient loadings and long residence time. In contrast, the potential for algal blooms could be reduced since nutrients would settle during the residence time, Lake Okeechobee water releases are expected to be less over time, and Caloosahatchee River nutrient TMDLs will be established. For the project, a 29% reduction in TP loads and a 28% reduction in TN loads at S-79, compared to the future without project condition, is predicted for preferred Alternative 3B (Table 6-3). This FEIS should further discuss nutrient water quality and the potential for algal blooms.	The FEIS will include a supplemental WQ analysis in which algal blooms will be discussed.
	2. As suggested above, nutrient levels are expected to decrease in part due to reduced discharges from Lake Okeechobee. Specifically, page 6-16 states that "…the reduction in nutrient loads at S-79 is largely the result of the reduction in discharges from Lake Okeechobee." The reasons for such "reduction in discharges" and its relationship with reduced nutrient concentrations should be further discussed in the FEIS.	Section 6.8.2 will include a sentence that states that the reduction in discharges from Lake Okeechobee is expected to be a result of the rest of CERP. (There is really no relationship between reduction in discharges and reduced nutrient concentrations so a discussion of this will not be included.)
	3. Resuspensions: Also, since nutrients and particulates are expected	The FEIS will include a supplemental WQ

1151

	to settle out in the reservoir, it becomes unclear if such precipitants would be resuspended in the water column when the reservoir is filled during the wet season. The proposed 1,500 cfs inflow pump (PS-1) could potentially also entrain sediment from the Calooshatchee River source water. Use of a larger pump (3,800 cfs) could exacerbate this water quality condition. The FEIS should discuss the potential for resuspension and sediment entrainment, as well as the overall inflow process. Reservoir operations should be designed to minimize inflow turbidity in the reservoir.	analysis in which sediment re-suspension is assessed.
	4. Site Contaminants: The residual soils of the existing orange grove proposed for the reservoir site contain pesticide and copper residues. We also understand that copper and lead were found within the Townsend Canal that would provide a conduit for reservoir inflows. As such, these contaminants can be expected to enter reservoir waters. However, we understand that introduction of these pesticides and metals in the impoundment waters are not expected to result in exceedances of State WQS. The FEIS should verify this and offer resolutions if any such contaminants are predicted to exceed WQS in the reservoir water. Beyond WQS, fish bioaccumulation may also be a concern. Regarding site contaminants, we suggest that the COE's protocol for establishing STAs on agricultural lands also be applied to the C-43 reservoir.	Presently there is no way of verifying that copper and lead concentrations in a yet to be constructed reservoir will or will not meet WQS in the future. However, it is reasonable to expect that copper concentrations in the Townsend will decrease as a result of the elimination of 10,000 acres of citrus which is the probable source of the copper. As for lead, since the "lead contaminated Townsend Canal water" will contribute only a small fraction of the total water budget to the reservoir, it is reasonable to conclude that lead concentrations in the reservoir will not exceed WQS since the Townsend water will be significantly diluted by other water that does not have excessive lead. The monitoring plan includes testing of fish for a list of contaminants that includes lead and copper. All HTRW site assessments and remediation efforts were coordinated with the FWS and reviewed by the COE.
	5. TMDLs: The FEIS should more fully discuss the ongoing TMDL	The FEIS will include more discussion of

1152

	effort in the Caloosahatchee Basin. It should also describe how the September 2007 start-up of the Caloosahatchee Watershed PIR will coordinate with the TMDL effort in setting appropriate water quality restoration targets for the Caloosahatchee Basin, particularly in the case of nitrogen loading at S-79.	the development of TMDLs.
	6. Dissolved Oxygen: Beyond nutrients and particulates, DO levels of return water could be of concern. DO levels should meet or exceed State WQS for waters returned to the Caloosahatchee River. Preferably, DO concentations should approximate or exceed ambient River levels (if greater than WQS) to prevent an in-stream oxygen sag at the discharge. Although we understand that return water can be siphoned from outlets at various reservoir depths to help increase DO levels, some DO augmentation may be needed prior to release to insure adequate levels.	The supplemental WQ analysis included in the FEIS will address the dissolved oxygen levels. The need for DO augmentation can be assessed after the reservoir is operational.
	7. Water Quality Monitoring Plan: Periodic reports from the Water Quality Monitoring Plan (WQMP) should be provided to FDEP and EPA's South Florida Office. Due to the current lack of water quality data (particularly nutrients) in peninsular Florida for above-ground pumped impoundments, reporting of water quality conditions within the C-43 Reservoir and on reservoir discharge waters is critical to future water quality modeling evaluations, project design and adaptive management for future CERP projects. EPA finds the value of the water quality data that will be provided upon operation of the C-43 Reservoir critical to the project and CERP in general.	Water quality data collected as part of this project will be stored in the SFWMD's web based DBHYDRO database as is all CERP data. The Test Cell data will be placed on DBHYDRO by Fall 2007.
	8. Reservoir Operating Manual: The Water Quality Section (D.1.6.3) in the Project Operating Manual should be expanded to more fully address possible operational actions to improve water quality conditions in discharge waters, while achieving other project objectives. The COE and SFWMD should consult with natural resource agencies (including EPA) in developing more detailed operational manuals and in implementing adaptive management activities after project start-up. EPA's South Florida Office should be	The Water Quality section of the O&M manual has been revised in the FEIS to include a discussion of how operations might be modified to improve water quality. The operating manual was and will continue to be developed with the input from the project delivery team which consists of not only SFWMD and COE members, but also

	provided copies of periodic evaluations associated with the Water Quality Monitoring Plan.	federal and state natural resource agencies.
	9. Project Sizing: As previously suggested, EPA will defer to the COE and SFWMD regarding the need for a larger inflow pump (3,800 vs 1,500 cfs) or a greater reservoir capacity (dike height or surgace area) to further minimize estuarine impacts. We note that Preferred Alternative 3B with its 1,500 cfs pump (PS-1) would require 57 days to fill the reservoir (pg.5-17), while Alternative 3C with its 3,800 cfs pump would take only 23 days (pg 5-18). In essence, how much environmental benefit will this project provide to the lower Caloosahatchee River and Estuary and is it sufficient at this time relative to the additional CERP storage capacity proposed (STAs, reservoirs, ASR wells), authorized and/or appropriated (or otherwise funded) at this time?	The project team recognizes that this project (CRWBSR) is not the full solution to the water storage issues in the Caloosahatchee Basin. That is why another project is scheduled to start the planning phase later this year. The Caloosahatchee Watershed Project will take another look at the total storage needs of the basin. However, that said, this project (CRWBSR) will provide significant and timely environmental benefit to the Caloosahatchee Estuary.
	10. Waters of the United States: We note that 125 acres of vegetated wetlands plus some 900 acres of farmland ditches would be inundated by the 10,500-acre reservoir. We understand that these waters of the United States are generally degraded due to existing orange grove farming. The FEIS should provide additional discussion on the quality and function of these areas, particularly the wetlands, from a NEPA disclosure perspective. The FEIS should also briefly discuss if the other sites considered would impact notably less or more wetlands from the selected "Berry Groves" site.	UMAM sheets depicting the function and value of the wetlands proposed for impact have been added to the FEIS. Wetland impact information for other sites considered has been added to the FEIS.
	11. Page 6-20 states that "(t)here will be mitigation for wetlands as a result of the federal project". Page xviii states that "(t)he loss of this wetland habitat will be offset by the increase in habitat function and quality in the Caloosahatchee Estuary." Specifically, the DEIS (pg xv) assumes that the project would benefit 71,000 acres in the Caloosahatchee Estuary. Compared to the No Action, it would also generate an average annual increase of approximately 13,000 habitat units within the Estuary. Since the C-43 Reservoir is a CERP project, it may also be noted that the overall CERP would restore numerous	Agreed.

1154

	acres of wetlands in the Everglades. From a cumulative impacts perspective, many more wetland acres would be restored collectively by CERP projects than would be lost.	
	12. We also note that the banks of the perimeter canal will be designed to include 109 acres of littoral zone. We concur with such design, but also assume that any existing littoral habitat will be lost along those reaches of Townsend Canal interrupted by the construction of the reservoir and perimeter canal.	Noted, however the Townsend Canal currently has limited littoral habitat due to very steep banks and overgrowth of exotic plants.
	13. Water Supply: Reference is made in the DEIS (e.g. pg 6-3) that the C-43 reservoir is not to be used for "elimination or transfer" of water supply. We assume the no "transfer: of water supply implies that new water supply will not be created by the reservoir (the FEIS should clarify). EPA believes that the C-43 impounded waters should be returned to the Caloosahatchee River during dry seasons for the benefit of natural systems as opposed to serving as source water for new urban or agricultural development. We recommend that such assurances be clarified in the FEIS	Concur.
	14. The term "water supply' is used for various purposes in the DEIS (pg 6-13). We recommend that this term be better qualified in the FEIS to indicate the intended use of the water supply (e.g. urban/potable, agricultural or natural system water supply). This would be helpful since without descriptors, we offer that the term "water supply" connotes source water for human consumption.	Concur. Will clarify water supply usage in the FEIS
	15. NEPA Process: From a NEPA disclosure, we find certain sections (e.g. Summary of Affected Resources: pg 6-7) to be well written and would likely be understandable to the layman reader. However, other analytical sections (e.g. modeling) would benefit from additional discussion in the FEIS. For example, the results from the Habitat Suitability Index modeling (Table 6-4) should be further discussed. That is, differences in suitability between Preferred Alternative 3B and the No Action (2050 FWO) are only +0.08 for oyster, +0.13 for Vallisneara, +0.05 for seagrass, and +0.13 for extreme events. It is	Table 6-4 will be removed as it is confusing in its current location. The same table can be found in section 5.3.7.4 (Table 5-12) along with an extensive explanation of our methodology as well as its limitations. Appendix C details the entire habitat unit methodology in great detail. The HSI assumptions, listed in section C.1.3.3, also speaks to the limitations of the HSI models.

1155

	unclear if these differences (or the differences for other alternatives) are significant and what the significance thresholds are for this index. The FEIS should clarify such technical sections with additional discussion for the benefit of the public.	Although we do not have a sensitivity analysis (or significance thresholds), we feel that these models are a fair comparison between alternatives and the best available science for this analysis. The models were reviewed extensively by the Interagency Modeling Center as well as peer reviewed by species experts. The team also found that the results of the models were comparable to the best professional judgement expected results of the analysis (i.e. the results made sense).
	16. System Recovery (pg ix): The DEIS states that "(w)ithout actions taken to reverse the effects of too much and too little freshwater entering the Caloosahatchee Estuary at the wrong times, the estuarine ecosystem will continue to be degraded and will likely worsen to the point that primary ecological functions such as nursery and forage habitat for aquatic plants and animals, are not recoverable." We agree that the current flow rates, volumes and timing are degrading the lower Caloosahatchee River and Estuary, and that continuance of such flows (i.e., the "without project" scenario) would extend and worsen this impact. However, most systems are recoverable once the stressors have been removed or sufficiently lessened (e.g., CERP is attempting to restore the Everglades) unless certain species become extinct in the process or hazardous materials are involved. As such, while we support the need for and implementation of the proposed reservoir project, we suggest that the "are not recoverable" portion of the above excerpt is somewhat of an over-statement.	Concur. Will change the wording in the Final PIR.
	17. Wetland Acreage (pg 6-20 vs 6-38): Regarding wetlands quantification, we note that page 6-19 suggests that the 6.39 acres of wetlands already inundated by the C-43 Test Cell Project are not included in the 125-acre total, while page 6-38 suggests the reverse.	Noted

1156

	This inconsistency should be clarified in the FEIS.	
	18. Pump Entrainment (pg6-21): The DEIS acknowledges that "(d)ue to operation of the pumps there likely will be some entrainment and impingement of fish and other aquatic organisms." Although we defer to the U.S. Fish and Wildlife Service (FWS) and their State counterparts in this regard, the FEIS should discuss how impingement of aquatic juveniles/adults and entrainment of eggs/larvae will be minimized during the 1,500 cfs pumping operations. It may be noted that are larger pump (3,800 cfs) would likely increase these impingement/entrainment impacts.	We will note that the larger pumps would likely increase the impingement/entrainment impacts. However, USFWS and FFWCC did not recommend any additional measures for minimizing impingement and entrainment.
	19. Air Quality: Although Hendry County is in attainment, emissions from the project could affect local air quality for project workers and any nearby residents. The FEIS should provide general information of the number of residences in the area that may be affected by the project. By project design, we assume populations near the proposed C-43 Reservoir are rural and scattered. The FEIS should discuss this.	The FEIS will include a few sentences regarding air emissions and potentially effected residents.
	20. As we have suggested in some of our other previous COE NEPA reviews, we recommend the use of reduced idling practices, cleaner fuels, and emission retrofits for construction equipment used by COE contractors whenever feasible to help minimize construction emissions. The COE may wish to discuss this further with EPA Region 4 (Dale Aspy at 404/562-9041). In any case, all construction equipment should be tuned to manufacturer's specifications to minimize air emissions. In addition to construction equipment, air emission from the operation of the reservoir inflow pump (PS-1) would generate emissions. For the 57 days needed to fill the reservoir for Preferred Alternative 3B using the proposed 1,500 cfs diesel pump, would the pump be operating essentially the whole time? We request that the FEIS include more information on the size of the PS-1 pump (break-horsepower, manufacturer, fuel requirements, etc) for our impact	We will ensure that this requirement is included in the contract documents. The 57 days is a general reference for the time needed to fill the reservoir if 1,500 cfs is pumping continuously. The intake pump would not run constantly in a single 57-day fill operation. Rather, the reservoir fills or releases at a given point in time based on the state of the flow in C-43 at the S-79 structure, the available capacity of the reservoir, and the season. In general, the pump would run more often in the wet season when flows occur at S-79 that would be in excess of the estuarine restoration target.

1157

	review. We also offer that use of an electric pump would eliminate such air emissions.	Horsepower information for PS-1 was provided in Section A.6.1.2.1 of the Draft PIR Engineering Appendix. Total horsepower of the proposed 4 pumps is 10,800. The pump(s) manufacturer will not be known until the bid process and the fuel requirements may vary across manufacturers.
	21. Noise: For the project PS-1 pump, we note (pg 6-5) that the pump station (housing) was offered as noise shielding. We agree that housing would provide some shielding. Source reductions with the pump itself (type, quality, etc) would also reduce noise levels. As indicated above for the air emissions, we also offer that the noise emissions would essentially be eliminated if an electric pump was used instead of the proposed diesel pump. In addition to the pump, all other construction equipment (bulldozers, etc) should be tuned to manufacturer's specifications as well as being equipped with appropriate mufflers and engine housings to minimize noise. It is clear, however, that such noise abatement is more important if residents and other sensitive receptors are located nearby and are affected by the project. In any case, however, project workers could be affected.	FP&L has indicated that their area substations do not have sufficient capacity to serve the requirements of a 1,500 cfs pump station, and therefore, a new substation would be required for a 1,500 cfs pump station with electric driven pumps. The cost benefits analysis does not support this approach.
	22. From a NEPA disclosure standpoint, the FEIS should document construction noise data available from the literature for typical construction equipment such as would be used for the reservoir project (e.g. dBA noise levels at 50 ft). Disclosure of the estimated construction time is also suggested in order to help determine the magnitude of the noise (and air) impact.	The fEIS will include the following indormation: typical construction equipment generates an average of 80-88 dBA at 50 ft. This impact should be minimal as the area within and surrounding the construction is mostly rural. The estimated timeline for construction is 38 months.

1158

	23. Environmental Justice (EJ): Page 6-43 states that "(i)n public outreach efforts to date, only one potential environmental justice issue has been identified: the loss of jobs for low income and minority workers as a result of acquiring agricultural land for the construction of the reservoir." To help offset this, we are pleased to note (pg 6-44) that "…the SFWMD is conducting training programs to allow local individuals to acquire the skills needed to construct the reservoir." We assume that the locally affected people (particularly minorities and low-income populations) will not only benefit from the training but that at least some will be candidates for actual employment. In addition to this proposed offset, we recommend that the COE also provide people affected by the project continued project updates and coordination with their community leaders.	Concur. The SFWMD will be providing regular updates at the County Commission meetings which are open to the public. They will also have public meetings with stakeholders on an as needed basis.
	24. For better NEPA documentation for EJ, the FEIS should provide U.S. Census 2000 data (e.g. one or more block groups) for the project area to specifically account for any minority concentrations ("pockets"). For perspective, this project block group data should also be compared to adjacent block groups, the project county (Hendry) and the project state (Florida) to further determine any minority concentrations near the project. Overall the number of minority and low-income residents affected by the project (through relocation or other impacts), their demographics and any potential disproportionate effects should be reasonably documented. The FEIS should address this further.	Section 2.14.1 contains a rigorous description of the demographic makeup of the study area, including census tracts. Environmental justice is described in the socio-economic appendix, and irregardless of the demographic of the study area, no adverse impacts are expected to the populations identified in the census data.
	25. EPA rates this COE DEIS as "EC-1" (i.e., we have environmental concerns and request some additional information in the FEIS).	Noted.
FDACS June 12, 2007		
	1. During development of the conceptual plan for the Restudy, one of the main concepts of the regional storage components was to provide additional storage for water supply in the Caloosahatchee, St. Lucie and Kissimmee Basins which should ultimately reduce irrigation	Per section 9.1.3.1 of the Restudy "The purpose of this feature is to capture C-43 Basin runoff and releases from Lake Okeechobee. These facilities will be

1159

	demands on Lake Okeechobee. Water could then be conserved in the lake and would be "…available for sustaining the health of lake and downstream natural areas …" (Sections 6.4.2 and 6.4.1.2). The source for agricultural irrigation demands would be "switched" to the reservoirs as much as possible and be supplemented as needed by the lake. More lake water would be available for natural system needs. Since the only purpose of the C-43 reservoir is now to meet estuary demands, and not to "switch sources" for local irrigation demands, that change from the Yellowbook concept needs to be acknowledged and the planning conditions for other projects need to be updated based on that change. At this time, urban and agricultural demands have all been removed from the alternative evaluation. How does this fit into the regional plan as developed by CERP for the capture of local basin run-off to meet existing demands in the "reservoir" basins (Caloosahatchee, St. Lucie, and EAA basins) and retaining Lake Okeechobee water for natural system needs. How will the difference in concepts be accommodated going forward?	designed for water supply benefits, some flood attenuation, and to provide environmental water supply deliveries to the Caloosahatchee Estuary and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary." The reservoir proposed in this project allows estuary demands to be supplemented by reservoir storage during the dry season, thus relieving some dry-season demands on Lake Okeechobee allowing more water within the lake to be used system wide.
FDACS June 5, 2007		
	1. Annex C4, "Analyses Required by WRDA 2000 and State Savings Clause Analyses," describes assumptions made for the current and future sources of agricultural irrigation water and concludes that the project will not affect those sources. No supporting data or analyses are provided for either the local of regional project area to support the conclusion. The Department recommends that the data and analyses used to determine that the project will not affect the quantity and quality of the existing local and regional water supply, and data used to determine the existing flood control will not be impacted, be included in Annex C. This information is necessary to provide the reasonable assurances, required by 373.1501(5)(d), Florida Statutes, that implementation of the proposed project will not diminish the	By basing the water budget analysis for the reservoir on excess flows over S-79, the spreadsheet analysis ensures that all basin uses are preserved. The uses take their input from the C-43 or connected sources upstream of S-79 and would have pulled their needed volume before flow over S-79 occurs. The decision to fill the reservoir therefore does not occur until basin needs have been met as were without the reservoir in place. While this creates a situation where available volume for restoration may

1160

	quantity of water available to existing legal users or diminish the levels of service for flood protection.	exist within the basin that is not considered for reservoir operations it ensures that the reservoir does not capture flows that could or would have been used by any existing demand. This assumption is necessary to ensure that the project located in the lower pool does not cause unintended impacts to existing users that it can not rectify. Optimization to fully utilize water within the basin will occur with subsequent projects that have the opportunity to make up flow to the entire C-43 basin (lower and upper pool).
	2. In addition, the Department is concerned regarding the absence of a plan for controlling invasive exotic plant species, and that the estimated annual and operations maintenance costs do not include costs for monitoring and controlling invasive exotic plants.	Invasive species control, both terrestrial and aquatic, are estimated in the O&M cost estimate. Standard procedures for controlling invasive exotic plant species will be implemented.
	3. The Department is also concerned about language in the report inferring that timber practices promote the decline of red-cockaded woodpecker; rather it should more specifically state that certain activities should not be conducted within red-cockaded woodpecker foraging areas designated by the U.S. Fish and Wildlife Service.	Noted. The language will be removed.
	4. A water resource concern of existing legal users in the vicinity of the C-43 Basin Storage Reservoir Phase 1 Project is the change in water quality that may occur when the groundwater source for local wells is replaced by seepage from the perimeter canal. It appears that some wells may be completely switched form a watershed seepage source to a C-43 supplied perimeter canal seepage source when the C-43 Reservoir Phase 1 becomes operational. Data should be presented that was used to determine the impacts of the perimeter canal seepage on local ground water wells, as well as any conclusions	The water levels in the various sections of the perimeter seepage canal are generally set to provide the same level of water supply and flood protection as currently exists on the site. In other words, the perimeter canal water level should largely match the existing drainage/ water supply canal levels. Given this, the project should not substantially change groundwater flow

	reached regarding the need to mitigate for deterioration in water quality. Language should also be included that reinforces the local sponsor's commitment to mitigate any future negative impacts to legal users that result from such "source switching."	patterns such that groundwater quality will be measurably altered in most cases. However, if a given groundwater well is located such that the distance to the planned perimeter canal is less than the distance the well is from an existing water body there may be measurable impact to its water quality. In any case, the project assurances requirements of CERP also protects legal users from project related water quality degradation.
	5. Water supply and flood protection in the vicinity of the reservoir might be impacted by reservoir features and operations. Reports and supporting data should be included in the report that support the local sponsor's determination that detrimental changes to water supply and flood protection in the vicinity of the reservoir are not anticipated. Language should also be included that reinforces the local sponsor's commitment to mitigate any future negative impacts to legal users resulting form the construction or operation of the reservoir.	The project team analyzed irrigation results for the entire basin from the S-77 structure to the S-79 structure and also compared irrigation results for random locations near the Caloosahatchee River. Results generated cannot be considered an exact value since the irrigation component could not be calibrated at a field scale. A summary of average irrigation applied for the selected locations for the years 1978 - 1985. Although the model results generally indicate that the amount of irrigation water applied in the "With Project" condition is very slightly less than the "Without Project" condition, this difference is attributed to uncertainty associated more with the model irrigation input parameters and scale effects than with any real irrigation impacts. The year 1981 until June 1982 was a period of drought and the predicted irrigation

1162

		results show little difference in the volume of irrigation water applied for the evaluated locations.
	6. Section 7.6.1. (pg 7-23) discusses the estimated annual operations and maintenance costs. Exotic plant monitoring and treatment costs should be factored in this section.	Invasive species control, both terrestrial and aquatic, are estimated in the O&M cost estimate.
FDEP June 11, 2007		
	1. The Department supports the project with its purpose to increase storage in the regional watershed, which will restore ecological function and productivity in the Caloosahatchee estuary.	Noted.
	2. The note under figure 2-6 says that *Vallasneria americana* is found at stations 1-3. However, there is no station 3 depicted on the figure.	Noted. We will modify the text.
	3. Page 4-30, Table 4-7: Ecological Performance Measures does not include preferred flow range (cfs) for *Vallasneria americana.* However, pages 4-25 says that flow distribution EST05 will provide mean monthly flows above 450 cfs with most flows (75 percent) in the ideal range of 450-800 cfs.	A preferred flow for Vallisneria will be added to the table.
	4. Page 5-24, Table 5-9: Target Flow Distribution for EST05 shows mean monthly flows between 450-1,500 cfs occurring 74.5 percent of the time. However, Table 4-7 shows that most flows will occur in the range of 450-800 cfs. Please explain the inconsistency.	Table 4-7 only shows preferred flow ranges for specific species. However, throughout the document there may be different flow ranges used to explain different information. Although 450-800 cfs is the optimum flow range, EST05 also allows for flows in other flow ranges such as 800-1500 cfs.
	5. The HTRW assessment and remediation plans do not indicate coordination with the Department. Please specify if HTRW coordination has occurred.	Coordination with DEP has occurred and will be noted in the FEIS.
	6. Table C-13- Typographical error in the title, "Estimates of annual TP and TP loading…"	Noted. Correction will be made.
	7. Appendix C (Section C.9.3.1.1.1 and C.9.3.1.2.1: Project vs. 2050 Future Without Project Conditions). These sections refer to TP load	Noted. Suggested changes will be made

1163

	reduction of 29%-34% and a TN load reduction of 28%-33% under the "with project" conditions, which includes the nutrient load reductions associated with flow reductions from CERP implementation. In order to avoid confusion regarding the estimated nutrient removal potential of the C-43 West Reservoir, please include language clarifying the source of the nutrient removal estimation (i.e. clarify when nutrient removal estimations include overall CERP implementation, or solely C-43 WSR). This comment also applies to Table C-13, Section C.9.5, as well as other sections referring to nutrient removal associated with the selected alternative.	
	8. Appendix C (Section C.9.3.2: Wet/Dry Season Nutrient Loading) - Suggest revising language from "targets" to either "critical loads" or "threshold loads". The term target implies a goal, however the critical loads being referred to are actually threshold loads, above which Chlorophyll a concentrations exceed water quality criteria, therefore the goal in below this threshold.	Noted. Suggested edits will be included in FEIS.
	9. "The quality of the water discharged from the reservoir should be no worse than the quality of the water pumped into the reservoir." The C-43 West Basin Reservoir is required to achieve water quality standards at the discharge point. Please clarify throughout the PIR that, in addition to outflows being equal to or of better quality than the inflows, the Reservoir will achieve state water quality standards.	The statement that water in the reservoir will meet WQS is in the document in several places. Some addition wording to the effect will be placed in the FEIS.
	10. "The operation of the reservoir should not result in a substantial shift of nutrient loading from the wet season to the dry season." The Department is of the understanding that, absent a treatment mechanism or wetland buffer design, a shift in nutrient loads from wet season to dry season is anticipated. The Department had been working concurrently with the Corps to obtain the information necessary to determine whether the shift in nutrient loads from the wet season to the dry season, consistent with the expected operations of the	The requested document will be included in the FEIS

1164

	reservoir, would be harmful to waters downstream of the S-79 structure. Upon resolution, please include *The Supplemental Analysis C-43 West Basin Reservoir Effects on Dry Season Water Quality Downstream of the S-79 Structure* in the PIR. This document should provide the Department with the reasonable assurances necessary to ensure that the C-43 West Basin reservoir will not cause or contribute to an imbalance of flora and fauna in the waters downstream of the S-79 structure.	
	11. Please note that the Programmatic Regulations (Section 385.28 (c)(xvii)) require Project Implementation Reports (PIR) to include as appropriate, information necessary for the non-Federal sponsor to address the requirements of Chapter 373 of the Florida Statutes, and other applicable planning and reporting requirements of the Florida law. In order to serve as local sponsor of the Everglades national Park Seepage Management Project, or prior to seeking an appropriation from the Save Our Everglades Trust Fund, the South Florida Water Management District (SFWMD) will be required to obtain approval from the Department under §373.026(8)(b), Florida Statutes(F.S.). Approval is based on the Department's determination that the SFWMD has provided sufficient documentation to demonstrate compliance with the criteria set forth in Section 373.1501(5) F.S. The statute requires the SFWMD to analyze and evaluate water resource issues, natural system and habitat needs, determine that project components are feasible and consistent with applicable laws and regulations, provide assurances for water supply and flood protection, and coordinate with existing utilities and infrastructure to minimize impacts. We recommend that as the federal sponsor, the U.S. Army Corps of Engineers keep these criteria in mind during PIR development, and assist the South Florida Water Management District as appropriate in providing the necessary information to comply with these and any	Agreed. The Draft State Compliance Report was informally submitted to the FDEP on May 1, 2007. The formal submittal will occur after the Civil Works Review Board. This will allow for public input and agency reviews to be reflected in the final report. The timing will allow for the FDEP approval of the State Compliance Report prior to the issuance of the Chief's Report for the FPIR/EIS. The WBS for the PIR is structured so that State requirements can be satisfied as the PIR moves through the final approval process.

	other applicable requirements. Please note that the §373.026/1501, F.S. review is separate from the State Clearinghouse review required for all federal projects under the Coastal Zone Management Act, and requires a separate formal submittal from the SFWMD to the Department.	
	12. Upon completion of detailed design, this project will require a Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permit pursuant to Chapter 373.1502, F.S. The project may require a NPDES Generic Permit for Stormwater Discharge from Large and Small Construction Activities in accordance with Rule 62-621.300(4), Florida Administrative Code (F.A.C.). Other department permits may be required during the construction phase of this project, as applicable. We recommend that the Corps and the SFWMD coordinate closely with the Department in order to facilitate permit issuance.	Concur
FFWCC June 8, 2007		
	1. The numerous water control structures associated with this project could entrap, injure or kill manatees that may encounter them. Water control structures have been responsible for hundreds of manatee deaths (Fish and Wildlife Research Institute's manatee mortality database); however, with the appropriate safeguards, these structures can be rendered relatively benign. The most efficient way to achieve this goal is to prevent manatee ingress and egress to the C-43 reservoir by constructing manatee barriers at all access points to the perimeter canal and reservoir.	The USFWS, SFWMD, and USACE are in consultation to determine appropriate measures for the manatees. We have also consulted with representatives of FFWCC on this matter. Manatees will not be allowed in the perimeter canal or reservoir.
	2. Standard manatee construction conditions should be used in all waters accessible by manatees during the construction of this project.	Concur.
	4. We highly recommend using the information provided in the document entitled "Guidelines for Manatee Conservation during Comprehensive Everglades Restoration Plan Implementation."	This document is being used as a reference as consultation occurs.

1166

	5. During the winter season (November 1 through March 31) we recommend that water releases from the C-43 reservoir be monitored hourly for temperature with data retrieved daily, near the point of discharge (S-11). Monitoring data will be used to determine if water releases from the C-43 basin have the potential to create a warm-water site that is insufficient to sustain manatees.	The USFWS, SFWMD, and USACE are in consultation to determine appropriate measures for the manatees. We have also consulted with representatives of FFWCC on this matter.
	6. During the winter season, if water released from the reservoir creates a thermal plume that is greater than 20°C, or if manatees are observed using the site of the reservoir discharge on two consecutive days, then we request that the FWC-Imperiled Species Management section (850-922-4330) and U.S. Fish and Wildlife Service be consulted to resolve the issue of impacts on manatees.	The USFWS, SFWMD, and USACE are in consultation to determine appropriate measures for the manatees. We have also consulted with representatives of FFWCC on this matter.
	7. Recommendation: FWC requests that the U.S. Army Corps of Engineers and the South Florida Water Management District keep FWC apprised of the results of ongoing ASR studies and monitoring efforts so future manatee-related issues can be identified, refined and resolved proactively prior to the implementation of ASR technology.	Concur.
	8. Specifically, we support allowing waterfowl hunting and fishing as recreational opportunities that should be allowed on the C-43 reservoir.	Agreed. Fishing will be allowed subject to satisfactory agreements with FDEP and EPA. FWC, as the SFWMD partner, would need to provide the regulatory framework, hunt administration, and law enforcement support necessary to open the reservoir for any and all hunting activities. Hunting and fishing activities would be proposed provided such hunting and fishing activity is sustainable and compatible with the resource and does not conflict with the primary project purpose. Such activities remain subject to formal SFWMD and FWC cooperative authorizations.
	9. We recommend that the South Florida Water Management District	See FFWCC #8 above.

1167

	work with our staff during the assessment period to refine what types of activities could be accommodated. We would like to operate and maintain waterfowl hunting cooperatively with the South Florida Water Management District and others, as appropriate.	
	10. Recommendation: The use of soil cement for construction of the reservoir embankments is not conducive to the establishment and growth of submerged aquatic vegetation, an attractant for waterfowl. We recommend the placement of a natural substrate within the interior of the reservoir to allow for vegetation growth, which will increase the wildlife habitat value and assist with improvements in water quality through the reduction of nutrients.	Soil cement is needed for erosion protection of an earth embankment, so it is a safety consideration.
	11. We recommend planning for recreational alligator hunting on the C-43 Reservoir in the future.	See FFWCC #8 above.
	12. Project plans should provide roads and boat ramps allowing adequate public access.	Boat ramps for maintenance purposes are being constructed in a manner that could allow public access. Public use of the ramps and reservoir will be decided upon once the reservoir has been in operation for 18 to 24 months so that reasonable use can be determined.
	13. Portions of the reservoir footprint have been in citrus production. We recommend that these areas not be cleared prior to reservoir flooding. Citrus is fairly durable wood and should not degrade rapidly, thereby creating long-lasting fish and wildlife habitat. A similar recommendation provided a cost-savings during the construction planning of the Site 1 impoundment.	The citrus trees need to be cleared, since the contractor will need to obtain material for construction of the embankment from the reservoir interior. Citrus trees left in the reservoir may also present an operational problem if any are dislodged and caught in the outlet structures.
	14. Minimizing dry outs would benefit wildlife habitat through the reduction of nutrients and re-suspension of contaminants while providing for a stable aquatic community.	The reservoir will be operated to maximize benefits to the estuary, not to maintain habitat within the reservoir.
Seminole Tribe of Florida,		

1168

Rhianna Rogers, Tribal Historic Preservation Officer June 12, 2007		
	1. How was the APE determined for ths project and what archeological criteria was used for its construction? How are the archeological sites not included in the National Register being handled? (i.e., are they being surveyed and/or excavated)? ARCGIS includes a number of sites in this area and the STOF-THPO would like to know how those are being addressed.	Initial consultation with the Florida SHPO was conducted in 2002 (DHR Project File No. 2002-1944), follow up consultation based on the EIS scoping letter occurred in 2003 (DHR Project File No. 2003-2300), based on the comments a cultural resource survey was conducted on the 12,500 acre project area that was proposed at that time. This survey was conducted under contract to the Corps by New South Associates. Out of the 12,500 project acres approximately 2000 acres in 40 areas were identified as having a moderate to high probability of containing cultural resources. These moderate to high probability areas were identified using pre-development 1940 and 1944 aerial photos. The probability areas were based on proximity to drainage systems, high ground as evidenced by vegetation, and proximity to historic travel ways (as indicated on the historic aerial photos and on historic maps). A total of 3,606 shovel tests were conducted within the moderate to high probability areas. Four historic vernacular structures dating the 1950 were identified during the survey

		(8HN102, 8HN103, 8HN104 and 8HN105) these structures were determined no eligible for listing on the National Register of Historic Places. Additionally, four archeological occurrences were also identified. These consisted of an isolated sand tempered plain sherd, an isolated chert flake, a chert shatter fragment along with a railroad spike, and 11 bone fragments recovered from three shovel test units spaced 60 and 90 meters apart. There was no evidence that the bone fragments were part of a prehistoric archeological site. A no effect determination was made and concurred with by the Florida SHPO (DHR Project File No. 2004-8676). Because the proposed project area was modified to include areas not covered by the 2004 New South survey an additional survey was conducted in 2006 by Janus Research under contract with the South Florida Water Management District. This supplemental survey covered 597 acres and resulted in the identification of the prehistoric site 8HN129. This site is located near the eastern edge of the project area. The project was designed to exclude this site from the impact area. Because the identified site is outside of the potential impact area a determination of no effect was made for the additional project area (DHR Project File No. 2006-04319 and 2006-07757).

1170

	2. Is more archeological work planned for this project area?	At this time no additional cultural resource work is planned for the project area.
	3. The report provided sparse information about the archeology conducted for this project area. STOF-THPO did notice the mention of site (8HN129) and its possible eligibility for the NRHP but we could not determine if the other sites alluded to in the project as well as sites not mentioned planning to be surveyed and/or excavated in association with this project.	If you would like copies of the survey reports I can send them to you.
Hendry County June 11, 2007		
	1. The recreation features are being planned in the C-43 West Basin Reservoir project as an incidental project benefit according to language in Appendix H, Section H.2.1. Hendry County believes the proposed recreational activities should be a permanent part of the reservoir project. The recreational activities need to be clearly defined and not subject to removal. Hendry County would like a commitment, from SFWMD, to provide equestrian trails, biking and hiking trails, fishing, hunting, nature watching, and ramps for motorized and non-motorized boating.	The current plans for public access and recreation facilities will serve a wide variety of nature based recreation. All the activities asked for are reasonably expected activities and are not eliminated by the design. The levees, external canals and littoral zone designs will accommodate public access but their designs are not specific to that purpose. Specifics on how activities will be managed have not been determined and would likely change over time based on number of users and actual affects to the project. Managing recreational activities will be needed to ensure the project's purposes are served first, user conflicts managed second. SFWMD has developed rule 40E-7 which provides the ability to regulate the public access as may be needed.

1171

	2. Hendry County believes the recreational activities should be available upon completion of the construction and opening of the reservoir.	Recreational facilities will be opened to the public after the engineers and operations and maintenance staff are confident the project is functioning properly. The initial operational period is uncertain, but thought to be one to two years.
	3. The reservoir, during low volumes, should be opened to non-motorized boating and airboats at a minimum. There needs to be agreement between SFWMD and Hendry County on set standards that define low volumes.	Boat types and operations will be determined following the initial operational phase which will last from one to two years. Boats would need to be regulated. It is expected especially so during low water conditions. SFWMD hopes to develop a recreation management partnership with Hendry County and boat regulation would be a part of that.
	4. In Appendix H, Section H.2.1, page H-3, it is stated that shade trees are proposed on the outside area of the north rim canal adjacent to parking. Hendry County would like to see additional trees and vegetations planted outside and around the reservoir to promote bird watching, aesthetics, shade areas for the public, etc. The County wants the reservoir to become an asset and not an eyesore.	To date engineers have not allowed landscaping on the levee itself as this undermines the integrity of the levee and hinders the ability to visually inspect for signs of problems. We can consider landscaping on the outside edges of the exterior canal but will need to discuss the issue with Operations and Maintenance staff to determine any possible impacts.
	5. Restroom facilities should be provided and operated by the SFWMD. Additional facilities should be added at the expense of SFWMD, as the need arises, determined by Hendry County. The recreational opportunities of the reservoir should not be limited due to the size and number of restroom facilities.	We hope to develop a recreation management partnership with Hendry County. Types, location and management of recreational facilities will be a part of that negotiation.
	6. In Appendix H, Section H.2.2, page H-4, it is stated that the SFWMD has the ability to regulate boat types and engine types.	Please see Hendry County #3 above.

1172

	Hendry County wants the reservoir to be open to motorized boats and airboats. Any limitations on boat and engine types should be proposed in agreement with Hendry County.	
	7. No mention is made of SFWMD's plan, expressed publicly, to lease to Hendry County 100 acres north of the power line adjacent to SR 80 for a park. This is a critical component to the recreational opportunities this project should provide.	SFWMD hopes to develop a recreation management partnership with Hendry County and lease of the 100 acres north of the power line adjacent to SR 80 will be a part of that discussion. Full access for the SFWMD for operations and maintenance will need to be maintained through the 100 acres.
	8. Hendry County would like to see walking and biking trails placed around the levee.	Please see Hendry #1 above
	9. Hendry County would like to see the reservoir and rim canal open to boating, fishing, and hunting.	Please see Hendry #1 above
	10. SFWMD needs to provide additional littoral areas in the rim canal and within the reservoir to provide appropriate and adequate habitat for fish.	The reservoir design calls for littoral shelves on both banks of the perimeter canal, with "expanded" areas at the corners. The reservoir itself will have soil cement on the interior sides.
	11. The reservoir should be open from dawn to dusk for recreational activities.	We envision daylight hours as well
Lee County Southwest FL Board of County Commissioners June 11, 2007		
	1. Page XII Goals and Purposes of the Project—The document discusses the need to ensure that current levels of service for water supply in the Caloosahatchee basin could still be met with implementation of the Tentatively Selected Plan. In other portions of	Ensuring that the 2000 level of service for water supply are met is a project constraint for purposes of plan formulation. Any

	the document, water supply benefits are described as "indirect." According to the C-43 Draft PIR, all water available from the CRWBSR is slated to be available only for the environment. If there is even an "indirect" potable water supply benefit, this should be quantified. The County is supportive of placing a priority on the needs of the Caloosahatchee Estuary, but the multiple purposes of the project should not be lost.	additional water supply which may be provided by the project are considered incidental benefits, as increasing water supply for agricultural and municipal use is not a goal of this project. No water supply benefits will be quantified.
	2. Page XVI Goals and Purposes of the Project—The document describes the requirements for water to be identified for the natural system and other water related needs. This analysis was based on a draft of Programmatic Guidance Memorandum 4. It is the County's understanding that the methodology to make these determinations has not be(en) finalized and that a final methodology is still forthcoming in terms of this Guidance Memorandum. Is that still the case and will this have an effect on identifying water for the natural system and other water related needs?	GM 4 does not specify a methodology for identifying water made available. The methodology for determining water made available for the natural system and other water related needs may be found on pg. C-8 of Annex C. Identification of water for the natural system is based on the concept of water needed to achieve the benefits of the project and the overarching objective of restoration, preservation and protection of the S. Florida Ecosystem.
	3. Page XVI Goals and Purposes of the Project—The document lists the primary functions of the reservoir as capturing excess runoff and discharges and providing an additional source of water to maintain desirable salinity in the Caloosahatchee Estuary during periods of low flow. All water from the CRWBSR is then identified for the natural system. First, there are several differing goal and purpose statements for the project throughout the document. The goals and purposes for the CRWBSR from the original CERP "Yellow Book" should guide the project's implementation (see page 1-9 of the C-43 Draft PIR for a portion of this statement). If those goals and purposes have changed for some reason, the document should state that and the rationale for the change. Second, as stated earlier in these comments, the multiple purposes of the project should not be lost and even "indirect" water	The purpose and objectives of this project have not changed. This PIR is an affirmation of the conceptual plan developed in the Yellow Book. Water supply for agricultural and municipal use is considered a secondary benefit and will not be quantified in this report. As discussed on pages 5-3 and 5-4 the complexity of creating a whole-basin approach within one report would require a significantly extended study period and does not provide immediate relief to the

1174

	supply benefits should be quantified. The statement on this page, "The project will not provide any additional water for water supply of other water-related needs in the Caloosahatchee River basin," contravenes these concepts. See similar discussion on pages 5-3 and 5-4.	estuary. An incremental approach to restoration through smaller focus reports allows the immediate needs to be met sooner.
	4. Page XVI Goals and Purposes of the Project—The County supports maintaining the same level of water supply deliveries to agricultural lands adjacent to the CRWBSR where water supply canals were interrupted due to the location of the project, consistent with Section 601(h) of the Water Resources Development Act of 2000.	The operational plans provide for continued water supply deliveries to the adjacent agricultural lands.
	5. Page 1-9 Goals and Purposes of the Project—Page 1-9 lists a portion of the CRWBSR restoration objective from the original CERP documents (1999) as including water supply benefits, some flood attenuation, to provide environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. All of these benefits should be identified, consistent with 33 C.F.R. Part 385, or the Programmatic Regulations for CERP. Additionally, this restoration objective limits nutrient impacts to "runoff to the estuary" while ignoring the effects of Lake Okeechobee discharges. Estuary benefits and water quality benefits are "primary" system benefits and flood attenuation and water supply are "secondary" system benefits. Again, the water supply benefit originally envisioned in the restoration objective should not be lost and should be identified and this "restoration objective" should be consistently listed throughout the document.	The intent of the reservoir is to capture some of the releases from Lake Okeechobee and basin runoff. The water supply benefits are referred to throughout the report and are intended to supplement deliveries to the estuary during the low periods to maintain proper salinity balance to promote habitat suitability. Table 4-4 shows the relationship of project specific objectives with the CERP goals. The draft PIR does follow the programmatic regulations for CERP which include meeting all legal requirements of WRDA 2000 including maintaining existing levels of service for water supply, water quality and flood protection.
	6. Page 1-11 Goals and Purposes of the Project—While the County is supportive of addressing water supply needs and water quality in the upper basin in the subsequent PIR, any water supply benefits achieved now by the CRWBSR, although they may be de minimis, should be identified consistent with Federal law and the Programmatic	DPIR is consistent with Federal Law and Programmatic Regualtions. Benefits due to additional water made available are considered incidental and will not be quantified in this report.

	Regulations. This comment is also relative to Section 4.1.4.1 on Water Supply and the Annex C Saving Clause Analysis. See also Section 8.5.3.1 on identification of water made available and water for other water related needs.	
	7. Page XXIV CERP Project Phasing—The document describes that a subsequent PIR will be initiated to address the remaining water resource problems in the Caloosahatchee River basin which were not fully addressed by the Tentatively Selected Plan. These remaining water resource problems include: additional pumping and storage capacity, the need for additional water storage and management features in the upper basin and improving water quality. The County has been supportive of the "Phase II" approach for the CRWBSR. The last paragraph of that section further describes the Caloosahatchee ASR features being investigated as part of a **third PIR.** While we understand the need for the two-phase approach, the County is concerned that three PIRs, phases or studies to address the Caloosahatchee basin is excessive and sets a bad precedent for the implementation of CERP projects. The County does not support a third PIR effort for this project and all outstanding issues should be resolved in the Phase 2.	The decision to separate the Caloosahatchee ASR features from the rest of the basin features was made several years ago in order to gather more technical data from pilot projects prior to development of specific alternative plans, and in order to reduce risk and uncertainty associated with the technology. Depending on the timing of pilot project results, we may consider including the ASR analysis in the second PIR.
	8. Pages XI-XII-The Tentatively Selected Plan—The document lists the array of final alternatives. Alternative 3B, 170,000 acre-foot ("ac-ft") storage reservoir with a 1,500 cubic feet per second ("cfs") pump station is the chosen alternative. The County supports these features for the Tentatively Selected Plan at this time.	Noted.
	9. Pages XII-The Tentatively Selected Plan—The document lists a minimum flow of 450 cfs at the S-79 during dry periods. In later sections of the document (pages1-16 &2-34) there is an explanation of why this target was chosen in lieu of the established minimum flow and level ("MLF") criteria of 300 cfs. The County is supportive of using this higher minimum target although it is quite possible that this 450 cfs target is also slightly lower than the true needs of the restored	Noted.

1176

	Caloosahatchee Estuary. This should form the basis for the guiding the Phase II PIR effort. This comment also relates to the discussion on page 4-10.	
	10. Page XII-The Tentatively Selected Plan—The document describes structures C-43s 16, 17, 18 and 19 as possibly being constructed in "partnerships" between the SFWMD and Hendry County as a separate project under a different program. The cost of these structures is $4.5 Million. This commitment does not appear to be strong, because the structure "may" be constructed under the partnership. The document needs to address whether or not this partnership is tentative in nature or not and if so, the structures, and their cost, needs to be added to the overall project cost for the CRWBSR.	The SFWMD is currently in negotiations with Hendry County to go forward with the design, permitting and construction of needed infrastructure to resolve the problems that S16, S17, S18, and S19 were identified to resolve.
	11. Page XIV-The Tentatively Selected Plan—The document describes the added feature for the placement of 20 acres of artificial substrate in the Caloosahatchee Estuary for oyster, plant and animal recruitment. Although the County is supportive of this project feature this 20 acres equates to reaching roughly half to a third of the 40-60 acre targets for increases in the aerial extent of oyster reefs. See also page 7-4.	Your comment is noted. However, the oyster reef restoration plan has been removed from the federal project. The PIR is still recommending this placement for the health of the estuary, but it will not be recommended for funding as part of this PIR. It was felt that this plan could be executed more effectively by other entities.
	12. Page XX-The Tentatively Selected Plan—The document lists the project cost as $446,460,000. See also page 7-15 & page 8-2. It is unclear whether or not contamination clean-up costs, or a contingency fund for them, are included in this figure. A contingency should be added for the $4.5 Million in structures listed in the comment above (C-43s, 16-19) if that partnership project is tentative in nature. On page 5-36, Total Project Investment for Alternative 3B is listed as $486,307,000. Consistent cost figures should be used throughout the document.	Costs associated with the remediation of HTRW contamination is by law not cost-shared in Federal Civil Works projects. The project cost estimate included in the PIR does not include land remediation costs. The SFWMD is responsible for coordinating and paying for all remediation. The structures are being removed from the Federal project so their costs will be removed. Concur - consistent costs will be used

1177

		throughout the FPIR.
	13. Page XX-The Tentatively Selected Plan—The document states that the SFWMD constructed a test cell project to evaluate seepage and embankment design and water quality effects of the project (see also page 2-2). A brief summary of the results of that analysis and project in this section should be included. This comment is also relative to page 4-16.	Concur. This will be provided.
	14. Page 5-6-The Tentatively Selected Plan—Table 5-1 describes the various "management measures" (both structural and non-structural) that were considered in conjunction with the CRWBSR. All management measures were then screened out leaving only the actual reservoir and operations of that reservoir to achieve the planning goals and objectives. This entire analysis seems a bit misleading because the two factors driving this analysis were likely cost and time delay. While the County is supportive of expediting the CRWBSR and we support the approach of a Phase II to more fully address basin needs, it should be clear that these management measures will again be analyzed throughout the Phase II process. While they are not being implemented in conjunction with this phase of the project, they have not been removed from the table for further consideration. This seems to be why Table 5-2 was included, but the statement in that Table that "STAs may not be needed" is alarming before that analysis has concluded.	The second PIR will focus on water supply and water quality in the Caloosahatchee watershed. Therefore, the second PIR will develop structural and non-structural measures which are appropriate for the objectives of the project. The primary focus for this PIR is to evaluate various reservoir sizes for use in storing basin run off and lake releases to supplement dry season flows while proving high-flow attenuation.
	15. Page 5-24-The Tentatively Selected Plan—The County is supportive of the rational for the Alternative 3B being chosen as the Tentatively Selected Plan. It appears to achieve comparable environmental performance while taking an incremental approach on determining the appropriate pump size. Until more water storage is provided in the overall basin, it does not seem as though a larger pump is warranted at this time (see page 5-26). Page5-34 states that most project benefits accrue in the dry season and pump size would not affect these benefits. Any operational or incidental environmental or	The environmental benefits have been measured using habitat units as described in the document. The larger pump (Alternative 3C) did show higher environmental benefit, but additional factors were also used to determine the TSP. A larger pump allows more flows to be captured during the wet season and reduces

	water supply benefit achieved by a larger pump should be clearly reflected in the C-43 Draft PIR. This comment is also relevant to discussion of page 5-42.	the time to fill the reservoir.
	16. Page 5-43-The Tentatively Selected Plan—Is there an effect on project performance if there is a reduction in the 13-foot assumption for freeboard?	Project performance is related to the reservoir's design storage volume (approx 170,000 acre-ft). The required freeboard is necessary for embankment safety and is added to the embankment height which is necessary to provide the design storage volume. Passive overflow spillways C43CS1 and C43CS2 are included to prevent overfilling of the reservoir above the design volume.
	17. Page 5-47-The Tentatively Selected Plan—When the MIKESHE water budget modeling shortfalls discussed in this section be rectified? This should be completed before the C-43 Final PIR.	The MIKESHE irrigation water budget discrepancy was corrected. The corrected model was then used in the local flood protection assurance analysis presented in the DPIR. A separate spreadsheet analysis which utilizes modeling output from the SFWMM regional hydrologic simulation model was used in the next added increment analysis of the TSP to show no impacts to water supply. Therefore, rerunning the corrected MIKESHE model for all the project alternatives in order to evaluate water-supply related performance is not necessary to move forward with the TSP in the Final PIR.
	18. Page 5-49-The Tentatively Selected Plan—What "alternative methods" were used to show the Tentatively Selected Plan is in compliance with CERP Programmatic Regulations, WRDA 2000 and Florida State Law?	A spreadsheet analysis, utilizing modeling outputs, was used in the next added increment analysis of the TSP. A revised MikeSHE/Mike11 model was used to look

1179

		at the localized areas around the reservoir to demonstrate that the project does not have an impact to flood levels on lands adjacent to the reservoir.
	19. Page 6-9-The Tentatively Selected Plan—Alternative 3B is projected to meet the desired flows for the Estuary 74.8% of the time as compared to the current 46% estimate. This appears to be significant improvement but full restoration benefits must be the guide to project success.	Noted. We are trying to achieve the greatest benefit possible in a timely manner. There is recognition that additional water storage may be needed in the basin. This is why a second PIR is planned for the near future.
	20. Page 6-10-The Tentatively Selected Plan—The structural canal changes contemplated do not appear to be significant, but coordination with affected property owners must commence to avoid any delay in project implementation. See also discussion on page 7-3.	All needed easements and rights of way have been acquired.
	21. Page 6-15-The Tentatively Selected Plan—It does not appear as though there are any significant effects on groundwater elevations except the small increase (albeit in the dry season) north of the project site. Again, this effect must be coordinated with affected property owners to avoid any delay in project implementation.	Modeling indicates localized impacts less than 0.5 foot, which will likely be imperceptible to downstream users.
	22. Page 7-16-The Tentatively Selected Plan—The benefits and potential detriments of the public-private partnership described in this section are unclear. Which project features would be constructed in this fashion and are there any formal proposals for this effort?	There is no plan to form a public-private partnership for the design or construction of the project. The report will be corrected.
	23. Page X-Related Project, Permitting and Process Issues—The document discusses how aquifer storage and recover ("ASR") project features will be evaluated and implemented separately. Will this occur in a second PIR or separate initiative? How will this project be coordinated with the ASR contingency plan?	The ASR project features are currently being evaluated under the ASR pilot project program. These pilot projects will help determine "if" and "how many" and "where" permanent ASR wells might be established. A second PIR or separate initiative (not yet determined) would then use that information to further evaluate the ASR feature for this basin. The ASR

		contingency plan would be engaged if ASR technology is found to be not feasible for parts or all of the basin. Essentially, ASR in the C-43 Basin is a separate initiative.
	24. Page X-XI-Related Project, Permitting and Process Issues—The document similarly discusses an additional project to store basin runoff for backpumping and treatment form the C-43 Canal to return to Lake Okeechobee. Will this occur in a second PIR or separate initiative?	The backpumping and treatment that is discussed is a stand alone project under CERP. It will not be included in the second PIR.
	25. Page XXI-Related Project, Permitting and Process Issues—The document lists the C-43 Draft PIR process and the Department of the Army Section 404 (Clean Water Act) permit as separate but related activities. The estimated timeframes for the issuance of the permit should be included in the document. Will this be the July 2007 date for initiation of clearing and grubbing of the site?	The Regulatory Division anticipates using the FEIS as the NEPA documentation for the 404 permit. Consistent with CEQ Regulations the Corps cannot proceed with a federal action until 30 days after NOA of a FEIS. Therefore a Section 404 permit is not anticipated until after October 7, 2007. Additionally, clearing and grubbing in uplands anticipated to commence in July 2007, does not require a Section 404 permit.
	26. Page 1-12-Related Project, Permitting and Process Issues—The document lists the ASR Pilot Project as being conducted in parallel with a regional study on ASR. The timing of this pilot project and regional study needs to be listed to determine if these features can, and should, be included in the Phase II PIR. The document also lists the Caloosahatchee Backpumping with Stormwater Treatment (20,000 ac-ft) as a project used to agument regional system water supply. The County has not been supportive of this backpumping effort until we are sure the Caloosahatchee system targets are met first, including wet season and dry season flows, but again, any indirect water supply benefits from the CRWBSR must be identified in the current C-43 Draft PIR. The land acquisition needs to f this feature are uncertain at the time and due to land value escalation, this effort should be	The ASR Pilot Project for the Caloosahatchee is currently being reviewed. One unsuccessful well was began on the Berry Groves site. Other sites are currently being considered. In addition, the regional study is currently ongoing. The Caloosahatchee Backpumping project is not currently scheduled.

1181

	expedited.	
	27. Page 1-15-Related Project, Permitting and Process Issues—This section lists the various "State Initiatives" having an impact on future water quality both upstream and downstream of S-79. Projects and programs included in this year's Northern Everglades and Estuary Protection Act should be included in this section. This information should also be added to Section 3.6 on Water Quality, page 3-7 and page 6-40	At the time that the draft report was issued the Northern Everglades and Estuary Protection Act had not be signed in to law. It will be added.
	28. Page 1-17-Related Project, Permitting and Process Issues—The Caloosahatchee Water Management Plan ("CWMP") is referenced as identifying the need for 220,000 ac-ft of storage in the lower West Caloosahatchee Basin as a target for environmental restoration of the Caloosahatchee Estuary. With the CRWBSR including 170,000 ac-ft of storage, a gap of 50,000 ac-ft storage need to be met exists based on the CWMP. The 20,000 ac-ft target in the Caloosahatchee Backpumping with Stormwater Treatment project is less than this target. This additional storage need must be identified as quickly as possible due to the aforementioned land value escalation issues. This comment is relevant to Section 5.3.4.5 on Alternative 4A.	As mentioned in previous responses, a recognition that there may be a need for additional storage in the basin is one of the reasons for the second PIR which is planned to begin later this year.
	29. Page 1-18-Related Project, Permitting and Process Issues—Will the permits referenced on this page, Section 404 Clean Water Act, be issued before construction commences in July 2007?	Clearing and grubbing in uplands with anticipated to begin in July 2007 does not require a Section 404 permit provided there is no discharge of dredge of fill material in waters of U.S. At this time the SFWMD does not anticipate any discharge associated with clearing and grubbing.
	30. Page 2-11-Related Project, Permitting and Process Issues—Water use analysis is based on the CWMP document dated April 2000. The 2005-2006 Updated to the Lower West Coast Water Supply Plan should be utilized and referenced for this analysis. This comment is also relevant to Section 3.16 on municipal and agricultural water supply.	Your comment is noted. However, due to the expedited schedule we will not have time to utilize the new data.

1182

	31. Page 3-8-Related Project, Permitting and Process Issues—The Lake Okeechobee Operating Permit ("LOOP") is currently being used and discussion are ongoing regarding changes to the LOOP relative to structures that discharge from Lake Okeechobee into the Caloosahatchee basin. This information should be incorporated into the C-43 Final PIR. It should also be added the section on "Existing Operations" on page 8-4.	Operation of Lake Okeechobee is not a part of this PIR. The proposed reservoir does not affect the operations of the lake.
	32. Page 4-18--Related Project, Permitting and Process Issues—The Water Supply discussion references the Lower West Coast Water Supply Plan Update. This Plan has already been adopted by the SFWMD and should be a basis for water supply information in this C-43 Draft PIR.	The Lower West Coast Water Supply Plan is the basis for the water supply information in the Draft PIR.
	33. Page 6-22-- Related Project, Permitting and Process Issues—Will formal consultation with the U.S. Fish and Wildlife Service be completed by the release of the C-43 Final PIR?	Yes. Formal consultation with USFWS will be complete for the Florida panther, Audubon's crested caracara, and Eastern indigo snake.
	34. Page XVII – Water Quality Benefits and Impacts—The document states that "Impoundment water quality will be further assessed as part of the permit application and review process." It is important that this analysis occur as quickly as possible so that operational adjustments can be made or additional features can be analyzed to address any problems. The timing of this water quality analysis in conjunction with "the permit application and review process" is unclear. Is that a concurrent effort?	The referenced paragraph has been removed from the final document. The FEIS includes additional water quality analysis that further demonstrates that the project will not cause or contribute to water quality degradation. This additional information will be available for the 404 permit application review as well as subsequent permit applications.
	35. Page 3-8 – Water Quality Benefits and Impacts—Reference is made to the land use specific runoff quality factors adapted from Harper 2003. These figures have been updated since that time and a more current reference may be more accurate.	Using updated runoff quality coefficients is not possible at this time. While the total nutrient load calculations would change as a result of using different land use quality runoff coefficients, it would not materially change the overall water quality analysis or the project design.

	36. Page 3-9 – Water Quality Benefits and Impacts—The document makes the statement that nutrient loads delivered through S-79 to the estuary are expected to be no more than presently delivered to the estuary. This assumption is highly speculative given historical loading from Lake Okeechobee and the changes to those loading rates based on unforeseen events such as hurricanes. The summary of that section should include a statement on these unforeseen effects.	The prediction of 2050 water quality conditions are based on 20 years of historical water quality data, 35 years of hydrologic data, projected land use, and planned future operations. The effects of one time event such as hurricanes are reflected in the predictions since the historical data include these events. As with any prediction of the future, there is a good deal of uncertainty regarding its accuracy. The write up provided in the PIR adequately reflects this uncertainty.
	37. Page 4-8 – Water Quality Benefits and Impacts—The document states, "According to CERP guidance memorandum 23.01 "Water Quality Considerations for the PIR Phase," the C-43 Basin Project falls into Category B, which means the project should be designed to achieve water quality improvements." The significance of this statement, and reason for referencing this document, are unclear.	The purpose of referencing GM 23 is to indicate that CERP guidance was followed in regards to assessing and considering the water quality aspects of the project.
	38. Page 4-16–Water Quality Benefits and Impacts—The "Nutrient Reductions Opportunities" section discusses water quality benefits from just operation of the CRWBSR, but there is no mention of the actual amount of nutrient loading that will be reduced. It is the County's understanding that some of this more detailed information is available based on the Test Cell project. This section would benefit from some specificity in terms of the actual reduction contemplated by the CRWBSR alone.	The Environmental Appendix includes the detailed water quality analysis results requested here. The final analysis and interpretation of the Test Cell data is not available at this time (June 2007).
	39. Page4-30–Water Quality Benefits and Impacts—The Section on Water Quality Evaluation Criteria lists improving water quality as a secondary goal of the project. Improving water quality is not listed as a secondary goal in the original "Yellow Book" purpose statements regarding the project. This statement should be struck from the document.	Though water quality improvement may not be specifically mentioned in the "Yellow Book" as a "secondary goal" for this project it is one of the goals of the CERP. The statement will not be struck from the FEIS.

1184

	40. Page 5-34–Water Quality Benefits and Impacts—The document states that assuming no water quality treatment in the basin, TP, and TN loads are expected to be reduced 28 to 35% at S-79. On page 6-16, this figure is listed as 28%. Please explain the methodology for the 35% figure and the methodology to calculate these figures overall should be included in document. Additionally, the short term increases contemplated in TN, yet the achievement of the average annual load reduction, are unclear.	The water quality analysis presented in Appendix C includes a complete description of the calculation methods used to estimate project related nutrient removal. The water quality analysis did include an investigation of the likely impact of short-term increases in TN concentration. These short-term increases in TN concentration are not likely to have a significant impact on the average annual TN load at S-79.
	41. Page 5-35–Water Quality Benefits and Impacts—While the County agrees there may be a benefit from mere operations of the CRWBSR without a water quality feature at this time, it may be premature to conclude that the CRWBSR will not cause or contribute to water quality degradation under future conditions. See also page 6-17. Based on additional issues associated with contamination and clean up of the land and the short term TN issues identified in the comment above, this statement cannot be substantiated at this time. This comment is also relevant to the statement made on page 8-15, "The Caloosahatchee River (C-43) West Basin Storage Reservoir project selected plan complies with water quality standards applicable to the project and adjacent waters."	The water quality analysis presented in Appendix C includes a supplemental analysis prepared in conjunction with the FDEP that concludes that the project is unlikely to cause or contribute to water quality degradation. The Corps believes that the project will comply with state and federal water quality standards.
	42. Page 1-2—Miscellaneous Comments—There is a typographical error in the last paragraph on this page. "Achieve" should be changed to "achievement".	Noted. We will fix the text.
	43. Page 2-1—Miscellaneous Comments—The land exchange between the 541.31 acres located north of the project boundary for the 600.13 acre Paul property should be clarified. The effects of this swap on adjacent property owners should be reviewed. Will this land be needed for the activities commencing in July of 2007?	The land exchange is needed for the activities commencing in July 2007. The SFWMD has been coordinating with the adjacent land owners.
	44. Page 2-37—Miscellaneous Comments—The document states that without additional basin storage planned by CERP projects, flows	To be clear, we will change this sentence to read "in an average year flows exceed the

	exceed the target about seven months per year. The "CERP projects" referenced in the sentence should be identified.	target about seven months of the year."
	45. Section 2.12—Miscellaneous Comments—This section describes Hazardous, Toxic and Radioactive Waste property issues. The costs and commitments on remediating the sites are unclear. For example, is this issue considered in the $446 Million estimated project cost or is it a future cost to be borne by the State of Florida?	Costs associated with the remediation of HTRW contamination is by law not cost-shared in Federal Civil Works projects. The project cost estimate included in the PIR does not include land remediation costs. The SFWMD is responsible for coordinating and paying for all remediation.
	46. Pages 4-18—Miscellaneous Comments—The Flood Damage Reduction section says that the project will not compromise the existing level of protection and that some incidental benefits may be achieved. These incidental benefits should be more clearly identified.	This PIR will not quantify any incidental benefits. Only environmental benefits will be quantified.
	47. Page 5-4—Miscellaneous Comments—The County is in agreement that the Caloosahatchee Estuary is in need of immediate helps and cannot wait until a holistic approach is developed to address all of the issues within the entire basin. But, there should also be specific timelines and commitments to address the remaining issues in one additional single study to be completed by a dated certain. Potentially three PIRs and "subsequent studies" will continue to piecemeal the solution, cost more and delay that holistic approach to solving the Estuary's problems.	The second PIR will address the needs and issues of the Caloosahatchee watershed and will incorporate the findings of this PIR. Dennis Duke has committed that a second PIR will be initiated in Sept. 2007 to evaluate solutions to broader Caloosahatchee Basin restoration needs. The timeline for completion of this PIR is expected to be approximately 3 years.
	48. Page 5-37—Miscellaneous Comments—The following statement in the document is confusing, "If nothing was done to improve the conditions in the estuary, the project team determined that the future without project condition would experience a gradual improvement for 15 year at which point the ecosystem would stabilize." The statement should be clarified or struck from the document because it seems to say that the CRWBSR may not even be needed because eventually the ecosystem will stabilize. For instance, how will it stabilized when data shows (such as water quality) conditions have been deteriorating?	The statement will be altered to state that "eventually the ecosystem will stabilize at a severely degraded condition". The original statement addressed the fact that an outcome of our boundary conditions for the 2050 RD was a reduction in large volume flows released to the Caloosahatchee. This is thought to be due to a larger water demand on Lake Okeechobee from the southeast region of Florida. So although the

1186

		Caloosahatchee is expected to continue to deteriorate under existing conditions, the boundary conditions on our "future without project" model run result in less excessive flows released to the river.
	49. Page6-7—Miscellaneous Comments—The document should clarify the difference between "completely resolving the problems of the Caloosahatchee Estuary and Caloosahatchee River (C-43) Basin and "the immediate needs of the estuary."	The last sentence of the paragraph will be reworded to state "However, they all help to move towards restoration of the estuary by lowering the number and severity of extreme events and they all provide a significant improvement to the health of the estuary."
	50. Page 6-31--Miscellaneous Comments—The "commitment" from the SFWND that "all of the outstanding point source remediation efforts will be completed" is unclear. Does the SFWMD have funding allocated to meet this commitment and when will it occur? Is it subject of an agreement and if so, what agreement? This section is concerning because soil contamination has also been identified in cultivated areas on the site. Remediation efforts are to place these soils into the core of the reservoir dam. While the County understands the funding constraints on the project the efficiency of using on site resources to construct the dam. The document states that there is still a risk to benthic organisms and the solution would be additional remediation efforts if needed. Costs for these efforts and more detail is necessary to assure that this issued does not cause project delay. See discussion also on pages 7-18—17-19.	The point source remediation is about 75% complete, and the remaining point sources will be remediated by November 2007. The larger area copper and chlordane contaminated soils will be incorporated into the reservoir interior embankment (covered with soil cement).
Southwest Florida Regional Planning		

1187

Council June 5, 2007		
	1. A water quality treatment component needs to be included in the design of the reservoir project. The need for a water quality treatment component was identified early in the process of alternative development review by federal, state, regional and local agency participants of the PDT in the development of the PIR. It was deferred from consideration by the SFWMD and USACOE. Apparently, this reservoir project is the only reservoir design currently under consideration for CERP funding that does not have a water quality treatment feature. Based upon materials posted on the CERP web-site, east coast reservoirs have water quality treatment features included in their design. It is important that the current project design not preclude the necessary water quality treatment features. It is important that land not be surplused from the project footprint before necessary water quality treatment features are planned and constructed. Addressing hydrology without including water quality improvement is insufficient in protecting the estuary and aquatic resources of the Caloosahatchee River and the nationally recognized Outstanding Florida Waters estuaries at its confluence. H.R. 1816, the "Restoring the Caloosahatchee River: A Legacy for Florida" Act, was introduced by Congressman Connie Mack and the State of Florida Appropriations Bill delivered to Governor Crist includes funding a water quality component for the C-43 Reservoir project. The TSP should include water quality treatment features with sufficient space for their construction.	The need for a water quality treatment facility as a part of the CRWBSR Project was never identified. The need for a water quality treatment facility is being investigated through the State of Florida's Northern Everglades Program as well as the Caloosahatchee Watershed Project Implementation Report which is scheduled to begin in September 2007. In this PIR, the broader needs of the Caloosahatchee Watershed, including the need for water quality improvements, will be addressed.
	2. The littoral areas proposed at the corners of the seepage canal as part of the project should be constructed. We concur with the Florida Fish and Wildlife Conservation Commission that these littoral areas will provide habitat benefits and potential water quality benefits.	The reservoir design calls for littoral shelves on both banks of the perimeter canal, with "expanded" areas at the corners.
	3. All shade trees proposed on the outside area of the north rim canal adjacent to parking areas should be native to the Caloosahatchee	Noted.

	basin. Past selection and planting of exotic tree species in USACOE projects has led to damage to reservoir banks and project canal banks resulting in expensive remove programs and the need to construction repairs.	
	4. The missing pages in the Final Biological Assessment concerning methodology that should be present between pages A-95 and A-96 in Annex A of the FWCA Report and Endangered Species Act Compliance should be inserted into the documentation of the PIR.	This information is available at the Jacksonville District office and can be requested at any time. It was left out of the document in order to reduce the size of the final document and save paper.
	5. The SWFRPC supports the concept and development of the C-43 reservoir project to reduce the negative hydrologic discharges to the Caloosahatchee River, restoration of base flows for the Caloosahatchee River, and improvement in water quality of the Caloosahatchee River. Our staff has participated cooperatively in the development of the PIR and EIS. We did not and do not agree; however, that water quality protections should be deferred in development of this project.	See response SFRPC #1 above.
Committee of the Islands May 10, 2007		
	1. COTI urges the Army Corps of Engineers to work with South Florida Water Management District to include a filtration marsh in plans for the proposed C-43 Reservoir.	See response SFRPC #1 above.
A. Duda & Sons, Inc June 11, 2007		
	1. Well abandonment and ASR effects on local groundwater supply.	ASR is not a part of the CRWBSR Project. All wells at the reservoir site will be abandoned as appropriate.
	2. Public recreation on the outside of the Reservoir perimeter canal. This would provide the public with direct access to our property. Real recreational activity exists inside the proposed perimeter canal.	The SFWMD hopes to develop a recreation management partnership with Hendry County. Types, location and management

1189

	Access to the outside should be restricted to provide a buffer between offsite lands and the public.	of recreational facilities will be a part of that negotiation.
	3. The Townsend Canal capacity may become a problem in terms of our irrigation withdrawal. What measures are in place to offset this potential conflict?	The Townsend Canal is being improved to assure that the required capacity for both the Duda pump station and the CRWSBR pump station is available. Detailed Townsend Canal modeling has been performed, which included A. Duda & Sons current operations. Additionally, the CRWBSR goals are to pump water in the wet season, when A. Duda & Sons will most likely be discharging, and release water in the dry season when A. Duda & Sons will be irrigating. Therefore, the Townsend Canal capacity is thought to be sufficient to not impact A. Duda & Sons current operations.
	4. Will the Reservoir become a "consumptive user" of water in dry times? Other South Florida reservoirs require a minimum water level.	No, in periods of the drought, the reservoir will be dry. Only the perimeter canal will require water, but A8 modeling has shown that it is less than what is currently supplied to the same property for irrigation.
	5. ADS has an existing easement along the east side of the Townsend to SR80. What provisions have been made for equivalent access?	ADS access along the east side of the Townsend Canal will be maintained and accessible to ADS.
	6. Piezometers are in place to monitor lateral seepage to adjacent lands.	Agree
	7. Conversion of habitat on a tract this large may displace a	The animal population will disperse in all

	significant wildlife population. What mitigation avenues are available to an adjacent landowner if their property becomes a site for a refugee population?	directions and is not expected to cause a noticeable change in animal population for any adjacent landowners, as any area of land will only support the carrying capacity for each species. Please contact the USFWS for specific programs regarding threatened and endangered species movement to new lands.
	8. Page 1-5–1.1 Report Authority—this paragraph approves the ecosystem restoration, "while providing for other water related needs of the region." This phrase indicates a corresponding action, i.e., the water supply element is authorized along side the environmental releases to the estuary.	The CRWBSR Project does not have a water supply element associated with other than for the natural system to meet environmental demands downstream. This phrase indicates the intention to balance ecosystem restoration while maintaining existing levels of service for water supply, water quality and flood protection.
	9. Page 2-53—2.15 Existing Land Use—This paragraph limits the regional water supply benefit to a secondary concern. This is inconsistent with Section 601 of WRDA (see page 49)	The CERP is a multi-purpose project. The entire CERP will address water supply but each individual PIR may not address water supply. The analysis conducted is not inconsistent with section 601 of WRDA. Please note the following language as found in the WRDA. The savings clause is addressed elsewhere in the report. Calculating water supply benefits as incidental on a specific project is not inconsistent with WRDA *" (A) IN GENERAL- Except as modified by this section, the Plan is approved as a framework for modifications and operational changes to the Central and Southern Florida Project that are needed to*

1191

		restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection." Please note the language on the savings clause for water supply protection, which this PIR does address, additionally this PIR does provide water-related needs of the region which are not used for justification but are incidental to ecosystem restoration goals. Please see the agreement and project justification sections. The agreement below depicts the logic behind Section 2.15 *(2) AGREEMENT-* *(A) IN GENERAL- In order to ensure that water generated by the Plan will be made available for the restoration of the natural system, no appropriations, except for any pilot project described in subsection (b)(2)(B), shall be made for the construction of a project contained in the Plan until the President and the Governor enter into a binding agreement under which the State shall ensure, by regulation or other appropriate means, that water made available by each project in the Plan shall not be permitted for a consumptive use or otherwise made unavailable by the State*

1192

		until such time as sufficient reservations of water for the restoration of the natural system are made under State law in accordance with the project implementation report for that project and consistent with the Plan. Please see the section on evaluation of projects for language regarding the justification of a PIR. *(f) EVALUATION OF PROJECTS-* *(1) IN GENERAL- Before implementation of a project authorized by subsection (c) or (d) or any of clauses (i) through (x) of subsection (b)(2)(C), the Secretary, in cooperation with the non-Federal sponsor, shall complete, after notice and opportunity for public comment and in accordance with subsection (h), a project implementation report for the project.* *(2) PROJECT JUSTIFICATION-* *(A) IN GENERAL- Notwithstanding section 209 of the Flood Control Act of 1970 (42 U.S.C. 1962-2) or any other provision of law, in carrying out any activity authorized under this section or any other provision of law to restore, preserve, or protect the South Florida ecosystem, the Secretary may determine that--* *(i) the activity is justified by the environmental benefits derived by the South Florida ecosystem; and*

1193

		(ii) no further economic justification for the activity is required, if the Secretary determines that the activity is cost-effective. *(B) APPLICABILITY- Subparagraph (A) shall not apply to any separable element intended to produce benefits that are predominantly unrelated to the restoration, preservation, and protection of the natural system.* *(5) SAVINGS CLAUSE-* *(A) NO ELIMINATION OR TRANSFER- Until a new source of water supply of comparable quantity and quality as that available on the date of enactment of this Act is available to replace the water to be lost as a result of implementation of the Plan, the Secretary and the non-Federal sponsor shall not eliminate or transfer existing legal sources of water, including those for--* *(i) an agricultural or urban water supply;* *(ii) allocation or entitlement to the Seminole Indian Tribe of Florida under section 7 of the Seminole Indian Land Claims Settlement Act of 1987 (25 U.S.C. 1772e);* *(iii) the Miccosukee Tribe of Indians of Florida;* *(iv) water supply for Everglades National Park; or*

1194

		(v) water supply for fish and wildlife.
	10. Page —2-44--2.12 Hazardous, Toxic and Radioactive Waste—I did not see any summary of wells to be abandoned. Significant local and regional ground water contamination could result from improper or no well abandonments. Any proposed ASR wells would be far below any local aquifers, I presume?	See response to Duda #1 above.
	11. Page 2-49—4-17-- (repeated on page 173) The dependence of these "critical industries" on water supply points to the importance of maintaining the water supply benefits while providing the environmental releases for the estuaries. Agriculture and tourism have co-existed for over 100 years. To suddenly subjugate one to the other is unwarranted.	The intention of this project is to balance the needs of the natural system while allowing tourism and agriculture, both of which have a reliance on water, to continue.
	12. Page 4-14--..This comparison of the urban areas along the estuary to areas upstream of the S-79 tells only part of the story. If an acreage or total flow comparison of the entire S-79 tributary watershed were included, the 90% to 95% conclusion would not be surprising, given that the watershed extends from the S-79 to Orlando. In other words, the urban areas along the estuary are a very small portion of the total flow and therefore a small contributor to loading. Water quality issues within the local urban watershed should not be overlooked.	Comment noted.
	13 Page 4-18-- 4.1.4.1 Water Supply---The classification of water supply as "incidental" is contrary to Section 601 of WRDA 200o.	WRDA 2000 requires that water supply for existing legal users be maintained. Any additional water supply which may be made available through this project is considered an incidental benefit and not a primary purpose of this project.
Concerned Citizen Craig Mary @ Juno.com	1. In regards to the modeling of the Townsend Canal what eng. data or hydrolic data did you use as a baseline for the modeling. The question still remains how the 1500 cfs and or any additional pumps in the future and the 195 cfs pump st. to the south will effect the ability of other users of the canal.	CRWBSR will be pumping water in the wet season and releasing water in the dry season, which is opposite the Townsend Canal's current use. Detailed Townsend Canal modeling has

1195

	Beth comments mention the possibility of additional pumps but without saying at that time Townsend Canal improvements must take place. Why such a big pump st. to the south just to maintain an elevation in the perimeter canal	been performed, which included a 1,500 cfs pump station and A. Duda & Sons 300 cfs current operations. Improvements to the Townsend Canal to ensure sufficient capacity for the C-43 project and A. Duda & Sons are based on this modeling. If additional pumps were added, analysis would be conducted to determine what (if any) modifications would be needed to the Townsend Canal. The CRWBSR project needs to continue to supply the Paul property to the east and Berry groves to the north with the 195 cfs pump station.
Private Citizens	Comment	Response
William Morscheck, private citizen	1. I am writing to insist that the storage reservoir planned along the Caloosahatchee must include a filtration marsh. I understand that the Army Corps and the South Florida Water Management District (SFWMD) is planning this "C-43" reservoir without any stormwater treatment area (STA), or filtration marsh. STAs are included with other such reservoirs to the east and south of Lake Okeechobee. Why shouldn't the Caloosahatchee's reservoir also have such a filtration marsh? As the test cells for the planned reservoir have demonstrated, the water stored there will grow algae in great quantities. When it is time to release that water into the river, it will be even more degraded than when it went into the storage	The Caloosahatchee River (C-43) West Basin Storage Reservoir Project has, from the Restudy forward, always been envisioned primarily as a water storage feature. In addition to restoring more natural flows and salinities in the Estuary, the Restudy acknowledged the West Basin Storage Reservoir could achieve some water quality improvement benefits. Analysis conducted during this study indicates the Tentatively

1196

	reservoir. Without filtration, the reservoir will be simply an algae farm, and releases will be even more damaging. Releases into the Caloosahatchee River are having a huge negative impact on the estuaries along the Gulf to the south. Everything that can be done, must be done to mitigate this impact if the releases continue.	Selected Plan will reduce the average annual load of Total Phosphorus passing S-79 by approximately 29%, compared to the predicted future without-project conditions in 2050. It will reduce the average annual load of Total Nitrogen passing S-79 by approximately 28%. Most of this positive benefit is due to a reduction in flows from Lake Okeechobee. Nutrient loads will be shifted from the wet season to the dry season, but there will be a net decrease in frequency of exceeding dry and wet season, and annual TN loading performance measures. Some small amount of nutrient removal may occur due to settling out during residence time in the reservoir. Construction and operation of the reservoir neither cause, nor contribute to, water quality degradation. Both the US Army Corps of Engineers and the South Florida Water Management District want to construct this reservoir and provide benefits to the Caloosahatchee Estuary as quickly as possible. Further analysis of water quality treatment in this Project Implementation Report would delay the construction of the reservoir and realization of positive ecosystem restoration benefits to the Estuary. Water quality improvement features cannot be adequately designed without nutrient load targets, or

1197

		Total Maximum Daily Load targets. Unfortunately, such targets have not yet been developed for the Caloosahatchee River Watershed and Estuary. We have committed to further address water quality improvement needs in a follow-on Caloosahatchee Watershed Project Implementation Report, scheduled to begin in September, 2007. In this PIR, the broader needs of the Caloosahatchee Watershed, including the need for water quality improvement, will be addressed. In addition, the SFWMD is moving forward with plans to address water quality needs in the Caloosahatchee Watershed through its Northern Everglades program.
Richard B. Hasselman, private citizen	2. Please include a water treatment plant in the design of this reservoir and its associated systems, so that all nutrients and other pollutants are removed from any and all water which flows down the Caloosahatchee River. Thousands of us residents of Southwest Florida are suffering from the red drift algae and other problems which have been created by the flow of untreated water from Central Florida, and we desperately need the Corps of Engineers to correct that quickly. May we hear from you, please?	See reply to private citizen comment #1 above.
Henry Glissman, private citizen	3. Why are you doing only half a job on thus critical project. No way to clean the water is criminal!	See reply to private citizen comment #1 above.

1198

Barbara Joy Cooley, private citizen	4. I object to the plans for the C-43 reservoir because they do not include a stormwater treatment area (STA, or filtration marsh) to treat the water before it is released into the Caloosahatchee. Without such an STA, the reservoir will be an algae farm and will actually harm the water quality in the Caloosahatchee estuary.	See reply to private citizen comment #1 above.
Hazel & Ed Schuller, private citizen	5. Please attend to our community-in-crisis and need for environmentally safe water quality. Isolated chemical elements, and/or combinations of red-tide organisms & algae-producing agents, are poisoning Florida rivers, estuaries, Gulf of Mexico and the City of Sanibel coasts and waterways. Red drift algae, especially offensive when stinking dead fish decay within an algae tidal mass, makes the beach undesirable at times for recreation and visitor uses. The City is considering approval of abusive cleaning methods that may destroy unknown minutest beach & marine life, bird habits and other conservation uses. Resorting to mechanically cleaned beaches, achieving a sterile environment such as in Naples, may soon be Sanibel Island's final "last resort" solution. Thank you.	See reply to private citizen comment #1 above.
William (Bill) Kelley, private citizen	6. It makes absolutely no sense to store polluted water in the C-43 Reservoir and release it into the Caloosahatchee river. It is absolutely necessary to provide storm water treatment such as a filtration marsh. If all other reservoirs for the project has filtration what possible reason can their be for no filtration for C-43.	See reply to private citizen comment #1 above.
Eric Orkin, private citizen	7. It has come to my attention that a "C-43" reservoir without any stormwater treatment area (STA), or filtration marsh is planned along the Caloosahatchee. This will undoubtedly lead to increased algae in	See reply to private citizen comment #1 above.

	the estuaries and coastal waters around Sanibel. I have lived here for just over three years and have already seen a remarkable degradation in the water quality, the presence of grasses, and the presence of fish. We participate in the Osprey counting and the number of offspring has dropped precipitously from over 80 last year to the mid-teens this year. Although it may not yet be proven, it is very likely due to the water quality around the island. In addition to our usual incidence of red tide, this year we have had unheard of quantities of red drift algae. This has had a serious economic impact on the island. It is my understanding that STAs are included with other reservoirs to the east and south of the lake. Why has the Caloosahatchee reservoir been singled out? Please consider the impact of the plan on this area that is so dependent on the quality of its waters for its economic health. Do not make short term decisions. Do not sacrifice one region, which is a gem within the nation and the state, for the economic gain of powerful commercial interests. Imagine that you lived in one of the towns around Pine Island Sound, that you boated with your family and fished these waters. Imagine that your family had jobs dependent on tourism. Now, make the right decision.	
Private citizen	8. The c-43 reservoir must have a STA to be effective	See reply to private citizen comment #1 above.
Allen Cater, Private citizen	9. It would be a gross waste of out taxes to build C43 without an STA!	See reply to private citizen comment #1 above.
Newton E. Cook, private citizen	10. I will be unable to attend the meeting 5/17 in LaBelle due to conflicts, including a meeting the evening before on the CERP DECOMP project. However, I want to emphasize the need to include sufficient access for public recreational use on the Reservoirs and STAs being constructed in the massive Everglades project. The Reserviors will be meccas for ducks and other waterfowl, as well as	The current plans for public access and recreation facilities will serve a wide variety of nature based recreation. All the activities asked for are reasonably expected activities and are not eliminated by the design. The levees, external canals and littoral zone

1200

	offer some fishing. The inititial construction plans for the C-43 Reservior must include a boat ramp or ramps that will be suitable for public use. We understand a test period will be required on the reservoirs before public access, but there is no reason to expect any restrictions on access and the basic construction is much less expensive if done as part of the project. We also want to insure "hunting", specifically "waterfowling", will be included in the approved recreational plan. Thank you for the opportunity to comment.	designs will accommodate public access but their designs are not specific to that purpose. Specifics on how activities will be managed have not been determined and would likely change over time based on number of users and actual affects to the project. Managing recreational activities will be needed to ensure the project's purposes are served first, user conflicts managed second. SFWMD has developed rule 40E-7 which provides the ability to regulate the public access as may be needed.
Donald L. and Meleanor L. Deming, Private citizens	11. We would like to add our voice to the insistence that the storm water treatment area proposed for C-43 must include a filtration marsh to go with the C-43 reservoir.	See reply to private citizen comment #1 above.
Curt Stendahl, Private citizen	12. Now after Hurricane Charlie the local eco system has been seriously disrupted and Sanibel Island as well as neighboring municipalities have been plagues with red drift algae accumulating on our shores. We now urge the U.S. Army Corps of Engineers to do your part in assisting our efforts to eliminate this plague from our beaches. You can help by adding a storm water treatment area (STA) to C-43 as you have done with other reservoirs you have developed in south Florida. Without these STAs I am convinced that some form of algae will form, be subsequently discharged to the Caloosahatchee River and end up on our beaches when C-43 is drained. We are only asking for fairness. If other areas are provided with STAs to provide them with quality water why not do the same for Southwest Florida?	See reply to private citizen comment #1 above.
Rhonda Roff,	How many acre-feet are capable of being stored in both cells?	The reservoir will be able to store 170,000

1201

Conservation Chair for the Hendry-Glades Audubon Society, President of the Save It Now, Glades! organization		acre-feet of water and the average depth will be seventeen to nineteen ft.
	Where would the natural salt line of the Caloosahatchee River be in the absence of the Franklin lock?	There would be no specific salt line. The salinity would vary as a function of wet season and dry season conditions. The saline water would move upriver during the dry season and then back out into the estuary in the wet season.
	And with the lock in place, is it right there at the lock all the time?	No, it depends on freshwater flows. At high flows the saltwater/freshwater interface will move out into the estuary, and at low flows it will move upstream to the lock or beyond. During the dry season, we actually release freshwater from the lake specifically to manage the salinity at the Olga Water Treatment plant located upstream of the Franklin Lock. So the saltwater/freshwater interface still fluctuates, but not like it did when it was a natural system.
	Any habitat augmentation that would be available within the project to allow for bird nesting, migration, and wildlife utilization of the reservoir would be greatly appreciated.	
	There are plans to build a coal-fired power plant in Moore Haven. Some SFWMD employees have stated that a benefit of the power plant would be its potential to withhold upstream freshwater from moving downstream and creating additional freshwater pulses. The plant, if built, will occupy 4,900 acres, some of which will be used to store recycled cooling water. Will this power plant offer substantial freshwater storage and is it needed for that capacity. Will the reservoir provide enough storage so that the power plant is not needed as a source of water storage?	The power plant would only be holding enough water to operate their cooling system, probably not anywhere near the amount the reservoir will hold. The power plant is not looking just at surface water as a water source, but also ground water. The Northern Everglades Project that the state of Florida has initiated will provide the most water storage in the region. This project will hold excess water north of Lake Okeechobee. The SFWMD has not taken an

1202

		official position on the Glades Power Plant at this time. The power plant is currently in the siting permit review phase. You can submit your questions to DEP as part of the public response process to the power plant's application for approval.
	The proposed power plant is requesting 28 million gallons of water per day. Of the average daily volume of flow in the Caloosahatchee River, what percentage does 28 million gallons constitute?	We do not have an answer for you at this time, but we will get that information to you.
Chris Shepard, Lake Okeechobee fishing guide	When the reservoir is completely filled, how many feet above sea level will the average water level be? And how high will the levees be?	The water will be at about 42ft. above sea level when the reservoir is full. The levees will be 38ft. to 48ft. above grade.
	During a major event, what percent of the volume of water moving downstream in the Caloosahatchee can be captured in the reservoir?	The pump on the reservoir can pump 1,500 cubic feet per second (cfs). What passes down the Caloosahatchee obviously varies with the amount of discharge coming out of the lake. But we've passed as much as 20,000 cfs or 25,000 cfs over the S-79 structure, but keep in mind that a lot of that's generated within the basin downstream of the proposed reservoir. So water can be pumped into the reservoir at a rate of 1,500 cfs, and we see peak flows of 20,000 cfs in the river. Fortunately, the peak flows happen rarely. We cannot give you an exact number but that gives you an idea.
	Is there going to be a hurricane preparedness/response plan in place for the reservoir?	Yes, that will be part of the operating plan for the reservoir.

1203

	If the reservoir is full and Lake Okeechobee is full and we get hit with another Wilma, who's going to be bringing the boats around to pick everybody up? The downstream flow from those two reservoir cells is going to go to Lehigh and Ft. Myers and there are a lot of homes in that area. I would rather see the $$ for C-43 go to fixing Lake Okeechobee. Do not see C-43 helping that much.	The addition of the reservoir to the Caloosahatchee system should reduce the chance of flooding to the areas downstream of the reservoir because the reservoir will provide a place for some of that flood water to be captured. We are able to release water 72 hours in advance of a storm to make room for flood waters. The reservoir levee system will be built to compliance so that the reservoir itself should not flood. Noted.
Joe Frank, Tribal Representative	1. If the aim of this project is to restore the quality and timing of flows to the natural levels, then it seems a more worthy project would be to restore the Caloosahatchee River, not build another lake. 2. It seems that this project is just being built to further the development of western Hendry county, so maybe the developers should pay for the project rather than the tax payers. 3. If the project is for Everglades restoration, the excess lake water that the reservoir is supposed to be receiving should be going south through the Everglades not west out the river. 4. You should consider building the reservoir in the likeness of and in the historic location of Lake Flirt so that the reservoir mimics a feature of the original Caloosahatchee watershed.	1 – 4. The Everglades system today is only half the size it used to be. We still have the same amount of rainfall. Because of Herbert Hoover Dike, the lake can only hold half of the water it historically could. So we've got the same amount of water but only half the area to put it. If we direct all of the water that used to go to the Everglades back into the Everglades, it would be twice as deep as it used to be. This would be extremely harmful to the health of the system. So we are trying to balance the water budget. That's part of the overall goal of CERP.

1204

	5. Will there be job training for agricultural workers displaced by this project?	5 - 6. The Water Management District, Senator Pruit, and other state representatives have been very active in developing job training programs with the local college communities; and they've been training people for that. They're structuring their contracts to provide on-site training for workers. We're projecting the loss of up to 5,000 jobs as a result of the project. However, the project itself and many of the CERP projects will offer some new opportunities for employment in the areas of construction, operations, and maintenance. The SFWMD has taken the lead on developing the job training programs. The Corps is currently looking at incorporating the job training into our contract for this project and future CERP projects.
	6. How will this project affect the tax base of Hendry county?	
	7. Will seepage problems ultimately drive up the cost of this project? The soil is pretty sandy out there. It's going to be very expensive to line 20,000 acres with barriers.	7 – 8. There were test cells constructed to determine the rate of seepage in the Berry Grove area. Cutoff walls will be constructed around the embankment to control seepage, and the canal around the
	8. Such a large body of water is going to lead to increased algal blooms in the river. It's also going to create more pestilence problems,	

1205

	more insects and such.	perimeter will collect the seepage that gets out of the reservoir. Water Resource Development Act of 2000 states that when a project is built for restoration purposes, the project cannot harm existing levels of service for flood protection or existing sources of water for water supply without a similar source being made in lieu of that. A thorough water quality monitoring plan has been recommended to track any water quality issues (such as algal blooms) in the reservoir. In addition, a second PIR for the Caloosahatchee Basin is planned which will evaluate water quality in the basin and propose potential solutions.
Margaret England, Hendry-Glades Audubon Society and Caloosahatchee River System Association River Watch representative	Will the littoral zone on the perimeter canal provide habitat, like a sloped area for wading birds and migratory birds, and if so will this habitat be seasonal or year-round? Will habitat be provided or maintained for the caracara and other birds that are currently on this site and will native vegetation be planted to encourage some of our native species including the caracara and gopher tortoise? How will water quality be monitored and when will this begin? What	The littoral zone habitat will be a year-round feature. The caracara nests are actually not on the reservoir site. There's one to the north and one to the southeast of the site. We're currently in formal consultation with the Fish and Wildlife Service on the caracara to determine what we'll do to account for those nests. The reservoir is actually part of the caracara's secondary foraging zones. There will be some kind of compensation, but it hasn't been worked out yet what that will be. In terms of permitting released discharges

1206

	pollutants will be monitored; nutrients, fertilizers, chemicals from sewage?	from the reservoir, part of the water quality certification that are we going through with the State specifies monitoring requirements that address a lot of those parameters. The State will compose a list of parameters of concern. Our water quality monitoring plan will depend on what parameters of concern; phosphorus, nitrogen, e-coli, et cetera, are indicated by the State. The Phase 2 PIR for the Caloosahatchee River basin will deal more directly with water quality issues.
John Cassani, Private Citizen	At any time after the reservoirs construction, will the stored volume of water be available to water supply users for uses such as agricultural irrigation? If so, is there any mechanism or requirement to legally reserve the water for its intended purpose?	The water is not going to be discharged directly from the reservoir to any water supply user. Now, considering that, when the water is released from the reservoir into the Caloosahatchee River, it's going to flow downstream past the Lee County water supply intake, and we can not control water uptake there.
	In the modeling for this project, under average conditions during the period of record regarding low flows, the performance of the system on average, the do nothing alternative was about 38 percent of the time that low flow exceedences would occur. With the reservoir in place and working, what would be the performance on low flows? What percentage of the time would it be out of specs operating at peak performance under average rainfall conditions?	We're within the desired flow envelope 75 percent of the period of record that we modeled. We can get you more detailed information explaining by what margin we're within that minimum flow rate. Our model was based on period of record, not average conditions.
	You shouldn't imply that the project is going to get flows in spec 75 percent of the time because they're already within specs 60 percent of the time. So you're going from about 38 or 40 percent out of specs to about 25 percent. So the difference between the two is really the performance on the project. It's not 75 percent of the time. It's kind of	We're actually comparing to the future without project condition. And as we

1207

	an important distinction.	modeled that future without project conditions, the model flows were only within the envelope about 46 percent of the time, so it's jumped from 46 percent to 75 percent.
Richard Hamann, University of Florida	Will the PIR recommend an amount of water to be reserved?	Yes, this PIR will have that in the operating plan, but that amount has not been defined yet. The way the law reads, the reservation has to be adopted into rule prior to or at the time of our signing of the Project Cooperation Agreement. And the Project Cooperation Agreement will not be signed until Congress authorizes the project because the federal government can't sign a cooperative agreement if they're not authorized to do the work. Within the Caloosahatchee Western Basin Storage Reservoir PIR there is a whole chapter on project assurances discussing what amount of water will be reserved, how we got to that amount, and how we're impacting existing legal uses. The water amount is not a simple number though.
	Does that reflect the fact that you don't quite know how to describe the reservation for the rule making yet?	No. It's actually a function of how the water is to be delivered to be of benefit to the environment. We want to not only reserve the quantity but also the timing and distribution of that water. It's a complicated process.

1208

B.4.1 Written Correspondence

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

June 7, 2007

Mr. Stuart J. Appelbaum, Chief
Planning Division
U.S. Army Corps of Engineers
Jacksonville District
P.O. Box 4970
Jacksonville, FL 32232-0019

SUBJ: EPA NEPA Review of the COE "Draft Caloosahatchee River (C-43) West Basin Storage Reservoir Project" (April 2007); Hendry County; CEQ# 20070159; ERP# COE-E39068-FL

Dear Mr. Appelbaum:

In accordance with our responsibilities under Section 102(2)(C) of the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA) has reviewed the referenced U.S. Army Corps of Engineers (COE) Draft Environmental Impact Statement (DEIS) for the proposed Caloosahatchee River (C-43 Canal) West Basin Storage Reservoir Project (C-43 Reservoir). This proposal is a major component of the Comprehensive Everglades Restoration Plan (CERP) and therefore was reviewed as a project implementing the overall goals and objectives of Everglades restoration. EPA (Water Management Division) attended the COE's project Public Hearing in LaBelle, Florida on May 17, 2007.

Current Ecological Conditions

The Caloosahatchee River and Estuary are being stressed by seasonal freshwater releases from Lake Okeechobee and historic water management/urban/agricultural development within the C-43 Basin. The downstream releases from Lake Okeechobee result in seasonal high and low flows (too much or too little freshwater), elevated nutrients, and salinity fluctuations for the fresh and brackish water ecosystems below S-79 (including riverine and estuarine fisheries, oysters and submerged aquatic vegetation (SAVs) such as *Vallisineria*). While the COE's ongoing modifications to Lake Okeechobee's water release schedule (WSE) will temper these downstream impacts, additional water storage is needed to more effectively reduce these impacts and control the volume and timing of releases to the affected lower Caloosahatchee River and Estuary. In addition to these natural system impacts from seasonal flows, the impacts of losing large volumes of freshwater to tide is another consideration. Overall, 1.7 billion gallons of water per day are lost to the Gulf of Mexico and Atlantic Ocean that once flowed through the Everglades.

Proposed C-43 Reservoir

The proposed C-43 reservoir would be an above-ground, 10,500-acre impoundment with a 34-39 ft high dike constructed on an existing 12,372-acre orange grove farmland site in Hendry County. The 15-25 ft deep reservoir would have a 170,000 ac-ft storage capacity and would be compartmentalized into two cells. Water inflows would be controlled by a 1,500 cfs pump that would process some 20% of average annual Caloosahatchee River flows (Lake Okeechobee release water and basin runoff water) by way of Townsend Canal during wet seasons, and return impounded water back to the Caloosahatchee River upstream of S-79 during dry seasons. The average hydraulic residence time (HRT) of the impounded waters would be lengthy (192 days), allowing for some settling of nutrients (TP&TN) and particulates (TSS). Such water quality benefit could be slightly counteracted by algal nitrogen fixation in the reservoir.

Resident fish and other fauna can be expected to establish within the impoundment, although the reservoir habitat will be minimal since it will have no littoral zones and will experience dry-downs. However, the impoundment's sloped bottom design could create a remaining pool in the northwest deep end (25 ft) for fish refugia. Much better habitat would exist in the perimeter canal that would surround the reservoir and include 109 acres of littoral habitat along its banks. The perimeter canal is designed for impoundment seepage control and to allow continued agricultural water supply from Townsend Canal.

In addition to flow management to moderate the impacts to the lower Caloosahatchee River and Estuary, the project is to also provide a total of 20 acres of oyster habitat (shell for spat) over a period of the first 10 years of the project. Also, although the impoundment is designed to benefit the lower Caloosahatchee systems rather than provide agricultural or urban water supply, it would nevertheless generate some water supply benefit by providing more dependable, year-round flows at S-79 where an existing urban water supply intake is located.

Alternatives

In addition to the No Action Alternative, four action alternatives were carried forward for analysis in the DEIS (Alts. 2, 3B, 3C & 4). These alternatives would have the similar designs (2 cells and a 10,500-ac footprint), differing only in capacity (100,000, 170,000 or 220,000 ac-ft volume with a 27-44 ft high dike, and an inflow pump size of 1,500 or 3,800 cfs). The COE's Tentative Selected Plan (= preferred alternative) for the C-43 reservoir is Alternative 3B, which proposes a 34-39 ft high dike and a 1,500 cfs pump (PS-1). Although a larger pump would be beneficial in minimizing pulsed high flows and providing greater flexibility (pg. 6-9), we understand that the 3,800 cfs pump would be considerably more expensive. A larger reservoir would also have similar benefits but would also have higher attendant land and other costs (e.g., a larger reservoir alternative (4B) was eliminated due to cost).

The performance of these final four action alternatives was reviewed (Table 6-2) against a "desired envelope" or flow target (EST05). Preferred Alternative 3B agreed with the desired envelope 74.8% of the time compared to only 45.5% for the No Action (= 2050 Future Without Project). As expected, project alternatives with a larger pump (Alt. 3C: 82.3%) and greater reservoir volume (Alt. 4: 83.8%) performed slightly better (since they would reduce high flows better), while those with a smaller volume and similar pump (Alt. 2: 67.9%) performed slightly less. Therefore, at its capacity level, Preferred Alternative 3B is in the middle of the ordered performance range (Alts. 2, 3B, 3C & 4). We will defer to the COE as to whether such capacity is sufficient to recover the lower Caloosahatchee River and Estuary, or if additional performance is needed through the selection of a larger design in the FEIS, or through monitoring and adaptive management of preferred 3B (if implemented), and/or through the addition of supplemental storage capacity along the Okeechobee Waterway in the near future.

Project Implementation

Above-ground, in-ground and/or underground reservoirs were planned components of the original Restudy and current CERP. However, due to federal delays in project authorization and funding, the present C-43 Reservoir project is being implemented by the State of Florida (South Florida Water Management District sponsor) for the COE through its Acceler8 Program to expedite the project. The present EIS is expected to serve as the COE's NEPA documentation for the federal project (once appropriated) and presumably also for any regulatory permitting responsibilities. EPA appreciates the State's role in this regard in order to advance the implementation of CERP components of Everglades restoration.

EPA appreciates that the Jacksonville District has committed to initiating a Calooshatchee Watershed Project Implementation Report (PIR) effort in September 2007, to further address water storage and water quality treatment needs in the Caloosahatchee basin. Under the 1999 TMDL (Total Maximum Daily Load) Consent Decree, TMDLs for nutrients, DO, fecal coliforms and metals must be proposed by the Florida Department of Environmental Protection (FDEP) and approved by EPA no later than September 30, 2010 (or proposed by EPA by that date). The recently passed State of Florida 2007 Northern Everglades legislation requires earlier action by FDEP; specifically, to "...no later than 12/31/2008, propose for final agency action, TMDLs for nutrients for the tidal portions of the Caloosahatchee river and estuary." It is therefore important that close coordination between the Caloosahatchee Watershed PIR effort and FDEP/EPA TMDL programs occurs, such that nutrient reduction target setting is consistent between these efforts. It appears likely that future proposed TMDL-related nitrogen (TN) loading requirements at S-79 will require additional water quality treatment efforts in the Basin, such as agricultural BMPs and Stormwater Treatment Areas (STAs). In addition to the PIR effort, the Project Operating Manual should be expanded to more fully address possible operational actions to improve water quality conditions in discharge waters, while still achieving other project objectives.

When completed, the proposed project will be a large reservoir. As a reservoir, it will be considered waters of the United States and waters of the State, and State Class III Water Quality Standards (WQS) will apply. EPA has water quality concerns with the reservoir given the potential for high nutrient loads into the reservoir, and the resulting potential for high nutrient concentrations, low DO, presence of nuisance aquatic plants such as blue-green algae, and pesticides within the reservoir and downstream during releases. Since there is the potential for the reservoir to have poor water quality, it is important to identify what potential operational, management or other steps will be taken to address these water quality concerns if they arise. We also note that the Section 401 water quality certification has not been issued at this time and reserve our authority to comment further at that time.

Project Impacts

EPA fully supports the concept of providing additional water storage along the Okeechobee Waterway such as the C-43 Reservoir. Therefore, our concerns with the C-43 reservoir project are not conceptual but rather focus on project improvements from an environmental perspective. Our main concern is water quality assurance for flows released from the impoundment to benefit the lower Caloosahatchee natural systems. More specifically, we are concerned about the potential for warm weather blue-green algal blooms with algal toxins in reservoir waters, as well as low levels of dissolved oxygen (DO) in the waters released from the reservoir. Reductions in the algal growth potential and augmentation of DO levels for impoundment waters may be needed to improve water quality for the proposed project. Warm weather blue-green algal monitoring (monthly) should be required in the reservoir Water Quality Monitoring Plan.

EPA DEIS Rating

EPA rates this COE DEIS as "EC-1" (i.e., we have environmental concerns and request some additional information in the FEIS). Our primary concern for this project is water quality assurance. Our water quality and other comments are further developed in the *Detailed Comments* enclosure.

Should you have questions regarding our comments, feel free to contact Chris Hoberg of my staff for NEPA-related issues (404/562-9619 or hoberg.chris@epa.gov) or Eric Hughes in our EPA Water Management Division (located in your Jacksonville District office) for technical issues (904/232-2464 or hughes.eric@epa.gov).

Sincerely,

Heinz J. Mueller, Chief
NEPA Program Office
Office of Policy and Management

Enclosure: *Detailed Comments*

cc:

Ray Judah – Lee County Commissioner; Ft. Myers, FL
Roland Ottolini – Lee County Natural Resources; Ft. Myers, FL (Attn: Wayne Daltry)
Mike Sole – Secretary: FDEP, Tallahassee, FL (Attn: Greg Knecht)
Paul Souza – Field Supervisor: FWS; Vero Beach, FL (Attn: Joyce Mazourek)
Carol Wehle – Executive Director: SFWMD; West Palm Beach, FL (Attn: Larry Gerry)

DETAILED COMMENTS

We offer the following recommendations for the COE's consideration in the development of the FEIS:

Water Quality

* *Nutrients* - As suggested in the DEIS, the water quality of the water released from the C-43 impoundment to the Caloosahatchee River should be no worse than the inflow water. We agree. Consistent with the purpose of the reservoir to improve estuarine health, water quality management should complement water quantity management as an important project goal. As such, we recommend that the algal growth potential (AGP) of the impounded waters be assessed to minimize algal blooms and associated toxins in the water column. Intuitively, reservoir conditions are conducive for algal blooms due to the impounded water's warm temperature, high nutrient loadings and long residence time. In contrast, the potential for algal blooms could be reduced since nutrients would settle during the residence time, Lake Okeechobee water releases are expected to be less over time, and Caloosahatchee River nutrient TMDLs will be established. For the project, a 29% reduction in TP loads and a 28% reduction in TN loads at S-79, compared to the future without project condition, is predicted for preferred Alternative 3B (Table 6-3). The FEIS should further discuss nutrient water quality and the potential for algal blooms.

As suggested above, nutrient levels are expected to decrease in part due to reduced discharges from Lake Okeechobee. Specifically, page 6-16 states that "...the reduction in nutrient loads at S-79 is largely the result of the reduction in discharges from Lake Okeechobee." The reasons for such "reduction in discharges" and its relationship with reduced nutrient concentrations should be further discussed in the FEIS.

* *Resuspensions* – Also, since nutrients and particulates are expected to settle out in the reservoir, it becomes unclear if such precipitants would be resuspended in the water column when the reservoir is filled during the wet season. The proposed 1,500 cfs inflow pump (PS-1) could potentially also entrain sediment from the Caloosahatchee River source water. Use of a larger pump (3,800 cfs) could exacerbate this water quality condition. The FEIS should discuss the potential for resuspension and sediment entrainment, as well as the overall inflow process. Reservoir operations should be designed to minimize inflow turbidity in the reservoir.

* *Site Contaminants* – The residual soils of the existing orange grove proposed for the reservoir site contain pesticide and copper residues. We also understand that copper and lead were found within the Townsend Canal that would provide a conduit for reservoir inflows. As such, these contaminants can be expected to enter reservoir waters. However, we understand that introduction of these pesticides and metals in the impoundment waters are not expected to result in exceedances of State WQS. The FEIS should verify this and offer resolutions if any such contaminants are predicted to exceed WQS in the reservoir water. Beyond WQS, fish bioaccumlation may also be a concern.

Waters of the United States – We note that 125 acres of vegetated wetlands plus some 900 acres of farmland ditches would be inundated by the 10,500-acre reservoir. We understand that these waters of the United States are generally degraded due to existing orange grove farming. The FEIS should provide additional discussion on the quality and function of these areas, particularly the wetlands, from a NEPA disclosure perspective. The FEIS should also briefly discuss if the other sites considered would impact notably less or more wetlands than the selected "Berry Groves" site.

Page 6-20 states that "[t]here will be no mitigation for wetlands as a result of the federal project". Page xviii states that "[t]he loss of this wetland habitat will be offset by the increase in habitat function and quality in the Caloosahatchee Estuary." Specifically, the DEIS (pg. xv) assumes that the project would benefit 71,000 acres in the Caloosahatchee Estuary. Compared to the No Action, it would also generate an average annual increase of approximately 13,000 habitat units within the Estuary. Since the C-43 Reservoir is a CERP project, it may also be noted that the overall CERP would restore numerous acres of wetlands in the Everglades. From a cumulative impacts perspective, many more wetland acres would be restored collectively by CERP projects than would be lost.

We also note that the banks of the perimeter canal will be designed to include 109 acres of littoral zone. We concur with such design, but also assume that any existing littoral habitat will be lost along those reaches of Townsend Canal interrupted by the construction of the reservoir and perimeter canal.

Water Supply – Reference is made in the DEIS (e.g., pg. 6-3) that the C-43 reservoir is not to be used for "elimination or transfer" of water supply. We assume the no "transfer" of water supply implies that new water supply will not be created by the reservoir (the FEIS should clarify). EPA believes that the C-43 impounded waters should be returned to the Caloosahatchee River during dry seasons for the benefit of natural systems as opposed to serving as source water for new urban or agricultural development. We recommend that such assurances be clarified in the FEIS.

The term "water supply" is used for various purposes in the DEIS (pg. 6-13). We recommend that this term be better qualified in the FEIS to indicate the intended use of the water supply (e.g., urban/potable, agricultural or natural system water supply). This would be helpful since without descriptors, we offer that the term "water supply" connotes source water for human consumption.

NEPA Process – From a NEPA disclosure perspective, we find certain sections (e.g., *Summary of Affected Resources*: pg. 6-7) to be well written and would likely be understandable to the layman reader. However, other analytical sections (e.g., modeling) would benefit from additional discussion in the FEIS. For example, the results from the Habitat Suitability Index modeling (Table 6-4) should be further discussed. That is, differences in suitability between Preferred Alternative 3B and the No Action (2050 FWO) are only +0.08 for oyster, +0.13 for *Vallisneria*, +0.05 for seagrass, and +0.13 for extreme events. It is unclear if these differences (or the differences for other alternatives)

requirements, etc.) for our impact review. We also offer that use of an electric pump would eliminate such air emissions.

* Noise – For the project PS-1 pump, we note (pg. 6-5) that the pump station (housing) was offered as noise shielding. We agree that housing would provide some shielding. Source reductions with the pump itself (type, quality, etc.) would also reduce noise levels. As indicated above for air emissions, we also offer that noise emissions would essentially be eliminated if an electric pump was used instead of the proposed diesel pump. In addition to the pump, all other construction equipment (bulldozers, etc.) should be tuned to manufacturer's specifications as well as being equipped with appropriate mufflers and engine housings to minimize noise. It is clear, however, that such noise abatement is more important if residents and other sensitive receptors are located nearby and are affected by the project. In any case, however, project workers could be affected.

From a NEPA disclosure standpoint, the FEIS should document construction noise data available from the literature for typical construction equipment such as would be used for the reservoir project (e.g., dBA noise levels at 50 ft). Disclosure of the estimated construction time is also suggested in order to help determine the magnitude of the noise (and air) impact.

* *Environmental Justice (EJ)* – Page 6-43 states that "[i]n public outreach efforts to date, only one potential environmental justice issue has been identified: the loss of jobs for low income and minority workers as a result of acquiring agricultural land for the construction of the reservoir." To help offset this, we are pleased to note (pg. 6-44) that "...the SFWMD is conducting training programs to allow local individuals to acquire the skills needed to construct the reservoir." We assume that the locally affected people (particularly minorities and low-income populations) will not only benefit from the training but that at least some will be candidates for actual employment. In addition to this proposed offset, we recommend that the COE also provide people affected by the project continued project updates and coordination with their community leaders.

For better NEPA documentation for EJ, the FEIS should provide U.S. Census 2000 data (e.g., one or more block groups) for the project area to specifically account for any minority concentrations ("pockets"). For perspective, this project block group data should also be compared to adjacent block groups, the project county (Hendry) and the project state (Florida) to further determine any minority concentrations near the project. Overall, the number of minority and low-income residents affected by the project (through relocation or other impacts), their demographics and any potential disproportionate effects should be reasonably documented. The FEIS should address this further.

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

June 11, 2007

Colonel Paul Grosskruger
U.S. Army Corps of Engineers
701 San Marco Blvd.
Jacksonville, FL 32207

Dear Colonel Grosskruger:

Thank you for the opportunity to review and provide comments on the *Central and Southern Florida Project Comprehensive Everglades Restoration Plan Caloosahatchee River West Basin Storage Reservoir (C-43) Draft Integrated Project Implementation Report and Environmental Impact Statement* (Draft Report), dated April 2007. We appreciate the efforts of your staff in producing the Draft Report and support the Tentatively Selected Plan (TSP).

The Caloosahatchee River and Estuary is at the head of a vast estuarine and marine ecosystem that includes aquatic preserves managed by the State of Florida, the federally designated Charlotte Harbor National Estuary and the J.N. "Ding" Darling National Wildlife Refuge. Currently, there is not enough storage capacity in the regional water management system to minimize or prevent the harmful of periodic excessive discharges of freshwater to the Caloosahatchee Estuary. Conversely, during dry periods, there are many times when there is not enough freshwater available in the regional system to maintain desirable salinity levels in the estuary. The combined result of too much or too little freshwater flowing to the Caloosahatchee Estuary is a degraded estuarine ecological community. Restoration of a healthy and productive aquatic ecosystem in the Caloosahatchee River is essential to maintaining the ecological integrity in these publicly owned and managed areas.

1. The Department of the Interior (Department) supports the TSP for the project. When constructed, the plan will provide approximately 170,000 acre-feet of above-ground storage in a two-cell reservoir. The proposed reservoir would allow the capture of some excess basin runoff and discharges from Lake Okeechobee. This stored water would then provide an additional source of freshwater to maintain desirable salinity levels in the Caloosahatchee Estuary during dry periods. The project features would be constructed on approximately 10,500 acres acquired, in part, with federal funds appropriated to the Department for Everglades Watershed Restoration.

Florida Department of Environmental Protection

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Charlie Crist
Governor

Jeff Kottkamp
Lt. Governor

Michael W. Sole
Secretary

June 11, 2007

Ms. Susan L. Conner
Jacksonville District, Planning Division
U.S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, FL 32232-0019

RE: Department of the Army, Jacksonville District Corps of Engineers – Draft Integrated Project Implementation Report and Environmental Impact Statement for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project – Hendry County, Florida.
SAI # FL200704263301C

Dear Ms. Conner:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16, U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4231, 4331-4335, 4341-4347, as amended, has coordinated a review of the Draft Integrated Project Implementation Report and Environmental Impact Statement (DPIR/EIS).

The Florida Department of Environmental Protection (DEP) supports the proposed project, which will increase storage in the regional watershed and restore ecological function and productivity in the Caloosahatchee Estuary. DEP staff has provided a number of comments requesting clarification of certain items in the DPIR/EIS and inclusion of the water quality/resource data and information necessary to address the applicable planning, permitting, and reporting requirements of Chapter 373, *Florida Statutes*. For further information, please refer to the enclosed DEP memorandum.

The Florida Department of Agriculture and Consumer Services (FDACS) appreciates the opportunity to review the DPIR/EIS and notes that Annex C.4, "Analyses Required by WRDA 2000 and State Savings Clause Analyses," describes assumptions made for the current and future sources of agricultural irrigation water and concludes that the project will not affect those sources. No supporting data or analyses are provided for either the local or regional project area to support that conclusion. The FDACS recommends that the data and analyses used to determine that the project will not affect the quantity and quality of the existing local and regional water supply, and data used to determine that existing flood control will not be impacted, be included in Annex C. This information is

Ms. Susan L. Conner
June 11, 2007
Page 2 of 3

necessary to provide the reasonable assurances, required by Section 373.1501(5)(d), *Florida Statutes*, that implementation of the proposed project will not diminish the quantity of water available to existing legal users or diminish the levels of service for flood protection.

In addition, the FDACS Division of Forestry has expressed concerns regarding the absence of a plan for controlling invasive exotic plant species, and that the estimated annual and operations maintenance costs do not include costs for monitoring and controlling invasive exotic plants. FDACS staff requests that the language in the report inferring that timber practices promote the decline of red-cockaded woodpeckers be revised to specifically state that certain activities should not be conducted within red-cockaded woodpecker foraging areas designated by the U.S. Fish and Wildlife Service. Please refer to the enclosed FDACS comments for further details and recommendations.

The Florida Fish and Wildlife Conservation Commission (FWC) fully supports the construction and operation of the proposed reservoir for the benefit of the Caloosahatchee River and estuarine habitats and recommends that the completed open waterbody also be made available and accessible to the public for compatible recreational opportunities. FWC staff has provided a number of comments and recommendations regarding operation and design of the proposed project water-control structures to prevent manatee entrapment, injuries, and mortalities and reservoir design features to enhance wildlife habitat and recreational use. Please see the enclosed FWC letter for additional details.

The Florida Department of Transportation (FDOT) has expressed concerns that the existing bridges on State Road 80 (Bridges 070066 & 070067, SR 80 over the Townsend Canal) have experienced scour below the 500-year projection as indicated in the Bridge Hydraulics Report. The primary reason for the excessive scour is likely that the drainage basin supplying runoff is approximately 38% larger than the basin identified in the Bridge Hydraulics Report prepared for the construction of the bridges. Stanley Consultants, Inc. has identified a drainage basin of 77 square miles, whereas the Bridge Hydraulics Report identified a basin of 56 square miles. Further scour could jeopardize the integrity of the structures.

FDOT personnel have met with the representatives of the SFWMD and Stanley Consulting, Inc. - engineers for the SFWMD. Stanley Consulting's contract with the SFWMD proposes to modify the Townsend Canal Channel and the cross section through the bridges. They are proposing to excavate the existing channel a depth of four feet and to line the channel beneath the structures with four-foot deep rubble rip-rap. The flows through the structure and the projected stage of the 100-year storm event are proposed to be reduced by the construction of the reservoir. The FDOT has reviewed the proposal and is in agreement with the proposed modifications to the channel beneath the structures. As construction plans for the channel modifications are prepared, FDOT District One Structures and Facilities, Structures Design and Drainage staff requests the opportunity to

Ms. Susan L. Conner
June 11, 2007
Page 3 of 3

review the proposed plans to insure compliance in accordance with the agreed-upon conceptual plan presented to the FDOT.

The Southwest Florida Regional Planning Council (SWFRPC) notes the project's potential beneficial effects on Caloosahatchee River area hydrology, water quality, wetlands, and wildlife and recommends that the Tentatively Selected Plan incorporate: a water quality treatment component in the design of the reservoir project; plans for construction of littoral areas at the corners of the seepage canal; and the planting of native shade tree species where new trees are proposed. Though the SWFRPC supports the concept and implementation of the C-43 reservoir project, water quality protections should not be deferred in development of the project. Please refer to the enclosed SWFRPC letter for further comments and recommendations.

Based on the information contained in the DPIR/EIS and the enclosed state agency comments, the state has determined that, at this stage, the proposed activities are consistent with the Florida Coastal Management Program (FCMP). The concerns identified by our reviewing agencies must be addressed prior to project implementation. The state's continued concurrence with the project will be based, in part, on the adequate resolution of issues identified during this and subsequent reviews. The state's final review of the project's consistency with the FCMP will be conducted during the environmental permitting stage.

Thank you for the opportunity to review the proposed project. Should you have any questions regarding this letter, please contact Ms. Lauren P. Milligan at (850) 245-2170.

Yours sincerely,

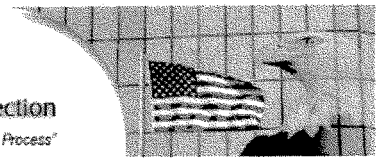
Sally B. Mann, Director
Office of Intergovernmental Programs

SBM/lm
Enclosures

cc: John Outland, DEP, MS 45
Shelley Yaun, DEP, MS 3560
Forrest Watson, FDACS
W. Ray Scott, FDACS
Mary Ann Poole, FWC
Lisa Stone, FDOT
Nichole Gwinnett, SWFRPC



Florida
Department of Environmental Protection
"More Protection, Less Process"



Categories

Project Information	
Project:	FL200704263301C
Comments Due:	05/29/2007
Letter Due:	06/11/2007
Description:	DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT CORPS OF ENGINEERS - DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT (PIR) AND ENVIRONMENTAL IMPACT STATEMENT FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT - HENDRY COUNTY, FLORIDA
Keywords:	ACOE - DIPIR/EIS CALOOSAHATCHEE RIVER C-43 WEST BASIN STORAGE RESERVOIR - HENDRY
CFDA #:	99.997

Agency Comments:

AGRICULTURE - FLORIDA DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES

The FDACS appreciates the opportunity to review the proposal and notes that Annex C.4, "Analyses Required by WRDA 2000 and State Savings Clause Analyses," describes assumptions made for the current and future sources of agricultural irrigation water and concludes that the project will not affect those sources. No supporting data or analyses are provided for either the local or regional project area to support that conclusion. The FDACS recommends that the data and analyses used to determine that the project will not affect the quantity and quality of the existing local and regional water supply, and data used to determine that existing flood control will not be impacted, be included in Annex C. This information is necessary to provide the reasonable assurances, required by Section 373.1501(5)(d), Florida Statutes, that implementation of the proposed project will not diminish the quantity of water available to existing legal users or diminish the levels of service for flood protection. In addition, the FDACS Division of Forestry has expressed concerns regarding the absence of a plan for controlling invasive exotic plant species, and that the estimated annual and operations maintenance costs do not include costs for monitoring and controlling invasive exotic plants. FDACS staff requests that the language in the report inferring that timber practices promote the decline of red-cockaded woodpeckers be revised to specifically state that certain activities should not be conducted within red-cockaded woodpecker foraging areas designated by the U.S. Fish and Wildlife Service.

COMMUNITY AFFAIRS - FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS

DCA has no comments.

ENVIRONMENTAL PROTECTION - FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

DEP supports the proposed project, which will increase storage in the regional watershed and restore ecological function and productivity in the Caloosahatchee Estuary. DEP staff has provided a number of comments requesting clarification of certain items in the DPIR/EIS and inclusion of the water quality/resource data and information necessary to address the applicable planning, permitting, and reporting requirements of Chapter 373, Florida Statutes.

FISH and WILDLIFE COMMISSION - FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

The FWC fully supports the construction and operation of the proposed reservoir for the benefit of the Caloosahatchee River and estuarine habitats and recommends that the completed open waterbody also be made available and accessible to the public for compatible recreational opportunities. FWC staff has provided a number of comments and recommendations regarding operation and design of the proposed project water-control structures to prevent manatee entrapment, injuries, and mortalities and reservoir design features to enhance wildlife habitat and recreational use.

STATE - FLORIDA DEPARTMENT OF STATE

No Comment/Consistent

TRANSPORTATION - FLORIDA DEPARTMENT OF TRANSPORTATION
The Florida Department of Transportation (FDOT) is concerned that the existing bridges on SR 80 (Bridges 070066 & 070067, SR 80 over the Townsend Canal) have experienced scour below the 500-year projection as indicated in the Bridge Hydraulics Report. The primary reason for the excessive scour is probably because the drainage basin supplying runoff is approximately 38% larger than the basin identified in the Bridge Hydraulics Report that was prepared for the construction of the bridges. Stanley Consultants, Inc. has identified a drainage basin of 77 square miles whereas the Bridge Hydraulics Report identified a basin of 56 square miles. Further scour could jeopardize the integrity of the structures. FDOT personnel have met with the representatives of the SFWMD and Stanley Consulting, Inc., Engineers for the SFWMD. Stanley Consulting, Inc., in their contract with the SFWMD is proposing to modify the Townsend Canal Channel and the cross section through the bridges. They are proposing to excavate the existing channel a depth of four feet and to line the channel beneath the structures with four-foot deep rubble rip-rap. The flows through the structure and the projected stage of the 100-year storm event are proposed to be reduced by the construction of the reservoir. The FDOT has reviewed the proposal and is in agreement with the proposed modifications to the channel beneath the structures. As construction plans for the channel modifications are prepared, FDOT District One Structures and Facilities, Structures Design and Drainage staff requests the opportunity to review the proposed plans to insure compliance in accordance with the agreed-upon conceptual plan presented to the FDOT.
SOUTH FLORIDA WMD - SOUTH FLORIDA WATER MANAGEMENT DISTRICT
This project will require an Environmental Resource Permit (ERP). The project design should minimize impacts to wetlands and aquatic resources via practicable design modifications and should include mitigation for any remaining unavoidable impacts. It appears that the proposed activities will occur over state-owned sovereign submerged lands. A title determination from the FDEP will be necessary. If the submerged lands are state-owned sovereign lands, the ERP application submitted to the SFWMD will need to include information for a sovereign submerged lands public easement. If any construction dewatering activities are proposed, certain activities may require a Water Use Permit. If any ground or surface water withdrawals are proposed for project landscaping, a Water Use Permit will be required. Further inquiries concerning the above should be directed to the SFWMD's permitting staff in the Ft. Myers Service Center at 1-800-248-1201.
SW FLORIDA RPC - SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL
The SWFRPC notes the project's potential environmentally beneficial effects on Caloosahatchee River area hydrology, water quality, wetlands, and wildlife and recommends that the Tentatively Selected Plan incorporate: a water quality treatment component in the design of the reservoir project; plans for construction of littoral areas at the corners of the seepage canal; and the planting of native shade tree species where new trees are proposed. Though the SWFRPC supports the concept and implementation of the C-43 reservoir project, water quality protections should not be deferred in development of the project.
HENDRY -
Comments may be forthcoming - sent under separate cover.

For more information or to submit comments, please contact the Clearinghouse Office at:

3900 COMMONWEALTH BOULEVARD, M.S. 47
TALLAHASSEE, FLORIDA 32399-3000
TELEPHONE: (850) 245-2161
FAX: (850) 245-2190

Visit the Clearinghouse Home Page to query other projects.

Copyright and Disclaimer
Privacy Statement

Memorandum

TO: Florida State Clearinghouse

THROUGH: Shelley Yaun, Environmental Administrator
Water Quality Standards & Special Project Program

FROM: John Outland, Ernie Marks, and LaDawna McDonald

DATE: June 1, 2007

SUBJECT: USACE, Jacksonville District – Draft Integrated Project Implementation Report and Environmental Impact Statement for the Caloosahatchee River West Basin Storage Reservoir Project, Hendry County, Florida

SAI#: FL37-3011C

Background:

The purpose of the Caloosahatchee River (C-43) West Basin Reservoir project is to contribute to the restoration of the Caloosahatchee Estuary as part of the Comprehensive Everglades Restoration (CERP) established by the 2000 Water Resources Development Act. The tentative selected plan, Alternative 3B, consists of a 170,000 acre-feet above-ground storage reservoir, a 1500 cfs pump station, external and internal embankments, internal control and outflow water control structures, and environmentally responsible design features to provide fish and wildlife habitat such as littoral areas in the perimeter canal and deep water refugia within the reservoir.

At the present time, there is a lack of adequate water storage capacity in the regional watershed to prevent episodic large discharges of freshwater flow below S-79 to maintain submerged aquatic vegetation and the diversity of organisms they support. The project is designed to capture and store basin runoff and excess water delivered from Lake Okeechobee and to release the stored water in a way that will mimic more natural flow regimes to the Caloosahatchee Estuary below S-79.

The Department supports the project with its purpose to increase storage in the regional watershed, which will restore ecological function and productivity in the Caloosahatchee Estuary. It is expected that the construction permit for the C-43 West Basin Reservoir will be issued for the Acceler8 project, which would not authorize operations of the project. The Department expects that a final operations plan will be developed during the construction and operational testing and monitoring, which would be necessary for the operational permit. The Department believes that this project, in its entirety, will meet Department permitting requirements. The project should result in an improvement in overall water quality conditions at S-79 as well as in the estuary.

Comments:

1. The note under Figure 2-6 says that *Vallisneria Americana* is found at stations 1-3. However, there is no station 3 depicted on the figure.

2. Page 4-30, Table 4-7: Ecological Performance Measures does not include preferred flow range (cfs) for *Vallisneria Americana*. However, page 4-25 says that flow distribution EST05 will provide mean monthly flows above 450 cfs with most flows (75 percent) in the ideal range of 450-800 cfs.

3. Page 5-24, Table 5-9: Target Flow Distribution for EST05 shows mean monthly flows between **450-1,500 cfs** occurring 74.5 percent of the time. However, Table 4-7 shows that most flows will occur in the range of **450-800 cfs**. Please explain the inconsistency.

4. The HTRW assessment and remediation plans do not indicate coordination with the Department. Please specify if HTRW coordination has occurred.

5. Table C-13 – Typographical error in the title, "Estimates of annual TP and TP loading..."

6. Appendix C (Section C.9.3 (C.9.3.1.1.1 and C.9.3.1.2.1: Project vs. 2050 Future Without Project Conditions). These sections refer to TP load reduction of 29%-34% and a TN load reduction of 28%-33% under "with project" conditions, which includes the nutrient load reductions associated with flow reductions from CERP implementation. In order to avoid confusion regarding the estimated nutrient removal potential of the C-43 West Reservoir, please include language clarifying the source of the nutrient removal estimation (i.e. clarify when nutrient removal estimations include overall CERP implementation, or solely C-43 WSR). This comment also applies to Table C-13, Section C.9.5, as well as other sections referring to nutrient removal associated with the selected alternative.

7. Appendix C (Section C.9.3.2: Wet/Dry Season Nitrogen Loading) - Suggest revising language from "targets" to either "critical loads" or "threshold loads". The term target implies a goal, however the critical loads being referred to are actually threshold loads, above which Chlorophyll a concentrations exceed water quality criteria, therefore the goal is below this threshold.

On page C-81 of the draft PIR, the Corps states that the project delivery team and FDEP have identified the following issues as components of the primary measure of acceptability of the project in terms of water quality:

8. "The quality of the water discharged from the reservoir should be no worse than the quality of the water pumped into the reservoir."

- The C-43 West Basin Reservoir is required to achieve water quality standards at the discharge point. Please clarify throughout the PIR that, in addition to outflows being

equal to or of better quality than inflows, the Reservoir will achieve state water quality standards.

9. "The operation of the reservoir should not result in a substantial shift of nutrient loading from the wet season to the dry season."

- The Department is of the understanding that, absent a treatment mechanism or wetland buffer design, a shift in nutrient loads from wet season to dry season is anticipated. The Department has been working concurrently with the Corps to obtain the information necessary to determine whether the shift in nutrient loads from the wet season to the dry season, consistent with the expected operations of the reservoir, would be harmful to waters downstream of the S-79 structure. Upon resolution, please include *The Supplemental Analysis C-43 West Basin Reservoir Effects on Dry Season Water Quality Downstream of the S-79 Structure* in the PIR. This document should provide the Department with the reasonable assurances necessary to ensure that the C-43 West Basin Reservoir will not cause or contribute to an imbalance of flora and fauna in the waters downstream of the S-79 structure.

Please note that the Programmatic Regulations (Section 385.28 (c)(xvii)) require Project Implementation Reports (PIR) to include as appropriate, information necessary for the non-Federal sponsor to address the requirements of Chapter 373 of the Florida Statutes, and other applicable planning and reporting requirements of Florida law. In order serve as local sponsor for the Everglades National Park Seepage Management Project, or prior to seeking an appropriation from the Save Our Everglades Trust Fund, the South Florida Water Management District (SFWMD) will be required to obtain approval from the Department under §373.026(8)(b), Florida Statutes (F.S.). Approval is based on the Department's determination that the SFWMD has provided sufficient documentation to demonstrate compliance with the criteria set forth in Section 373.1501(5), F.S. The statute requires the SFWMD to analyze and evaluate water resource issues, natural system and habitat needs, determine that project components are feasible and consistent with applicable laws and regulations, provide assurances for water supply and flood protection, and coordinate with existing utilities and infrastructure to minimize impacts.

We recommend that as the federal sponsor, the U.S. Army Corps of Engineers keep these criteria in mind during PIR development, and assist the South Florida Water Management District as appropriate in providing the necessary information to comply with these and any other applicable requirements. Please note that the §373.026/1501, F.S. review is separate from the State Clearinghouse review required for all federal projects under the Coastal Zone Management Act, and requires a separate formal submittal from the SFWMD to the Department.

Upon completion of detailed design, this project will require a Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permit pursuant to Chapter 373.1502, F.S. The project may require a NPDES Generic Permit for Stormwater Discharge from Large and Small Construction Activities in accordance with Rule 62-621.300(4), Florida Administrative Code (F.A.C.). Other department permits may be required during the construction phase of this

project, as applicable. We recommend that the Corps and the SFWMD coordinate closely with the Department in order to facilitate permit issuance.

If you have any questions regarding these comments, please contact LaDawna McDonald at (850) 245-7534.

ec: John Outland (e-mail)
Shelley Yaun (e-mail)
Ernie Marks (e-mail)
Jennifer Nelson (e-mail)
LaDawna McDonald (e-mail)
Sara Cleveland (e-mail)

Florida Department of Agriculture and Consumer Services
CHARLES H. BRONSON, Commissioner
The Capitol • Tallahassee, FL 32399-0800
www.doacs.state.fl.us

TO: Lauren Milligan, Environmental Manager
Florida State Clearinghouse
Department of Environmental Protection

FROM: W. Ray Scott, Conservation and Water Quality Federal Programs Coordinator
Department of Agriculture and Consumer Services

DATE: June 5, 2007

SUBJECT: Clearinghouse Review of the Draft Integrated Project Implementation Report (PIR) and Environmental Impact Statement for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project

---

The Florida Department of Agriculture and Consumer Services (Department) appreciates the opportunity to comment and requests the following concerns be considered in the state clearinghouse review of the Corps' April 2007 Draft Integrated Project Implementation Report and Environmental Impact Statement for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project.

Annex C.4, "Analyses Required by WRDA 2000 and State Savings Clause Analyses", describes assumptions made for the current and future sources of agricultural irrigation water and concludes that the project will not affect those sources. No supporting data or analyses are provided for either the local or regional project area to support that conclusion. The Department recommends that the data and analyses used to determine that the project will not affect the quantity and quality of the existing local and regional water supply, and data used to determine that existing flood control will not be impacted, be included in Annex C. This information is necessary to provide the reasonable assurances, required by 373.1501(5)(d), Florida Statutes, that implementation of the proposed project will not diminish the quantity of water available to existing legal users or diminish the levels of service for flood protection.

In addition, the Department is concerned regarding the absence of a plan for controlling invasive exotic plant species, and that the estimated annual and operations maintenance costs do not include costs for monitoring and controlling invasive exotic plants. The Department is also concerned about language in the report inferring that timber practices promote the decline of red-cockaded woodpeckers; rather, it should more specifically state that certain activities should not be conducted within red-cockaded woodpecker foraging areas designated by the U.S. Fish and Wildlife Service.

An attachment, "FDACS Comments," provides additional detail regarding the issues raised above. We would appreciate your considering inclusion of our comments in the state clearinghouse review. If you have any questions or I can assist in any way, please feel free to call me at (850) 410-6714.

FDACS Comments on the Draft Integrated Project Implementation Report (PIR) and Environmental Impact Statement (EIS) for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project

Staff Comments from the Office of Agricultural Water Policy

1) Water Supply in the C-43 basin

Construction and operation of the C-43 Phase I Reservoir on the Berry Groves site will create a substantial change in the hydrodynamic interactions between groundwater, surface water, and water use in the vicinity of the reservoir that could impact water availability for existing legal users dependent upon the C-43 Canal and Lake Okeechobee for water supply.

The slurry wall will prevent seepage currently flowing north from properties south of the reservoir site from reaching the C-43 Canal along the historic path under the reservoir site. The C-43 Canal and the properties between the reservoir and the C-43 Canal will no longer be supplied by the historic groundwater seepage source. The C-43 Phase I Reservoir operating plan uses perimeter canal seepage to maintain groundwater levels and water supply to existing legal users in the vicinity of the reservoir. Water will be pumped from the C-43 Canal to maintain the perimeter canal water levels and seepage during dry conditions when the reservoir can no longer be used to supply the perimeter canal.

Supporting data and an analysis of potential impacts on existing legal users are not presented in Annex C of the Draft document. According to the RECOVER report included in the Draft C-43 Phase I Reservoir PIR, the type of data needed to determine if the Lake Okeechobee Service Area water shortage frequency of occurrence target was met was not available and the water supply evaluation was incomplete. The report should include an analysis to determine that basin-wide water use assurances have been quantified and met. Data and an evaluation tool to project the changes from pre-project to post-project conditions are not provided. An analysis is needed that compares pre-project and post-project water volumes associated with "replacing" the historic ground water seepage flows into the C-43 Canal along the length of the reservoir and maintaining surface water levels of the perimeter canal throughout the period of record. Ideally, a subregional evaluation tool would be used to compare the pre-project and post-project water budget performance over the period of record between S-77 and S-79.

2) Water Quality in Ground Water Supply Wells in the Vicinity of the Reservoir

A water resource concern of existing legal users in the vicinity of the C-43 Basin Storage Reservoir Phase I Project is the change in water quality that may occur when the groundwater source for local wells is replaced by seepage from the perimeter canal. It appears that some wells may be completely switched from a watershed seepage source to a C-43 supplied perimeter canal seepage source when the C-43 Reservoir Phase I becomes operational. Data should be presented that was used to determine the impacts of the perimeter canal seepage on local ground water wells, as well as any conclusions reached regarding the need to mitigate for deterioration in water quality. Language should also be included that reinforces the local sponsor's commitment to mitigate any future negative impacts to legal users that result from such "source switching."

3) Determination that Reservoir Operations will not Result in Negative Impacts to Agricultural Operations in the Vicinity of the Reservoir

Water supply and flood protection in the vicinity of the reservoir might be impacted by reservoir features and operations. Reports and supporting data should be included in the report that support the local sponsor's determination that detrimental changes to water supply and flood protection in the vicinity of the reservoir are not anticipated. Language should also be included that reinforces the local sponsor's commitment to mitigate any future negative impacts to legal users resulting form the construction or operation of the reservoir.

Staff Comments from the Division of Forestry

Section 2.9.6.7 (page 2-26) states that the primary threat to red-cockaded woodpeckers (RCW) continues to be the destruction or degradation of its habitat as a result of "timbering" and other land-clearing activities. The language should not infer as it does now that all timber practices promote the decline of RCW habitat. It should be specified that certain activities should not be conducted within U.S. Fish and Wildlife Service designated RCW foraging areas.

Section 6.10.2 (pages 6-18 & 19) discusses anticipated impacts to plant communities. The last paragraph states that exotic plant species are not expected to be a problem as appropriate construction and maintenance procedures would be established to deter and control exotic establishment at the project site. Exotic plants are likely to come in regardless of initial construction and maintenance procedures to deter them. A plan should be developed to address this issue before construction begins.

Section 7.6.1 (page 7-23) discusses the estimated annual operations and maintenance costs. Exotic plant monitoring and treatment costs should be factored in this section.

Florida Fish and Wildlife Conservation Commission

Commissioners
Rodney Barreto
Chair
Miami
David K. Meehan
Vice-Chair
St. Petersburg
Kathy Barco
Jacksonville
Richard A. Corbett
Tampa
H. A. "Herky" Huffman
Enterprise
Dwight Stephenson
Fort Lauderdale
Brian S. Yablonski
Tallahassee

Executive Staff
Kenneth D. Haddad
Executive Director
Victor J. Heller
Assistant Executive Director
Darlyn A. Stockfisch
Deputy Chief of Staff

Office of Policy and Stakeholder Coordination
Mary Ann Poole
Director
(850)410-5272
(850)922-5679 FAX

Managing fish and wildlife resources for their long-term well being and the benefit of people.

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850)488-4676
Hearing/speech impaired:
(800)955-8771 (T)
(800)955-8770 (V)
MyFWC.com

June 8, 2007

Ms. Lauren P. Milligan
Florida State Clearinghouse
Department of Environmental Protection
3900 Commonwealth Blvd., MS 47
Tallahassee, Florida 32399-3000

Re: SAI #FL200704263301C, Draft Integrated Project Implementation Report and Environmental Impact Statement for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Hendry County

Dear Ms. Milligan:

The Division of Habitat and Species Conservation of the Florida Fish and Wildlife Conservation Commission (FWC) has coordinated an agency review of the proposed C-43 Basin Storage Reservoir project in Hendry County. The following comments and recommendations are being provided in accordance with Chapters 370 and 372, Florida Statutes, and are intended as a determination of consistency for purposes of the Florida Coastal Management Program/Coastal Zone Management Act.

Project Description

The proposed project is the first of two phases of a larger project to better manage water deliveries to the Caloosahatchee River (C-43) and estuary. This phase is limited to an above-ground reservoir that would discharge to the river, and would later be supplemented by aquifer storage recovery (ASR) wells. The project is located west of Lake Okeechobee and south of the Caloosahatchee Waterway in western Hendry County near the city of LaBelle. The proposed C-43 reservoir would contain approximately 160,000 acre-feet of water storage capacity on 10,492 acres of land. The reservoir would be divided into two cells contained by an embankment ranging between 27 and 38 feet above grade. An internal embankment 31 feet high would divide the cells of the reservoir, while a perimeter canal would encompass the entire reservoir. Numerous water-control structures would be constructed in conjunction with this project. The water-control structures would include an inflow pump station, a perimeter canal pump station, and multiple spillways and culverts.

Although a boat ramp is proposed, we understand that the South Florida Water Management District plans on monitoring the performance of the reservoir for 18 months before deciding on which forms of recreation will be allowed within the reservoir.

The proposed construction of the C-43 basin storage reservoir project is to provide an overall benefit to the Caloosahatchee River by providing additional control of the timing and quantity of water releases from watershed runoff and Lake Okeechobee water releases. The reduction of large freshwater discharges into the Caloosahatchee River, especially during the seasonal dry periods, would assist in imitating historical water flow patterns and would reduce nutrient influx and moderate salinity regimes associated with flood waters. In addition, the C-43 basin reservoir would provide the potential to reduce flooding and potentially provide water supply storage.

Ms. Lauren Milligan
Page 2
June 8, 2007

Potentially Affected Resources

Project Site:

The South Florida Water Management District owns the majority of the property and currently leases it for citrus farming. Of the 10,492 acres, approximately 1,024 are jurisdictional wetlands, 899.59 acres of which are canals and ditches and 125 acres are pre-existing wetlands. The uplands that would be flooded currently provide marginal wildlife habitat, while the downstream freshwater and estuarine habitats could benefit greatly from the retention of freshwater that would otherwise flow to the river and estuary, often in large pulses that are seasonally ill timed. In addition, there may be opportunities within the completed reservoir to manage for freshwater fisheries, and improving habitats for many other wildlife species including songbirds, wading birds, waterfowl, and alligators.

Caloosahatchee River and Estuary:

Major changes resulting from this project should be beneficial to most existing Florida habitats within this project's influence. The primary beneficiary will be the estuarine communities associated with the Caloosahatchee River, including submerged aquatic vegetation and oyster (*Crassostrea virginica*) populations. Improvements in water quality and more appropriate salinity regimes should provide improved conditions for associated habitats and the wildlife resources dependent upon them.

West Indian (Florida) manatee:

Improved riverine and estuarine habitats as a result of this project would benefit the endangered West Indian (Florida) manatee (*Trichechus manatus*) through increases of stable submerged aquatic vegetation. Potential adverse affects could occur to the manatee during construction and operation of numerous water-control structures associated with the proposed reservoir. Reservoir waters have the potential to retain daily solar heating due to their deep depths. Discharge of reservoir waters that are warmer than the ambient waters of the C-43 canal could create conditions similar to manatee warm-water aggregation sites; however, suitable warm-water sites require consistent flows that create refuge areas with temperatures greater than 20°C during the winter months. If the water temperatures do not remain near 20°C or are inconsistent in their availability, the site becomes an attractive nuisance that increases the risk of cold season death for manatees that locate and use them.

Concerns and Recommendations

Caloosahatchee River and Estuary:

The Caloosahatchee estuary stands to be the primary beneficiary of this project. Storing water from Lake Okeechobee and runoff from the basin's watershed for future releases that are measured and seasonally appropriate could provide a boon to estuarine habitats. Riverine and estuarine habitats in this system have long suffered due to large freshwater

releases that have caused significant shifts in salinity, large influxes of nutrients and increases in turbidity (Chamberlain and Doering 1998). Habitats most likely to benefit from this project include eelgrass (*Vallisneria americana*) beds located in the upper Caloosahatchee River, shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), turtle grass (*Thalassia testudinum*) and oyster reefs all located in the estuarine waters. The increased viability of these habitats should enhance the animal communities that use them as nursery and foraging habitat. While we understand that this will remain the primary objective of this project, we add our support that measured and seasonally appropriate freshwater releases from the C-43 basin storage reservoir remain the primary goal of this project while other worthy purposes for the reservoir (flood control, agriculture, and drinking water supply) remain secondary except for emergency purposes.

West Indian (Florida) Manatee:

The numerous water-control structures associated with this project could entrap, injure, or kill manatees that may encounter them. Manatees are frequent travelers of the Caloosahatchee waterway, traversing the entire waterway through Lake Okeechobee. Water-control structures have been responsible for hundreds of manatee deaths (Fish and Wildlife Research Institute's manatee mortality database); however, with the appropriate safeguards, these structures can be rendered relatively benign. The most efficient way to achieve this goal is to prevent manatee ingress and egress to the C-43 reservoir by constructing manatee barriers at all access points to the perimeter canal and reservoir.

During the winter months manatees are dependent on warm-water refuges to survive during periods of cold air and water temperatures (O'Shea et al. 1985; Hartman 1974). Water temperatures greater than 20°C are needed for survival; however, water temperatures that inconsistently reach 20°C can create an attractive nuisance that may jeopardize the health of manatees (Worthy et al. 2000; Laist and Reynolds 2005).

Recommendations:

- Barriers should be used at all ingress structures to the perimeter canal to eliminate manatee access to the perimeter canal and reservoir.
- Standard manatee construction conditions should be used in all waters accessible by manatees during the construction of this project.
- We highly recommend using the information provided in the document entitled "Guidelines for Manatee Conservation during Comprehensive Everglades Restoration Plan Implementation."
- During the winter season (November 1 through March 31) we recommend that water releases from the C-43 reservoir be monitored hourly for temperature with data retrieved daily, near the point of discharge (S-11). Monitoring data will be used to determine if water releases from the C-43 basin have the potential to create a warm-water site that is insufficient to sustain manatees.
- During the winter season, if water released from the reservoir creates a thermal plume that is greater than 20°C, or if manatees are observed using the site of the reservoir discharge on two consecutive days, then we request that the FWC-Imperiled Species Management section (850-922-4330) and the U.S. Fish and Wildlife Service be consulted to resolve the issue of impacts on manatees.

Although not part of the proposed project, aquifer storage recovery (ASR) wells are also a proposed component of this overall project, but in a subsequent phase. We believe that the ASR component could present similar issues related to thermal effects. ASR wells at this site have a projected capacity to store an additional 220 million gallons of water. Limited information is available at this time but monitoring suggests that water from some ASR wells has been retrieved at temperatures greater than 20°C. Reservoir waters discharged at greater than ambient water temperature that are near 20°C could be attractive to manatees during the winter months. Discharge waters that are inconsistent or insufficient in temperature could result in cold stress-related manatee mortality.

Recommendation:

- FWC requests that the U.S. Army Corps of Engineers and the South Florida Water Management District keep FWC apprised of the results of ongoing ASR studies and monitoring efforts so future manatee-related issues can be identified, refined, and resolved proactively prior to the implementation of ASR technology.

Recreation:

The proposed C-43 reservoir project would create over 10,000 acres of open water with depths reaching 25 feet. Although this project's primary purpose is water storage for the benefit of the downstream estuary, some form of recreation is contemplated by the proposed project. The FWC encourages public access to areas that can allow opportunities for recreational pursuits, whenever compatible. The C-43 reservoir has the potential to be managed for public activities that include alligator and waterfowl hunting, fishing, hiking, and wildlife observation.

Specifically, we support allowing waterfowl hunting and fishing as recreational opportunities that should be allowed on the C-43 reservoir. There is a very high public demand for waterfowl hunting and angling in the southern portion of peninsular Florida, and we believe that use of this area for these recreational purposes would meet all criteria of recreational features proposed on CERP projects:

1. Compatible with the authorized project purposes
2. Affordable within project limits
3. Easily operated and maintained

Allowing the above opportunities on the reservoir should add little to no extra cost to the project, as a boat ramp is currently a proposed Acceler8 component of the project. We recommend that the South Florida Water Management District work with our staff during the assessment period to refine what types of activities could be accommodated. We would like to operate and maintain waterfowl hunting cooperatively with the South Florida Water Management District and others, as appropriate.

Recommendations:

- The use of soil cement for construction of the reservoir embankments is not conducive to the establishment and growth of submerged aquatic vegetation, an

attractant for waterfowl. We recommend the placement of a natural substrate within the interior of the reservoir to allow for vegetation growth, which will increase the wildlife habitat value and assist with improvements in water quality through the reduction of nutrients.

- We recommend planning for recreational alligator hunting on the C-43 Reservoir in the future.
- Project plans should provide roads and boat ramps allowing adequate public access.
- Portions of the reservoir footprint have been in citrus production. We recommend that these areas not be cleared prior to reservoir flooding. Citrus is fairly durable wood and should not degrade rapidly, thereby creating long-lasting fish and wildlife habitat. A similar recommendation provided a cost savings during the construction planning of the Site 1 impoundment.
- Minimizing dry outs would benefit wildlife habitat through the reduction of nutrients and re-suspension of contaminants while providing for a stable aquatic community.

Conclusion

The FWC fully supports the construction and operation of the proposed reservoir for the benefit of the Caloosahatchee River and estuarine habitats. Recognizing this priority, we also recommend that completed public works projects be made available to the public for recreational opportunities that are compatible with the primary intended purposes. The C-43 reservoir project appears to offer a variety of potential recreational pursuits including waterfowl and alligator hunting, fishing, hiking and wildlife observation. The FWC is willing to assist in achieving these multiple-use goals.

If you or your staff would like to coordinate further on the recommendations contained in this report, please contact me at 850-410-5272 or email me at MaryAnn.Poole@MyFWC.com, and I will be glade to help make the necessary arrangements. If your staff has any specific technical questions regarding our comments, please contact Ron Mezich at 850-922-4330; email ron.mezich@myfwc.com.

Sincerely,

Mary Ann Poole

Mary Ann Poole, Director
Office of Policy and Stakeholder Coordination

map/rrm
ENV 1-3-2
C-43 Basin_838_841_843
cc: J. Feiertag
J. Fury

Referenced Cited:

Chamberlain, R.H., and P.H. Doering. 1998. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach. South Florida Water Management District Report. West Palm Beach, Florida. 21 pp.

Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute Manatee Mortality database. http://myfwc.com/manatee/

Hartman, D. S. 1974. Distribution, status, and conservation of the manatee in the United States. U.S. Fish and Wildlife Service, National Fish and Wildlife Laboratory contract report No. 14-16-0008-748. NTIS publication No. PB81-140725, pp.1-246.

Laist, D.W. and Reynolds, J.E., III. 2005b. Florida manatees, warm-water refuges, and an uncertain future. *Coastal Management* 33:279-295.

O'Shea, T.J., C.A. Beck, R.K. Bonde, H.I. Kochman and D.K. Odell. 1985. An analysis of manatee mortality patterns in Florida, 1976-81. *Journal of Wildlife Management*, 49(1): 1-11.

U.S. Fish and Wildlife Service, CERP Interagency Manatee Task Force. 2006. Guidelines for manatee conservation during Comprehensive Everglades Restoration Plan implementation.

Worthy, G. A. J., T.A. Miculka, and S.D. Wright. 2000. Manatee response to cold: how cold is too cold? Pages 16-22 *in* U.S. Fish and Wildlife Service. Florida Manatees and Warm Water: Proceedings of the Warm-Water Workshop, Jupiter, Florida, August 24–25, 1999.

Annex B

NEPA Information 4007-032

FLORIDA STATE CLEARINGHOUSE
RPC INTERGOVERNMENTAL COORDINATION AND RESPONSE SHEET

SAI#: FL200704263301C DATE: 4/30/2007
COMMENTS DUE TO CLEARINGHOUSE: 5/29/2007

CFDA#: 99.997 COUNTY: **HENDRY** CITY:

☐ FEDERAL ASSISTANCE ☑ DIRECT FEDERAL ACTIVITY ☐ FEDERAL LICENSE OR PERMIT ☐ OCS

PROJECT DESCRIPTION
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT CORPS OF ENGINEERS - DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT (PIR) AND ENVIRONMENTAL IMPACT STATEMENT FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT - HENDRY COUNTY, FLORIDA

ROUTING: **RPC**

X SW FLORIDA RPC

RECEIVED
JUN 11 2007
OIP / OLGA

PLEASE CHECK ALL THE LOCAL GOVERNMENTS BELOW FROM WHICH COMMENTS HAVE BEEN RECEIVED; ALL COMMENTS RECEIVED SHOULD BE INCLUDED IN THE RPC'S CLEARINGHOUSE RESPONSE PACKAGE. IF NO COMMENTS WERE RECEIVED, PLEASE CHECK "NO COMMENT" BOX AND RETURN TO CLEARINGHOUSE.

COMMENTS DUE TO RPC: 5/22/2007

___ **HENDRY** Hendry County has indicated that they have comments to submit but haven't submitted them to us at this time (6/5/07). They will be sent under separate cover.

NO COMMENTS: ___
(IF THE RPC DOES NOT RECEIVE COMMENTS BY THE DEADLINE DATE, THE RPC SHOULD CONTACT THE LOCAL GOVERNMENT TO DETERMINE THE STATUS OF THE PROJECT REVIEW PRIOR TO FORWARDING THE RESPONSE PACKAGE TO THE CLEARINGHOUSE.)

NOTES:

RECEIVED
JUN 1 2007
Federal

ALL CONCERNS OR COMMENTS REGARDING THE ATTACHED PROJECT (INCLUDING ANY RPC COMMENTS) SHOULD BE SENT IN WRITING BY THE DUE DATE TO THE CLEARINGHOUSE. PLEASE ATTACH THIS RESPONSE FORM AND REFER TO THE SAI # IN ALL CORRESPONDENCE.

IF YOU HAVE ANY QUESTIONS REGARDING THE ATTACHED PROJECT, PLEASE CONTACT THE STATE CLEARINGHOUSE AT (850) 245-2161.

Southwest Florida Regional Planning Council

1926 Victoria Avenue, Fort Myers, Florida 33901-3414

(239)338-2550 FAX (239)338-2560 SUNCOM (239)748-2550

RECEIVED

JUN 11 2007

OIP / OLGA

June 5, 2007

Ms. Sally B. Mann
Coordinator
Florida State Clearinghouse
Florida Department of Environmental Protection
3900 Commonwealth Boulevard, Mail Station 47
Tallahassee, Florida 32399-3000

Re: IC&R #s: 2007-032 & 2007-035/SAI #: FL200704263301C
Permit 3005-5958 (IP-TKW), Hendry County, Caloosahatchee River (C-43) West Basin Storage Reservoir, Draft Project Implementation Report (PIR), Environmental Impact Statement (EIS), and Tentatively Selected Plan (TSP), http://www.evergladesplan.org/pm/projects/docs_04_c43_pir.aspx

Dear Ms. Mann:

The Southwest Florida Regional Planning Council (SWFRPC) has reviewed the Proposed Permit 3005-5958 (IP-TKW) for the Caloosahatchee River (C-43) West Basin Storage Reservoir, Draft Project Implementation Report (PIR) and Environmental Impact Statement (EIS), and has the following comments.

The request dated April 30, 2007 was received for our review on May 4, 2007.

The proposed project has the potential to effect hydrology, water quality, wetlands, and wildlife within one of the largest manmade canal systems within the Southwest Florida Region.

There are several components of the Tentatively Selected Plan (TSP) that will have environmental benefits including:

- Construction of a 170,000 acre-feet reservoir with the expressed purpose of reducing the number and duration of extreme hydrologic events at S-79 locks on the Caloosahatchee River.
- Reduction in the number and duration of high flow (>4500 cfs) and low flow (<450 cfs) events in the Caloosahatchee River.
- Adopting and implementing targets of 0 flows below 450 cfs and above 4500 cfs for the Caloosahatchee River.

TO: Ms. Sally B. Mann
DATE: 6/5/2007
PAGE: 2
RE: IC&R #s: 2007-032 & 2007-035/ SAI #: FL200704263301C

- An Oyster Restoration Plan for the Tidal Caloosahatchee which anticipates an increase from 3.02 acres of oyster reef habitat in 2004 to 30 acres of oyster reef habitat within 10 to 15 years. With the ultimate addition of hard, suitable substrate the target of oyster reef habitat increases to 100 acres.
- Commitment to use the water quality prediction tools currently in development, such as reservoir and estuary water quality models, to optimize the reservoir operations with the goal of improving downstream water quality.
- Commitment to 5 years of water quality monitoring associated with design and initial operations of the reservoir

The SWFRPC strongly recommends for incorporation into the TSP of:

1) A water quality treatment component needs to be included in the design of the reservoir project. The need for a water quality treatment component was identified early in the process of alternative development review by federal, state, regional, and local agency participants of the PDT in the development of the PIR. It was deferred from consideration by the SFWMD and the USACOE. Apparently, this reservoir project is the only reservoir design currently under consideration for CERP funding that does not have a water quality treatment feature. Based upon materials posted on the CERP web-site, east coast reservoirs have water quality treatment features included in their design. It is important that the current project design not preclude the necessary water quality treatment features. It is important that land not be surplused from the project footprint before necessary water quality treatment features are planned and constructed. Addressing hydrology without including water quality improvement is insufficient in protecting the estuary and aquatic resources of the Caloosahatchee River and the nationally recognized Outstanding Florida Waters estuaries at its confluence. H.R. 1816, the "Restoring the Caloosahatchee River: A Legacy for Florida" Act, was introduced by Congressman Connie Mack and the State of Florida Appropriations Bill delivered to Governor Crist includes funding a water quality component for the C-43 Reservoir project. The TSP should include water quality treatment features with sufficient space for their construction.
2) The littoral areas proposed at the corners of the seepage canal as part of the project should be constructed. We concur with the Florida Fish & Wildlife Conservation Commission that these littoral areas will provide habitat benefits and potential water quality benefits.
3) All shade trees proposed on the outside area of the north rim canal adjacent to parking areas should be native to the Caloosahatchee basin. Past selection and planting of exotic tree species in USACOE projects has led to damage to reservoir banks and project canal banks resulting in expensive remove programs and the need to construction repairs.

TO: Ms. Sally B. Mann
DATE: 6/5/2007
PAGE: 3
RE: IC&R #s: 2007-032 & 2007-035/ SAI #: FL200704263301C

4) The missing pages in the Final Biological Assessment concerning methodology that should be present between pages A-95 and A-96 in Annex A of the FWCA Report and Endangered Species Act Compliance should be inserted into the documentation of the PIR.

The SWFRPC supports the concept and development of the C-43 reservoir project to reduce the negative hydrologic discharges to the Caloosahatchee River, restoration of base flows for the Caloosahatchee River, and improvement in water quality of the Caloosahatchee River. Our staff has participated cooperatively in the development of the PIR and EIS. We did not and do not agree; however, that water quality protections should be deferred in development of this project.

We look forward to cooperating with the applicant and other relevant agencies to resolve the issues that we have identified in this letter in order to ensure consistency with the Coastal Zone Management Act/Florida Coastal Management Program and to ensure that the TSP proceeds in a fashion that minimizes impacts to water quality, hydrology and fish and wildlife resources in the Southwest Florida Region. Staff has been in contact with Hendry County Planning and they had indicated that they will be submitting comments; but to this date they have not been completed. Please note that Hendry County's comments will be submitted under separate cover.

Please call me if you would like to coordinate further discussion of these issues; I will be glad to facilitate any such efforts. If you have specific questions about the content of this letter, please contact Mr. Jim Beever directly at (239) 338-2550 ext 224, e-mail jbeever@swfrpc.org.

Sincerely,

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL

Mr. David Y. Burr, AICP
Executive Director

JB/DYB/nlg

TO: Ms. Sally B. Mann
DATE: 6/5/2007
PAGE: 4
RE: IC&R #s: 2007-032 & 2007-035/ SAI #: FL200704263301C

Cc: Mr. David S. Hobbie
Chief, Regulatory Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32332-0019

U.S. Fish and Wildlife Service
6620 Southpoint Drive South, Suite 310
Jacksonville, Florida 32216-0912

Ms. Susan Conner
U.S. Army Corps of Engineers
701 San Marco Blvd.
Jacksonville FL 32207-8175
CRWBSRComments@evergladesplan.org

SFWMD
3301 Gun Club Road
West Palm Beach, FL 33406

COUNTY: HENDRY
SCH - CORPS-CERP- PIR-EIS
2007 - 3443

DATE: 4/27/2007
COMMENTS DUE DATE: 5/29/2007
CLEARANCE DUE DATE: 6/11/2007
SAI#: FL200704263301C
REFER TO: FL200303261382C

MESSAGE:

STATE AGENCIES	WATER MNGMNT. DISTRICTS	OPB POLICY UNIT	RPCS & LOC GOVS
AGRICULTURE	SOUTH FLORIDA WMD		
COMMUNITY AFFAIRS			
ENVIRONMENTAL PROTECTION			
FISH and WILDLIFE COMMISSION			
X STATE			
TRANSPORTATION			

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evaluation and is categorized as one of the following:

- **Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.**
- X **Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.**
- **Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.**
- **Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.**

Project Description:

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT CORPS OF ENGINEERS - DRAFT INTEGRATED PROJECT IMPLEMENTATION REPORT (PIR) AND ENVIRONMENTAL IMPACT STATEMENT FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT - HENDRY COUNTY, FLORIDA

To: Florida State Clearinghouse

AGENCY CONTACT AND COORDINATOR (SCH)
3900 COMMONWEALTH BOULEVARD MS-47
TALLAHASSEE, FLORIDA 32399-3000
TELEPHONE: (850) 245-2161
FAX: (850) 245-2190

EO. 12372/NEPA

- ☑ No Comment
- ☐ Comment Attached
- ☐ Not Applicable

Federal Consistency

- ☑ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:
Division/Bureau: Division of Historical Resources
Bureau of Historic Preservation

Reviewer: Laura A. Kammerer, Deputy SHPO

Date: 5. 15. 2007

RECEIVED
BUREAU OF
HISTORIC PRESERVATION
2007 MAY -1 P 12:41

RECEIVED
11 Jun 07

FLORIDA DEPARTMENT OF STATE
Kurt S. Browning
Secretary of State
DIVISION OF HISTORICAL RESOURCES

Mr. Stuart J. Appelbaum, Chief
Jacksonville District Corps of Engineers
Planning Division, Environmental Branch
Post Office Box 4970
Jacksonville, Florida 32232-0019

June 5, 2007

Re: DHR No. 2007-3148 / Date Received: April 26, 2007
Draft Project Implementation Report with an integrated Environmental Impact Statement
Caloosahatchee River (C-43) West Basin Storage Reservoir Project
Hendry County

Dear Mr. Applebaum:

Our office received and reviewed the above referenced project in accordance with Section 106 of the *National Historic Preservation Act of 1966*, as amended and *36 CFR Part 800: Protection of Historic Properties* and the *National Environmental Policy Act of 1969, as amended.* The State Historic Preservation Officer is to advise Federal agencies as they identify historic properties (listed or eligible for listing, in the *National Register of Historic Place*, assess effects upon them, and consider alternatives to avoid or minimize adverse effects.

We reviewed the referenced environmental document, and concur that the recommended action will not impact culturally significant properties.

If you have any questions concerning our comments, please contact Laura Kammerer, Deputy State Historic Preservation Officer for Review and Compliance, by telephone at 850-245-6333, or by electronic mail at lkammerer at dos.state.fl.us. Thank you for your interest in protecting Florida's historic properties.

Sincerely,

Frederick P. Gaske

Frederick P. Gaske, Director, and
State Historic Preservation Office

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6436
☐ Archaeological Research (850) 245-6444 • FAX: 245-6436
☑ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Southeast Regional Office (561) 416-2115 • FAX: 416-2149
☐ Northeast Regional Office (904) 825-5045 • FAX: 825-5044
☐ Central Florida Regional Office (813) 272-3843 • FAX: 272-2340

LEE COUNTY
SOUTHWEST FLORIDA

BOARD OF COUNTY COMMISSIONERS

Bob Janes
District One

A. Brian Bigelow
District Two

Ray Judah
District Three

Tammy Hall
District Four

Frank Mann
District Five

Donald D. Stilwell
County Manager

David M. Owen
County Attorney

Diana M. Parker
County Hearing Examiner

Via Email: CRWBSRComments@evergladesplan.org
And Regular U.S. Mail

June 11, 2007

Janet Starnes
South Florida Water Management District
2301 McGregor Boulevard
Fort Myers, FL 33901

Susan Conner
U.S. Army Corps of Engineer s
701 San Marco Blvd.
Jacksonville FL 32207-8175

Re: Comments Regarding the Central and Southern Florida Project Comprehensive Everglades Restoration Plan, Caloosahatchee River (C-43) West Basin Storage Reservoir Project, Draft Integrated Project Implementation report and Environmental Impact Statement

Dear Ms. Starnes and Ms. Conner:

Please find attached to this correspondence are specific comments, submitted on behalf of Lee County ("the County"), regarding the *Caloosahatchee (C-43) West Basin Storage Reservoir ("CRWBSR") Draft Integrated Project Implementation Report and Environmental Impact Statement* ("C-43 Draft PIR"). As you are well aware, the County is supportive of the expedited implementation of the Caloosahatchee (C-43) West Basin Storage Reservoir ("CRWBSR") in order to bring immediate benefits to the Caloosahatchee River and Estuary. The County must balance multiple interests, as must the United States Army Corps of Engineers ("Corps") and the South Florida Water Management District ("SFWMD"), but our primary concern is the health of the Caloosahatchee River and Estuary. Our comments on the C-43 Draft PIR can generally be summarized as follows:

- Reconcile conflicting statements regarding the availability of water to meet municipal and agriculture needs from the CWBSR project;
- Please indicate whether or not there is a contingency fund for contamination clean-up costs for the project lands and whether or not the C-43s structures (16, 17, 18 and 19 at $4.5 million) are included in the overall cost estimates;
- The discharges from the CRWBSR under Alternative 3B are projected to meet the flow targets 74.8% of the time. Although this shows a benefit, the C-43 Draft PIR

must show that this actually results in the restoration needs of the Estuary being met based on current water budgets and consumptive use permit withdrawals;

- To accomplish expedited implementation of the CRWBSR, unnecessary procedural obstacles must be avoided, such as multiple project phasing and PIRs. More water storage options need to be included in this C-43 Draft PIR effort rather than delayed to a Phase 2 or even a Phase 3; and,

The County considers itself a partner in the Comprehensive Everglades Restoration Plan ("CERP") in addition to your respective agencies. We appreciate the opportunity to participate in the process for the implementation of the CRWBSR and look forward to timely completion of the C-43 Final PIR.

Sincerely,

DEPARTMENT OF PUBLIC WORKS
Division of Natural Resources

(Signed in his absence to avoid delay)

Roland Ottolini, P.E.
Division Director

Attachment

Detailed Comments Regarding the Caloosahatchee (C-43) West Basin Storage Reservoir Draft Integrated Project Implementation Report and Environmental Impact Statement ("C-43 Draft PIR" or "the document")

Goals and Purposes of the Project

Page XII — The document discusses the need to ensure that current levels of service for water supply in the Caloosahatchee basin could still be met with implementation of the Tentatively Selected Plan. In other portions of the document, water supply benefits are described as "indirect". According to the C-43 Draft PIR, all water available from the CRWBSR is slated to be available only for the environment. If there is even an "indirect" potable water supply benefit, this should be quantified. The County is supportive of placing a priority on the needs of the Caloosahatchee Estuary, but the multiple purposes of the project should not be lost.

Page XVI — The document describes the requirements for water to be identified for the natural system and other water related needs. This analysis was based on a draft of Programmatic Guidance Memorandum 4. It is the County's understanding that the methodology to make these determinations has not be finalized and that a final methodology is still forthcoming in terms of this Guidance Memorandum. Is that still the case and will this have an effect on identifying water for the natural system and other water related needs?

Page XVI — The document lists the primary functions of the reservoir as capturing excess runoff and discharges and providing an additional source of water to maintain desirable salinity in the Caloosahatchee Estuary during periods of low flow. All water from the CRWBSR is then identified for the natural system. First, there are several differing goal and purpose statements for the project throughout the document. The goals and purposes for the CRWBSR from the original CERP "Yellow Book" should guide the project's implementation (see page 1-9 of the C-43 Draft PIR for a portion of this statement).[1] If those goals and purposes have changed for some reason, the document should state that and the rationale for the change. Second, as stated earlier in these comments, the multiple purposes of the project should not be lost and even "indirect" water supply benefits should be quantified. The statement on this page, "The project will not provide any additional water for water supply or other water-related needs in the Caloosahatchee River basin", contravenes these concepts.[2] See similar discussion on pages 5-3 and 5-4.

[1] The C-43 Draft PIR states at page 1-11, "Draft Programmatic Regulations Guidance Memoranda #1 and #2 instruct project teams to affirm and optimize the component identified in the Restudy unless conditions or planning objectives have changed, or if the component no longer meets the purposes outlined in the Restudy, to formulate new alternatives."

[2] For comparison, see page 2-53 which states, "This reservoir is intended to reduce the fresh water pulses into Charlotte Harbor and the Caloosahatchee Estuary, and provide water storage for meeting environmental needs. Additional water, after environmental needs are met, could be used as supplemental water to help meet the needs of agriculture and urban communities in Southwest Florida." See also page 4-8, "The project was formulated to provide water supply benefits, some flood attenuation, environmental water supply deliveries to the Caloosahatchee Estuary and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary." Finally, see page 4-19 stating, "The Restudy purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir is to capture Caloosahatchee Basin runoff and releases from Lake Okeechobee as a means to meet water demands (moderate extreme damaging high and low flows) for ecosystem restoration within the Caloosahatchee Estuary, with some benefits to municipal and agricultural water supply."

Page XVI The County supports maintaining the same level of water supply deliveries to agricultural lands adjacent to the CRWBSR where water supply canals were interrupted due to the location of the project, consistent with Section 601(h) of the Water Resources Development Act of 2000.

Page 1-9 Page 1-9 lists a portion of the CRWBSR restoration objective from the original CERP documents (1999) as including water supply benefits, some flood attenuation, to provide environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. All of these benefits should be identified, consistent with 33 C.F.R. Part 385, or the Programmatic Regulations for CERP. Additionally, this restoration objective limits nutrient impacts to "runoff to the estuary" while ignoring the effects of Lake Okeechobee discharges. Estuary benefits and water quality benefits are "primary" system benefits and flood attenuation and water supply are "secondary" system benefits. Again, the water supply benefit originally envisioned in the restoration objective should not be lost and should be identified and this "restoration objective" should be consistently listed throughout the document.

Page 1-11 While the County is supportive of addressing water supply needs and water quality in the upper basin in a subsequent PIR, any water supply benefits achieved now by the CRWBSR, although they may be de minimis, should be identified consistent with Federal law and the Programmatic Regulations. This comment is also relative to Section 4.1.4.1. on Water Supply and the Annex C Saving Clause Analysis. See also Section 8.5.3.1 on identification of water made available and water for other water related needs.

CERP Project Phasing

Page XXIV The document describes that a subsequent PIR will be initiated to address the remaining water resource problems in the Caloosahatchee River basin which were not fully addressed by the Tentatively Selected Plan. These remaining water resource problems include: additional pumping and storage capacity, the need for additional water storage and management features in the upper basin and improving water quality. The County has been supportive of this "Phase II" approach for the CRWBSR. The last paragraph of that section further describes the Caloosahatchee ASR features being investigated as part of a **third PIR**. While we understand the need for the two-phase approach, the County is concerned that three PIRs, phases or studies to address the Caloosahatchee basin is excessive and sets a bad precedent for the implementation of CERP projects. The County does not support a third PIR effort for this project and all outstanding issues should be resolved in the Phase 2.

The Tentatively Selected Plan

Pages XI-XII The document lists the array of final alternatives. Alternative 3B, 170,000 acre-foot ("ac-ft") storage reservoir with a 1,500 cubic feet per second ("cfs") pump station is the chosen alternative. The County supports these features for the Tentatively Selected Plan at this time.

Page XII The document lists a minimum flow of 450 cfs at the S-79 during dry periods. In later sections of the document (pages 1-16 & 2-34) there is an explanation of why this target was chosen in lieu of the established minimum flow and level ("MFL") criteria of 300 cfs. The County is supportive of using this higher minimum target although it is quite

possible that this 450 cfs target is also slightly lower than the true needs of the restored Calooshatchee Estuary. This should form the basis for the guiding the Phase II PIR effort. This comment also relates to the discussion on page 4-10.

Page XIV — The document describes structures C-43s16, 17, 18 and 19 as possibly being constructed in "partnerships" between the SFWMD and Hendry County as a separate project under a different program. The cost of these structures is $4.5 Million. This commitment does not appear to be strong, because the structure "may" be constructed under the partnership. The document needs to address whether or not this partnership is tentative in nature or not and if so, the structures, and their cost, needs to be added to the overall project cost for the CRWBSR.

Page XIV — The document describes the added feature for the placement of 20 acres of artificial substrate in the Caloosahatchee Estuary for oyster, plant and animal recruitment. Although the County is supportive of this project feature this 20 acres equates to reaching roughly half to a third of the 40-60 acre targets for increases in the aerial extent of oyster reefs. See also page 7-4.

Page XX — The document lists the project cost as $446,460,000. See also page 7-15 & page 8-2. It is unclear whether or not contamination clean-up costs, or a contingency fund for them, are included in this figure. A contingency should be added for the $4.5 Million in structures listed in the comment above (C-43s, 16-19) if that partnership project is tentative in nature. On page 5-36, Total Project Investment for Alternative 3B is listed as $486,307,000. Consistent cost figures should be used throughout the document.

Page XX — The document states that the SFWMD constructed a test cell project to evaluate seepage and embankment design and water quality effects of the project (see also page 2-2). A brief summary of the results of that analysis and project in this section should be included. This comment is also relative to page 4-16.

Page 5-6 — Table 5-1 describes the various "management measures" (both structural and non-structural) that were considered in conjunction with the CRWBSR. All management measures were then screened out leaving only the actual reservoir and operations of that reservoir to achieve the planning goals and objectives. This entire analysis seems a bit misleading because the two factors driving this analysis were likely cost and time delay. While the County is supportive of expediting the CRWBSR and we support the approach of a Phase II to more fully address basin needs, it should be clear that these management measures will again be analyzed throughout the Phase II process. While they are not being implemented in conjunction with this phase of the project, they have not been removed from the table for further consideration. This seems to be why Table 5-2 was included, but the statement in that Table that "STAs may not be needed" is alarming before that analysis has concluded.

Page 5-24 — The County is supportive of the rationale for Alternative 3B being chosen as the Tentatively Selected Plan. It appears to achieve comparable environmental performance while taking an incremental approach on determining the appropriate pump size. Until more water storage is provided in the overall basin, it does not seem as though a larger pump is warranted at this time (see page 5-26). Page 5-34 states that most project benefits accrue in the dry season and pump size would not affect these benefits. Any operational or incidental environmental or water supply benefit achieved by a larger

pump should be clearly reflected in the C-43 Draft PIR. This comment is also relevant to discussion on page 5-42.

Page 5-43 Is there an effect on project performance if there is a reduction in the 13-foot assumption for freeboard?

Page 5-47 When will the MIKESHE water budget modeling shortfalls discussed in this section be rectified? This should be completed before the C-43 Final PIR.

Page 5-49 What "alternative methods" were used to show the Tentatively Selected Plan is in compliance with CERP Programmatic Regulations, WRDA 2000 and Florida State Law?

Page 6-9 Alternative 3B is projected to meet the desired flows for the Estuary 74.8% of the time as compared to the current 46.% estimate. This appears to be significant improvement but full restoration benefits must be the guide to project success.

Page 6-10 The structural canal changes contemplated do not appear to be significant, but coordination with affected property owners must commence to avoid any delay in project implementation. See also discussion on page 7-3.

Page 6-15 It does not appear as though there are any significant effects on groundwater elevations except the small increase (albeit in the dry season) north of the project site. Again, this effect must be coordinated with affected property owners to avoid any delay in project implementation.

Page 7-16 The benefits and potential detriments of the public-private partnership described in this section are unclear. Which project features would be constructed in this fashion and are there any formal proposals for this effort?

Related Project, Permitting and Process Issues

Page X The document discusses how aquifer storage and recovery ("ASR") project features will be evaluated and implemented separately. Will this occur in a second PIR or separate initiative? How will this project be coordinated with the ASR contingency plan?

Pages X-XI The document similarly discusses an additional project to store basin runoff for backpumping and treatment from the C-43 Canal to return to Lake Okeechobee. Will this occur in a second PIR or separate initiative?

Page XXI The document lists the C-43 Draft PIR process and the Department of the Army Section 404 (Clean Water Act) permit as separate but related activities. The estimated timeframes for the issuance of the permit should be included in the document. Will this be the July 2007 date for initiation of clearing and grubbing of the site?

Page 1-12 The document lists the ASR Pilot Project as being conducted in parallel with a regional study on ASR. The timing of this pilot project and regional study needs to be listed to determine if these features can, and should, be included in the Phase II PIR. The document also lists the Caloosahatchee Backpumping with Stormwater Treatment (20,000 ac-ft) as a project used to augment regional system water supply. The County has not been supportive of this backpumping effort until we are sure the Caloosahatchee system targets are met first, including wet season and dry season flows, but again, any

indirect water supply benefits from the CRWBSR must be identified in this current C-43 Draft PIR. The land acquisition needs of this feature are uncertain at this time and due to land value escalation, this effort should be expedited.

Page 1-15 This section lists the various "State Initiatives" having an impact on future water quality both upstream and downstream of S-79. Projects and programs included in this year's Northern Everglades and Estuary Protection Act should be included in this section. This information should also be added to Section 3.6 on Water Quality, page 3-7 and page 6-40.

Page 1-17 The Caloosahatchee Water Management Plan ("CWMP") is referenced as identifying the need for 220,000 ac-ft of storage in the lower West Caloosahatchee Basin as a target for environmental restoration of the Caloosahatchee Estuary. With the CRWBSR including 170,000 ac-ft of storage, a gap of 50,000 ac-ft storage need to be met exists based on the CWMP. The 20,000 ac-ft target in the Caloosahatchee Backpumping with Stormwater Treatment project is less than this target. This additional storage need must be identified as quickly as possible due to the aforementioned land value escalation issues. This comment is relevant to Section 5.3.4.5 on Alternative 4A.

Page 1-18 Will the permits referenced on this page, Section 404 Clean Water Act, be issued before construction commences in July 2007?

Page 2-11 Water use analysis is based on the CWMP document dated April 2000. The 2005-2006 Update to the Lower West Coast Water Supply Plan should be utilized and referenced for this analysis. This comment is also relevant to Section 3.16 on municipal and agricultural water supply.

Page 3-8 The Lake Okeechobee Operating Permit, ("LOOP") is currently being issued and discussion are ongoing regarding changes to the LOOP relative to structures that discharge from Lake Okeechobee into the Caloosahatchee basin. This information should be incorporated into the C-43 Final PIR. It should also be added the section on "Existing Operations" on page 8-4.

Page 4-18 The Water Supply discussion references the Lower West Coast Water Supply Plan Update. This Plan has already been adopted by SFWMD and should be a basis for water supply information in this C-43 Draft PIR.

Page 6-22 Will formal consultation with the U.S. Fish and Wildlife Service be completed by the release of the C-43 Final PIR?

Water Quality Benefits and Impacts

Page XVIII The document states that "Impoundment water quality will be further assessed as part of the permit application and review process." It is important that this analysis occur as quickly as possible so that operational adjustments can be made or additional features can be analyzed to address any problems. The timing of this water quality analysis in conjunction with "the permit application and review process" is unclear. Is that a concurrent effort?

Page 3-8 Reference is made to the land use specific runoff quality factors adapted from Harper 2003. These figures have been updated since that time and a more current reference may be more accurate.

Page 3-9 The document makes the statement that nutrient loads delivered through S-79 to the estuary are expected to be no more than presently delivered to the estuary. This assumption is highly speculative given historical loading from Lake Okeechobee and the changes to those loading rates based on unforeseen events such as hurricanes. The summary of that section should include a statement on these unforeseen effects.

Page 4-8 The document states, "According to CERP guidance memorandum 23.01 "Water Quality Considerations for the PIR Phase," the C-43 Basin Project falls into Category B, which means the project should be designed to achieve water quality improvements." The significance of this statement, and reason for referencing this document, are unclear.

Page 4-16 The "Nutrient Reduction Opportunities" section discusses water quality benefits from just operation of the CRWBSR, but there is no mention of the actual amount of nutrient loading that will be reduced. It is the County's understanding that some of this more detailed information is available based on the Test Cell project. This section would benefit from some specificity in terms of the actual reduction contemplated by the CRWBSR alone.

Page 4-30 The Section on Water Quality Evaluation Criteria lists improving water quality as a secondary goal of the project. Improving water quality is not listed as a secondary goal in the original "Yellow Book" purpose statements regarding the project. This statement should be struck from the document.

Page 5-34 The document states that assuming no water quality treatment in the basin, TP and TN loads are expected to be reduced 28 to 35% at S-79. On page 6-16, this figure is listed as 28%. Please explain the methodology for the 35% figure and the methodology to calculate these figures overall should be included in the document. Additionally, the short term increases contemplated in TN, yet the achievement of the average annual load reduction, are unclear.

Page 5-35 While the County agrees there may be a benefit from mere operations of the CRWBSR without a water quality feature at this time, it may be premature to conclude that the CRWBSR will not cause or contribute to water quality degradation under future conditions. See also page 6-17. Based on additional issues associated with contamination and clean up of the land and the short term TN issues identified in the comment above, this statement cannot be substantiated at this time. This comment is also relevant to the statement made on page 8-15, "The Caloosahatchee River (C-43) West Basin Storage Reservoir project selected plan complies with water quality standards applicable to the project and adjacent waters."

Miscellaneous Comments

Page 1-2 There is a typographical error in the last paragraph on this page. "Achieve" should be changed to "achievement".

Page 2-1 The land exchange between the 541.31 acres located north of the project boundary for the 600.13 acre Paul property should be clarified. The effects of this swap on adjacent

property owners should be reviewed. Will this land be needed for the activities commencing in July of 2007?

Page 2-37 The document states that without additional basin storage planned by CERP projects, flows exceed the target about seven months per year. The "CERP projects" referenced in the sentence should be identified.

Section 2.12 This section describes Hazardous, Toxic and Radioactive Waste property issues. The costs and commitments on remediating the sites are unclear. For instance, is this issue considered in the $446 Million estimated project cost or is it a future cost to be borne by the State of Florida?

Page 4-18 The Flood Damage Reduction section says that the project will not compromise the existing level of protection and that some incidental benefits may be achieved. These incidental benefits should be more clearly identified.

Page 5-4 The County is in agreement that the Caloosahatchee Estuary is in need of immediate helps and cannot wait until a holistic approach is developed to address all of the issues within the entire basin. But, there should also be specific timelines and commitments to address the remaining issues in one additional single study to be completed by a date certain. Potentially three PIRs and "subsequent studies" will continue to piecemeal the solution, cost more and delay that holistic approach to solving the Estuary's problems.

Page 5-37 The following statement in the document is confusing, "If nothing was done to improve the conditions in the estuary, the project team determined that the future without project condition would experience a gradual improvement for 15 year at which point the ecosystem would stabilize." The statement should be clarified or struck from the document because it seems to say that the CRWBSR may not even be needed because eventually the ecosystem will stabilize. For instance, how will it stabilize when data shows (such as water quality) conditions have been deteriorating?

Page 6-7 The document should clarify the difference between "completely resolving the problems of the Caloosahatchee Estuary and Caloosahatchee River (C-43) Basin and "the immediate needs of the estuary".

Page 6-31 The "commitment" from the SFWMD that "all of the outstanding point source remediation efforts will be completed" is unclear. Does the SFWMD have funding allocated to meet this commitment and when will it occur? Is it subject of an agreement and if so, what agreement? This section is concerning because soil contamination has also been identified in cultivated areas on the site. Remediation efforts are to place these soils into the core of the reservoir dam. While the County understands the funding constraints on the project the efficiency of using on site resources to construct the dam. The document states that there is still a risk to benthic organisms and the solution would be additional remediation efforts if needed. Costs for these efforts and more detail is necessary to assure that this issue does not cause project delay. See discussion also on pages 7-18 – 7-19.



HENDRY COUNTY PLANNING & ZONING DEPARTMENT

POST OFFICE BOX 2340 • 165 S. LEE STREET • LABELLE, FLORIDA 33975 • (863) 675-5240 • FAX: (863) 675-5317 • SUNCOM 744-4750

June 11, 2007

Mrs. Susan Conner
U.S. Army Corps of Engineers
PO Box 4970
Jacksonville, Fl 32232-0019

RE: Comments on the Caloosahatchee (C-43) West Basin Storage Reservoir Draft Integrated Project Implementation Report and Environmental Impact Statement

Dear Mrs. Conner,

The Hendry Planning and Zoning Department is in receipt of the Draft Integrated Project Implementation Report and Environmental Impact Statement. Based upon our review of the draft package, we offer the following comments:

1. The recreation features are being planned in the C-43 West Basin Storage Reservoir project as an incidental project benefit according to language in Appendix H, Section H.2.1. Hendry County believes the proposed recreational activities should be a permanent part of the reservoir project. The recreational activities need to be clearly defined and not subject to removal. Hendry County would like a commitment, from SFWMD, to provide equestrian trails, biking and hiking trails, fishing, hunting, nature watching, and ramps for motorized and non-motorized boating.
2. Hendry County believes the recreational activities should be available upon completion of the construction and opening of the reservoir.
3. The reservoir, during low volumes, should be open to non-motorized boating and airboats at a minimum. There needs to be agreement between SFWMD and Hendry County on set standards that define low volumes.
4. In Appendix H, Section H.2.1, page H-3, it is stated that shade trees are proposed on the outside area of the north rim canal adjacent to the parking. Hendry County would like to see additional trees and vegetation planted outside and around the reservoir to promote bird watching, aesthetics, shade areas for the public, etc. The County wants the reservoir to become an asset and not an eyesore.
5. Restroom facilities should be provided and operated by the SFWMD. Additional facilities should be added at the expense of SFWMD, as the need arises,

Southwest Florida Regional Planning Council

1926 Victoria Avenue, Fort Myers, Florida 33901-3414

(239)338-2550 FAX (239)338-2560 SUNCOM (239)748-2550

June 5, 2007

Ms. Sally B. Mann
Coordinator
Florida State Clearinghouse
Florida Department of Environmental Protection
3900 Commonwealth Boulevard, Mail Station 47
Tallahassee, Florida 32399-3000

Re: IC&R #s: 2007-032 & 2007-035/SAI #: FL200704263301C
Permit 3005-5958 (IP-TKW), Hendry County, Caloosahatchee River (C-43) West Basin Storage Reservoir, Draft Project Implementation Report (PIR), Environmental Impact Statement (EIS), and Tentatively Selected Plan (TSP), http://www.evergladesplan.org/pm/projects/docs_04_c43_pir.aspx

Dear Ms. Mann:

The Southwest Florida Regional Planning Council (SWFRPC) has reviewed the Proposed Permit 3005-5958 (IP-TKW) for the Caloosahatchee River (C-43) West Basin Storage Reservoir, Draft Project Implementation Report (PIR) and Environmental Impact Statement (EIS), and has the following comments.

The request dated April 30, 2007 was received for our review on May 4, 2007.

The proposed project has the potential to effect hydrology, water quality, wetlands, and wildlife within one of the largest manmade canal systems within the Southwest Florida Region.

There are several components of the Tentatively Selected Plan (TSP) that will have environmental benefits including:

- Construction of a 170,000 acre-feet reservoir with the expressed purpose of reducing the number and duration of extreme hydrologic events at S-79 locks on the Caloosahatchee River.
- Reduction in the number and duration of high flow (>4500 cfs) and low flow (<450 cfs) events in the Caloosahatchee River.
- Adopting and implementing targets of 0 flows below 450 cfs and above 4500 cfs for the Caloosahatchee River.

TO: Ms. Sally B. Mann
DATE: 6/5/2007
PAGE: 3
RE: IC&R #s: 2007-032 & 2007-035/ SAI #: FL200704263301C

4) The missing pages in the Final Biological Assessment concerning methodology that should be present between pages A-95 and A-96 in Annex A of the FWCA Report and Endangered Species Act Compliance should be inserted into the documentation of the PIR.

The SWFRPC supports the concept and development of the C-43 reservoir project to reduce the negative hydrologic discharges to the Caloosahatchee River, restoration of base flows for the Caloosahatchee River, and improvement in water quality of the Caloosahatchee River. Our staff has participated cooperatively in the development of the PIR and EIS. We did not and do not agree; however, that water quality protections should be deferred in development of this project.

We look forward to cooperating with the applicant and other relevant agencies to resolve the issues that we have identified in this letter in order to ensure consistency with the Coastal Zone Management Act/Florida Coastal Management Program and to ensure that the TSP proceeds in a fashion that minimizes impacts to water quality, hydrology and fish and wildlife resources in the Southwest Florida Region. Staff has been in contact with Hendry County Planning and they had indicated that they will be submitting comments; but to this date they have not been completed. Please note that Hendry County's comments will be submitted under separate cover.

Please call me if you would like to coordinate further discussion of these issues; I will be glad to facilitate any such efforts. If you have specific questions about the content of this letter, please contact Ms. Jim Beever directly at (239) 338-2550 ext 224, e-mail jbeever@swfrpc.org.

Sincerely,

SOUTHWEST FLORIDA REGIONAL PLANNING COUNCIL

Mr. David Y. Burr, AICP
Executive Director

JB/DYB/nlg

CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE EVERGLADES RESTORATION PLAN

CALOOSAHATCHEE RIVER (C-43)
WEST BASIN STORAGE RESERVOIR PROJECT

DRAFT INTEGRATED
PROJECT IMPLEMENTATION REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

Comments prepared by:
Pete Coultas, P.E.
Manager of Agricultural Engineering
A.Duda & Sons, Inc.

Dated:
June 11, 2007

As a landowner adjacent to the proposed Reservoir south boundary, A.Duda & Sons (ADS) has specific concerns, some of which have been, are being, or should be addressed through direct discussions with the Reservoir Project management. Some of these specific concerns are as follows:

1) Well abandonment and ASR effects on local groundwater supply.
2) Public recreation on the outside of the Reservoir perimeter canal. This would provide the public with direct access to our property. Real recreational activity exists inside the proposed perimeter canal. Access to the outside should be restricted to provide a buffer between offsite lands and the public.
3) The Townsend Canal capacity may become a problem in terms of our irrigation withdrawal. What measures are in place to offset this potential conflict?
4) Will the Reservoir become a "consumptive user" of water in dry times? Other South Florida reservoirs require a minimum water level.
5) ADS has an existing easement along the east side of the Townsend to SR80. What provisions have been made for equivalent access?
6) Piezometers are in place to monitor lateral seepage to adjacent lands.
7) Conversion of habitat on a tract this large may displace a significant wildlife population. What mitigation avenues are available to an adjacent landowner if their property becomes a site for a refugee population?

Following a review of a large portion of the Draft Report and Statement, I am providing the following general comments. Excerpts were taken from the ACOE Draft Integrated Project Implementation Report and Environmental Impact Statement. Each is followed by the PDF file page number and my associated comments.

1.1 REPORT AUTHORITY

The CERP was approved in Section 601 of WRDA 2000, which states, in part:

> *(b) Comprehensive Everglades Restoration Plan Approval –*
> *(1) APPROVAL*
> *(A) IN GENERAL. —Except as modified by this section, the Plan is approved as a framework for modifications and operational changes to the Central and Southern Florida Project that are needed to restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Plan shall be implemented to ensure the protection of water quality in, the reduction of the loss of fresh water from, and the improvement of the environment of the South Florida ecosystem and to achieve and maintain the benefits to the natural system and human environment described in the Plan, and required pursuant to this section, for as long as the project is authorized.*

Page 49
This paragraph approves the ecosystem restoration, "while providing for other water related needs of the region". This phrase indicates a corresponding action, i.e. the water supply element is authorized along side the environmental releases to the estuary.

2.15 EXISTING LAND USE

The Caloosahatchee River (C-43) West Basin Storage Reservoir is proposed for construction in north-western Hendry County. This reservoir is intended to reduce the fresh water pulses into Charlotte Harbor and the Caloosahatchee Estuary, and provide water storage for meeting environmental needs. Additional water, after environmental needs are met, could be used as supplemental water to help meet the needs of agriculture and urban communities in Southwest Florida. The study area includes Lee, Hendry, Glades and parts of Charlotte County. Collier County is located in the general vicinity of the study area. ***Figure 2-12*** depicts the 2000 land use map for the South West Florida Region. This map was generated for the South West Florida Feasibility Study and includes the Caloosahatchee River (C-43) West Basin Storage Reservoir study area.

Page 121
This paragraph limits the regional water supply benefit to a secondary concern. This is inconsistent with Section 601 of WRDA 2000 (see page 49).

2.12 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

The five major land parcels acquired for the Caloosahatchee River (C-43) West Basin Storage Reservoir project are the Berry Groves tract, Bryan Paul Grove tract, Bob Paul Grove tract, the Winthrop property, and the Griffin property. Prior to the 1960s these lands were primarily used as unimproved pasture. For the last 30 to 40 years these five parcels have been used to cultivate citrus. Over the operating life of these groves, fertilizers, herbicides and pesticides have been applied routinely as part of normal agricultural operations. From the 1960s to 1980s, pesticide use would have included the application of persistent organic

Page 112
I did not see any summary of wells to be abandoned. Significant local and regional ground water contamination could result from improper or no well abandonments. Any proposed ASR wells would be far below any local aquifers, I presume?

The Governor's Commission for a Sustainable South Florida identified agriculture and tourism as "critical industries" for maintaining the economy in the southern part of the state. In Lee and Hendry County, agriculture is a major industry and citrus production predominates. A rapidly expanding human population demanding more developable lands and advancing agricultural development now threatens the relatively pristine natural areas. The tourism industry is also dependent upon the region's ability to sustain its economy and its quality of life through management of its resources. Agriculture and tourism depend on a system that can provide vital water supply needs and flood protection.

Page 118 (repeated on page 173)
The dependence of these "critical industries" on water supply points to the importance of maintaining the water supply benefits while providing the environmental releases for the estuaries. Agriculture and tourism have co-existed for over 100 years. To suddenly subjugate one to the other is unwarranted.

The watershed downstream of the S-79 structure that contributes directly to the Tidal Caloosahatchee River is primarily urban (Cape Coral and Fort Myers). Although some of this urban area pre-dates the 1979 state rule regarding the prevention of the pollution of state waters from stormwater runoff (62-25 Florida Administrative Code), much of it was developed after this rule went into place. Although urban areas can be significant sources of nutrients and pollutants, the impact from this urban area appears to be relatively minor compared to the proportion of nutrient loads delivered to the Caloosahatchee Estuary through S-79 inflows. A study by ERD (2003) found that, discharge from S-79 contributes from 90 percent to 95 percent of the mean annual mass of total nitrogen (TN) and total phosphorus (TP) to the Tidal Caloosahatchee River (for this report, the USACE has estimated that S-79 contributes more than 75 percent of the nutrient loads). The next largest contributor to the Tidal Caloosahatchee River was the Orange River with 1.1 percent to 3.8 percent of the annual mass of TN and TP.

Page 170
This comparison of the urban areas along the estuary to areas upstream of the S-79 tells only part of the story. If an acreage or total flow comparison of the entire S-79 tributary watershed were included, the 90% to 95% conclusion would not be surprising, given that the watershed extends from the S-79 to Orlando. In other words, the urban areas along the estuary are a very small portion of the total flow and therefore a small contributor to loading. Water quality issues within the local urban watershed should not be overlooked.

4.1.4.1 Water Supply

While providing additional water supply for urban and agricultural users represents a potential opportunity to be addressed by the Caloosahatchee River (C-43) West Basin Storage Reservoir, providing water supply to meet the environmental needs of the estuary during dry periods is one of the primary purposes of this project. Upon meeting flow targets at the S-79 structure necessary for ecosystem restoration in the Caloosahatchee Estuary, any additional water stored by the Caloosahatchee River (C-43) West Basin Storage Reservoir could be delivered to the C-43 Canal and would be available for other water related needs.

Water supply and flood control benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir implementation will be classified as incidental. Increases to flood damage reduction benefits and water supply benefits will not be further analyzed as part of this study; however, a later PIR will investigate opportunities to increase the quantity of water available for municipal, agricultural, and other environmental interests in the basin. Analysis of area water supply is being conducted by the SFWMD in a report entitled Lower West Coast Water Supply Plan Update.

Page 174
The classification of water supply as "incidental" is contrary to Section 601 of WRDA 2000.

May 10, 2007

Ms. Susan Conner
U.S. Army Corps of Engineers
701 San Marco Blvd.
Jacksonville, Florida 33207 - 8175

Subject: Draft PIR and EIS on the Caloosahatchee River (C - 43) West Basin Storage Reservoir Project

Dear Ms. Conner:

Committee of the Islands (COTI) is a Florida not - for - profit corporation which has as one of its missions, preservation of the unique natural environment of Sanibel and Captiva Islands. COTI urges the Army Corps of Engineers to work with the South Florida Water Management District to include a filtration marsh in plans for the proposed C - 43 Reservoir.

The waters surrounding our islands are being degraded by excessive nutrient run off into the Caloosahatchee River. As a direct result, abnormal algae blooms threaten our wildlife, the tourism business which supports tens of thousands of workers and property values of all residents of Lee County. The proposed C - 43 Reservoir will do little to alleviate this problem unless it includes a Storm Water Treatment Area (STA) to remove excess nitrogen and phosphorous before the stored water is reintroduced into the Caloosahatchee. This will require the prompt acquisition of lands for use as a filtration marsh near the C - 43 Reservoir.

Storm Water Treatment Areas are routinely included in projects of this type throughout the state of Florida. The Calooshatchee is in dire condition. Rather than be singled out for less effective treatment than other localities, it should be treated in the same way. A STA for he C - 43 Reservoir is therefore essential.

We thank you for your consideration of these comments.

Respectfully submitted,

Lawrence M. Schopp, President

U.S. Army Corps of Engineers
701 San Marco Blvd.
Jacksonville, Fl. 32207-8175

Attention: Susan Conner

Dear Sirs,

We would like to add our voice to the insistence that the storm water treatment area proposed for C-43 must include a filtration marsh to go with the C-43 reservoir.

Sincerely,

Donald L. Deming
Melanora L. Deming

May 11, 2007

Curt Stendahl
3135 West Gulf Drive, Apt. 204
Sanibel, FL 33957

May 10, 2007

Ms. Susan Conner
U.S. Army Corps of Engineers
701 San Marco Blvd.
Jacksonville FL 32207-8175

Dear Ms Conner,

I greatly appreciate the opportunity to comment on the C-43 reservoir project. Regrettably I will not be able to attend your public meeting on May 17, but please accept this letter as a substitute for the comments I would have made had I been able to attend.

My wife and I have been residents of Sanibel for some 22 years after I retired from a position up north. We were attracted to this area because of its pristine environment and we like to think that we have contributed in some small way to keep it that way. Now after Hurricane Charlie the local eco system has been seriously disrupted and Sanibel Island as well as neighboring municipalities have been plagued by red drift algae accumulating on our shores. We now urge the U.S. Army Corps of Engineers to do your part in assisting our efforts to eliminate this plague from our beaches.

You can help by adding storm water treatment areas (STA) to C-43 as you have done with other reservoirs you have developed in south Florida. Without these STAs I am convinced that some form of algae will form, be subsequently discharged to the Caloosahatchee River and end up on our beaches when C-43 is drained. We are only asking for fairness. If other areas are provided with STAs to provide them with quality water why not do the same for Southwest Florida?

Regards,

Curt Stendahl

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

October 6, 2006

RECEIVED
10 Oct 06

Stuart J. Appelbaum
Chief, Planning Division
U.S. Army Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

Attention: Susan Conner

Service Federal Activity Code: 41420-2006-0443
Date Received: September 7, 2006
Project: C-43 Basin Storage Reservoir Project, Part I-Phase I
Counties: Hendry, Glades, Charlotte, Lee

Dear Mr. Appelbaum:

Thank you for your letter dated September 1, 2006, in which you formally invited the Fish and Wildlife Service (Service) to become a cooperating agency for an Environmental Impact Statement (EIS) on the C-43 Basin Storage Reservoir Project, Part I-Phase I (C-43 Project). The C-43 Project is a component of the Comprehensive Everglades Restoration Plan, authorized under the Water Resources Development Act of 2000.

The objective of the proposed action is to improve the quality, quantity, timing and distribution of freshwater flows in the Caloosahatchee River and Estuary to restore ecosystem function. The proposed action includes construction of an above-ground storage reservoir (i.e., C-43 West Reservoir) in Hendry County, Florida, that will provide a significant portion of the overall water storage needed in the Caloosahatchee basin for estuary restoration as described in the Central and South Florida Project Comprehensive Review Study.

The Service, as part of the C-43 Project Environmental Sub-team, is actively working with project managers to develop alternative plans that provide significant ecological benefits while supporting project goals and objectives. Although we intend to continue our work on the study team, the Service declines your invitation to become a cooperating agency for the development of the EIS on this project. We will continue to take a broad system-wide perspective and a balanced approach in our evaluation of the potential effects of the proposed action on fish and wildlife resources, including threatened and endangered species, and to assist with the development of appropriate alternatives to avoid and minimize potential adverse affects of the action. The Service must balance its role as a study team member with its statutory

responsibilities to independently review this proposed action under the Fish and Wildlife Coordination Act and the Endangered Species Act.

Thank you for this opportunity to provide comments on this project. The Service appreciates your efforts in helping to protect the fish and wildlife resources of south Florida. If you have questions regarding this letter, please call Joyce Mazourek at 239-472-1100, extension 231.

Sincerely yours,

Paul Souza
Field Supervisor
South Florida Ecological Services Office

cc:
District, Fort Myers, Florida (Janet Starnes)
FWC, Vero Beach, Florida (Dr. Joseph Walsh)
Service, Jacksonville, Florida (Miles Meyer)
Service, Atlanta, Georgia (Jeff Weller)

B.4.2 Public Meeting Transcript

UNITED STATES ARMY CORPS OF ENGINEERS

PUBLIC MEETING

HELD ON

THURSDAY, MAY 17, 2007

6:30 p.m. to 7:49 p.m.

AT

LABELLE CIVIC CENTER
481 WEST HICKPOCHEE
LABELLE, FL 33440

RE: CALOOSAHATCHEE RIVER (C-43) WEST BASIN
STORAGE RESERVOIR PROJECT
DRAFT PIR PUBLIC MEETING

ORIGINAL

GUARDIAN REPORTING, INC.
~ Proudly Serving Southwest Florida ~
(941) 575-9533 * www.guardianreporting.com * *Fax* (941) 575-8618

MR. DUKE: We're going to get started.

THE INTERPRETER: Before beginning, if there's anyone here who would prefer to hear the presentations in Spanish, there is simultaneous translation available. (Continues in Spanish).

MR. DUKE: Okay. Thanks. Okay. Thank you all for coming out tonight. We brought a little rain with us, much needed. At least it cleans the lovebugs off the windshield after a while. Tonight's meeting's about the Caloosahatchee C-43 west basin storage reservoir. This is a part of the Comprehensive Everglades Restoration Plan, the ten and a half billion dollar program that the State of Florida and the Corps of Engineers on behalf of the federal government are launched into in partnership with other state and federal agencies to restore the South Florida ecosystem which includes primarily the Florida Everglades as well as the estuaries and other areas around the entire peninsula of southern Florida. This is one of the components of the 68 total components that comprise that comprehensive plan. It is -- was approved as part of the Water Resource Development Act of 2000 by congress as a road map and overall plan for the restoration of the ecosystem.

What we're here tonight to talk about and, hopefully, this is not the bus to Abilene. This is about

the C-43 basin reservoir. We're going to go through a detailed presentation of where we are to date. The team has been working. We have what's called a project delivery team that comprises members of the Corps of Engineers, the Water Management District, US Fish & Wildlife, and other agencies that participate on this team to develop the plan that was originally identified in that -- what we call the Restudy Report that was submitted to congress that provided the basis for the authorization back in the year 2000.

We've been working on this for several years now developing and refining that plan, identifying the benefits, and so forth, and they'll walk you through the purpose, the objectives of the overall study, what they've identified as alternatives, and the results of the findings to date. We'll go through part of the plan and describe the features of the plan, the components of that, and the operations of the reservoir once it's completed, and then we'll take public comments.

Okay. We do have transcriber here who will be taking a record of the meeting. It will be recorded in that fashion. Comments will be taken. If you have long comments, I'll go through that. Just remind you, please submit them in written form. We take written comments now as a part of this overall process and include them in

our environmental document, environmental impact statement that we have for this project. Okay. That'll all become part of the official record, and I encourage you to participate and provide comments to us and feedback.

Again, this is part of the overall CERP plan. The state of Florida through the South Florida Water Management District is part of the initiative to bring restoration benefits earlier initiated back in 2004, a program they called Acceler8. It was dubbed the A8 program in which they would up front fund and initiate the design and construction of certain components of the South Florida Restoration program in advance of the Corps of Engineers receiving funding from congress.

They also have as a part of this a -- one of their A8 programs or projects is the C-43 reservoir; so they've been out there building test cells and doing their detail, design, and so forth on this project to move forward with construction. They're waiting for us to finish the PIR to identify the plan that is to be actually implemented, and that will be the project that's actually constructed by them. So in case you're wondering, we're going to answer questions about how the two fit together and how that's being funded totally by the state at this point in time and what the ultimate

benefits and purpose of this.

So if you have questions, I'd ask that you hold it to until end of the presentation. Hopefully we'll answer a lot of those as we go through this. But we'll get into the public comment period. If you have additional questions or questions at that time, please feel free to state those. If you would like to make a public comment, there was comment cards up at the table. Please fill one out for our records with your name, address, and so forth. We don't sell it to a mailing list, but we do keep it as part of our official record so we know who you are and what your comment is and have that for our transcription. Okay?

Okay. And with that, I'll introduce Janet Starnes from the South Florida Water Management District who will start this off. Thank you, Janet.

MS. STARNES: Okay. In that case, and I'll have to play with this first. The first thing I want to point out is I am Janet Starnes. I am with the South Florida Water Management District, and I am the project manager for the South Florida Water Management District. But with us here tonight are many, many staff members that have dedicated a tremendous amount of time, energy, and effort, in particular over the last five months, to getting this project to a Draft Project Implementation

Report; and they are here to assist us in answering your questions and providing you the information you need.

In particular, Beth Marlowe is here. Beth is the -- my counterpart at the Corps. She is the project manager. We also have David Apple. He is our planning technical lead. He's the one who makes sure that all the actual hard work gets done. And we also have Aaron Kelly with us, which is our engineering technical lead, and he's the one that makes sure that when we build it it'll actually stay up. And those are very important things.

That being said, the purpose of this meeting, as Dennis was pointing out, is to go over the project and kind of give you an overview of what the project is and why we are building the Caloosahatchee River West Basin Storage Reservoir Project. And I should have pointed out this sooner. We actually have changed the name of this project. Many of you may have known it as the C-43 Basin Storage Reservoir Project. It is actually officially now known as the Caloosahatchee River West Basin Storage Reservoir Project, and that's -- that is the official name. That was changed, oh, a couple weeks ago through the process of internal reviews. It was just felt that rather than referring to it as a numbered canal that due to the fact that this was an environmental restoration it was far more appropriate to refer to it as the

Caloosahatchee River, which is what we are actually attempting to restore is the Caloosahatchee River and the associated estuary of the Caloosahatchee estuary.

We are also going to go over the draft operating manual. That is required; so we will be doing that. In addition to that, as Dennis was pointing out, we will be taking questions, concerns, and issues.

That being said, the purpose of this project is to restore the quality of -- the quantity of water, the timing, the flows to the Caloosahatchee estuary. This is a basin storage reservoir project, and we have named it "basin storage" for a very specific reason. It is -- the focus, the primary focus of this project is actually on the quantity of water when it hits S-79 or the Franklin lock and dam and the impact that that fresh water has on that estuary. Fresh water, in and of itself, in high level -- high quantities affects the salinity in such a fashion that it, in and of itself, can cause a water quality problem; so we thought we need to solve that problem first, really focus on that quantity issue, and then we'll work with the quality issue as we move along.

What we will be doing is we will be grabbing the high flows in the river during wet season, and then during dry season when those high flows are no longer there and we actually have extreme dry seasons or dry

seasons beyond what would be the normal range, we will then release that water out of the reservoir so that it goes to the estuary. And the whole purpose and intent of that is actually to maintain a more natural salinity regime within the estuary. So the focus of this project is environmental restoration of the estuary. And that's a real important piece to remember as we go through this process.

Just to familiarize you all with the Caloosahatchee watershed, although I know many of you are familiar with it, and then I know there are some folks here that are less familiar, the Caloosahatchee watershed begins at Lake Okeechobee. It's at Structure 77. It travels down, it passes through another structure, which is the Structure 78. These are both lock and dams. And then at S-79 -- in this project we actually consider the Structure 79, or the Franklin lock and dam, to be the beginning of the saline or the estuarine system. So we are -- we basically are looking and we will be managing and operating based on flows at S-79, and that's fresh water flows at S-79. And we are going to manage it for quantity and for timing so that we get a flow regime that is closer to the more natural regime prior to man impacting this system.

Before the C-43 canal was put into place, the

Caloosahatchee River was actually not connected to Lake Okeechobee. It was only during very, very, very extreme events when the lake came out of its banks and flowed as sheet flow towards the west that it would end up actually coming into Lake Flirt, which is right about in here. So it was not -- the natural river was not connected to Lake Okeechobee. That is actually a function of man's actions.

The Caloosahatchee River estuary is actually going to be located here in LaBelle. It's just west of LaBelle. It is along State Road 80. It's at the Berry Grove site for those of you who are familiar with the Berry Grove citrus operation, that is actually the location of the reservoir itself.

And as Dennis pointed out, this project was authorized for planning purposes in the Water Resources Development Act of 2000; however, it will go back to congress as a Project Implementation Report for full authorization and then subsequent appropriation. It is one of the critical projects in terms of the implementation of the Comprehensive Everglades Restoration Plan; so, therefore, the State of Florida is moving forward with the construction of this project under what's known as our Acceler8 project.

And that -- The whole intent of the Acceler8 project

is to get the larger projects in the ground as quickly as possible so we can move as quickly as possible forward with implementation of CERP in order to begin to alleviate some of the impacts that the management of Lake Okeechobee has been having on the Caloosahatchee estuary as well as the St. Lucie estuary and south.

To accomplish the goal of getting the Acceler8 project -- keeping the Acceler8 project moving, and still dealing with all of the many, many concerns within the Caloosahatchee watershed, a determination was made about two years ago that rather than going forward with a single Project Implementation Report that covered both the upper basin and the lower basin and covered not only quantity problems and issues but quality problems and issues, as well, a decision was made that, again, the first and foremost issue is the quantity. We've got to solve the quantity problem first; so a decision was made to split the Project Implementation Report into two project implementation reports.

The first one, the one we're here about tonight, is the Caloosahatchee River west basin storage reservoir. It is a reaffirmation of the restudy or the Comprehensive Everglades Restoration Plan as adopted in the Water Resources Development Act of 2000. And it will provide immediate relief to the Caloosahatchee estuary by pulling

off many of those high flows that occur today because it is a man-influenced system and switching those flows out so that they actually get there during dry season when it is more appropriate for -- when we're short on water during dry season and we've got lots of extra water during wet season. We're going to be able to now grab the wet season flows and then release them during dry season when the system is desperately in need of fresh water.

We will be doing the second Project Implementation Report that will also go to congress for authorization. We're actually going to kick that off in September of this year. It will focus on the broader problems in the watershed itself. It will also deal to a much greater extent with what we call the upper watershed or those portions that are in Glades and eastern Hendry County. It is also where we will focus more on water quality features and the needs to do water quality -- I don't want to use the word "treatment." That's not a good term -- but water quality enhancements. Thank you, Aaron. That's a perfect good. And our goal is to identify where there's a problem so we can -- and do the treatment or do the -- do the restoration associated with water quality where the problem occurs, not all the way at the downstream end of this system. So that's much of

the focus in the second Project Implementation Report of the Caloosahatchee River watershed will actually be -- we will focus on watershed -- on water quality.

In addition to that, we know that this Project Implementation Report is only going to solve about 70 percent of the quantity problems. In other words, we're still going to have high flows going to the estuary in times that we don't want them. And there will still be dry season flows that are too low to maintain a healthy estuary even within what would be a average kind of regime. There will always be floods. There will always be extreme events. We aren't even attempting to do away with extreme events. The natural systems actually need it, extreme events, in order to stay healthy. But we have about 30 percent additional storage capacity that we will need to identify and then move forward with in terms of the Project Implement -- the second Project Implementation Report as well as deal with the water quality issues within the basin itself.

And at this point, I do believe I'm turning this over to Beth, and she's going to walk you through the technical aspect of the Project Implementation Report.

MS. MARLOWE: Hi, everyone. Thank you very much for joining us this evening. We really appreciate everybody's interests in this project.

When the Corps of Engineers goes through a ecosystem restoration planning study, or in this case we had the restudy or the yellow book road map as a starting point. But, still, before we can go to congress and say, you know, we'd really like the American taxpayers to invest money in this project because we think it's really important, we need to do a study so that we can be sure that we've looked at all the problems and opportunities, we've come up with some good alternative plans, and we've really picked the best one.

So one of the things that we need to do is look at the future without project condition. Well, what really is that? We look out into the future, usually about 50 years, and say what do we expect the conditions in this ecosystem that we're trying to restore to be like if we don't do anything. So that's kind of what this is -- this is looking at: What if we didn't do anything for the Caloosahatchee estuary. What would we expect to happen.

Well, we would expect the regulatory releases from Lake Okeechobee to continue with the extreme highs in the wet season and then not enough flow in the dry season. For the ecosystem of the estuary we would expect the continuing extreme changes and variability in salinity that is degrading the ecosystem there. And that would

have impacts on sea grasses, on small fish and other little invertebrates that the larger animals in the ecosystem depend on. And that eventually has an impact, too, on people and our socioeconomics. It would impact commercial and recreational fisheries as well as just boating and people liking to be out in the estuary. So that would be our future without project condition.

From there we say, okay, well, what can we and should we do based on the problems and opportunities. We work with the public to identify and start coming up with solutions to try to solve these problems. As Dennis and Janet mentioned, we have the restudy as a road map and a starting point. And if you're not familiar with that, the feature that was identified to try to help solve Caloosahatchee estuary problems in the restudy was an above-ground reservoir. At the time they were guessing around 160,000 acre-feet of storage would be needed and an approximate location and approximate size and depth. And the restudy said when we go into this Project Implementation Report phase, we'll refine that design and the actual location. And that's what we've been focusing on in this draft report. We've been optimizing the feature that was in the yellow book.

So what we did was look at some smaller reservoirs, larger reservoirs, and one kind of in the middle that was

about the same size. Also, if you're not familiar with an acre-foot of water, that's just a way of saying imagine one acre of land with water one foot deep. And we're looking at several hundred thousand acre-feet; so it's a lot of water. We developed lots of different alternatives throughout our study and eventually screened them down to these five.

The first alternative is always the no action alternative or the future without project condition, what if we didn't do anything. That's what we're going to compare all of our alternatives to. The others are the different variations on the reservoir.

If you look at the second and third columns, you see the difference in size. And it's a difference in the storage capacity, but all of these reservoirs are looking at actually the same footprint on the ground. The embankment heights would differ to hold the different amounts of water. We also have differing pump capacities. The pump is used to pull water out of the Townsend Canal, ultimately the Caloosahatchee River, into the reservoir. And the pump capacity has to do with how fast you can pull water in.

And then the other columns go into how we look at benefits and costs for these alternatives. If you have several different alternatives for something you want to

try to accomplish, it's a good idea to look at, well, what kind of benefits do I get from that and how much does it cost me. If you're looking at something that has benefits you can measure in dollars, that's pretty easy. You look at, you know, what's the dollar benefit that you get out of it versus the dollar cost that you put into it. Well, with ecosystem restoration there's no good or easy or agreed upon way to put a dollar value on a healthy Caloosahatchee estuary; so we had to come up with another method to do that.

And right now the Corps of Engineers were using something that's called a habitat unit which is a way of trying to capture a quality -- an index of the quality of your ecosystem and also the spacial extent of it. And we'll talk about that a little bit more later on. Bottom line, these numbers show how much more benefit we think the estuary is going to get compared to the future without project condition; so the higher the number the better, all other things equal.

Then we also look at the costs, and what you have here are average annual costs over the life of the project and a cost per habitat unit. The three rows in the middle are highlighted in green because they are -- have been determined to be cost-effective projects. And what does that mean? Well, that means that you can't get

more benefits for less cost -- no -- for the same cost for any one of those or you can't find another project that costs less for the same amount of benefits. I may have confused you a little bit there, but we can talk more about that after the presentation.

So how do we start talking about ecosystem benefits. Well, first we do have a hydrologic flow range that we're trying to target. We have a minimum flow level we want to try to be above and an upper flow level we want to try to stay below. And that range is about 450 to 2,800 cubic feet per second of flow over Structure 79 at the beginning of the estuary. Our analysis shows that about 75 percent of the time the alternative that we're recommending will be within that flow range. Now, as Janet mentioned, we can't solve all of the problems with excessive flow or low flows with this one reservoir, but we can get there about 75 percent of the time. So that's one way of looking at it. But that's -- that's a change in flow.

How do we relate that to positive benefits in the estuary. What our team did was take several species from the estuary that are ecologically important because they influence a lot of other species or are economically or recreationally important, and we developed some habitat suitability models for these species. And we looked at

how our flows from our alternatives would affect these species, how these species would respond in these models. And we came up with kind of a quality score. So if you combine that with our hydrologic performance, you can get sort of an overall indicator of what's the improvement in the quality of this ecosystem as a result of what I'm trying to manage in my alternatives. And we did pick these species because they all provide habitat or they're at the base of a food chain; and they also, importantly, have an established link or response to this stressor that we're trying to manage, which is flow, which impacts salinity.

So bottom line we came up with a way to try to predict the change in quality of the ecosystem as a result of our alternatives; and then we tried to apply, well, how much area would that change in quality affect. And if you look at this graphic, it shows you up here -- Sorry. Let me go back. Up here that is where Structure 79 is at the head of the estuary. And we are anticipating that this project will affect all of these areas where you see the red, and that's approximately 71,000 acres of estuary. So to get that habitat unit that you saw in the chart, you take your quality index score times your area of benefit; and you come up with that habitat unit number.

And, again, this is just a recap of the alternative that we are recommending. It's 170,000 acres of reservoir with 1,500 cfs pump. Our total initial cost is about $446 million, and we're expecting the benefit in habitat units to be about close to 13,000 a year. Now, why did we pick this alternative and not one of the others. Well, it is a cost-effective plan. We have to pick a cost-effective plan. We wouldn't be doing our duty to the American taxpayers if we didn't do that. It also fully meets our planning objectives.

Now, there is another alternative, 3C, that is identical to 3B except that it has a little bit larger pump size. That one has a little bit lower cost per habitat unit; but when we looked at that, we said, well, there are some potential risks associated with that one in terms of what we might have to do to improve the Townsend Canal to allow the amount of flow that would be coming through to use that larger pump. So since this alternative is cheaper, it meets our goals and objectives, why don't we build this one. It's acceptable to our local sponsor. If we decide at some point in the future that we do need more pump capacity, that can always be added on; and we can -- we can base that on actual operations of the reservoir as we go forward.

Okay. This graphic is virtually the same as this

display board up here. This one actually might be easier to see than this. It just gives you a little bit of an overview of the site plan. The red line in the rectangle is showing you where the top of the embankment would be. We're looking at a reservoir approximately 10,500 acres; so it is very large. We're looking at two cells. That helps us be able to manage the water better, and it also minimizes the water we lose to the atmosphere from evaporation. Up here in the northwest corner is our main pump station. That's where we would draw the water from the Caloosahatchee River, that you can see up here in this corner, through the Townsend Canal and into the reservoir. The -- Both cells have a main discharge structure up in the northwest corner. There's two.

Then, let's see, the average depth of the reservoir pools would be 17 to 19 feet. The embankments are about 35 feet above grade; so if you're trying to picture this, it's a pretty massive structure. We are designing the embankments to dam safety criteria. These are not just hills of dirt. They're very exactly engineered, and they are designed first and foremost to be safe, to be sure that no property or people are impacted. We also have in this design some armoring to help prevent erosion of the embankments as well as a cutoff wall which helps -- it's kind of a wall that's built into the embankment structure

that helps eliminate seepage water out of the reservoir. Also around the embankments the blue line that you see is the perimeter canal. That helps control seepage as well as delivering water to users around this site that got their water from I think this canal here previously. So we are maintaining the flows that those water users are entitled to. I think those are the major points on the design.

We also are including, as kind of an add-on to the project, some potential recreation features. I do need to point out that the primary purpose of this reservoir is to be operated to maintain the health of the estuary. But from the Corps of Engineers's perspective, if we can add on some recreational features to this project without compromising the purpose of it for ecosystem restoration, then, by all means, we want to try to do that. So some of the features that are anticipated are a boat ramp that would allow access to both cells, some hiking and biking along the embankment, the top of the embankment, at least part of it, maybe not all the way around, and then also an access road around the perimeter canal. We would envision fishing, bird watching, horseback riding, potentially some boating. I think we're not settled yet on exactly which types of boats we would be talking about but definitely some boating.

And this is a breakdown of the costs of the recommended plan. Again, total initial cost of $446 million, and that does include about $2 and a half million for the recreation features. So that is, in a nutshell, the Caloosahatchee River west basin storage reservoir.

If you would like to make comments, please, by all means, we would love to have your comments tonight. But I know this is a lot of information. If you're hearing some of this for the first time, it can be hard to digest. Our full report is posted on our website, evergladesplan.org. You can also ask us to send you a copy, either a paper copy or a CD. We'll be more than happy to do that. If you have comments after you do some thinking about it or after you read a little bit of the report, by all means, please send them to us. Our 45-day public comment period runs until June 11th. And what we will do then is we will have a matrix of all the comments we got and then how we respond to those comments; and that will become part of our final report and our official record. All the comments can be sent to Susan Conner. And, Susan, would you mind standing up and waving? Susan is the one who will take your comments. She's very nice. She's not scary at all. You can send her your comments. And that's her contact information

right there. Okay.

That said, I think we will move now to the draft operating manual.

MS. RAULERSON: Hi. My name is Stephanie Raulerson, and I'm a hydraulic engineer in the water management section with the Corps of Engineers. And I guess I'll say this is the no-frills portion of the presentation because I don't have any pretty pictures or anything; so hopefully I'll get this right, too.

Okay. What's the purpose of an operating manual. The purpose is to describe the day-to-day water management operations for all conditions affecting the reservoir and the project. Now, I think a better description is they used to be called the Water Control Plan. So we're actually saying how we're going to control -- the waters will be operated to control that water. And Beth had already touched on some of the features; so I won't dwell on this too long. But the main inflow pump station is Pump Station 1 over -- let me get this -- over here to this corner. And then the Culvert 12.

She had mentioned that we have two cells, and that allows us more flexibility in the operations. And we have Culvert 12 right here in the middle. If we wanted to perform maintenance in either one of these cells, we

can cut off one and operate, like -- so we could cut off cell one and operate cell two or vice versa because of the structure. The reservoir we operate to store excess basin runoff and discharges from Lake Okeechobee and deliver water to the Caloosahatchee River. And operations are based on maintaining desirable salinity levels in the Caloosahatchee estuary system. And, as said previously, as measured by the flows at S-79.

One thing is we -- the operations would be seasonal. And the bullets are all back there, too, and I won't elaborate too much, but the main gist of this without reading it to you is that early in the dry season we will partially begin releasing from the reservoir rather than just send it all out initially. And then, like I said, this is based on when -- on S-79 flows. For instance, when flow at S-79 is less than 450 cfs, we'll begin partially opening to allow releases out of the reservoir. And that's early in dry season. And when it -- the flows increases above --

MR. FRANK: You need to speak into the microphone, please.

MS. RAULERSON: I'm sorry. Maybe I need to lower it, too. I'm short. Is that better?

MR. FRANK: Yes.

MS. RAULERSON: Sorry. When the flow is greater

than 450 cfs, then we will close off the reservoir and, see, the pump station will begin bringing into the reservoir rather than releasing. Excuse me. Let me restate that. Okay. As we move along in the dry season, we'll begin releasing more when we have flows decreasing at S-79.

Okay. When we begin our early in the wet season, and, once again, we have flows at S-79 less than 450 cfs, then the Structure 1 will be opened to allow releases from the reservoir and the pump station will be off. And, once again, when S-79 has flows greater than 450 cfs, Structure 1 will be closed and the pump station will begin pumping to the reservoir. When we go into the late -- late wet season, these flows are still -- are decreasing, Structure 1 will be open to allow releases and the pump will be off. Likewise, when the flows -- when it increases, the structure will be closed and Pump Station 1 will begin to send in this water over to the reservoir.

I'm not sure about -- This is that pretty slide that someone stuck in here. Okay. Yeah. This is your artwork, isn't it, Dave? Sorry. I can't take credit for this one. It is pretty, though, isn't it? And I guess -- Whose thunder did I -- Dennis, did I steal those pretty ones from you?

MR. DUKE: Yeah.

MS. RAULERSON: Sorry about that.

MR. DUKE: What I want to point and note is that one where it showed the water running out of the reservoir, under extreme dry conditions, that could actually happen, the reservoir could go dry. Okay. There may be some holes, deep holes, to provide fish for effusion and so forth in there. But that's part of one of the challenges with the restoration program. We're rebuilding a reservoir to capture water for water storage and water supply and to attenuate floods. Understand that it may go dry; so, yeah, if your boat -- if you're trying to launch a boat, it will become difficult.

By the way, I apologize. My name is Dennis Duke. I am the chief of the Everglades division for the Army Corps of Engineers out of Jacksonville. I do this a lot; so sometimes I forget that little piece of information.

The next step for this overall program or project, to get it implemented, is basically we have the public review and comment period closes June the 11th. Okay. If we get comments after that, hm, it's kind of tough because everybody has the same time line. We go on to make some revisions, incorporate those comments, address those comments. And we do pay attention. We address -- we do look at all the comments. Yeah. We're a

government agency, so sure, you know. No. We do go through, and, yeah, yes, we'll contain the comments and responses to those comments. Like, the Lake Okeechobee regulation schedule we got 3,000 comments. We had to go through each and every one of those comments. You know, we get a lot of comments on our different stuff.

The final Project Implementation Report, PIR, and the Environmental Impact Statement, EIS, will be published in the Federal Register in the September time frame. That means that we'll have that final document out, have been reviewed, approved by our headquarters, hopefully, and for release to the public for 30-day review. And that's normally state and agency and general public review of the final document. We'll have a what we call a Chief's Report, that is a Chief of Engineers, when he signs the report and transmits it to the secretary of the Army for final processing and administration review. That should happen in the November time frame. And the record decision signed, hopefully, in January 2008.

That's after the administration, that's the Office of Management Budget, assistant secretary's office, Council on Environmental Quality, and the really top guys at Washington have reviewed it and concur on the findings and recommendations such that it will be transmitted to

congress with a recommendation for authorization, okay? And then congress will consider that authorization and take action as they deem necessary to either include it in their Water Resources Development Act or, you know, some other bill to get it authorized.

Let's see here. Okay. Well, that was good. Last slide. So at this point in the proceedings here what I'd like to do is take public comments. I have eight cards. We'll go through these. Again, if you have a lengthy statement, I would ask you to submit -- you can summarize your remarks and submit the written text for our records so we'll have an accurate transcript of those remarks. Okay. The first card I have is Kim Koleos.

MS. KOLEOS: I'm good.

MR. DUKES: You're good? Okay. Is that what your teachers say? You're from Gainesville? Well, welcome. I'm glad to have you all with us here tonight. I understand there's -- How many students are here tonight from Gainesville? And the course is about -- you're here because government action or government inaction? Sometimes those two words get thrown together too close for me. I'm sorry. What was the course?

MS. SPEAKER: Everglades ecosystem.

MR. DUKE: Everglades ecosystem. Okay. 18,000 square miles and you picked this place. Okay. It's

good. Sorry. Oh, the sheriff's coming to get me now, isn't he? I'm in trouble. No. This is a nice place. It's got a great place for pie and stuff down here. I guess you know Flora and Ella's. Okay. Enough of the local folklore. I'm sorry.

Rhonda Roff. Hi, there. Thank you. And if you would, just repeat your -- state your name and any organization affiliation that you --

MS. ROFF: Yeah. Hi. I'm Rhonda Roff. I actually have a couple of questions.

MR. DUKE: Absolutely.

MS. ROFF: How many acre-feet are capable of being stored in both cells?

MR. DUKE: I think the total is 170,000 acre-feet. That's the two cells together.

MS. ROFF: That's it? Seventeen to nineteen feet deep?

MR. DUKE: Yes, uh-huh.

MS. ROFF: Within that I would, as a conservation chair for the Hendry-Glades Audubon Society, I would like to comment that any habitat augmentation that would be available within the project to allow for -- for bird nesting, migration, for wildlife utilization of this would be greatly appreciated.

MR. DUKE: Okay.

MS. ROFF: But I wanted to also ask where the natural salt line of the Caloosahatchee would be in the absence of the Franklin lock.

MS. STARNES: It was variable. It was a function of wet season, dry season. There is no specific line. It was a function of -- Truly -- I'm sorry. It's truly a function wet season, dry season. With the structure not there, the saline water would come in during dry season. It has gone up past LaBelle well up into the river. During wet season it would have moved back out into the estuary, and it would have had that natural variability.

MS. ROFF: And with the lock in place, it's right there at the lock all the time?

MS. STARNES: No.

MS. ROFF: No. It's down --

MS. STARNES: No. Depending on the fresh water flows, the fresh water -- the salt/fresh interface will actually move out into the estuary -- well, as flows are coming down it, the high flows, it actually moves southwestish out in the estuary. And then during low flows it will move right up to the lock. And it actually does leak under the lock. Plus it's a lock and dam; so when that lock is open, if it's dry season, the salt water will actually move into the lock; and when they open it for the boat to move into the river, it will go

in with the river. The Olga water plant is actually -- which is the Lee County water supply plant which is just upstream of S-79, we actually do releases specifically to manage their saline content during dry season. So it does fluctuate but not like it did during -- when it was an all-natural system.

MS. ROFF: Another hat that I wear is the president of the Save it Now, Glades! organization. We focus on the lack of need that we perceive for a coal-fired power plant in Moore Haven. And one of the benefits that some South Florida Water Management District employees have stated is the ability to withhold upstream fresh water from moving downstream and creating additional fresh water pulses, nutrient-laden pulses, to the Caloosahatchee. What I was wondering is if anybody has an opinion, scientific opinion, engineering opinion, whether or not such upstream withholding would be just as well accomplished by this project.

MR. DUKE: You mean the holding of water by the plant, power plant?

MS. ROFF: The power plant is going to be occupied, if it's built, 4,900 acres, and some of that will be held -- recycled cooling water; so they're looking forward to that as being a potential source for withholding upstream fresh water pulses from the lake.

Will this kind of cover us on those needs even in the absence of that capacity?

MR. DUKE: Actually, the thing that helps the most is what's called the Northern Everglades Project to store -- that the State has initiated to store additional water north of the Lake Okeechobee, to help hold water out of the lake. And then as we divert water in through the system, that will be capturing more water. They will have storage on site for the -- you know, if they proceed and build the coal-fired plant. I don't think it'd be anywhere near this amount here.

MS. ROFF: That's what it seems to me, right.

MR. DUKE: Okay.

MS. ROFF: That's what I expected.

MR. DUKE: Yeah. Because generally they don't -- they have enough to operate their cooling systems. And the impact will probably be -- well, it just depends on, you know, how much they actually keep in their cooling cycling system.

MS. ROFF: And my last question is on that same vein. The proposed power plant is requesting above 28 million gallons per day of water. And how would -- how did that -- how does that number fit within -- There are a lot of minds who have spent a lot of time thinking about water supply in the Caloosahatchee watershed. What

does 28, or possibly more, million gallons a day mean to any of us here per day in Moore Haven?

MR. DUKE: What happens is that gets into the water allocation that the state does. And so, Janet, if you want to address that.

MS. STARNES: In reality, the South Florida Water Management District does not have and has not taken an official position on the Glades power park. We are in the process now. They are in -- they are in what's known as their siting permit review. That application is in house for review right now. We do not have -- I don't know what employee said what. And Agnes can probably speak to it probably better than I can, but we don't have an official position. And they're not looking just at surface water as a source, by any means, so --

MS. ROFF: No. I total -- I completely recognize that. And at this point I think the recommendation is that they're going to need to go down to the middle of Florida for their supply. But my question is 28 million gallons per day is what fraction of, say, the Caloosahatchee natural flow that we would desire to be able to send downstream?

MS. STARNES: I don't think there's anyone here that can answer that off the top of our head. And what I would suggest is because that -- that application is in

for review now that you submit that question as a part of that public review process.

MS. SPEAKER: Janet, that's not from our agency. That's the Department of Environmental Protection and the Department of Community Affairs. South Florida Water Management District is a commenting agency. South Florida Water Management District is a commenting agency on the site certification, and we're dealing with the same questions you're asking.

MS. ROFF: Yeah. I know. I didn't mean to shanghai this meeting to turn into a power plant discussion. I actually wanted to know about how that fits in terms of volumes what -- In general. Forget the power plant. Just say what does 28 million gallons a day mean in terms of the Caloosahatchee River.

MR. DUKE: Yeah. We'll get you an answer to that question, okay?

MS. ROFF: Okay. Thank you.

MR. DUKE: Sure. The engineers should be calculating that by now.

Okay. Chris Shepard.

By the way, just as -- while he's getting up here, one of the problems we face in constructing South Florida projects these days is our drain on our other construction materials, concrete and so forth. And since

she brought up the power plant, I saw on the news the other day that China is the major drain of our concrete and other building materials. They're building essentially one coal-powered plant a day. Yeah. That's what I said, Wow.

All right, Chris. How are you doing?

MR. SHEPARD: Pretty good. My name is Chris Shepard. I'm a LaBelle resident and a fishing guide Lake Okeechobee. The first question I got for you is when that C-43 is completely full, what's the average water level going to be above sea level for that containment area? Does anybody really have a ballpark?

MR. DUKE: It's going to be 40-something feet.

MS. JANET: Where's LuAnn? LuAnn's got an elevation.

MS. McVICKER: It's about elevation 42 when it's full.

MR. SHEPARD: So that's 42 foot above sea level when it's full. Okay. And the levees themselves are going to be how high --

MR. DUKE: Well, they said --

MR. SHEPARD: -- above grade? Thirty-five feet above grade?

MS. McVICKER: It's about 38 feet.

MR. SHEPARD: 38 feet?

MS. McVICKER: Thirty-eight to forty-eight feet maximum height.

MR. SHEPARD: Okay. Now, the amount of water that's going to be coming into that reservoir during a major event, what are we looking at as far as percentages for what goes down the Caloosahatchee that's actually going to actually get into those cells?

MR. DUKE: Well, as you saw on that, the pump size is 1,500 cfs is the pump. What passes down the Caloosahatchee obviously varies with the amount of discharge coming out of the lake. But we've passed as much as 20,000, 25,000, 20-, 25,000 cfs, cubic feet per second, over the S-79 structure; so you can see during -- but keep in mind that a lot of that's generated within the basin that will -- won't -- you know, won't be able to capture with this. But that gives you an idea. That's 1,500 compared to 20,000 on a peak flow. Fortunately, the peak flows happen rarely.

MR. SHEPARD: Right. Okay. Now, if we ever get the water level of Lake Okeechobee back up to where it needs to be and this reaches its capacity, okay, and then we're at, say, just an average heavy rainy season, okay, where is the water that's not going to be -- you know, where is the excess water going to end up? Is there going to be a plan -- I should rephrase it. Is there going to be a

planned stage for that reservoir for hurricane season?

MR. DUKE: Yeah. There's -- That's part of the operating plan in, you know, this case because of the size of the reservoir. You can pass -- you can release water in advance of, you know, like, 72-hour notice of water prep that we do. Unfortunately, the size of this it's kind of hard to get a lot of water out of it, but we'll do that.

But there is -- will be an operating rule for the reservoir. It won't be anything like Lake Okeechobee, you know, where we have quite an extreme fluctuation. It will operate over that way just in response to the natural rainfall. But in terms of hurricane season doing a load we've got, you know, what we're building into the levee is the levee height. And what makes it so high -- I mean, you heard the pool will be 17 to 19 feet high, and then on top of that we're having a 38-foot high levee or dam around it to actually provide for storage of that water and capture it so we don't have to get into a massive release at the same time we're doing our hurricane passing with "X" runoff, if that makes sense.

MR. SHEPARD: It sort of does, but the main thing I'm concerned with is if that's at capacity, Lake Okeechobee's at capacity, and we get hit with another Wilma, okay, who's going to be bringing the boats around

to pick everybody up because the levee at Lake Okeechobee -- fortunately, Wilma was a fast-moving storm, and during Wilma we started to incur breaches over around Pahokee. And I've been all over the levee, and I know the levee's got issues; but the levee's been a mainstay for many a year. You all did a good job of putting it together.

What I'm concerned with is because we are right here in this county, the down flow of those two cells is going to go to Lehigh and Fort Myers; and there's a lot of homes in that area, and that's my main concern.

MR. DUKES: Yeah. And basically, well, when they all get full, when everything's full, I mean, it would have been full with or without this one. The good news is with this one we have 170,000 acre-feet that we can actually hold out until the storm passes that we don't have to release during that time frame. And we can hold that out and not have to release it; so you're --

For heaven's sakes, one of the things we try and tell everybody is regardless of how big we think engineers think we can build stuff to guard against everything, Mother Nature always shows us who's the boss at the end of the day. And so you will still be subject to flooding same way you are now. It will be less than what you have now during those flood events because of

this. But when this thing gets full, Lake Okeechobee is full, and we have to release water out of Lake Okeechobee, you'll still get that. But because we're pulling water out, you know, it's going to be less than you have now.

MR. SHEPARD: Okay. One other thing I want to say to you all, you all are doing an excellent job on the Everglades. The fishery is kicking butt. It's some of the best water I've seen down there in years. All the birds seem to be really happy and kicking. The gators are really doing their thing. And all the things are really thriving really well, and I congratulate you all on that.

MR. DUKE: Well, thank you. We're just getting started. Kissimmee's a great project. But that's exactly right. And you mentioned something about the fishery habitat and that kind of thing. The perimeter canal's going to be one of the primary locations of that. Obviously, a deep reservoir, you know, when it gets up to 16 and 17 feet you lose all the vegetation that you would have. Some of our more productive areas are our stormwater treatment areas that we have around the Everglades agricultural area which provide wonderful habitat for wildlife.

Okay. Let's see. Joe Frank. Hi, Joe.

MR. FRANK: Good evening, Dennis. I'm glad to see you all made it down to Hendry County.

MR. DUKE: Hey, once in a while.

MR. FRANK: Yeah. Brought a lot of staff, too. Must have been them free cowboy hats you all were offering.

MR. DUKE: They come down here to protect me.

MR. FRANK: Just a few comments on some thoughts that went through my head as you all was doing the presentation. That's why I was asking the lady to speak into the microphone a little bit more. If the aim of this project, you know, is to restore the quality and timing of flows, you know, to the natural levels, then it seems to me that a more worthy project would be to restore the Caloosahatchee River, not build another lake. It just crossed my mind that this project is, you know, is just being built to further the development of western Hendry County and that maybe developers should pay for this project instead of the taxpayers.

If it's for Everglades restoration, the excess lake water that this is supposed to be receiving should be going south through the Everglades. If you're going to build a lake, you should consider what the water is for the watershed from where it would have been at Lake Flirt, or whatever, and build a lake to that

specification.

Secondly, if this project is implemented, it's going to result in some loss of jobs, the very people that need these agricultural jobs out there. Will there be job training programs for the displaces workers? How will it affect the tax base of Hendry County?

The seepage problems, will it ultimately drive up the cost of this half-a-billion-dollar project? Because it's pretty sandy soil out there. Probably barriers are going to be needed, and I think the plans call for some project or some test barriers now. But if you have to line 20,000 acres, that's going to be an expensive project.

And, further, with all this water here, you know, it's going to lead to more increased algae blooms for the river. It's going to create more of a pestilence problem, you know, a lot more insects year round and stuff. But, anyway, just some thoughts that crossed my mind. Thank you.

MR. DUKE: Okay. Thank you, Joe. One, on the seepage, there were some test cells that were constructed out by the Water Management District to determine the seepage that would be coming on so we could get a handle on that. They mentioned -- I think it was mentioned in the presentation about the cutoff walls that are being

put in the embankment to control seepage, the canal around the perimeter to collect the seepage that gets out of the system so -- I mean, one of the requirements of Water 2000, Water Resource Development Act of 2000, is what's called the savings clause. It means that when we build a project for restoration it cannot harm existing levels of service for flood protection or existing sources of water for water supply without a similar source being made in lieu of that.

Some of your other questions. Gee, you had a lot in that one question. Some of those were challenges for us. The Water Management District has been very active, so has Senator Pruitt and some other state representatives in developing job training programs with the local college communities; and they've been training people for that. They're structuring the contracts to provide on-site training for workers and retrain those.

This does provide some new opportunities as we build this huge reservoir there with operations and so forth the reservoir will require. So we've been taking a bigger look at that for the overall impact, not just for this reservoir but for the entire restoration program because we're, you know, projecting as many as 4- to 5,000 jobs could be lost because of impacts to agriculture by -- I mean, we're turning up -- this is,

you know, 10,000-plus acres of land. The entire CERP program has over 170,000 acres of land in surface reservoirs. But at the same time those jobs will be replaced by other jobs in the construction, operation, and maintenance industry.

And we've been working, again, like I said, primarily the lead of the Water Management District on those training programs. The Corps is actually looking now at trying to incorporate that into our contracts, as well, to train workers, provide a training program for workers, not only for these but for future projects. So it's a little bit of shift in the work force as we've seen throughout our economy, anyhow.

Okay. If you have another one, I've kind of lost it. But the water supply, again, is to capture water. I hear what you're saying about sending water south. Yes. Keep in mind, though, the Everglades -- for the restoration students here -- the Everglades is half the size it used to be. Okay. We still have the same amount of rainfall. Because of Herbert Hoover Dike, the lake can only be half the size it used to get to. So we've got the same amount of water; we've got half the area to put it. So if we put all of the water that used to go to the Everglades back into the Everglades, it will be twice as deep as it used to go. That will not be good. So,

anyhow, but it's a water budget balance that we're working through, and that's part of the overall comprehensive plan.

There's no silver bullet out there. It's a combination of all these things. Okay. And that's why there's 68 different components. Interestingly enough, there's 68 threatened and endangered species. I think we just picked one for each species to include in the plan so everybody would have one. What's the snail kite feature? What's the -- you know, those things. Okay. Sorry. Got off a little bit. See, you thought you were missing something at home. Craig Bartoshuk.

MR. BARTOSHUK: That was pretty good. I wrote my comments down.

MR. DUKE: Okay. Thank you. You can get up here. Go ahead. Margaret England. Good evening.

MS. ENGLAND: I'm Margaret England. I'm representing two organizations, Hendry-Glades Audubon and Caloosahatchee River System Association, Riverwatch. My first question is about the littoral zone on the perimeter canal. It's been mentioned several times, but will this littoral zone only be seasonal or will it be year round like a sloped area to provide habitat for wading birds and migratory birds year round, or is this seasonal?

MR. DUKES: It's a year-round feature.

MS. ENGLAND: Year round. Okay. Because in your information it said "may also include," and I didn't know if it should say "will."

MR. DUKE: Okay.

MS. ENGLAND: Also, in reading the environmental study I did notice that there were some caracara listed on the site. Is habitat going to be provided or maintained for the caracara and other birds who are currently on this site and native vegetation planted to encourage some of our native species including the caracara and gopher tortoise?

MR. DUKE: Okay. You want to --

MS. RAULERSON: We're currently --

MR. DUKE: Wait. A mic.

MS. RAULERSON: The caracara nests are actually not on the reservoir site. There's one to the north and one to the southeast. And we're currently in consultation with the Fish and Wildlife Service. We're in formal consultation on that species to determine what we'll do to account for those nests. The reservoir is actually part of their secondary foraging zones --

MS. ENGLAND: Right.

MS. RAULERSON: -- so there will be some kind of compensation for that, but it hasn't been worked out yet

what that will be.

MS. ENGLAND: Okay. Thank you. Okay. Now I'm going to put on my Riverwatch hat. I know there's been a discussion about, you know, the changes in water quality: How will the water quality be monitored, and when will this monitoring begin. And, also, I was very interested in exactly what will be monitored. Will it be nutrients, fertilizers, or chemicals from sewage, you know, or will it be a combination of all of these because I know we do have, you know, all of these components in the Caloosahatchee; and I'm very, you know, I'm very concerned about the chemicals and nutrients and fertilizers.

MR. DUKE: Yes. Basically, there is water quality monitoring that's going on now. In addition, when we put in the reservoir, part of the water quality certification that we go through with the State in terms of permitting released discharges from the reservoir has specific monitoring requirements that address a lot of the parameters. They list them as their parameters of concern. In this case, you know, phosphorus, nitrogen, e-coli, et cetera, those things, if they are designated or the State indicates they're a matter of concern, then, you know, those will be requirements of our monitoring plan. I don't believe -- we haven't applied for a permit

yet --

MS. STARNES: But it's in the Draft Monitoring Plan and in the report.

MR. DUKE: Yeah. So it is in the Draft Monitoring Plan and the report. Yeah. Okay? So thanks. By the way, right now the State of Florida, through the Water Management District, is spending over $50 million a year in monitoring, just monitoring, around the southern part of the system. So it's one thing to build these things; it's another thing to see how they operate and what impacts they do. That's a huge part of it is the water quality. That's actually what the second PIR, that overall Caloosahatchee River basin, we'll look at the water quality issues on a more holistic standpoint and determine if there is a need for a long-term fix. Okay. Thank you, ma'am.

John Cassani.

MR. CASSANI: Good evening. I live in Lee County, and I like to fish in the estuaries. There's concerns about downstream impacts. A couple quick questions. One, will the stored volume be available for water supply at any time after it's constructed? And if the answer is yes, is there a mechanism or requirement to legally reserve the water for its intended purpose?

MR. DUKE: There's two things here. One that the

stored water is to be released back into the Caloosahatchee. You saw the drive-maintained levels, desirable levels downstream. The requirement of Water 2000 is basically any water that's identified to be made available for the environment will be reserved and protected by the state. Now, considering that, to be perfectly frank, when we take the water out of the reservoir and put it back in the Caloosahatchee River, it's going to flow downstream, and here we have the Lee County water supply intake sitting downstream; so you can't separate the water.

MR. CASSANI: That's not what I meant. Yeah.

MR. DUKE: But it's not going to be discharged directly from the reservoir to any water supply user.

MR. CASSANI: So none of the volume will be available for any agricultural irrigation water supply at any time after construction?

MR. DUKE: That's correct. That's the way it's set up right now.

MR. CASSANI: That's good to know. Okay. Second quick question is the modeling that I remember in the past was that under average conditions during the period of record regarding low flows, the performance of the system on average, the do nothing alternative was about 38 percent of the time that low flow exceedences would

occur. And I'm wondering now with the reservoir in place and working, I'm not sure what year you modeled up to, but what would be the performance on low flows? What percentage of the time would it be out of specs operating at peak performance under average rainfall conditions?

MR. DUKE: Yeah. We'll have to get that information. I'm not sure -- I mean, he's looking for it now if we can answer that in a little bit.

MS. MARLOWE: We're within the flow envelope 75 percent of the period of record that we modeled. But I can't personally tell you how much we're within that bottom number. But we can get that information to you. It's just I don't have it off the top of my head.

MR. CASSANI: That's under average rainfall conditions?

MS. MARLOWE: That was over the period of record which includes --

MR. DUKE: That's actually over the period of record.

MR. CASSANI: Under average conditions. Yeah.

MS. MARLOWE: Well, but it includes all the different kind of -- It's got wet and dry and average years.

MR. CASSANI: I think it's just kind of liberal to say that the project -- or maybe you shouldn't imply that

the project is going to get low flows to 75 percent of the time because they're already within specs 60 percent of the time. So you're going from about 38 or 40 percent out of specs to about 25 percent. So the difference between the two is really the performance on the project. It's not 75 percent of the time.

MS. MARLOWE: Well, we're comparing actually -- We're actually comparing to the future without project. And as we modeled that future without project conditions, it was only within the envelope about 46 percent of the time --

MR. CASSANI: That's pretty poor, yeah.

MS. MARLOWE: -- so it's jumped from 46 to 75.

MR. CASSANI: Forty-six within or without?

MS. MARLOWE: In the future without we were only within our desired envelope 46 percent of the time. So less than half of the time were we able to stay within that desired envelope in our projected future without scenario.

MR. CASSANI: Kind of an important distinction. But it's good news about it's only for its intended purpose. Very good. Thank you.

MR. DUKE: Okay. The next speaker is John Fumero. You're good, John?

Okay. That's all of the cards I have. Are there

any other questions?

Was this helpful to the class? Okay. Yeah. You think it's all about just come up with this great idea for restoring something and you go out there and just do it. Nope, sorry. It's a long process.

Yes, sir. Please identify yourself, if you would.

MR. HEYMAN: Richard Heyman from the University of Florida.

MR. DUKE: Yes.

MR. HEYMAN: It wasn't clear to me whether there's going to be a -- whether this PIR recommends a reservation of water amount.

MR. DUKE: Every PIR has to address the water that's to be reserved through this. This PIR will have that in the operating plan about the amount of water to be reserved. I can't tell you what it is. It's in the -- it will be in the document or is in the document.

MR. HEYMAN: It will be? Okay. I though we were at the stage where that would have been developed.

MS. STARNES: It's -- the reservation actually will not be adopted and ruled -- the way the law reads the reservation has to be adopted and ruled prior to or at the time of our signing of the Project Cooperative Agreement. And the Project Cooperative Agreement will not be signed until congress authorizes the project

because the federal government can't sign a cooperative agreement if they're not authorized to do the work. So that's actually down the road.

Within this Project Implementation Report there is a whole chapter on project assurances and what water will be held back and reserved and how we got to that and how we're impacting existing legal uses. That is within the -- that is within the Project Implementation Report. I don't remember exactly what chapter it is. So that analysis has been done. It will be revisited at the time that we actually go to rule making because we, obviously, if we're going to go to rule making, want to make sure we're as close to correct as we can possibly be. So the information is in the existing report, but we will not actually go to rule making until right around the time that we're going to sign a Project Cooperative Agreement. That's true of all the Everglades restoration projects.

MR. HEYMAN: So there's a recommendation for what the reservation will encompass?

MS. STARNES: Well, it's not a simple number; so it's not a simple answer, it's not a flow of. That is -- It's far more complicated than that. But, yes, the analysis that we've done in terms of project assurances and savings clause analysis and reservations is within the report itself.

MR. HEYMAN: Is that the fact that you don't -- does that reflect the fact that you don't quite know how to describe the reservation for the rule making yet?

MR. DUKE: No. It's actually a function of how the water is to be delivered for beneficial to -- to be of benefit to the environment. I mean, even -- This is one of the hardest things for the Corps of Engineers to get its arms around because normally when we reserve water or allocate water within a reservoir, we can say it's, you know, so many thousand acre-feet, da, da, da, da within this reservoir. Here we're talking about releasing and reserving water that has a benefit over, as you saw, 71,000 acres of estuary. Okay. So what we want to do is we want to not only reserve the quantity but also the timing and distribution of that water. So that's why she meant -- It gets very complicated.

This actually, perhaps, is one of the simpler ones we have to deal with as opposed to, like, the Everglades agricultural reservoir which is going to spread its water over, you know, half a million acres and we have to reserve that, not just the quantity but the timing and distribution. Because if I get a half a million acre-feet of water all at one time, I don't want to reserve that, you know, because that'll flood everything. So it's a complicated process. It covers, basically, a

hydroperiod in the distribution of water. Okay?

MR. HEYMAN: Thanks.

MR. DUKE: And I'm sure I'll have fun trying to explain that to congress.

Any other questions? Well, thank you all for coming tonight. Be careful going home. Again, if you have any written comments, June the 11th, please get them to us by then. Good luck on your studies.

(The hearing concluded at 0:00)

STATE OF FLORIDA)

COUNTY OF CHARLOTTE)

I, DAWN M. ROUSH, Court Reporter, Notary Public in and for the State of Florida at Large, do hereby certify that a public meeting was held in the cause styled in the caption hereto, on Page 1 hereof; that I was authorized to and did attend said public meeting and report the proceedings had therein, fully and accurately, and the foregoing transcription consisting of pages numbered 01 through 66, inclusive constitute a correct transcript of my notes of the proceedings taken at said public meeting.

I FURTHER CERTIFY that I am neither an attorney nor counsel for the parties to this cause nor a relative or employee of any attorney or party connected with this cause and that I have no interest in the outcome of this action.

IN WITNESS WHEREOF, I have hereunto subscribed my name and affixed my seal this the 27th day of May, 2007.

Dawn M. Roush, Court Reporter
Notary Public
State of Florida at Large

DAWN M. ROUSH
MY COMMISSION # DD 428569
EXPIRES: April 27, 2009
Bonded Thru Notary Public Underwriters

ANNEX C
ANALYSES REQUIRED BY WRDA 2000 AND STATE LAW SAVINGS CLAUSE ANALYSES

This page intentionally left blank

TABLE OF CONTENTS

C.0 ANALYSES REQUIRED BY WRDA AND STATE LAW SAVINGS CLAUSE ANALYSES C-1
C.1 LEGAL BASIS - BACKGROUND C-1
C.1.1 WATER RESOURCES DEVELOPMENT ACT (WRDA 2000) C-1
C.1.1.1 Savings Clause Analyses C-2
C.1.1.2 Project-Specific Assurances C-3
C.1.2 PROGRAMMATIC REGULATIONS (33 CFR PART 385) C-4
C.1.2.1 Pre-CERP Baseline C-4
C.1.2.2 Elimination or Transfer of Existing Legal Sources of Water C-4
C.1.2.3 Flood Protection C-4
C.1.2.4 Identification of Water for the Natural System C-4
C.1.2.5 Identification of Water for Other Water-Related Needs C-5
C.2 METHODS C-5
C.2.1 Key assumptions for all project assurance analyses C-5
C.2.1.1 Comparison of Pre-CERP Baseline, Existing Conditions Baseline and Initial Operating Regime C-5
C.2.1.2 Assumptions Associated with Reservoir Operations and Spreadsheet Analyses C-6
C.2.2 Savings Clause - Elimination or Transfer of Existing Legal Sources and Flood Protection C-6
C.2.2.1 Project Effects C-6
C.2.3 Identifying Water Made Available for the Natural System and for Other Water Related Needs by the Caloosahatchee River (C-43) West Basin Storage Reservoir C-8
C.2.3.1 Inflow Basins affected by the Project C-9
C.2.3.2 Summary of the Analytical Method Used to Identify Water Made Available C-9
C.3 RESULTS C-12
C.3.1 Savings Clause - Elimination or Transfer of Existing Legal Sources and Flood Protection C-12
C.3.1.1 System wide Elimination or Transfer C-12
C.3.1.2 System-wide Flood Protection C-13
C.3.1.3 Project level Elimination or Transfer C-13
C.3.1.4 Project level Flood Protection C-14
C.3.2 Identifying Water Made Available by the Project for the Natural System C-21
C.3.2.1 Total Water Made Available by the Project C-21
C.3.2.2 Water Made Available by the Project for the Natural System C-22
C.3.2.3 Identifying Water to be Reserved or Allocated for the Natural System C-22
C.3.3 Project Assurances C-25
C.4 DRAFT STATE COMPLIANCE REPORT C-27

LIST OF TABLES

Table C-1: Summary of comparisons used for Savings Clause Analysis.....C-7
Table C-2: Summary of GM #4 analysis for the Identification of water made available and the water to be reserved or allocated.....C-11
Table C-3: Identification of the volume of water (Ac-ft/year) made available for the natural system to achieve the benefits of the project.....C-24

LIST OF FIGURES

Figure C-1: Local Reservoir MIKESHE model boundary outlining the project footprint, local canals and the locations of the simulated groundwater levels for the groundwater hydrographs.....C-15
Figure C-2: Depth to groundwater level for the with and without project at Location 1....C-16
Figure C-3: Depth to groundwater level for the with and without project at Location 2....C-16
Figure C-4: Depth to groundwater level for the with and without project at Location 3....C-17
Figure C-5: Depth to groundwater level for the with and without project at Location 4....C-17
Figure C-6: Depth to groundwater level for the with and without project at Location 5....C-18
Figure C-7: Depth to groundwater level for the with and without project at Location 6....C-18
Figure C-8: Depth to groundwater level for the with and without project at Location 7....C-19
Figure C-9: Depth to groundwater level for the with and without project at location 8.....C-19
Figure C-10: Depth to groundwater level for the with and without project at location 9...C-20
Figure C-11: Depth to groundwater level for the with and without project at location 10.....C-20
Figure C-12: Depth to groundwater level for the with and without project at location 11.....C-21
Figure C-13: Volume probability curves of total water made available to achieve benefits of the project.....C-22
Figure C-14: Variability of water made available By the project for the ior and NAI conditions.....C-23

C.0 ANALYSES REQUIRED BY WRDA AND STATE LAW SAVINGS CLAUSE ANALYSES

C.1 LEGAL BASIS - BACKGROUND

Federal law and regulation implementing the Comprehensive Everglades Restoration Plan (CERP) require Project Implementation Reports (PIRs) to address certain assurances as part of the project being recommended for approval and implementation. This section addresses provisions of Section 601(h) of the Water Resources Development Act of 2000 (WRDA 2000) and the Programmatic Regulations for the CERP (33 CFR Part 385) for Savings Clause requirements and Project-Specific Assurances.

The following sections describe the specific requirements from WRDA 2000 and the CERP Programmatic Regulations and present the methods and results of the analyses necessary to meet those requirements.

C.1.1 WATER RESOURCES DEVELOPMENT ACT (WRDA 2000)

Congress enacted the Water Resources Development Act of 2000, Section 601, Comprehensive Everglades Restoration Plan (WRDA 2000) which approved the CERP "as a framework for modifications and operational changes to the Central and Southern Florida (C&SF) Project that are needed to restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection." Section 601(h) of WRDA 2000, entitled "Assurance of Project Benefits" establishes project-specific assurances to be addressed as part of CERP implementation.

Section 601 (h) (1) of WRDA 2000 provides:

> *IN GENERAL - The overarching objective of the Plan is the restoration, preservation, and protection of the South Florida Ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Plan shall be implemented to ensure the protection of water quality in, the reduction of the loss of fresh water from, the improvement of the environment of the South Florida Ecosystem and to achieve and maintain the benefits to the natural system and human environment described in the Plan, and required pursuant to this section, for as long as the project is authorized.*

Sections C.1.1.1 and C.1.1.2 discuss the assurances required by WRDA 2000 to be addressed in each PIR. Section C.1.2 discusses the assurances provisions of the CERP programmatic regulations, which are intended to provide supplemental information for implementing the WRDA 2000.

C.1.1.1 Savings Clause Analyses

The Savings Clause analysis is listed in WRDA 2000 as a means to assure project benefits. Specifically, Section 601(h)(5) of WRDA 2000, entitled "Savings Clause", requires an analysis of each project's effects on legal sources of water that were in existence on the date of enactment of WRDA 2000 (i.e., December 2000) and effects on levels of service of flood protection in existence on the date of enactment of WRDA 2000. Section 601(h) (5) of WRDA 2000 states:

> *(A) NO ELIMINATION OR TRANSFER. – Until a new source of water supply of comparable quantity and quality as that available on the date of enactment of this Act is available to replace the water to be lost as a result of implementation of the Plan, the Secretary and the non-Federal sponsor shall not eliminate or transfer existing legal sources of water, including those for –*
>
> *(i) an agricultural or urban water supply;*
> *(ii) allocation or entitlement to the Seminole Indian Tribe of Florida under section 7 of the Seminole Indian Land Claims Settlement Act of 1987 (25 U.S.C. 1772e);*
> *(iii) the Miccosukee Tribe of Indians of Florida;*
> *(iv) water supply for Everglades National Park; or*
> *(v) water supply for fish and wildlife.*
>
> *(B) MAINTENANCE OF FLOOD PROTECTION. – Implementation of the Plan shall not reduce levels of service for flood protection that are –*
>
> *(i) in existence on the date of enactment of this Act; and*
> *(ii) in accordance with applicable law.*
>
> *(C) NO EFFECT ON TRIBAL COMPACT. – Nothing in this section amends, alters, prevents, or otherwise abrogates rights of the Seminole Indian Tribe of Florida under the compact among the Seminole Tribe of Florida, the State, and the South Florida Water Management District, defining the scope and use of water rights of the Seminole Tribe of Florida, as codified in section 7 of the Seminole Indian Land Claims Act of 1987 (25 U.S.C. 1772e).*

Section C.2.2 of this report contains a description of the assumptions, concepts and methodologies based on the procedures and guidance described in draft Programmatic Regulations Guidance Memorandum 3 (GM 3), "Savings Clause Requirements", at the time this PIR was being developed for identifying project effects on:

1. Existing legal sources of water as of the date of enactment of WRDA 2000 on the user categories listed in Section 601(h)(5)(A) of WRDA 2000.

2. Levels of service for flood protection as required by WRDA 2000.

Section C. of this report summarizes the results of these analyses.

C.1.1.2 Project-Specific Assurances

Section 601(h) (4) (A) of WRDA 2000, entitled "Project-Specific Assurances", contains the following requirements for project implementation reports:

> *(A) PROJECT IMPLEMENTATION REPORTS. –*
> *(i) IN GENERAL. – The Secretary (of the Army) and the non-Federal sponsor shall develop project implementation reports in accordance with Section 10.3.1 of the Plan.*
> *(ii) COORDINATION. – In developing a project implementation report, the Secretary and the non-Federal sponsor shall coordinate with appropriate Federal, S ate, tribal, and local governments.*
> *(iii) REQUIREMENTS. – A project implementation report shall –*
> > *(I) be consistent with the Plan and the programmatic regulations promulgated under paragraph (3);*
> > *(II) describe how each of the requirements stated in paragraph (3)(B)[sic] is satisfied*
> > *(III) comply with the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.);*
> > *(IV) identify the appropriate quantity, timing, and distribution of water dedicated and managed for the natural system;*
> > *(V) identify the amount of water to be reserved or allocated for the natural system necessary to implement under State law, subclauses (IV) and (VI);*
> > *(VI) comply with applicable water quality standards and applicable water quality permitting requirements under subsection (b)(2)(A)(ii);*
> > *(VII) be based on the best available science; and*
> > *(VIII) include an analysis concerning the cost-effectiveness and engineering feasibility of the project.*

Section C.2 of this report contains a description of the assumptions, concepts and methodologies for identifying water made available by the project for the natural system and for other water related needs of the region. The methodologies are based on the procedures and guidance described in draft Programmatic Regulations Guidance Memorandum 4 (GM 4), "Identifying Water Made Available for the Natural System and for Other Water Related Needs", available at the time this PIR was being developed.

Section C.3 of this report summarizes the results of these analyses, including identifying the amount of water made available by the project for the natural system to be reserved or allocated by the State of Florida and the amount of water made available for other water-related needs.

C.1.2 PROGRAMMATIC REGULATIONS (33 CFR PART 385)

The following summary of requirements of the Programmatic Regulations provides supplemental information for implementing the Savings Clause and Project Specific Assurances of WRDA 2000.

C.1.2.1 Pre-CERP Baseline

Section 385.35(a) of the Programmatic Regulations requires the development of a pre-CERP baseline to aid the Corps of Engineers and the South Florida Water Management District (SFWMD) when implementing the Savings Clause to determine if existing legal sources of water will be eliminated or transferred and to demonstrate that the levels of service of flood protection in existence on the date of enactment of WRDA 2000 and in accordance with applicable law will not be reduced by implementation of a project.

The final draft Pre-CERP Baseline document was issued by the U.S. Army Corps of Engineers and the SFWMD in April 2005. In accordance with the programmatic regulations, the final draft Pre-CERP Baseline document will be submitted to the Secretary of the Army for approval and concurrence by the Secretary of the Interior and the Governor.

C.1.2.2 Elimination or Transfer of Existing Legal Sources of Water

Section 385.36 of the Programmatic Regulations requires that project implementation reports determine if existing legal sources of water are to be eliminated or transferred as a result of project implementation. If a project is expected to result in an elimination or transfer of an existing legal source of water, the PIR shall include an implementation plan that ensures a new source of water of comparable quantity and quality is available to replace the source that is being transferred or eliminated.

C.1.2.3 Flood Protection

Section 385.37 of the Programmatic Regulations requires that PIRs include an analysis of the project's impacts on levels of service for flood protection that existed on the date of enactment of WRDA 2000, December 2000, and in accordance with applicable law. These conditions will be included in the Pre-CERP Baseline (see section C.1.2.1).

C.1.2.4 Identification of Water for the Natural System

Section 385.35(b) of the Programmatic Regulations requires that each project implementation report identify the quantity, timing, and distribution of water to be dedicated and managed for the natural system necessary to meet the restoration goals of CERP. This evaluation considers the availability of the Pre-

CERP Baseline water and previously reserved water, and whether improvements in water quality are necessary. The existing conditions model simulation for this project does not include any previously reserved water, since there have been no water reservations yet completed within the geographic boundary of the SFWMD.

C.1.2.5 Identification of Water for Other Water-Related Needs

Section 385.35(b) of the Programmatic Regulations also requires that procedures be developed for identifying water generated by CERP for use in the human environment and that the quantity, timing, and distribution of water for other water-related needs be identified in project implementation reports.

C.2 METHODS

C.2.1 Key assumptions for all project assurance analyses

C.2.1.1 Comparison of Pre-CERP Baseline, Existing Conditions Baseline and Initial Operating Regime

The analyses of the Saving Clause requirements includes considerations of three different sets of assumptions at potentially three different points in time or conditions: 1) Pre-CERP Baseline, 2) Existing Conditions, and 3) the Initial Operating Regime (IOR). The Pre-CERP Baseline is the condition existing on the date of enactment of WRDA 2000, December 2000. For this project, the Existing Conditions Baseline is the condition in 2000, and the IOR is the conditions existing in 2006. In accordance with GM #1, the 2006 conditions were used for the IOR because this is the year the Selected Alternative Plan (SAP) was identified. To perform the required project assurance analyses, land use and demand assumptions for the basins affected by the project were identified for each of these timeframes.

The Western Caloosahatchee River Basin, specifically the Caloosahatchee River and Estuary system west of the W. P. Franklin Lock and Dam (S-79 structure), is the only basin affected by the project as it is currently proposed to be constructed and operated in this PIR. Therefore, an analysis was conducted comparing changes in actual land use in 2000 to the actual land use in 2006 in the Western Caloosahatchee River Basin. The analysis showed that changes in actual land use between 2000 and 2006 were insignificant. As a result, analytical comparisons of the three conditions, 1) Pre-CERP Baseline, 2) Existing Conditions Baseline and 3) Initial Operating Regime without project, contains the same land use and demand assumptions, and are then labeled as the Existing Conditions Baseline.

C.2.1.2 Assumptions Associated with Reservoir Operations and Spreadsheet Analyses

The conceptual intent of the project is that the reservoir will be operated to supply water to the Caloosahatchee River (C-43 Canal) based on maintaining desirable salinity levels in the Caloosahatchee Estuary System as measured by flows calculated for the S-79 structure. The following are key assumptions utilized in this analysis and are consistent with this conceptual intent.

- The source of Caloosahatchee River (C-43 Canal) flow data for the spreadsheet analyses for the Existing Conditions Baseline (2000) and Future Without Project Condition (2050 with no-CERP projects in place) is derived from South Florida Water Management Model (SFWMM) version 5.4.2 base model simulation 2000RD, for the Existing Conditions Baseline and 2050RD model simulation for the 2050 with no CERP projects in place.
- The spreadsheet will take into consideration the ET losses from the reservoir. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, reservoir seepage (assumed to be zero based on results of the C-43 Test Cell Pilot Project – July 2006), ET losses (based on area volume relationship), and reservoir direct precipitation.
- No agricultural or urban water supply deliveries will be supplied by the reservoir. These demands continue to be supplied from Lake Okeechobee or existing groundwater sources.
- The Eastern Caloosahatchee River Basin (east of the S-78 structure) will not be affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary downstream of S-79, there will be no impacts on the Western Caloosahatchee River Basin.

C.2.2 Savings Clause - Elimination or Transfer of Existing Legal Sources and Flood Protection

The operations of the Caloosahatchee River (C-43) West Basin Storage Reservoir as described in C.2.1.2 focus on meeting estuary hydrologic restoration targets for the Caloosahatchee Estuary. However, the analyses associated with Savings Clause occurred at both the system-wide and project levels to confirm there will be no unexpected elimination or transfer of existing legal sources of water or significant adverse affects on the level of service of flood protection as a result of the project.

C.2.2.1 Project Effects

The effect of the Caloosahatchee River (C-43) West Basin Storage Reservoir on existing legal sources and flood protection will be documented at the system-

wide and project-level scale. Both the system-wide and project-level analyses compared the following shown in Table C-1.

TABLE C-1: SUMMARY OF COMPARISONS USED FOR SAVINGS CLAUSE ANALYSIS

Analysis	*"Without Project Condition"*	*"With Project Condition"*
	Savings Clause Analyses GM #3	
1. Elimination or Transfer 2. Flood Protection [system-wide: no impact by definition, project level: confirm with Acceler8-generated analyses]	Existing Conditions Baseline [2000 Without Project]	Initial Operating Regime [Existing Conditions Baseline + SAP]

C.2.2.1.1 System-wide effects

Defined as the hydrologic effects due to the storage, management, treatment, and delivery of water via the C&SF Project occurring outside the immediate project vicinity. By reviewing all of the water basins identified in GM #3 and based upon the assumptions described in C.2.1.2, the only basin that will be affected by the project is the Caloosahatchee Estuary.

C.2.2.1.2 Project-level effects

Project-level effects are defined as the hydrologic effects occurring within the immediate project vicinity (e.g., natural areas, wetlands, salinity control) or within the features of the project components (e.g., reservoirs, storm water treatment areas, well field recharge distribution canal).

The SFWMD Acceler8 design process evaluated field conditions at the project reservoir site through geotechnical evaluations which were followed by the construction of test cells. The test cells were constructed to determine the seepage potential of the proposed reservoir and to document local project-level groundwater affects. The embankment of test cell one did not contain a cut-off slurry wall, while the embankment of test cell two did contained a cut-off slurry wall designed to contain seepage. Results of the test cells are presented in the C-43 West Storage Reservoir Test Cell Pilot Project, July 2006. In summary, the groundwater levels within the embankment and seepage rates immediately increased upon filling of test cell one, while test cell two (with a cut-off slurry wall) showed virtually no impact to groundwater levels or in the rate of seepage through the embankment.

In addition, sections 6 and 12 in the C-43 West Basin Storage Reservoir Final Basis of Design Report (SFWMD, April 2006) describe the intended purpose and proposed operations of the perimeter canal. The primary operational intent for seepage management is to maintain the water levels in the perimeter canal to preserve existing groundwater levels and to intercept seepage, if any, from the reservoir.

These project-level, site specific investigations have been used to design a project that will have no adverse affects to the localized surface and ground-water resources adjacent to the project reservoir. In addition, modeling and analysis was conducted using the local MIKESHE reservoir model to assist in the design efforts and to evaluate the effects of the reservoir construction and operation on the area adjacent to the reservoir footprint.

C.2.3 Identifying Water Made Available for the Natural System and for Other Water Related Needs by the Caloosahatchee River (C-43) West Basin Storage Reservoir

The primary functions of the reservoir are two-fold: 1) to capture excess basin runoff and discharges from Lake Okeechobee during wet periods, and 2) to provide an additional source of water to maintain desirable salinity in the Caloosahatchee Estuary during low flow periods. Since the estuarine system is not in need of additional fresh water during wet periods, the analysis of water made available focused on the additional water delivered from the reservoir to the Caloosahatchee River (C-43 Canal) and Caloosahatchee Estuary during low flow periods.

The operational assumptions of the Caloosahatchee River (C-43) West Basin Storage Reservoir as described in C.2.1.2 focus on meeting estuary hydrologic restoration targets for the Caloosahatchee Estuary. In addition, as described in C.2.2.1, the project has been designed to be operated so there will be no adverse impacts on existing legal sources of water at the project level. Therefore, the analysis associated with identifying water made available by the project will focus on the project's effects to the Caloosahatchee Estuary. Furthermore, as noted in C.2.1.2, there will be no water made available for other water related needs by the reservoir and all water made available by the project is provided to the natural system.

Identification of water for the natural system is based on the concept of water needed to achieve the benefits of the project and the overarching objective of restoration, preservation and protection of the South Florida Ecosystem. The water made available for the natural system is the water required for the protection of fish and wildlife within natural systems, including water that contributes to meeting hydrologic, water quality, and ecologic targets for restoration of natural systems. A hydrologic target for the natural system (flow

at S-79) was utilized to identify the quantity of water that is required to meet estuary restoration objectives, in contrast to water which may be harmful or otherwise not contribute to meeting the estuary restoration targets.

C.2.3.1 Inflow Basins affected by the Project

Draft Guidance Memorandum #4 (GM #4) requires the identification of the inflow basins that will be affected by a project. In the case of the Caloosahatchee River (C-43) West Basin Storage Reservoir project the only inflow basin affected by the project is the Caloosahatchee Estuary.

C.2.3.2 Summary of the Analytical Method Used to Identify Water Made Available

To identify water made available by the project, a simplified spreadsheet analysis of the Caloosahatchee River (C-43) West Basin Storage Reservoir project was produced based on the capture of excess flow over S-79, which was derived from the SFWMM simulation of the 2000 (a.k.a Initial Operating Regime) and 2050 (a.k.a Nest Added Increment) conditions. The spreadsheet analysis evaluated the 2000 and 2050 condition with and without project for the purposes of fulfilling GM #4 requirements and incorporated the operational assumptions outlined in C.2.1.2.

The spreadsheet analysis is centered on a water budget equation for the reservoir. Equations are based on conservation of mass and relates the inflows to the reservoir and the outflows from the reservoir to the change in storage in the reservoir over some fixed time scale. The spreadsheet calculated the daily change in storage and associated water surface elevation, both of which are considered in determining fill and release operation in subsequent time steps. Then the spreadsheet created an updated flow over S-79 that reflects the changes to the original flow resulting from reservoir fill or release activities.

The focus of the spreadsheet analysis is the modification or adjustments of flow over S-79 with the intent of improving the salinity distribution in the downstream estuary. The spreadsheet however, has no salinity or ecological component and relies on a hydrologic surrogate to infer improved performance. The hydrologic surrogate used is the flow over S-79 and its ability to achieve, or trend towards, an estuary flow target time series (EST05 – See appendix C) which has been demonstrated to be a restoration time series that would result in optimal habitat conditions for several indicator species in the Caloosahatchee Estuary.

In this spreadsheet analysis and to satisfy GM #4 requirements to identify the variability of water made available by the project for the natural system, inflow volume probability curves were calculated and presented as total annual

cumulative inflow into the Caloosahatchee Estuary. The data presented are the daily numbers summed to yield an annual volume.

As a means to display achieving or trending toward the EST05 flow target as a whole and quantifying other desirable matches to portions of the restoration flow series, two graphics (***Figure C-13*** and ***Figure C-14***) were generated for the period of record 1965 - 2000 from the spreadsheet calculations for both the existing "without project" or base condition and the "with project" condition.

1. **Volume probability curves** - Plot flows in acre feet over S-79 for the EST05 restoration time series and the "with" and "without" project conditions for both the IOR and Next Added Increment (NAI) condition.

2. **Difference curves** - generated showing the percentage of time that flow is less than or equal to the target restoration flow series EST05 by ranking and plotting the flow over S-79 of the "with" and "without project" for the IOR and NAI conditions.

C.2.3.2.1 Comparisons of Conditions Used in Identifying Total Water, Water Made Available for the Natural System, and Water to Be Reserved or Allocated for the Natural System

The total water and the water made available for the natural system are quantified in terms of both when the project is expected to be initially operational (IOR) and in the future (NAI). For purposes of quantifying the water to be reserved or allocated, the timeframe of when the project is expected to become initially operational (IOR) is used.

To determine the quantity of water made available for the natural system and the quantity of water to be reserved or allocated in the Caloosahatchee Estuary, the restoration target EST05 flow target (Appendix C) were used to determine the quantity of water that is needed for the protection of fish and wildlife in the estuary, versus that which may be harmful to it or otherwise not contributing to the restoration targets of the estuary.

The IOR simulation is used to quantify the water to be reserved or allocated because physical and operational constraints may exist temporarily in the system that prevent the attainment of all of the project's projected benefits immediately upon initiation of operation. Once these constraints are removed, as evaluated in the NAI simulations, the quantity of water made available is expected to change. Furthermore, project operations would be expected to change due to a variety of reasons, including adjustments to operations and the construction and operation of other CERP and non-CERP projects. As conditions change, affecting the quantity of water made available for the natural system,

the reservation or allocation of water for the natural system will be updated to reflect the changed conditions.

The comparisons to be used to identify water made available and water to be reserved or allocated are shown in ***Table C-2.***

TABLE C-2: SUMMARY OF GM #4 ANALYSIS FOR THE IDENTIFICATION OF WATER MADE AVAILABLE AND THE WATER TO BE RESERVED OR ALLOCATED

Analysis	*"Without Project Condition"*	*"With Project Condition"*
Identification of Water Made Available		
Identification of Water Made Available 1. Total Water 2. Water for the Natural System 3. Water for Other Water Related Needs (non for this project)	1. Existing Conditions Baseline (2000) 2. Next Added Increment Baseline (2050)	1. Initial Operating Regime (IOR) – (existing conditions baseline + project) 2. Next Added Increment (NAI baseline + project)
Identification of Water to be Reserved or Allocated		
Identification of Water to be Reserved or Allocated	Existing Conditions Baseline (2000)	Initial Operating Regime (IOR) – (existing conditions baseline + project)

C.2.3.2.2 Identifying Water Made Available for Other Water Related Needs

The operations for this project focus on reducing excess, harmful flows in the wet season from S-79 and provide supplemental flows during low flow periods across S-79 to the Caloosahatchee Estuary to meet restoration targets. No additional water will be made available for other water related needs by this project. Agricultural and urban water supplies will continue to be met from the same sources as they are currently. Therefore, no additional analysis was conducted.

C.2.3.2.3 Volume probability curves

For purposes of identifying the water made available by the project for the natural system, inflow volume probability curves representing total annual cumulative inflows in accordance with GM #4 were produced depicting the range of the quantities of water delivered to the Caloosahatchee Estuary through S-79 under all climatic conditions through the period of record (1978 – 1986) described in C.2.3.2. This period includes sufficient climatological variability (including natural fluctuations of water) to be representative of long term hydrologic conditions in the region.

The identification of the total water made available by the project and water made available for the natural system will be determined by comparing the inflow volume-probability curves for two separate conditions (***Table C-2***). As noted in section C.2.3.2, to determine the quantity of water for the natural system and the water to be reserved or allocated in the Caloosahatchee Estuary, the EST 05 salinity envelope will be used to determine the portion of water that is needed for the protection of fish and wildlife in the estuary, versus that which may be harmful to it or otherwise not contributing to the restoration targets of the estuary. Changes in the quantities of water made available for the protection of fish and wildlife in the estuary as a result of the project will be displayed using four volume probability curves: the Existing Condition Baseline, the IOR, the NAI Baseline and the NAI with Project Condition.

C.2.3.2.4 Difference Curves

After the quantities of water needed for the protection of fish and wildlife have been identified and displayed using volume probability curves, two difference curves will be developed. The two difference curves will be derived from comparing the annual volume of inflows in the two conditions (Existing Conditions Baseline vs. IOR and NAI Baseline vs. NAI). The results will then be sorted, ranked (from greatest to least), and plotted as difference curves. The 10%, 50% and 90% exceedance points on the difference curve will be identified for each of the three percentiles.

C.2.3.2.5 Summary Tables to Identify Total Water, Water Made Available for the Natural System, and Water to Be Reserved or Allocated for the Natural System

The year corresponding to the volume for each of the percentiles will then be identified for both conditions. These results will then be displayed in a table. The table will display the total water made available by the project (NAI and IOR), the water made available for the natural system (NAI and IOR), and the water to be reserved or allocated for the natural system (IOR).

C.3 RESULTS

C.3.1 Savings Clause - Elimination or Transfer of Existing Legal Sources and Flood Protection

C.3.1.1 System wide Elimination or Transfer

The operations for this project focus on reducing detrimental, excess flows from S-79 and providing supplemental flows across S-79 to the Caloosahatchee Estuary to achieve restoration targets. Sources of water to meet agricultural and urban demand in the Caloosahatchee River (C-43 Canal) Basin will remain the

same as before the project. Sources of water for the Seminole and Miccosukee Tribes and Everglades National Park are influenced by the regional water management system (C&SF Project, including Lake Okeechobee), and will not be affected by this project. Therefore, there will be no elimination or transfer as a result of this project on existing legal sources of supply for:

- Agricultural or urban water supply
- Allocation or entitlement to the Seminole Indian Tribe of Florida under Section 7 of the Seminole Indian Land Claims Settlement Act of 1987 (25 U.S.C. 1772e)
- The Miccosukee Tribe of Florida
- Water supply for Everglades National Park
- Water supply for fish and wildlife

C.3.1.2 System-wide Flood Protection

The operations of this project will not change the operations of the Caloosahatchee River (C-43 Canal) based on the key assumptions outlined in C.2.1.2. Therefore, there will be no system-wide effects on flood protection as a result of the project.

C.3.1.3 Project level Elimination or Transfer

The existing water levels in the area adjacent to the reservoir will be maintained through the operating levels and control structures of the seepage canals surrounding the project reservoir. Output of groundwater level simulations using the local Reservoir-level MIKESHE model were displayed for eleven locations (represents a 1500 ft grid cell) around the reservoir shown in ***Figure C-1***. For each location modeled, a groundwater stage duration comparison (***Figure C-2*** through ***Figure C-12***) shows the groundwater levels below the land surface, represented as zero on the figures, and the percentage of time those levels are maintained for the with and without project conditions. The results of this groundwater analysis show there are no adverse affects to groundwater levels as a result of the project.

With the project in place, portions of the Roberts Canal and Header canal will become part of the project footprint. To continue to provide an irrigation source to the Bob Paul property, which in existing conditions pumps irrigation water from the Header canal and the Crawford canal, pump station #3 was included in the reservoir perimeter canal to pump water to the east down the remaining Header canal assuring the same volume of water is available compared to existing condition. The Crawford Canal will still be available to the Bob Paul property and is not affected by the project.

Therefore, there will be a transfer of existing legal sources of water from the Header Canal to the Perimeter canal, although there is no elimination of existing legal sources in the vicinity of the reservoir.

C.3.1.4 Project level Flood Protection

The results from the local reservoir-level MIKESHE modeling indicate a boundary slurry wall within the embankment prevents seepage out of the reservoir and impacts to groundwater levels. In addition, optimization of the operating levels of the seepage canals and canal control structures surrounding the reservoir will maintain existing groundwater levels adjacent to the project.

Of the eleven locations (***Figure C-1***) evaluated using the MIKESHE model, the only location where simulated groundwater elevations were increased compared to the without-project conditions was north of the project. Simulated "with project" groundwater elevations increased slightly compared to the "without project" condition. The greatest difference was during the dry period (e.g., 1981) not the wet periods. This minor effect is can be addressed through further optimization of perimeter canal control structure operations for the project. The remaining ten locations (***Figure C-2*** through ***Figure C-12***) show practically no differences in groundwater elevations.

Therefore, there will be no adverse effects on existing levels of flood protection in the vicinity of the reservoir.

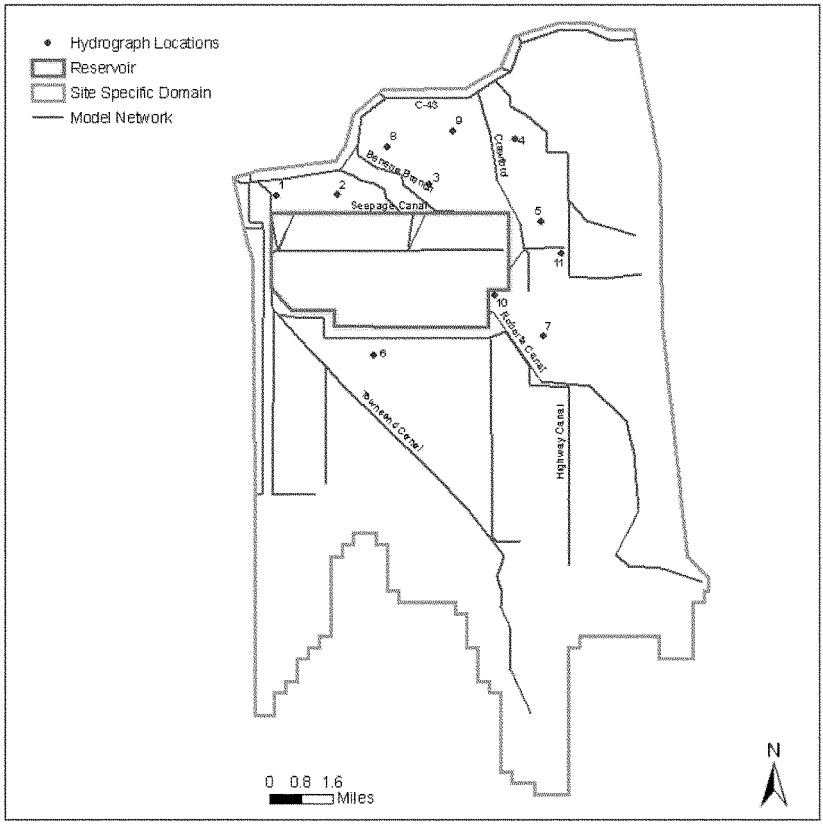


FIGURE C-1: LOCAL RESERVOIR MIKESHE MODEL BOUNDARY OUTLINING THE PROJECT FOOTPRINT, LOCAL CANALS AND THE LOCATIONS OF THE SIMULATED GROUNDWATER LEVELS FOR THE GROUNDWATER HYDROGRAPHS

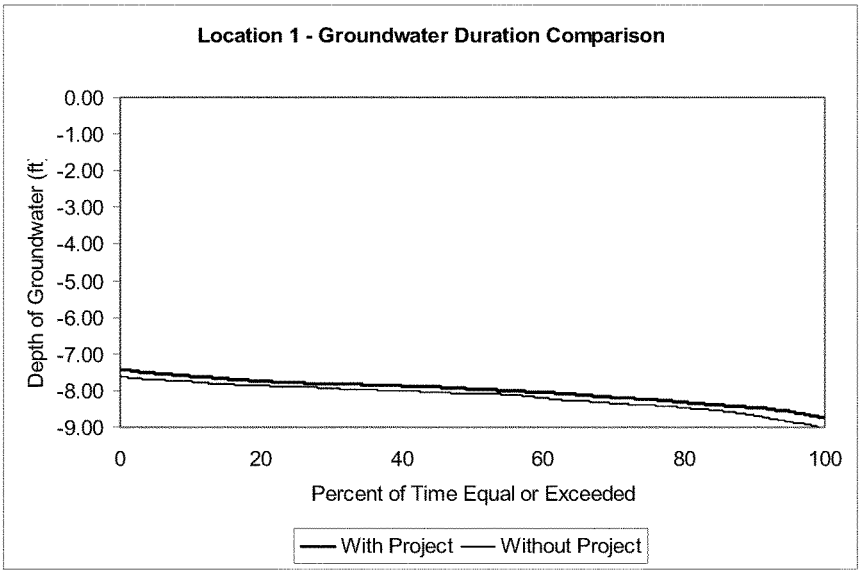


FIGURE C-2: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 1

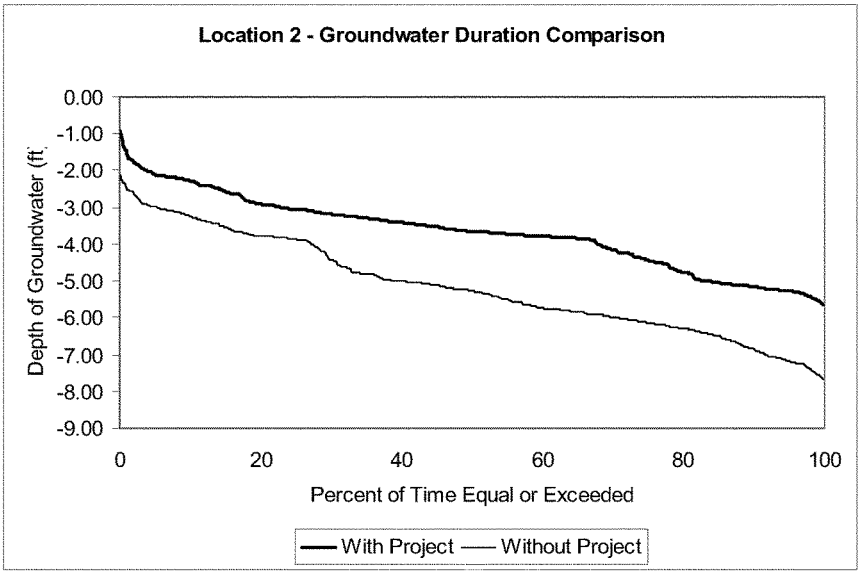


FIGURE C-3: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 2

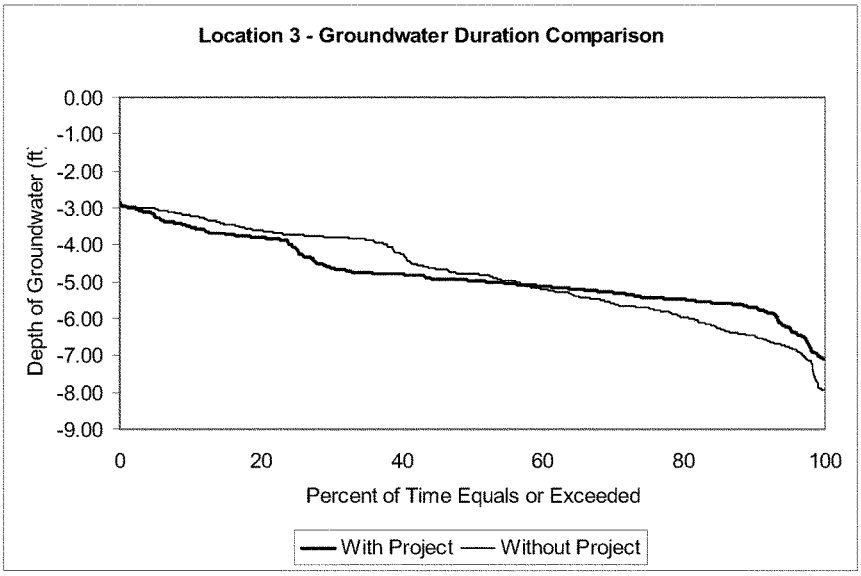


FIGURE C-4: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 3

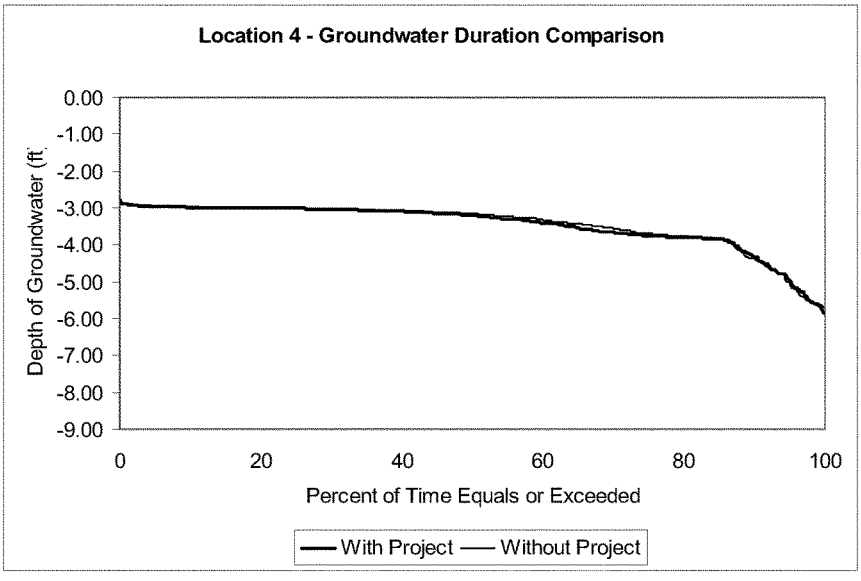


FIGURE C-5: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 4

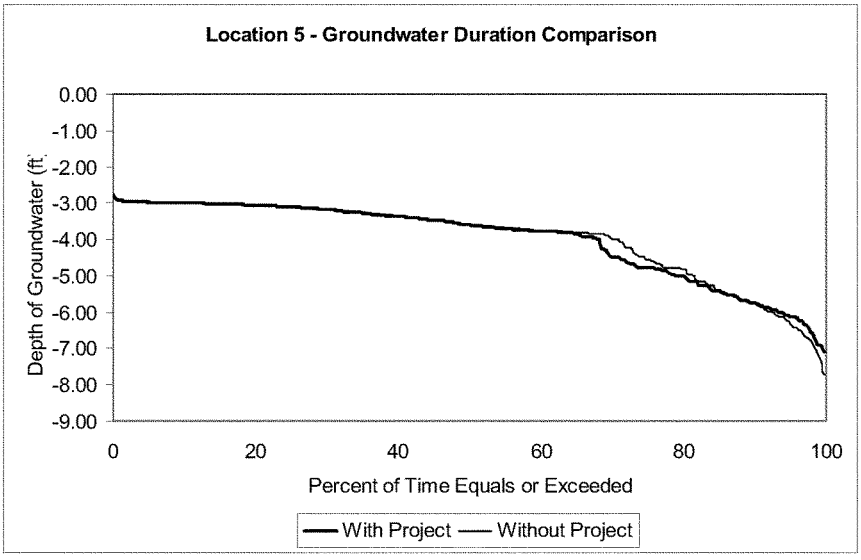


FIGURE C-6: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 5

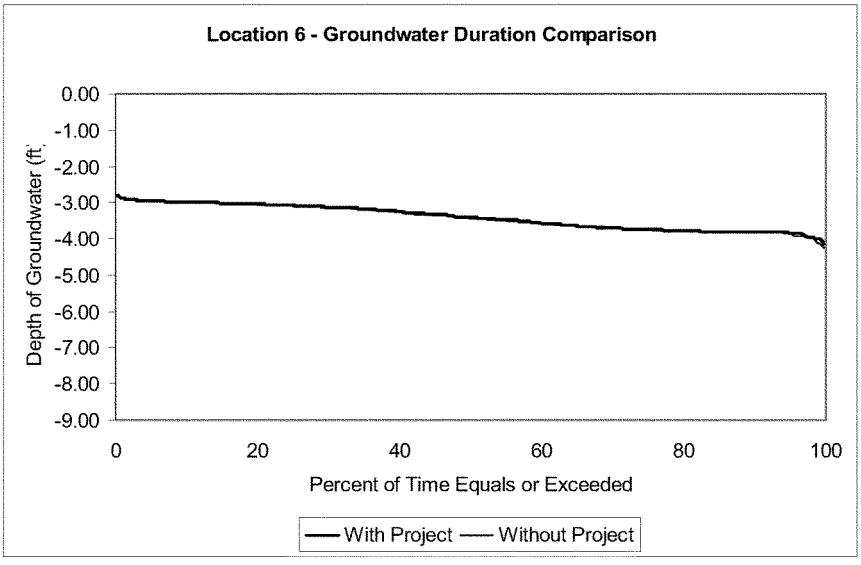


FIGURE C-7: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 6

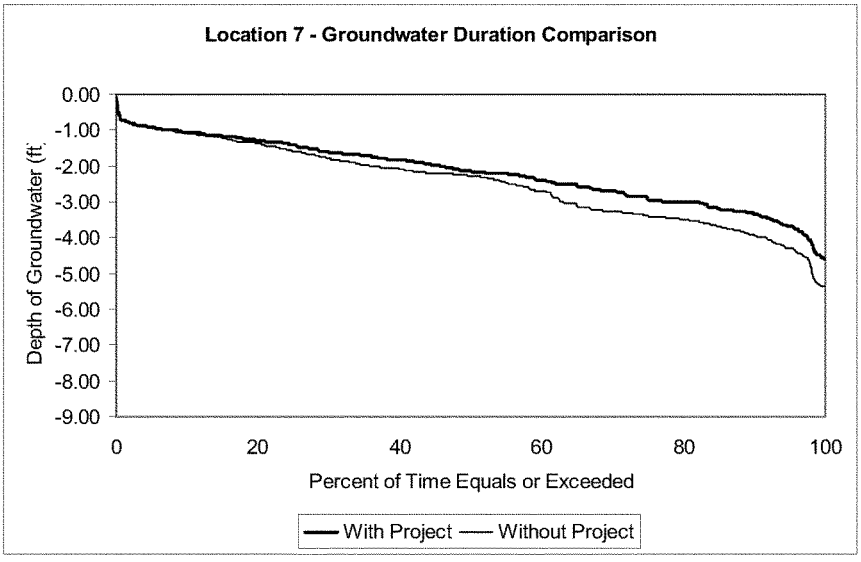


FIGURE C-8: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 7

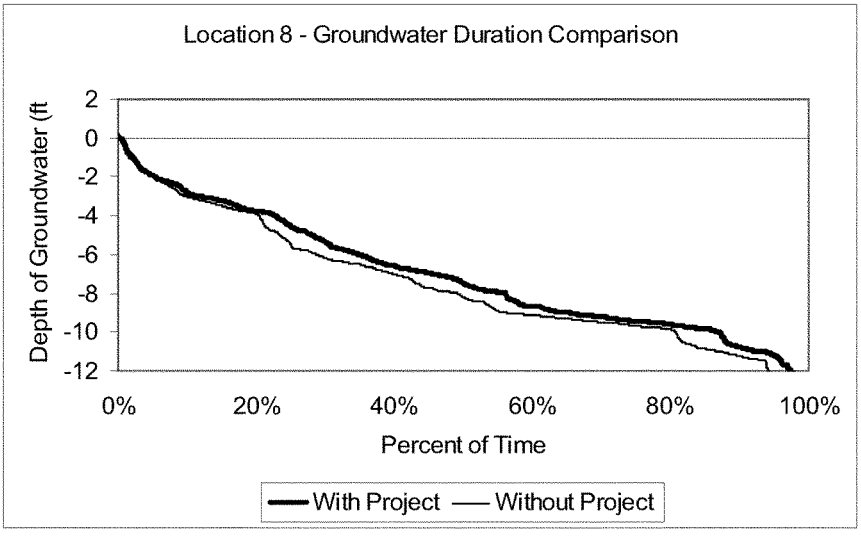


FIGURE C-9: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 8

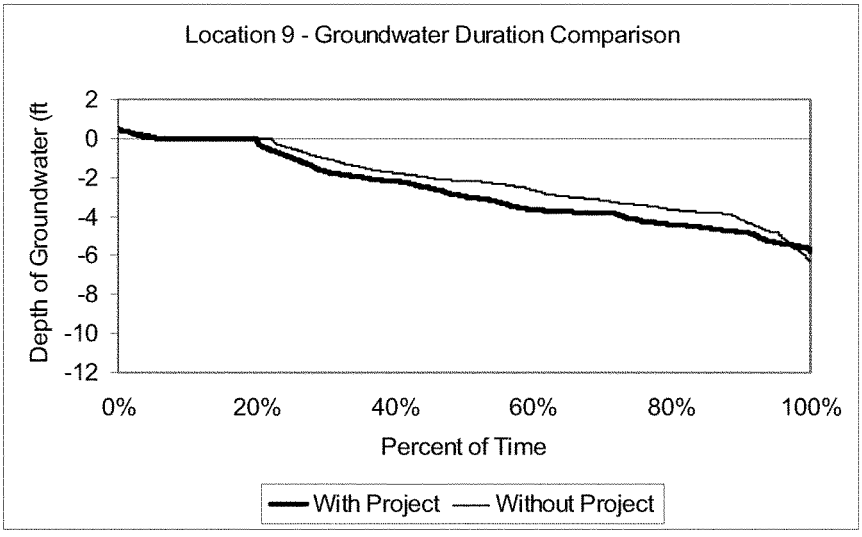


FIGURE C-10: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 9

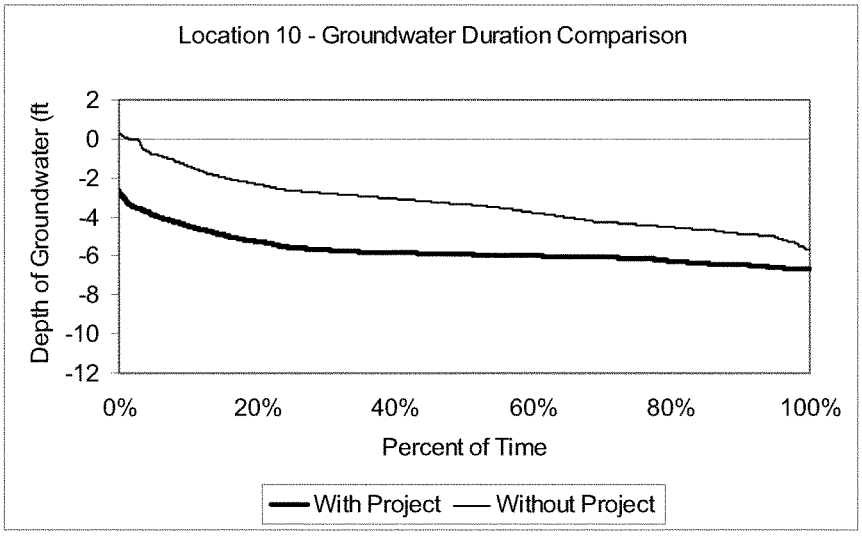


FIGURE C-11: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 10

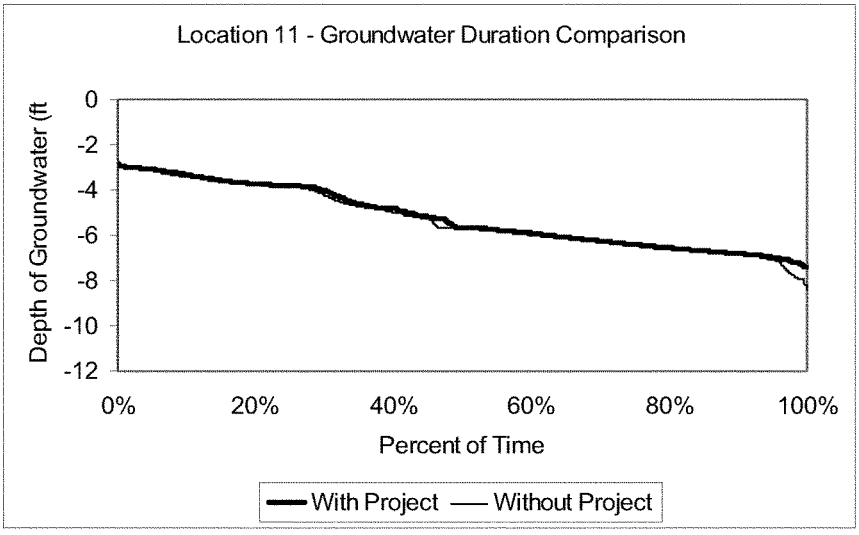


FIGURE C-12: DEPTH TO GROUNDWATER LEVEL FOR THE WITH AND WITHOUT PROJECT AT LOCATION 11

C.3.2 Identifying Water Made Available by the Project for the Natural System

C.3.2.1 Total Water Made Available by the Project

A graphic comparing how the project trends towards meeting the Caloosahatchee Estuary salinity restoration targets for the "with" and "without" project conditions is shown by the volume probability curves (***Figure C-13***) below. This graphic contains five volume probability curves. The period of record salinity target flows (EST 05) were plotted for comparison of both the IOR and NAI conditions to show project trends towards meeting restoration targets in both scenarios. To show the relative increase in water made available in both the IOR and NAI conditions, the baselines for each of those conditions were also plotted. It should be noted that the y-axis for this graphic indicates acre-feet per day. .

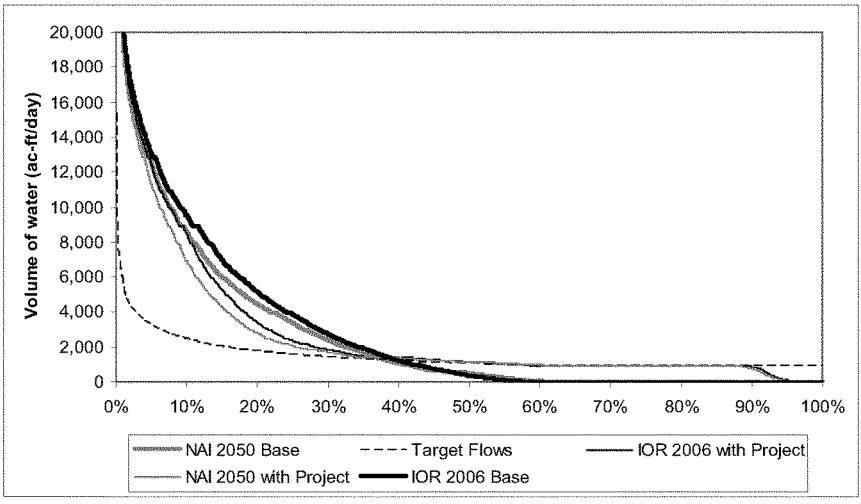


FIGURE C-13: VOLUME PROBABILITY CURVES OF TOTAL WATER MADE AVAILABLE TO ACHIEVE BENEFITS OF THE PROJECT

C.3.2.2 Water Made Available by the Project for the Natural System

Using the total water made available data two curves were plotted showing the variability of the water made available by the project for the natural system for both the IOR and NAI conditions (***Figure C-14***). These volumes were calculated by summing the difference between the two conditions and ranking the differences. A summary of the total water made available for the natural system with the project and without the project IOR and NAI conditions is provided (***Table C-3***). In addition the water made available by the project is identified for the 10th, 50th and 90th percentiles based on annual volume of water provided to the estuary.

C.3.2.3 Identifying Water to be Reserved or Allocated for the Natural System

The quantity of water to be reserved or allocated for the natural system is based upon the IOR condition. As described above, these volumes are shown in ***Figure C-14*** and ***Table C-3***. The annual volumes identified at 10th, 50th and 90th percentiles for the IOR condition are 159,485 ac-ft/year, 105,990 ac-ft/year and 27,619 ac-ft/year, respectively. This volume of water made available by the project in the IOR condition will be reserved or allocated for the natural system to achieve the benefits of the project.

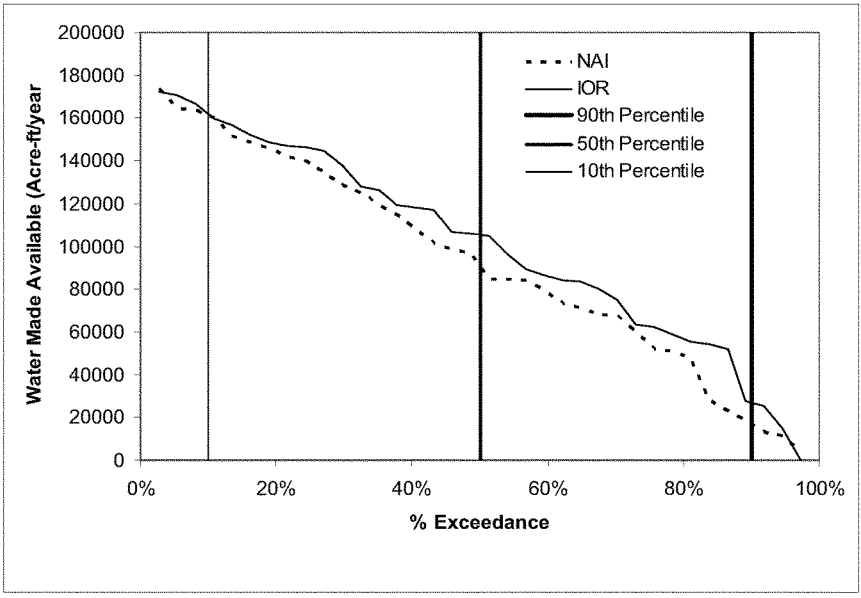


FIGURE C-14: VARIABILITY OF WATER MADE AVAILABLE BY THE PROJECT FOR THE IOR AND NAI CONDITIONS

TABLE C-3: IDENTIFICATION OF THE VOLUME OF WATER (AC-FT/YEAR) MADE AVAILABLE FOR THE NATURAL SYSTEM TO ACHIEVE THE BENEFITS OF THE PROJECT

Total Water and Water Made Available by the Project for the Natural System - Caloosahatchee Estuary									
	10%			50%			90%		
Condition	*Total water to achieve project benefits*	*Water available towards the target in the without project condition*	*Water made available by the project equaled or exceeded 10% of the time*	*Total water to achieve project benefits*	*Water available towards the target in the without project condition*	*Water made available by the project equaled or exceeded 50% of the time*	*Total water to achieve project benefits*	*Water available towards the target in the without project condition*	*Water made available by the project equaled or exceeded 90% of the time*
IOR 2006	321,575	162,090	159,485	395,900	289,910	105,990	668,881	641,263	27,619
NAI 2050	320,608	160,465	160,143	557,326	460,431	96,895	379,983	361,629	18,354

C.3.3 Project Assurances

The overarching objective of the Comprehensive Everglades Restoration Plan ("Plan") is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Federal Government and the State of Florida are committed to the protection of the appropriate quantity, quality, timing, and distribution of water to achieve and maintain the benefits to the natural system described in the Plan. As envisioned in WRDA 2000 and the Programmatic Regulations, each PIR will identify this appropriate quantity, quality, timing, and distribution of water for the natural system.

The following language sets forth these commitments:

> "The overarching objective of the Plan is the restoration, preservation, and protection of the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Federal Government and the non-Federal sponsor are committed to the protection of the appropriate quantity, quality, timing, and distribution of water to ensure the restoration, preservation, and protection of the natural system as defined in WRDA 2000, for so long as the project remains authorized. This quantity, quality, timing, and distribution of water shall meet applicable water quality standards and be consistent with the natural system restoration goals and purposes of CERP, as the Plan is defined in the programmatic regulations. The non-Federal sponsor will protect the water for the natural system by taking the following actions to achieve the overarching natural system objectives of the Plan:
>
> 1. Ensure, through appropriate and legally enforceable means under Federal law, that the quantity, quality, timing, and distribution of existing water that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report is available to the natural system, will be available at the time the Project Cooperation Agreement for the project is executed and will remain available for so long as the Project remains authorized.
>
> 2a. Prior to the execution of the Project Cooperation Agreement, reserve or allocate for the natural system the necessary amount of water that will be made available by the project that the Federal Government and the non-Federal sponsor have determined in this Project Implementation Report.
>
> 2b. After the Project Cooperation Agreement is signed and the project becomes operational, make such revisions under Florida law to this reservation or allocation of water that the Federal Government and the non-Federal sponsor determines, as a result of changed circumstances or new information, is beneficial for the natural system.

3. For so long as the Project remains authorized, notify and consult with the Secretary of the Army should any revision in the reservation of water or other legally enforceable means of protecting water be proposed by the non-Federal sponsor, so that the Federal Government can assure itself that the changed reservation or legally enforceable means of protecting water conform with the non-Federal sponsor's commitments under paragraphs 1 and 2. Any change to a reservation or allocation of water made available by the project shall require an amendment to the Project Cooperation Agreement

C.4 DRAFT STATE COMPLIANCE REPORT

DRAFT STATE COMPLIANCE REPORT

CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT



This page intentionally left blank.

Table of Contents — Page

1.1	Introduction	1
1.2	Comprehensive Needs Analysis and Evaluation	3
1.2.1	Water Supply	3
1.2.2	Water Quality	8
1.2.3	Flood Damage Reduction	20
1.2.4	Threatened and Endangered Species	21
1.2.5	Other Natural System and Habitat Needs	31
1.3	Determination of Project Component Feasibility [373.1501(5)(b)]	31
1.3.1	Standard Engineering Practices and Technologies	31
1.3.2	Efficiency and Cost Effectiveness	48
1.4	Determination of Project Component Consistency with Applicable Laws and Regulations [373.1501(5)(c)]	52
1.4.1	Pre-application Conference	53
1.4.2	Local Agency Information	54
1.4.3	State Agency Information	54
1.4.4	Federal Agency Information	56
1.5	Reasonable Assurances [373.1501(5)(d)]	58
1.5.1	Water Supply Assurance	60
1.5.2	Flood Protection Assurance	62
1.5.3	Adaptive Management to Meet the Needs of the Restored Natural Environment	65
1.6	Coordination with Existing Utilities and Public Infrastructure [373.1501(5)(e)]	66
1.6.1	Summary of Utilities Within Project Area	67
1.6.2	Summary of Coordination Efforts With Existing Utilities and Public Infrastructure	67
1.7	Increased Water Supply Available from Project [373.470]	67
1.7.1	State Requirements	67
1.7.2	System-Wide Effects	70
1.7.3	Caloosahatchee River (C-43) West Basin Storage Reservoir Project Effects	70
1.7.4	Water for Other Water-Related Needs of the Region	71

DRAFT

This page intentionally left blank.

AF

1.1 Introduction

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project will achieve estuarine restoration benefits in the Caloosahatchee Estuary, which is integral to achieving system-wide benefits in the south Florida ecosystem. The Project will help reduce damaging wet season high flows from Lake Okeechobee as well as contributing basin runoff from the lower West Caloosahatchee River Basin by capturing and storing a portion of these flows in the reservoir. Then during the dry season when water levels are at their lowest, water will be released from the reservoir to the Caloosahatchee River (C-43 Canal) to promote a healthy salinity balance in the Caloosahatchee Estuary, thereby reducing saltwater migration into the freshwater portion of the estuary. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project achieves the benefits described in the Comprehensive Everglades Restoration Plan (CERP) and is an integral part of CERP.

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project is located in western Hendry County and features a reservoir with a storage capability of 170,000 acre feet, a normal pool storage depth between 17 and 22 feet with a footprint of approximately 10,480 acres. The reservoir includes an individual inflow pump station of 1,500 cfs, discharge structures, emergency overflow spillways, and seepage control canals with associated structures.

Stakeholders in the basin have expectations that the Caloosahatchee River (C-43) West Basin Storage Reservoir Project will address additional water supply demands for urban and agricultural users in the area while providing water quality improvement features. The ability of the project to address these needs is affected by at least two factors:

- Agriculture in the area depends upon surface water and groundwater for water supply to meet irrigation needs, especially in the upper basin., and
- Several public water supplies sources in the basin rely on surface water withdrawals from the Caloosahatchee River (C-43 Canal) to meet urban water demands.

In order to address changing conditions and other issues and concerns that have arisen since the development of the Comprehensive Everglades Restoration Plan, it is recommended that the Caloosahatchee River (C-43) West Basin Storage Reservoir Project use an Incremental Adaptive Restoration approach, in which the project would be divided into two phases. This first phase, the Caloosahatchee River (C-43) West Basin Storage Reservoir Project will address the most immediate needs of the estuary, while ensuring that it is fully compatible and consistent with CERP. Then the second phase under

DRAFT

Caloosahatchee River (C-43) West Basin Storage Reservoir Project will provide a complete solution to addressing the needs of the entire basin.

It is important to note that the local sponsor for the project, South Florida Water Management District (SFWMD) is exploring alternative project delivery methods to expedite implementing portions of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project through the Acceler8 Program. Expedited implementation may involve the SFWMD initiating construction activities prior to executing a Project Cooperation Agreement (PCA) with the United States Army Corps of Engineers (USACE). Expedited implementation of portions of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project will provide early restoration benefits, potential cost savings and reduced cash flow demands. The USACE is recommending that SFWMD be credited for expenditures for work on the Caloosahatchee River (C-43) West Basin Storage Reservoir Project completed in advance of executing a PCA and for services provided under a public-private partnership. Credit for such work will be subject to the Secretary of the Army determining that the work is integral to the authorized CERP Project and that the construction is consistent with applicable USACE construction standards.

The total estimated first cost for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is $462,860,000 (October 2006 price level). The total first cost includes recreation features totaling $2,930,000. The estimated total annual cost of operation, maintenance, repair, rehabilitation and replacement (OMRR&R) of the ecosystem restoration elements is $3,160,000 with an estimated Federal annual cost of $1,580,000 and an estimated non-Federal cost of $1,580,000. The estimated cost for OMRR&R of the recreation elements is $25,000 which is 100% non-Federal.

This State Compliance Report is intended to address the requirements of Chapter 373, Florida Statutes (F.S.) as well as fulfill the requirements of WRDA 2000 and the Programmatic Regulations for CERP (33 CFR Part 385) which specifies requirements for the PIR. Section 373.470, F.S., requires the SFWMD, prior to executing a Project Cooperation Agreement (PCA), to complete a PIR to address the project component's economic and environmental benefits, engineering feasibility, and other factors provided in Section 373.1501 sufficient to allow the SFWMD to obtain approval under Section 373.026, F.S. In addition, Section 373.026(8), F.S., requires that prior to submitting a PIR to Congress for authorization, or receipt of an appropriation of State funds for construction of a CERP project, the Florida Department of Environmental Protection (FDEP) must first approve a PIR pursuant to Section 373.026(8), F.S. This review and approval is based on a determination that the SFWMD has complied with the requirements set forth in subparagraphs (a) through (e) of Section 373.1501(5),

F.S. and Section 373.470, F.S. This State Compliance Report addresses each of these requirements in subparagraphs (a) through (e).

This State Compliance Report seeks approval from the FDEP for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project that includes:

- a two-cell reservoir with a "normal pool" storage capacity of 170,000 acre-feet with armoring, cutoff walls, and embankments
- a project footprint of approximately 10,492 acres
- an intake pump station with 1,500 cfs capacity to pump water from the Townsend Canal to fill the reservoir
- pump stations, spillways with emergency overflow and vertical lifts, drawdown structures, culverts, canals, earthwork artificial habitat creation, and recreational features

1.2 Comprehensive Needs Analysis and Evaluation

Section 373.1501(5)(a), F.S. requires the SFWMD to "Analyze and evaluate all needs to be met in a comprehensive manner and consider all applicable water resource issues, including water supply, water quality, flood protection, threatened and endangered species, and other natural system and habitat needs." The following sections describe the procedures and methodologies used in assessing these water resources issues along with a description of how these issues have been met or resolved for this project. For detailed descriptions of these analyses the reader should refer to the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Draft PIR/EIS.

1.2.1 Water Supply

Water for urban and agricultural uses in the C-43 Basin is supplied from both groundwater and surface water systems. Surface water is used primarily for agricultural irrigation, with groundwater being used in areas that do not have access to the Caloosahatchee River. In addition, the Caloosahatchee River is a potable water supply source in Lee County. Groundwater and surface water are dependent upon rainfall for recharge.

The Caloosahatchee River (C-43 Canal) receives water from Lake Okeechobee, runoff from the basin, and base flow from the Surficial Aquifer System (SAS). The river in turn supplies water for public supply, agriculture, and the environment. This source can be unreliable during the dry season or in periods of inadequate rainfall, when releases are required from Lake Okeechobee to meet demands.

DRAFT

The Caloosahatchee River Water Use Basin is within the Lake Okeechobee Service Area (LOSA) and is primary source for agricultural irrigation and surface potable water supply. This area extends from the Franklin Lock (S-79) eastward to the Moore Haven Lock (S-77) and includes land in Lee, Glades, and Hendry counties. Discharges from Lake Okeechobee provide the primary flow in the river during the dry season. Water is released from the lake to meet the supplemental agricultural water demand as well as supplying water for municipal consumptive use.

Groundwater is an important component of the agricultural water supply in the freshwater portion of the Caloosahatchee Basin. The groundwater resources in the area include the surficial aquifer, the intermediate aquifer and the Floridan aquifer system. The yield and storage of the groundwater is highly variable throughout the basin. The surficial aquifer system is used for some irrigation in eastern Hendry and Glades counties.

The intermediate aquifers are used primarily for irrigation in the western portion of Hendry County. There is local recharge to both the surficial and intermediate aquifers. The Floridan aquifer is used in northern Glades County for irrigation and in the northwest corner of the basin and mixed with surface water for irrigation. The water from the Floridan aquifer is too highly mineralized elsewhere in the basin. This deep aquifer is recharged from outside the area.

Non-environmental surface water demands within the basin are primarily agricultural with some potable water supply, commercial and industrial uses. The commercial and industrial demands vary greatly by type of business. In the project vicinity, commercial and industrial demands constitute about one percent (1%) of the overall water demand. Because the demand is relatively small and difficult to generalize, an average demand is not calculated for this use category. The emphasis is placed on estimation of agricultural and potable water uses.

A thorough investigation of water use for the Caloosahatchee River and surrounding basins was conducted by the SFWMD for the Caloosahatchee Water Management Plan (April 2000). Table 1 summarizes the water use allocation for major agricultural land use categories based on the Integrated Surface Water/Ground Water Model.

Table 2 presents the United State Geological Survey estimate of water use, excluding mining and power generation water use, for 2000 for the four county study area. Total public-supply water use for the region is estimated at 71.85 million gallons per day (mgd), and total municipal and industrial (M&I) water use is estimated at 115.17 mgd. The addition of the 680.63 mgd of agricultural water use increases total water demand for the region to 796.24 mgd.

DRAFT

Agricultural water use accounts for 85% of the total use; public-supply water use accounts for 19% and recreational self-supply accounts for about 3%.

Table 1: Summary of 1995 Water Use Demand Based on the Integrated Surface Water/Ground Water Model for Major Agricultural Land Use Categories

Crop	Water Use (1,000 acre-feet/year)
Citrus	143
Sugarcane	110
Vegetables	36
Total	290

Note: Based on 1995 land use, MIKE SHE results indicate an additional 30,000 acre-ft/year of irrigation in addition to citrus, sugarcane and vegetables.

On the county-level, the largest total water user in the study area in 2000 was Hendry County, mainly because of agricultural water use. Hendry County used a total of 512.11 mgd, or 64% of the total regional water use. Of this amount, 503.91 mgd (98%) was agricultural use and 4.72 mgd was public-supply water use. Lee County's public-supply water use was about 52 mgd. Lee County's total water use was 144.95 mgd, the third highest in the region. Lee County had the highest self-supply domestic water use in the region at 8.86 mgd. Lee County also had high recreational water use of 22.66 mgd.

Table 2: USGS Estimated Total Water Use, for Selected Counties, 2000 - Excluding Mining and Power Generation (mgd)

	Municipal and Industrial							
		Self-Supply						
County	Public Supply	Domestic	Commercial	Industrial	Recreation	Sub Total	Agriculture	Grand Total
Charlotte	14.21	3.55	0.11	0	3.48	21.35	47.19	68.54
Glades	0.55	0.61	0.04	0	0.42	1.62	69.02	70.64
Hendry	4.72	1.67	0.21	0.51	1.09	8.2	503.91	512.11
Lee	52.37	8.86	0.46	0.09	22.66	84.4	60.51	144.95
Total	71.85	14.69	0.82	0.6	27.65	115.57	680.63	796.24

Note: Recreation self-supply water use includes golf course irrigation.
Source: USGS unpublished data, 2002.

Table 3 represents the conservation-adjusted, most likely population scenario, water use forecast and the percent of total water use associated with each county or county area in the study area, for 2000, 2025, and 2050. Lee County accounted for 90.7% of all municipal and industrial water use in the study area in 2000, and will account for 90.4% of all water use by 2050. The population of

Lee County is projected to increase by 97% over the same time period. The Glades County Area generates the smallest use, at slightly more than 2% of the total regional water use over all time periods. Due to the small population in the Charlotte County portion of the study area, the water use totals for Charlotte County are incorporated into those of Glades County and therefore the USGS 2000 baseline totals do not exactly equal the IWR-MAIN 2000 totals.

Table 3: C-43 Study Area, Municipal and Industrial Conservation-Adjusted Water Use and Distribution, by County Area Most-Likely Population Scenario, 2000, 2025, and 2050

	2000		2025		2050	
Area	MGD	Percent of Total	MGD	Percent of Total	MGD	Percent of Total
Lee County	92.7	90.7 %	129.5	90.4 %	148.0	90.4 %
Glades County Area	2.4	2.4 %	4.0	2.8 %	4.5	2.8 %
Hendry County Area	7.1	6.9 %	9.7	6.8 %	11.2	6.8 %
Total	**102.2**	**100.0%**	**143.2**	**100.0%**	**163.7**	**100.0%**

The Southwest Florida Regional Planning Council has estimated that total agricultural acreage will increase between 3% and 7% between 1995 and 2020 while citrus acreage will increase between 54% and 81% and sugarcane between 62% and 190%. The increase in citrus and sugarcane acreage is due in a large part to conversion of existing irrigated acreage that is in other crop types to citrus and sugarcane.

Table 4 summarizes the simulated 2020 irrigation demand for major agricultural land use categories for the area based on the MIKE SHE model. Irrigation demands are expected to increase approximately 55% in the Caloosahatchee Basin between 1995 and 2020. No projected increases in irrigated acreages between 2020 and 2050 are expected, and there may potentially be a slight decline, therefore 2050 demands are expected to approximate 2020 demands of 450,000 acre feet annually.

Table 4: Summary of 2020 Water Use Demand Based on the MIKE SHE for Major Agricultural Land Use Categories.

Crop	Water Use (1,000 acre-feet/year)
Citrus	242
Sugarcane	181
Vegetables	27
Total	450

Providing additional water supply for urban and agricultural users represents a potential opportunity to be addressed by the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. Upon meeting flow targets at the S-79 structure necessary for ecosystem restoration in the Caloosahatchee Estuary, any additional water stored by the C-43 project could be delivered to the C-43 Canal and would be available for urban and agricultural users.

It is anticipated that non-environmental water supply benefits associated with the Caloosahatchee River (C-43) West Basin Storage Reservoir Project will be incidental. Ongoing analysis and planning for water supply within the project area is being conducted by the SFWMD through updated to the Lower West Coast Water Supply Plan.

1.2.1.1 Increasing Water Supply through Storage

The main purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is to provide for the retention and management of excess water within the natural system that is lost to tide (Gulf of Mexico), then release it back into the natural system when needed to help moderate extreme salinity changes in the estuary which are detrimental to estuarine communities. Captured excess water is made up of regulatory releases from Lake Okeechobee, basin runoff from storm events passing through the Caloosahatchee Basin, and irrigation runoff from agricultural fields (Figure 1).

1.2.1.2 Impoundment Seepage Management

Seepage control of embankment through-seepage and underseepage is critical to managing the water resource as well as maintaining a safe and stable reservoir. Therefore, the control of seepage is a prime consideration for the proposed impoundment. Seepage can occur directly through an embankment constructed with pervious material (through-seepage) or it can occur as underseepage that travels in one of the foundation layers beneath an embankment. Both of these seepage pathways need to be controlled and monitored. Guidelines used by the USACE are found in EM-1110-2-1901 entitled "Seepage Analysis and Control for Dams".

Currently groundwater seeps from the project site north towards the river. All of the reservoir alternatives include a slurry wall within the embankment to effectively prevent this seepage. Once constructed the perimeter canal will provide this groundwater flow to the areas north of the project. In order to minimize the disturbance to the natural groundwater flow, the perimeter canal will be kept at levels adequate to maintain existing levels of groundwater in the area.

DRAFT

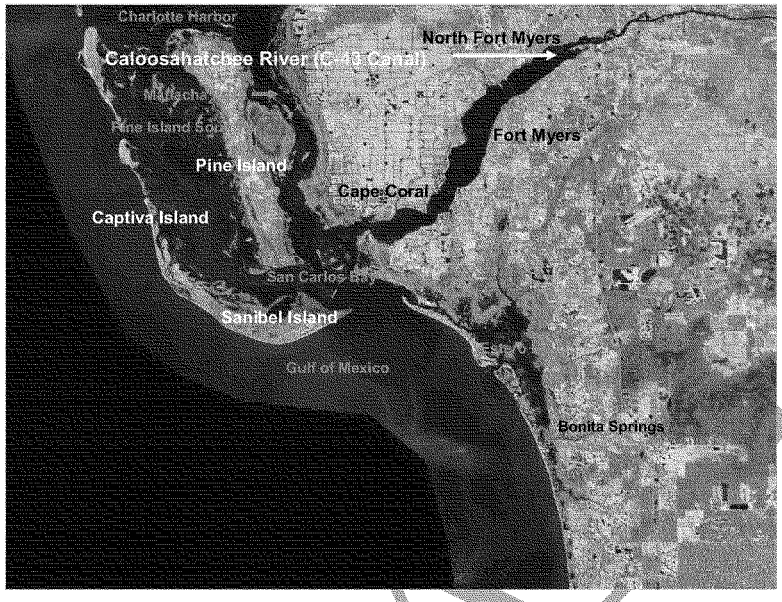


Figure 1: Caloosahatchee Estuary Area Map

1.2.2 Water Quality

The water quality conditions upstream and downstream of the S-79 structure were evaluated as part of recent Florida Department of Environmental Protection (FDEP) efforts within the C-43 basin. The FDEP Verified List for the Caloosahatchee, (FDEP June, 2005) identifies impaired waters in the C-43 sub-basin as well as the Caloosahatchee Estuary sub-basins. The report was prepared in order to meet the requirements of the Federal Clean Water Act. Under Florida's implementation of the Clean Water Act, waters listed as impaired are then subject to the development of Total Maximum Daily Loads (TMDLs) intended to limit the future discharge of the offending pollutant by point and non-point contributors. The FDEP has divided the Caloosahatchee Basin into five planning units. Two planning units, East Caloosahatchee, and West Caloosahatchee, are the two sub-basins that are upstream of the S-79 structure on the C-43 Canal. The three remaining planning units, Telegraph Swamp, Orange River, and Caloosahatchee Estuary, are downstream of the S-79 structure. In 2002, the FDEP performed a study to determine the relative loadings of total nitrogen and total phosphorus in the C-43 basin (Janicki, 2002). This report ranks the sub-basins within the C-43 basin in terms of their relative contribution of total nitrogen and total phosphorus. A third study, the Caloosahatchee Water Quality Data Collection Program" (ERD, 2002) sponsored

by the SFWMD, quantifies pollutant concentrations and loads from the various sub-basins within the C-43 basin.

Water quality within this study area has been significantly altered due to the construction of the three locks and dams, excavation of the riverbed to 25 feet, increases in both urban and agricultural land use, and by the construction of an extensive network of canals and drainage ditches to accommodate this level of development. These hydrologic alterations have resulted in discharges of unnaturally large quantities of freshwater runoff into the river and eventually into the downstream receiving estuarine systems. Extensive documented research on the tidal portion of the Caloosahatchee River has shown that salinity changes in the estuary are the result of either low to no flows or too high flows of freshwater being discharged at the S-79 structure. Together, extreme flows and changes in salinity are by far the largest problem affecting the ecologic health of the estuary.

1.2.2.1 Restoration Objective and Receiving Waters

The primary restoration objective for the C-43 Basin Storage Reservoir identified in the Restudy was:

> *"... to capture C-43 Basin runoff and releases from Lake Okeechobee. These facilities will be designed for water supply benefits, some flood attenuation, to provide environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary..."*

Primary system benefits would include:

(1) Improvements in salinity and
(2) Improvements in water quality in the estuary.

Secondary system benefits would include:

(1) Improvements in flood attenuation within the basin; and
(2) A possible additional water supply source for agricultural and urban uses (via runoff capture and reuse methodology) once the needs of the estuary are met.

Several ecological functions of the Caloosahatchee Estuary are directly affected by water quality. The water quality problems negatively impacting ecological resources are primarily related to excessive variations in freshwater inflow and salinity as well as increased nutrient loads and color that result from excessive freshwater discharges in the wet season.

DRAFT

It has long been established that freshwater inflow dynamics and salinity are major determinants of the distribution of estuarine species and those species' life stages, especially regarding their location and association with favorable habitat for rearing, protection and settlement. Therefore, the ability of each estuary to function as a nursery differs according to its biological features, physical configuration, and inflow volume, magnitude and timing. Research by the SFWMD on the tidal Caloosahatchee began in the mid-1980s to determine the proper timing and volume of water required to support valued ecosystem components (i.e., such key estuarine species as oysters and SAV, such as *Vallisneria* spp.) and general biotic indicators (plankton and benthic invertebrates). Since the predominant source of freshwater to the Tidal Caloosahatchee (especially in the wet season) is water through the S-79 (70 percent of total flow), the research focused on issues of timing and volume of water through this structure; however, the latest models and methods do take into account the other major sources of freshwater discharged to the Tidal Caloosahatchee from the "tidal" watershed. The SFWMD has focused on development of optimum S-79 flow ranges and delivery patterns for the estuary. As part of the state-mandated minimum flows and levels (MFLs) process, the SFWMD initially determined that a minimum dry season discharge at S-79 of 300 cfs (monthly average flow) is required to provide salinity conditions capable of supporting *Vallisneria*; however, the minimum flow target has been revised upwards to 450 cfs based on more recent scientific research by SFWMD staff. *Vallisneria* in the upper estuary is still recovering from the last drought and could suffer additional harm as the MFL requirements continue to be unmet.

Also as part of this research, maximum freshwater inflow limits (set at mean monthly values of 2,800 cfs and 4,500 cfs depending on frequency) and a frequency distribution of flows have been recommended that support valued ecosystem components and promote estuarine ecological benefits. It is these recommended flows that were used initially to determine CERP storage requirements and infrastructure changes in the Caloosahatchee Basin and Lake Okeechobee during the Restudy. These minimum and maximum flow targets have also been adopted for the PIR.

Restoring the flows and achieving the hydrologic targets is an environmental priority within the Caloosahatchee River Basin. The estuary will remain at risk as long the quantity and timing of freshwater flows into the estuary remains unchanged. Large releases will continue to have far reaching salinity and water quality impacts that may even influence Florida Bay unless water management practices are changed.

The majority (75 - 90%) of the nitrogen and phosphorus load sent to the Caloosahatchee Estuary comes from sources upstream of S-79. To address questions regarding the effect of reservoirs on water quality, specifically

DRAFT

nutrients, FDEP contracted with Tetra Tech (and subcontractors Janicki Environmental and Soil and Water Engineering Technology, Inc.) to examine the potential nutrient impairment problem in the estuary. The study developed regression equations to describe two relationships: 1) between chlorophyll-a concentration and nitrogen loading and 2) between chlorophyll-a concentration and phosphorus loading. Due to the naturally occurring high levels of phosphorus in the watershed, the indication was that nitrogen was the limiting nutrient, which is consistent with the other studies identified earlier. Thus, of the two regression equations, this study determined that the nitrogen/chlorophyll-a relationship was the best means of predicting nutrient impairment (or phytoplankton algal blooms) in the estuary. The report identified three preliminary targets for total nitrogen (TN) loading to the estuary from releases at S-79 in order to achieve chlorophyll-a concentration limits of 11 micrograms per liter (ug/l):

Maximum annual load less than 3,000 tons/year, where annual load ~ (wet season monthly load x 5) + (dry season monthly load x 7)
Dry season monthly load less than 190 tons/month, and
- Wet season monthly load less than 350 tons/month.

1.2.2.2 Applicable Water Quality Standards

Water quality within the Caloosahatchee watershed is influenced by fresh water inflows from Lake Okeechobee, non-point pollution in local basin runoff, as well as point sources such as wastewater treatment plant discharges. Due to the geology of the region, there is also a direct interaction between the surface water and groundwater, which can affect the dissolved oxygen and iron concentrations in the surface water column. The upper Caloosahatchee River watershed from the Moore Haven Lock and Dam (S-77) to the Lee/Hendry county line has been classified by the State of Florida as a Class III water body in accordance with Chapter 62-302, Florida Administrative Code. The Class III designation establishes specific water quality parameter requirements that are intended to protect and sustain the natural attributes necessary for these waters to meet their intended use (recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife). The surface water directly upstream of S-79 east to the Lee/Hendry county line is designated as a Class I water body and must meet the standards required for use as a potable water supply (see Table 5 for surface water classification status of Caloosahatchee River).

1.2.2.3 Water Quality Characterization in the Project Area

Water Quality Conditions Upstream of S-79 - The East Caloosahatchee and West Caloosahatchee planning units are the two sub-basins that lie upstream of the S-79 structure. While all of the East Caloosahatchee sub-basin is upstream

of the planned reservoir, approximately 70% of the West Caloosahatchee sub-basin is upstream of the planned reservoir. The water quality conditions in these two sub-basins will have a significant impact on the reservoir water quality. The predominant land use in both of these planning units is agriculture. Water quality impairments in this sub-basin are primarily caused by non-point sources rather than point discharges such as sewage treatment plants or other industrial activity. Within the East Caloosahatchee unit, six water body segments have been identified as impaired. The impairments are lead, coliforms, iron, dissolved oxygen, copper, and nutrients. Within the West Caloosahatchee planning unit, a total of three water body segments have been identified as impaired. One of these water bodies is impaired for iron and lead, one is impaired for nutrients, and the last one is impaired for copper and lead. Of direct interest to this project is the Townsend Canal, which is immediately upstream of the planned reservoir intake and is impaired for copper and lead.

Table 5: Surface Water Classification for Caloosahatchee River

Class I Water: Caloosahatchee River	East Lee County line to SFWMD structure S-79 (Franklin Lock & Spillway)
Class III Water: Caloosahatchee River	SFWMD structure S-77 (Moore Haven Lock & Spillway) at Lake Okeechobee to Lee/Hendry County line.

Water quality pollutant loading upstream of the S-79 structure is composed of loading from runoff generated within the basin and from loading associated with Lake Okeechobee releases. Excluding the load from Lake Okeechobee releases, approximately 50% of the total nitrogen load resulting from runoff in the Caloosahatchee Basin comes from basin lands upstream of S-79. Similarly, excluding the phosphorus load from Lake Okeechobee releases, approximately 65% of the total phosphorus load resulting from runoff in the Caloosahatchee Basin comes from basin lands upstream of the S-79. When Lake Okeechobee flows and loads are included, more than 75% of total nitrogen and total phosphorus loads to the Caloosahatchee Estuary are a result of discharges at S-79.

Water Quality Conditions Downstream of S-79 - The three watershed planning units downstream of S-79 are Telegraph Swamp, Orange River, and Caloosahatchee Estuary. Within these three planning units, land use patterns transition from agricultural/natural areas in the east to residential in the west. In the FDEP Verified List, there are no impaired waters in Telegraph Swamp planning unit.

DRAFT

As the furthest downstream planning unit, the Caloosahatchee Estuary has to contend with its own pollution plus pollutants from the four upstream planning units. According to the June 2005 (FDEP) Verified List for the Caloosahatchee, the estuary-planning unit has 13 impaired water body segments, six of which are part of the main estuary and seven are tributary streams. All thirteen listed water body segments are impaired for coliforms (either total or fecal), seven are impaired for nutrients, six are impaired for dissolved oxygen, three are impaired for heavy metals (copper, lead), and one is impaired for specific conductivity. The FDEP Basin Status Report (FDEP 2002) states that the observed water quality violations are probably linked to urban land uses within the Caloosahatchee Estuary planning unit, poorly flushed residential tributary streams, and the effect of heavy pollutant loads discharged from upstream sub-basins.

Within the Caloosahatchee Estuary planning unit there are a total of 31 permitted sewage treatment plants. The Caloosahatchee pollutant loading report (ERD 2002) includes pollutant-loading estimates for the four largest sewage treatment plants in the Caloosahatchee Estuary as well as for eight tributaries downstream of the S-79 structure. This report includes loading estimates for the following pollutants: ammonia, nitrate, nitrite, total kiejahl nitrogen, total nitrogen, orthophosphorus, and total phosphorus, and total suspended solids. With the exception of ammonia, 10% or less of the wet or dry season load of each of these pollutants to the Caloosahatchee Estuary comes from the portion of the watershed downstream of the S-79 structure. During the dry season, approximately 5% of the total ammonia load in the estuary comes from the portion of the watershed downstream of the S-79 structure; however, during the wet season, approximately 40% of the ammonia load to the estuary comes from downstream of the S-79 structure. A relatively large amount of the ammonia loading from downstream of the S-79 structure comes from the four large sewage treatment plants. The Caloosahatchee Estuary non-point sources of total nitrogen and phosphorus contribute around 20% of the total loads delivered to the estuary.

Unlike the St. Lucie Estuary, a geographically extensive muck sediment layer is not present in the Caloosahatchee Estuary. This is evidenced by the presence of both freshwater and marine submerged aquatic vegetation (SAV) that usually does not coexist in areas where muck sediments are present. Scientists from the SFWMD and U.S. Fish and Wildlife Service (USFWS) have concluded that flocculent sediments are not a significant cause of water quality problems in the main channel of the Caloosahatchee Estuary.

In 1999 the USGS collected 58 sediment samples from downstream of the S-79 structure and two sediment samples from just upstream of the structure. The five sampling locations relative to the S-79 structure were downstream at mile

3.1, 9.3, 10.5, 12.2, and 23.8. Samples were tested for physical characteristics, organic content, pesticides, and heavy metals. Heavy metal results were compared with Florida Sediment Quality Assessment Guidelines (SQAG). Samples from five sites contained heavy metals (chromium, copper, lead, mercury, and zinc) at levels that exceed the Probable Effects Level (PEL) concentration published in the Florida SQAGs. Although a limited number of samples exceeded the PEL concentrations, bioaccumulation and bioconcentration studies would have to be done to quantify the impact of these sediments on in-situ biota. At present, there is no reason to believe that sediment contamination is a significant concern within the main stem of the estuary.

1.2.2.4 Pre-land Acquisition Environmental Site Assessments

The five major land parcels acquired for the C-43 reservoir project are the Berry Groves tract, Bryan Paul tract, Bob Paul tract, the Winthrop property, and the Griffin property. Prior to the 1960s these lands were primarily used as unimproved pasture. For the last 30 to 40 years these five parcels have been used to cultivate citrus. Over the operating life of these groves, fertilizers, herbicides and pesticides have been applied routinely as part of normal agricultural operations. From the 1960s to 1980s, pesticide use would have included the application of persistent organic compounds such as DDT, chlordane, and toxaphene. Use of these and other persistent pesticides has since been severely restricted by the U.S. Environmental Protection Agency (USEPA). Normal farm operations would also typically result in point-source contamination associated with maintenance areas, pesticide mixing and loading sites, and fuel storage areas.

Over the last six years, the SFWMD has performed multiple Environmental Site Assessments (ESAs) as well as worked to remediate most of the point source contamination sites. At present, most of this land is leased to agricultural operators who continue to cultivate the thousands of acres of citrus groves located on the properties.

At this time, most if not all of these potential contamination sites have been either remediated or further investigated to characterize the sites and prepare remediation plans. The SFWMD has made a commitment to the USACE and USFWS that after it takes control of the properties from the present lessees and begins construction of the reservoir, all of the outstanding point source remediation efforts will be completed. In addition to the point source contamination sites, the SFWMD also identified distributed soil contamination in portions of the cultivated areas on all of the acquired properties. The remediation of the cultivated soil sites involves the placement of these soils into the core of the reservoir dam. This will isolate the contaminated soils from

DRAFT

benthic organisms that serve as food for higher level organisms and thus reduce the potential for bioaccumulation of contaminants by fish and wildlife.

The USFWS service has reviewed all of the SFWMD's remediation plans and indicated that they believe that the efforts will sufficiently reduce the risk of harm to fish and wildlife in those areas where the remediation will be performed. The USFWS has also stated that moderate levels of copper and other contamination of the cultivated areas are believed not to pose a direct threat to species of concern; however, they believe that an indirect effect may occur since widespread low-level soil contamination may reduce the population of benthic organisms upon which the species of concern normally feed.

Despite the diligent work performed by the SFWMD and USFWS to reduce the risk to environmental resources, it is possible that once the reservoir is built, bioaccumulation of soil contaminants does result in harm to one or more species of interest. If this does happen, additional remediation efforts, such as more extensive removal of the reservoir bottom sediments, could be done to further reduce the exposure of benthic organisms to near surface soil contamination at the end of a dry season. The cost of additional remediation, if necessary, would be the responsibility of the SFWMD. If such remediation is necessary, this remediation effort may be scheduled in one cell at a time, possibly during the late dry season, thereby keeping the reservoir somewhat operational. Short summaries of the environmental audits for each property are provided below.

Berry Groves Property - Phase I and II ESA studies as well as ERAs were performed on this parcel during the period from December 1999 through 2006. These investigations identified more than 40 potential point source contamination sites within the parcel boundaries. These point source sites typically consist of refueling sites, maintenance sheds, pesticide storage/mixing sites, and irrigation pump stations. Seventeen (17) of the 40 sites were designated as requiring no further action because further investigation determined that contamination was not present at levels requiring remedial action. Fifteen (15) of the sites were identified as presenting a contingent hazardous, toxic and radioactive waste (HTRW) risk because contamination has been identified and quantified but remediation has either not begun or been completed. An additional five sites were identified in March 2003 as requiring remediation. The 40 contaminated sites discussed above can be generally categorized as point source contamination sites in which the contamination is contained within an area of a few acres or less. Though most of these sites have been remediated as of February 2007, remediation of the remaining sites will be completed prior to transferring control of the land from the lessee to the SFWMD.

DRAFT

Of greater concern to the USACE and the USFWS is the widespread presence of elevated copper concentrations in the cultivated soils on the Berry Groves property. The presence of elevated copper in the soils is a result of the application of fungicides that have been applied to the citrus groves. To investigate the risk posed by copper, a Phase III ERA was conducted by the URS Corporation under contract with the SFWMD and in coordination with the USFWS. The purpose of the ERA was to determine the risk that elevated concentrations of copper in the soil posed to populations of invertebrates, fish, and birds (the listed snail kite, for instance) that would use the C-43 reservoir for habitat.

Winthrop Property - The Winthrop property is located south and west of the larger Berry Groves property. The Winthrop property (2,399 acres) has been used to cultivate citrus for the last 30 or more years. Like the Berry Groves property, persistent pesticides such as DDT, toxaphene, and chlordane were probably widely used until the application of such chemicals was restricted by the USEPA in the 1980s. A Phase II ESA report was prepared in March 2003 by Environmental Consulting & Technology, Inc. (ECT) on behalf of the SFWMD. This report identified five areas of potential concern including the cultivated areas, canal sediments, two maintenance areas, and an exploratory oil/gas well. Grid based testing was performed in the cultivated areas such as was done on the Berry Groves property. The results of these sediment analyses indicated the presence of aldrin and aldicarb at levels exceeding the threshold concentrations. A preliminary ERA was done using a fugacity-based food chain model to determine the risk that elevated aldrin concentrations might pose to avian species. The results of this modeling indicated that at the highest detected concentration (29 ug/kg), the calculated hazard quotient ranged from 0.01 to 0.02 for birds exposed to the contamination. Two of the remaining four suspected areas, Maintenance Area A and Maintenance Area B, require corrective action. Soils samples collected in the vicinity of Maintenance Area A had high levels of endrin, copper, and zinc. No contamination of groundwater was detected at this site. Soil samples collected in the vicinity of Maintenance Area B had high levels of anthracene, flourene, and acenaphthalene. No groundwater contamination was detected at this site.

Griffin Property - The Griffin property is located south and west of the larger Berry Groves property. The Griffin property (954 acres) has been used to cultivate citrus for the last 30 or more years. The Phase I/II report identified five areas of potential concern including the cultivated areas, canal sediments, maintenance area/chemical barn, fertilizer mix/load area, and burn area. Grid based testing in the cultivated areas was performed by dividing the property into 20 cells of 50 acres each. Discrete samples were collected from ten 5-acre sub-grids on each larger grid and composited into one sample. The results of these sediment analyses indicated evidence of low level contamination of barium,

copper, lead, mercury, zinc and paraquat. However, none of these analytes exhibited concentrations which exceeded the SQAG PEC. Aldicarb was detected in one sample grid at a concentration of 67 ug/kg which exceeds the site-specific SQAC of 1.75 uk/kg developed specifically for this site. Soils contaminated with polyaromatic hydrocarbons (PAHs) were found at the maintenance area/chemical barn. At the burn area, soils contaminated with copper were found. Seven sediment samples were collected from the drainage canal. One of these samples contained residual copper at a concentration exceeding the TEC of 32 mg/kg but not exceeding the interim screening concentration of 85 mg/kg. Another sample contained pentacholorophenol (PCP) at a concentration of 32 mg/kg which is well below the site-specific effect level of 617 ug/kg. Remediation was recommended for the maintenance area, and burn area.

Brian Paul Grove Property - The 600-acre Brian Paul Grove property is located east of the Berry Groves property. In the 1960s the property was converted from a cattle ranch to row crops such as tomatoes, watermelons, and peppers. In 1972, the property was converted to citrus groves. In 2004, the SFWMD conducted a Phase I/II Environmental Assessment as part of a due diligence investigation prior to acquiring the lands. The Phase I assessment identified the following seven sites of environmental concern: 1) pump stations, 2) former nursery barn, 3) C-1 mixing site, 4) auxiliary tank area, 5) solid waste site, 6) burn area, and 7) grove area. The results of the analysis indicated that the soil in two grids (8 and 9) had elevated chlordane levels in excess of the recommended 100 ug/kg limit. Further testing indicated that approximately 13 acres had chlordane impacted soils. At the solid waste area, soil samples were collected from below the buried waste. These samples indicated that the soils were not impacted though the presence of buried solid waste would have to be addressed. At the burn area, soil samples were collected to determine if concentrations of heavy metals exceed the standards. At the former pump stations, soil samples were collected and analyzed for petroleum and heavy metal contamination. The results indicate that the visibly contaminated soils should be removed. At the burn site, the analysis of soils indicated that the surrounding soils were not impacted. However, the removal of ash was recommended by the environmental consultant. From the drainage canal, eight soil/sediment samples were collected for analysis. The results indicated that canal sediments were not contaminated; however, some canal bank soil directly adjacent to a burn area had high levels of barium, copper, and silver. The consultant's recommendation was to remove the canal bank soil that appears to be contaminated by the adjacent burn site.

Bob Paul Grove Property - The 2,025-acre Bob Paul Grove property is located east of the Berry Groves property. Prior to 1972, the property was used as a cattle ranch. After 1972, the property was converted to citrus groves. The SFWMD performed Phase I/II ESA audits in 2004 and 2005. The Phase II audit

DRAFT

included the investigation of 12 point source sites of probable contamination previously identified in the Phase I audit and the investigation of residual soil contamination in the cultivated areas. Out of the 21 composite samples collected in the cultivated area, 15 of them had copper concentrations in excess of the TEC (32 mg/kg). Six of the discrete samples had copper concentrations in excess of 85 mg/kg which is the interim screening value; however, none of the calculated means for the grids exceeded 85 mg/kg. Concentrations of carbaryl and aldicarb were above their respective SCTLs in several of the composite samples. One composite sample contained chlordane at a concentration above its TEC of 3.2 ug/kg. Another composite sample contained 4,4' DDE at a concentration (4.3 ug/kg) above the TEC of 3.2 ug/kg. A screening level ecological risk assessment (SLERA) determined that the detected levels of aldicarb, chlordane and carbaryl do not present an unacceptable risk to any of the nine avian species of concern. This SLERA did find that the maximum concentration found in a discrete sample of 4,4' DDE did pose a risk to the nine avian species; however, the mean concentration of each grid cell was below TEC of 3.2 ug/kg so the overall risk to avian birds was considered acceptable by the USFWS.

The 12 point source areas identified for Phase II investigation included a maintenance area, chemical storage building, pole barn, shop, above ground storage tanks (ASTs), fuel dispenser island, equipment staging area, storage area, irrigation pump stations, burn areas, former airstrip, irrigation canals, and cultivated areas. Discrete soil, sediments, and groundwater samples were collected in the vicinity of the suspected point source contamination sites. Soil contaminated with multiple pesticides (chlordane, dieldrin, hepatochlor epoxide, and endrin) were detected at the chemical storage building. Chlordane and 4,4' DDE were detected above levels of concern at the pole barn/storage building, maintenance staging area, grove building, airstrip, and irrigation canals. Petroleum contamination at levels exceeding the SCTL for total recoverable petroleum hydrocarbons (TRPH) was detected at the pole barn, spray oil AST, grove building, and in the canal sediments. The remediation plan for each of these sites includes the removal of contaminated soils.

At the spray oil AST, petroleum hydrocarbon contamination was detected in the groundwater at a concentration exceeding the GCTL. The remediation plan for this site includes air sparging of the groundwater in addition to the soil removal

1.2.2.5 Water Quality Impacts Improvements Expected from Other Programs

Future water quality conditions in the basin will be strongly influenced by future land use, the operation schedule of Lake Okeechobee, and the implementation of Best Management Practices (BMPs) to control nutrient discharges. Since the 2050 population will be substantially greater than the year 2000 population, the quantity of treated wastewater effluent discharged to

the estuary will increase. However, with the expected implementation of TMDLs for the discharge of nutrients into the estuary, it is not unreasonable to expect that by 2050 most existing wastewater treatment plants and all future plants will incorporate tertiary treatment process to remove nutrients. If the TMDL program is effective, the 2050 nutrient loads from wastewater effluent will be similar to or less than the present nutrient loads.

Future water quality conditions will depend upon the overall change in nutrient loads delivered to the estuary from upstream of S-79 as well as below this structure. Nutrient loads to the estuary will likely increase by 10% or more if no BMPs or nutrient TMDLs are implemented in the Caloosahatchee basin. If the implementation of BMPs substantially reduces non-point source nutrient loads, discharges from Lake Okeechobee are significantly reduced and tertiary wastewater treatment is implemented basin wide, the 2050 Future Without nutrient loads may decrease by more than 30% as compared to the existing condition.

1.2.2.6 Water Quality Performance of Impoundment Project

Under the conservative assumption that no water quality treatment occurs in the reservoir, the project alternatives will reduce TP and TN loads at S-79 by approximately 28% to 35% in comparison to the future without the project condition. This reduction in nutrient loads at S-79 is largely the result of the reduction in discharges from Lake Okeechobee. All of the selected alternatives will cause a shift in nutrient load from the wet season to the dry season; however, all of the alternatives will decrease the frequency in which the monthly TN load exceeds the dry season, wet season, and annual targets established by DEP (dry-season 190 tons/month, wet-season 350 tons/month, annual 3,000 tons/month). While it is possible that nitrogen fixation within the reservoir will result in short-term increases in TN loading to S-79, the average annual TN load at S-79 will be reduced. Each of the alternatives results in an improvement in overall average water quality conditions at S-79 as well as downstream in the estuary. Given the uncertainty in the threshold chlorophyll-a concentration required for the restoration of the ecological function of the estuary, the degree to which the reservoir project will improve downstream water quality is unknown at this time. Based on the evidence presented here, it appears that the project will not cause or contribute to water quality degradation under future conditions.

The total load of sediments transported to the estuary from the freshwater Caloosahatchee sub-basin with the project will be reduced relative to future without conditions since some fraction of the available sediment load will be retained within the reservoir. Additionally, since construction of the reservoir will reduce the total area of farmed land by some 10,000 acres, sediment

DRAFT

transport associated with farming this acreage will also no longer be transported to the estuary. The reduction in sediment load will be on the order of 5% to 10% relative to existing without project conditions and approximately 30% relative to future without project conditions. This reduction in sediment delivered to the estuary should result in a slight improvement in sediment quality relative to without project conditions. However, since urbanization of the basin will continue over the next 50 years, non-project related anthropologic impacts will likely result in the continued degradation of estuary sediment quality over time.

1.2.2.7 Adaptive Assessment and Monitoring Program

An extensive Adaptive Assessment Program that includes a system-wide monitoring and evaluation program will be conducted to support the goals and objectives of CERP. Details of this monitoring program are included in Annex D of the PIR/EIS. As a region specific component of CERP, monitoring and assessment of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project will need to be closely coordinated with the larger comprehensive monitoring program for CERP. This program will provide an opportunity to continue investigating concepts and issues relative to the overall Caloosahatchee Watershed Plan while implementation of the initial project features is underway.

A fundamental component of adaptive assessment is a monitoring program that is based on the goals and objectives of the project. The Monitoring Program will be further developed during the Planning, Engineering, and Design (PED) phase of the project. There will be project specific monitoring (including water quality) and overall CERP monitoring. The current cost estimate is based on CERP estimates, and a more detailed estimate will be developed during PED. The project specific monitoring plan discussed in this document complements the regional monitoring plans developed by Restoration, Coordination, and Verification (RECOVER) and is at a feasibility level (enough detail for costs). Early during PED, the monitoring plan will be refined and coordinated with the appropriate agencies.

1.2.3 Flood Damage Reduction

1.2.3.1 Maintenance of Existing Level of Service

The intent of the level of service analysis for flood protection, required by WRDA 2000 and the CERP Programmatic Regulations as well as Florida State law regarding the implementation of CERP, is to ensure that CERP components do not negatively impact existing levels of flood protection.

DRAFT

The operations of this project will not change the operations of the C-43 Canal based on the key assumptions outlined in the Federal Assurances and Savings Clause Analysis in the PIR/EIS. Therefore, there will be no system-wide effects on flood protection as a result of the project.

1.2.3.2 Flood Protection Performance of Impoundments and Seepage Management System

Hydrologic and hydraulic analysis was performed, using surface water and groundwater modeling, to ensure that the levels of service of flood protection will not be diminished by this project. The results of the analysis indicate that the project is not expected to result in increases in stages in canal systems adjacent to the project site.

The results from the local reservoir-level MIKESHE modeling indicate a boundary slurry wall within the embankment will prevent seepage out of the reservoir and impacts to groundwater levels. In addition, optimization of the operating levels of the seepage canals and canal structures surrounding the reservoir will maintain existing groundwater levels adjacent to the project.

Of the eleven locations evaluated using the MIKESHE model, the only location where simulated groundwater elevations increased compared to the without-project conditions was north of the project. Simulated "with project" groundwater elevations increased slightly compared to the "without project" condition. The greatest difference was during the dry period (e.g., 1981) not the wet periods. This minor effect can be addressed through further optimization of perimeter canal control structure operations for the project. The remaining ten locations show practically no differences in groundwater elevations.

Therefore, there will be no adverse affects on existing levels of service for flood protection in the vicinity of the reservoir.

1.2.4 Threatened and Endangered Species

Nineteen federally listed species may potentially occur in the proposed project footprint or may be impacted by operations of the project. Although some of these species may be impacted by the loss of habitat within the project footprint, when implemented, the project has the potential to significantly contribute towards environmental restoration beyond the project footprint. For additional information on these species please refer to the Final Biological Assessment (BA) for the C-43 West Storage Reservoir Project found in Annex A of the PIR/EIS. The site information included in this report is based on surveys referenced in the Biological Assessment. Table 6 lists the threatened and endangered species within the study area.

Snail Kite - The snail kite (Rostrhamus sociabilis plumbeus) inhabits the watersheds of the Everglades, Lake Okeechobee, Lake Kissimmee, the upper St. Johns River, and the Caloosahatchee basin. Critical habitat for the snail kite is present immediately adjacent to the Caloosahatchee basin inside of the Herbert Hoover Dike in Lake Okeechobee. The snail kite could also be found foraging in a number of native wetlands and in canals and ditches adjacent to the project area. This medium-sized raptor has a highly specific diet composed almost entirely of Florida apple snails (Pomacea paludosa), which are found in palustrine emergent, long hydroperiod wetlands. As a result, the snail kite's survival is directly dependent on the hydrology and water quality of its habitat (Service 1999).

Table 6: Federally Listed Threatened (T) and Endangered (E) Species in C-43 Basin (Caloosahatchee River) Storage 1–Phase 1 Study Area

Scientific Name	Common Name	Status
Caretta Caretta	Loggerhead sea turtle	T
Chelonia mydas	Green sea turtle	E
Crocodylus acutus	American crocodile	E
Dermochelys coriacea	Leatherback sea turtle	E
Drymarchon corais couperi	Eastern indigo snake	T
Eretmochelys imbricata	Hawksbill sea turtle	E
Lepidochelys kempii	Kemp's (=Atlantic) ridley sea turtle	E
Ammodramus savannarum floridanus	Florida grasshopper sparrow	E
Aphelocoma coerulescens	Florida scrub jay	T
Charadrius melodus	Piping plover	T
Haliaeetus leucocephalus	Bald eagle	T
Mycteria americana	Wood stork	E
Picoides borealis	Red-cockaded woodpecker	E
Polyborus plancus audubonii	Audubon's crested caracara	T
Rostrhamus sociabilis plumbeus	Everglades snail kite	E
Felis concolor coryi	Florida panther	E
Trichechus manatus latirostris	West Indian manatee	E
Cucurbita okeechobeensis	Okeechobee gourd	E
Pristia pectinata	Smalltooth sawfish	E

One snail kite was observed on a wire and eating a snail along state road (SR) 80 during a February 2006 survey. This location was approximately 0.75 miles west of the project footprint. In addition, during several field visits 2004-2006, populations of two species of apple snails, the Florida apple snail (*Pomacea paludosa*) and the exotic ramshorn apple snail (*Marisa cornuarietis*) were observed in large ditches of the project site. The network of large agricultural

ditches provides suitable foraging opportunities but evidence of foraging/feeding (shell discards) was not observed.

Wood Stork - The wood stork (*Myctria Americana*) is primarily associated with freshwater and estuarine habitats for nesting, roosting, and foraging. They have nested, at one time or another, in every county in south Florida. Typical foraging sites include freshwater marshes and stock ponds, shallow, seasonally flooded roadside or agricultural ditches, narrow tidal creeks or shallow tidal pools, managed impoundments, and depressions in cypress heads and swamp sloughs. Wood storks use a specialized feeding behavior called tactolocation, or grope feeding. A foraging wood stork wades through the water with its beak immersed and partially open (7 to 8 cm). When it touches a prey item, a wood stork snaps its mandibles shut, raises its head, and swallows what it has caught (Kahl 1964). This unique feeding method of the wood stork gives it specialized habitat requirements; the habitats on which wood storks depend have been disrupted by changes in the distribution, timing, and quantity of water flows in south Florida. The loss or degradation of wetlands in central and south Florida is one of the principal threats to the wood stork.

The majority of the lands within the project footprint fall within the 18.6-mile core foraging area (CFA) of three wood stork colonies. The Biological Assessment only identified two colonies with a CFA that overlapped the project site but since that time a new colony has been identified. Individual wood storks have been observed foraging and loafing onsite, primarily in the tertiary and secondary canals. Within the project there are limited acres of wetlands that provide suitable wood stork foraging habitat. Wood stork foraging habitat available within the project site includes 6.72 acres of wetlands and 778.34 acres of ditches/canals.

West Indian Manatee - The West Indian manatee is recognized as an endangered species by both the USFWS and Florida Fish and Wildlife Conservation Commission (FFWCC). Manatees are also protected under the provisions of the Marine Mammal Protection Act of 1972, and by Florida law. The manatee, or sea cow, is a large, plant-eating aquatic mammal that can be found in the shallow coastal water, rivers, and springs of Florida. Florida is essentially the northernmost extent of the West Indian manatee's range, though some manatees are occasionally spotted as far north as Virginia and the Carolinas (FP&L, 1989). The endangered West Indian manatee is regularly found in the Caloosahatchee River and the Charlotte Harbor estuary. This large, aquatic mammal migrates along the Florida coast through fresh, brackish, and marine waters, with a seasonal distribution based on water temperatures. Water depths of at least 3 to 7 feet are preferred. Water temperatures below 20 degrees Celsius increase the manatee's susceptibility to cold-stress and cold-induced mortality. Distribution is also controlled by the availability of aquatic

DRAFT

vegetation, proximity to channels of at least 2 meters in depth, and location of fresh water sources (Service 1999). During the summer months manatees range throughout water bodies of South Florida, usually in small groups. In the winter months they tend to congregate in warm water areas such as springs and electric generation facilities (FP&L, 1989).

Designated critical habitat for the manatee is located in the Caloosahatchee River Basin. Critical habitat extends downstream from the State Highway 31 bridge and includes all U.S. territorial waters adjoining the coast and islands of Lee County.

Primary threats to manatees today consist of collisions with watercraft, degradation of seagrasses and accidents occurring at water control structures. Navigational locks along the Caloosahatchee River have a history of causing manatee mortality. Sixteen navigational lock/water control structure-caused manatee deaths have been recorded near Ortona Lock (S-78) between 1980 and 2001. Throughout those same years, six were discovered near S-77 at Moore Haven, and just one in 1999 at the Franklin Lock (S-79). Existing operational protocols for the structures and locks (unaffected by project planning for the C-43 reservoirs) are important considerations in reducing these deaths.

Manatees have been known to utilize the Townsend Canal, which lies immediately adjacent to and west of the project footprint. During times of inflow from the Caloosahatchee River, manatees are capable of passing over the weir and traveling southward into the Townsend Canal. Individuals have been observed at the outfall area immediately west of the project boundary as well as at the mouth of the canal in the Caloosahatchee River. However, manatees cannot access the main distribution canal (i.e., Header Canal) for the grove property due to differences in elevation.

Southern Bald Eagle - The bald eagle is currently listed as a threatened species by both the USFWS and Florida Fish and Wildlife Conservation Commission (FFWCC). The southern bald eagle (*Haliaeetus leucocephalus*) is considered common and known to breed throughout the state. Nest sites are usually located near large rivers, lakes, or estuaries where they feed primarily on fish and water-dependent birds. Their distribution is influenced by the availability of suitable nest and perch sites near large, open waterbodies, typically with high amounts of water-to-land edge (Service 1999). The bald eagle is the only eagle unique to North America. It ranges over most of the continent, from the northern reaches of Alaska and Canada down to northern Mexico. Current threats to the bald eagle include habitat loss and fragmentation, collisions with cars and powerlines, and shooting (USFWS 1998).

Data obtained from the Florida Fish and Wildlife Conservation Commission (FFWCC) 2004 Eagle Nest Database indicate that the closest documented bald eagle's nest, HE002, is located 3.4 miles east of the project and east of SR 29. This nest was documented to be last active during the 2003 nesting season. No other nests were observed in the project vicinity during field efforts in the summer of 2004 or spring of 2006.

Eastern Indigo Snake - The threatened eastern indigo snake (*Drymarchon corais couperi*) is present throughout the state, but its abundance is reduced to a point where it is uncommon. Its known habitat includes pine flatwoods, scrubby flatwoods, high pine, dry prairie, tropical hardwood hammocks, edges of freshwater marshes, agricultural fields, coastal dunes, and human altered habitats. This species was listed as a result of dramatic population declines caused by over-collecting for the domestic and international pet trade as well as mortalities caused by rattlesnake collectors who gassed gopher tortoise burrows to collect snakes. Since its listing, habitat loss and fragmentation by residential and commercial expansion have become much more significant threats to this species (Service 1999).

Specific information on the status of this species within the project area is not available; however, indigo snakes are known to occur in the Caloosahatchee River basin in low densities and are known to occur along roads and the banks of larger ditches and canals in citrus groves, particularly if burrows (e.g., tortoise, armadillo, small mammal, and/or land crab), debris piles, or other shelter are in close proximity. Although the eastern indigo snake was not observed during field visits, suitable habitat exists on the project site; therefore, it could potentially occur. Additionally, the species is known to utilize a variety of habitat types including citrus groves.

Florida Scrub-Jay - The Florida scrub-jay (*Aphelocoma coerulescens*), a threatened species, is present in limited areas of scrub habitat in the study area. It is a relict species of fire-dominated oak scrub habitat that occurs on well-drained sandy soils in peninsular Florida. Scrub-jays are extremely habitat-specific, sedentary, and territorial. Florida scrub-jays form family groupings; fledglings remain with their parents in their natal territory as helpers. The Florida scrub-jay is listed as a threatened species because of loss, fragmentation, and degradation of scrub habitats throughout Florida, due primarily to urbanization, agriculture, and fire suppression. During the last 10 to 23 years, the population has declined by an estimated 25 to 50%, and they have been extirpated from seven counties statewide.

No individuals, nests or appropriate habitat were detected in the project footprint during site visits. The nearest documented Florida scrub jay habitat

DRAFT

and population occurs 1.1 miles west of the project area. This colony is beyond the foraging distance for the species to access the project area.

Red-Cockaded Woodpecker - The red-cockaded woodpecker (*Picoides borealis*) was listed as threatened in 1970. The red-cockaded woodpecker (RCW) is one of 22 species of woodpeckers native to North America. Its historic range encompasses the southeastern Unite States from eastern Texas to Oklahoma to New Jersey, and it was characterized as "abundant" in the 19th century literature. Throughout the 20th century, however, the species' distribution within its historic range has become fragmented, and its total population numbers have decreased dramatically due to the destruction of its habitat. The primary threat to the species continues to be the destruction or degradation of its habitat as a result of timbering and other land-clearing activities. Although south Florida is not a designated recovery population for the red-cockaded woodpecker, the area contains significant support populations for recovery of the species in the southeast. Additional population surveys and research on habitat requirements within the hydric pine flatwoods of south Florida are needed to assess the current status of the birds and to adapt conservation measures used elsewhere to the distinct conditions in this area. The nearest documented RCW population occurs approximately 14 miles northwest of the project area (FFWCC data).

Florida Panther - The Florida panther (*Puma concolor coryi*), a subspecies of mountain lion, is one of the most endangered large mammals in the world. The most recent population estimate for the Florida panther is a total of 87 individuals, not including denning kittens (McBride 2003). This small population in south Florida represents the only known remaining wild population of an animal that once ranged throughout most of the southeastern United States from Arkansas and Louisiana eastward across Mississippi, Alabama, Georgia, Florida, and parts of South Carolina and Tennessee. The panther presently a contiguous system of large private ranches and public conservation lands in Broward, Collier, Glades, Hendry, Lee, Miami-Dade, Monroe, and Palm Beach counties totaling more than 809,400 ha. Panthers have a strong affinity for hardwood forests and mixed swamps but also use freshwater marshes, prairie and shrub/scrub habitats, agricultural lands (i.e., wooded pasture, rangeland, citrus groves, row crops, etc.), and even urban areas. Geographic isolation, habitat loss, population decline, and associated inbreeding have resulted in a significant loss of genetic variability and overall health of the Florida panther population. Natural gene exchange ceased when the panther became geographically isolated from other subspecies of *Puma concolor*. Population viability projects have concluded that under current demographic and genetic conditions, and without implementation of recovery actions, the panther will probably become extinct within two to four decades.

DRAFT

The Caloosahatchee basin plays an important role in the recovery of the Florida panther. The Service has organized a multi-agency subgroup of the Multi-species/Ecosystem Recovery Implementation Team (MERIT) to produce a Florida panther landscape conservation strategy. That strategy included the identification and prioritization of habitat zones (Dispersal, Primary, and Secondary Zones) that are essential for effective Florida panther conservation. In addition to protection of habitat for adult home ranges, the strategy includes provision of corridors for dispersal of juveniles between larger areas of contiguous habitat. Dispersal across the Caloosahatchee River, between existing primary habitat south of the river and habitat that is presently only occasionally used by panthers north of the river, is considered essential for recovery of the species.

The proposed project is located within the USFWS Consultation Area (CA) and includes areas within the panther primary, secondary, and "other" zones, as identified by the Florida panther subteam of the MERIT and USFWS CA updates. The most recent available FFWCC telemetry data of radio collared Florida panthers, current through January 2004, depicts three (3) Florida panthers and one (1) Texas cougar (Felis concolor) within a five-mile radius of the project area. A more landscape level inspection (25-mile radius) identifies habitat utilization by several additional panthers, particularly within Okaloacoochee Slough State Forest and other conservation lands.

Audubon's Crested Caracara - Audubon's crested caracara (*Polyborus plancus audobonii*) is another federally listed species present in the Caloosahatchee basin. It is a large, boldly patterned raptor, with a crest and unusually long legs. It is a resident, diurnal, and non-migratory species that occurs in Florida as well as the southeastern United States and Central America. In Florida, this species is found in the prairie area of the south-central region of the state. Historically, this species was a common resident in Florida from northern Brevard County, south to Ft. Pierce, Lake Okeechobee, and Hendry County. Today, the region of greatest abundance for this large raptor is a five-county area north and west of Lake Okeechobee. The preferred native habitat is dry or wet prairie with scattered cabbage palms (Service 1999). Improved and unimproved pastures are also highly utilized. Effect determinations for caracara are based mostly on potential impacts within the primary nest zone (i.e., within a radius of 985 feet from a nest tree) or the secondary zone (a radius of 6,600 feet). Additionally, potential effects within juvenile congregation areas are also considered.

The project falls within the caracara USFWS Consultation Area. One caracara nest site was confirmed to the north of the project during spring 2006 surveys. This nest is located along the southern edge of the SR 80 right-of-way (ROW) and approximately 4,750 feet north of the project boundary. While individuals

were not observed foraging in the project footprint, a portion of the project falls within 2,000 meters (secondary zone) of this nest, as defined in the Standard Local Operating Procedures for Endangered Species (SLOPES). In addition, a possible nest was identified approximately 1,065 feet south of the project boundary, within a pasture of the A. Duda & Sons, Inc. property. Individuals from the possible nest site were seen flying into and out of the C-43 project site. While the C-43 project area provides only sub-optimal foraging habitat for the species, and individuals were only observed utilizing the project area in the southeast portion of the footprint, it does fall within the home range of both the confirmed and possible nests.

Florida Grasshopper Sparrow - The Florida grasshopper sparrow (*Ammodramus savannarum floridanus*) is a subspecies of grasshopper sparrow that is endemic to the dry prairie of central Florida. This subspecies is extremely habitat-specific and relies on fire every two to three years to maintain its habitat. It is now known to occur only from Highlands, Okeechobee, Osceola, and Polk counties, but other populations may occur in Glades County, which may bring it into the study area considered here. The species is not known to occur in Hendry County but populations may occur in nearby Glades County (USFWS 4-11-02 PAL). The nearest Florida grasshopper sparrow record in the 1999 FNAI database is a 1984 observation located 17.3 miles north of the project. Mapping of potential Florida grasshopper sparrow habitat (Shriver and Vickery, 1999) shows marginal habitat zones to the northeast and southeast of the project, and the project area falls within the Florida grasshopper sparrow USFWS Consultation Area. However, the nearest marginal habitat zone is located approximately 2.5 miles to the southeast of the project footprint. No grasshopper sparrows were observed during field surveys and no suitable habitat exists in the project area.

Piping Plover - A wintering population of piping plovers (*Charadrius melodus*) uses the tidal area of the Caloosahatchee River. The piping plover was listed as threatened along the Atlantic coast in 1985. It is a small, migratory shorebird that breeds only in three geographic locations of North America: sandy beaches along the Atlantic Ocean: sand shorelines throughout the Great Lakes: and on riverine systems and prairie wetlands of the Northern Great Plains. This species does not breed in Florida, but all three breeding populations winter here. Bunche Beach, at the mouth of the Caloosahatchee, has a population of wintering piping plovers and is also designated critical habitat for this species. The USFWS established critical habitat areas for the species, which include several locations on barrier islands west of the Caloosahatchee Estuary. The nearest piping plover critical habitat zone to the project area includes Punta Rassa, a mainland location at the southwestern edge of the Caloosahatchee Estuary, and Bunch Beach.

DRAFT

Okeechobee Gourd - The Okeechobee gourd (*Cucurbita okeechobeensis*) is a vine that was locally common in the extensive pond apple forest that once grew south of Lake Okeechobee (Small 1922). It is a vine that is now restricted in the wild to two small distinct populations–one along the St. Johns River which separates Volusia, Seminole, and Lake Counties in north Florida, and a second around the shoreline of Lake Okeechobee in south Florida.

American Crocodile - The USFWS and the FFWCC list the American Crocodile (*Crocodylus acutus*) as endangered. This species occurs in extreme South Florida primarily in Biscayne and Florida Bays. Crocodiles have been observed as far north as the coasts of Lee and Collier Counties, but these counties are not thought to support a significant resident population of crocodiles. The American crocodile has not been documented in Hendry County but is present in coastal counties of the Caloosahatchee River basin, namely Lee and Collier Counties. The nearest documented individual occurrence to the project is on Sanibel Island in Lee County. The American crocodile is known to inhabit mangrove and seagrass habitats in coastal areas of south Florida.

Sea Turtles - Sea turtles including the Atlantic loggerhead turtle (*Caretta caretta*), Atlantic green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), Kemp's ridley turtle (*Lepidochelys kempii*), and hawksbill turtle (*Eretmochelys imbricata*) are listed as endangered by the USFWS and FFWCC with the exception of the loggerhead turtle, which is listed as threatened. These are marine species with a presence in south Florida waters and are known to utilize bays and estuarine habitats, such as the Caloosahatchee estuary, for feeding and resting. Sea turtles forage in the near shore waters, bays and sounds of Florida and come ashore at night to nest on the beaches above the high tide line. Alterations in the timing and quantity of freshwater flowing through the estuary has an impact on natural biodiversity by affecting food availability, predation pressure, reproductive success, and most likely has caused chronic and acute stress to these species.

1.2.4.1 Endangered Species Act (ESA) Consultation

The USFWS has been an active member of the project team for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project and has provided guidance through informal consultation during plan formulation and evaluation. The USFWS provided a Biological Opinion on November 30, 2005, for construction of the C-43 West Storage Reservoir Test Cells, an area of approximately 267 acres. This area is not included in the ongoing Section 7 evaluation for the reservoir since consultation has been completed.

The Final Biological Assessment for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project (January 2007) describes the potential effects of the

proposed Caloosahatchee River (C-43) West Basin Storage Reservoir Project on federally listed threatened and endangered species. The USACE determined that the Caloosahatchee River (C-43) West Basin Storage Reservoir Project would not affect the bald eagle, Florida scrub jay, Florida grasshopper sparrow, red cockaded woodpecker, Okeechobee gourd, or the beautiful pawpaw because they do not occur within or adjacent to reservoir footprint, nor would there be direct or indirect impacts to those species. The USACE determined that the proposed project may affect, but is not likely to adversely affect the smalltooth sawfish, wood stork, West Indian manatee, Everglade snail kite, American crocodile, piping plover, or the green, hawksbill, leatherback, Kemp's ridley or loggerhead sea turtles. The American crocodile, piping plover, or the green, leatherback, Kemp's ridley and loggerhead sea turtles do not occur within or adjacent to the reservoir footprint and indirect effects resulting from operation of the reservoir are expected to be negligible, discountable or beneficial to those species. Additionally, wintering piping plover critical habitat will not be adversely modified by the proposed project. Additionally, the USACE determined the project may adversely affect the eastern indigo snake, Audubon's crested caracara, and the Florida panther and requested initiation of formal consultation for these species. Formal consultation with the USFWS is ongoing for these species.

1.2.4.2 Fish and Wildlife Coordination Act (FWCA)

The central objective of the Fish and Wildlife Coordination Act (FWCA) is to allow for equal consideration of wildlife resources. Transfer funds have been made available to the USFWS in order to participate in team meetings and workshops scheduled in conjunction with the USACE's planning, implementation, and evaluation process. Funding has also been provided for the USFWS to conduct surveys and investigations necessary to determine impacts of the C-43 project on wildlife resources and to make recommendations to the USACE on measures to prevent loss of or damage to wildlife resources. Recommendations for optimizing opportunities related to the conservation and enhancement of fish and wildlife resources have been provided through the submittal of Planning Aid Letters listed above. A draft CAR has been prepared and is included in Annex A of the PIR/EIS. Additionally, the Florida Fish and Wildlife Conservation Commission (FWC) has been an active participant on this project and have provided a Scoping Letter dated June 10, 2003.

This project has been coordinated with the USFWS and the Florida Fish and Wildlife Conservation Commission (FWC). The FWC has been an active participant of the project team. The FWCA report is included in the PIR/EIS for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. This project is in full compliance with the Fish and Wildlife Coordination Act.

DRAFT

1.2.4.3 Florida State Historic Preservation Officer

The USACE has reviewed information regarding historical properties that might be affected by the C-43 project, in compliance with Section 106 of the National Historic Preservation Act of 1966 (PL89-665), as amended in 2000; its implementing regulations (36 CFR Part 800) and the Archaeological and Historic Preservation Act of 1974 (PL93-291), as amended. A Phase I survey has been completed on all sections of the C-43 West Reservoir site.

Coordination with the State Historic Preservation Office (SHPO) has occurred and the Section 106 process is complete. In consultation with the Florida State Historic Preservation Officer (Florida State Department of Historic Preservation numbers 2004-8676 and 2006-07757) a determination of no historic properties affected has been made. This project is in compliance with the National Historic Preservation Act.

1.2.5 Other Natural System and Habitat Needs

The existing condition of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project area is described in detail in Section 2 of the PIR/EIS. The differing hydrologic conditions were assessed as to the effects on flora and fauna.

1.3 Determination of Project Component Feasibility [373.1501(5)(b)]

Section 373.1501(5)(b), F.S. requires the SFWMD to "Determine with reasonable certainty that all project components are feasible based upon standard engineering practices and technologies and are the most efficient and cost-effective of feasible alternatives or combination of alternatives, consistent with restudy purposes, implementation of project components, and operation of the project." The following sections form the basis for this determination.

1.3.1 Standard Engineering Practices and Technologies

1.3.1.1 Summary of Project Features

The selected plan consists of the following features: construction, operational modifications, real estate requirements, an adaptive assessment and monitoring program, and operation and maintenance details of the completed project.

The risk and uncertainty associated with the construction and operation of these features of the proposed project should be minimal. All features have been designed and constructed through established and applied technology. No experimental design was necessary for any component of the proposed impoundment. Additionally, both the U.S. Army Corps of Engineers and the

DRAFT

South Florida Water Management District have extensive and reputable credibility in the design, construction, and operation and maintenance of the proposed features from previous water resources planning efforts.

Purpose - The Caloosahatchee River (C-43) West Basin Storage Reservoir Project is planned and designed primarily to restore the ecosystem function in the Caloosahatchee Estuary by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuary system. The project also helps to maintain a desirable minimum flow of fresh water to the estuary during dry periods. These two primary functions help to moderate unnatural changes in salinity which is extremely detrimental to estuarine communities.

Location - The Caloosahatchee River (C-43) West Basin Storage Reservoir Project is located in western Hendry County. The site is a few miles south of State Road 80 and approximately two miles west of State Road 29.

Existing Site Development and Conditions - The project footprint covers approximately 10,492 acres located in Hendry County west of LaBelle (Figure 2). The property is predominantly owned by the South Florida Water Management District (SFWMD) and is under a leasing agreement with Jack M. Berry Inc. for agricultural land use. (Currently the SFWMD is processing an exchange of 541.31 acres located north of the project boundary for the 600.13-acre Paul Property. This was necessitated by a requirement to locate the reservoir footprint away from existing power lines to the north and a need for additional lands to the east or west in order to maintain storage). The project site is currently a producing citrus grove. The site contains three major arterial canals that transport water for the purpose of irrigation and attenuation of Caloosahatchee Basin runoff waters. Two of the three canals, Roberts and Townsend, lie along the eastern and western perimeters of the footprint, respectively, The Header Canal, also called the LPDD Canal, transects the entire reservoir area and its use is primarily to cross feed water between the Roberts and Townsend Canals.

Approximately 267 acres within the project site have been impacted through construction of the C-43 Basin Storage Reservoir Test Cells Project. The SFWMD initiated construction of the test cells in January 2006, in order to evaluate seepage and water quality effects and improve embankment design. The test cells are also shown in Figure 2.

Operation and Design - The operation of the selected plan is keyed to conditions at the W. P. Franklin Lock and Dam (structure S-79) on the Caloosahatchee River as the flows over the dam are a good indicator of the resulting health of the estuary. The project will be operated to improve

environmental conditions in the Caloosahatchee Estuary by reducing flows over S-79 during wet periods, and helping to maintain a minimum flow of 450 cfs at S-79 during dry periods. The S-79 structure is located approximately ten miles down-river (west) of the project site.

Project operations involve pumping inflows from the C-43 Canal (Caloosahatchee River) via an existing canal (Townsend Canal) into Cell 1. An internal cell balancing structure in the internal embankment will allow water in Cell 1 to enter Cell 2. Water may be released from both cells by outlet structures into the perimeter canal for delivery back to the C-43 Canal via the Townsend Canal and two other direct connections (Fort Simmons Branch and Banana Branch Canal) to the C-43 Canal. Other project structures help to maintain water levels in the perimeter canal and Townsend Canal, and provide water supply deliveries to adjacent lands affected by construction and operation of the reservoir.

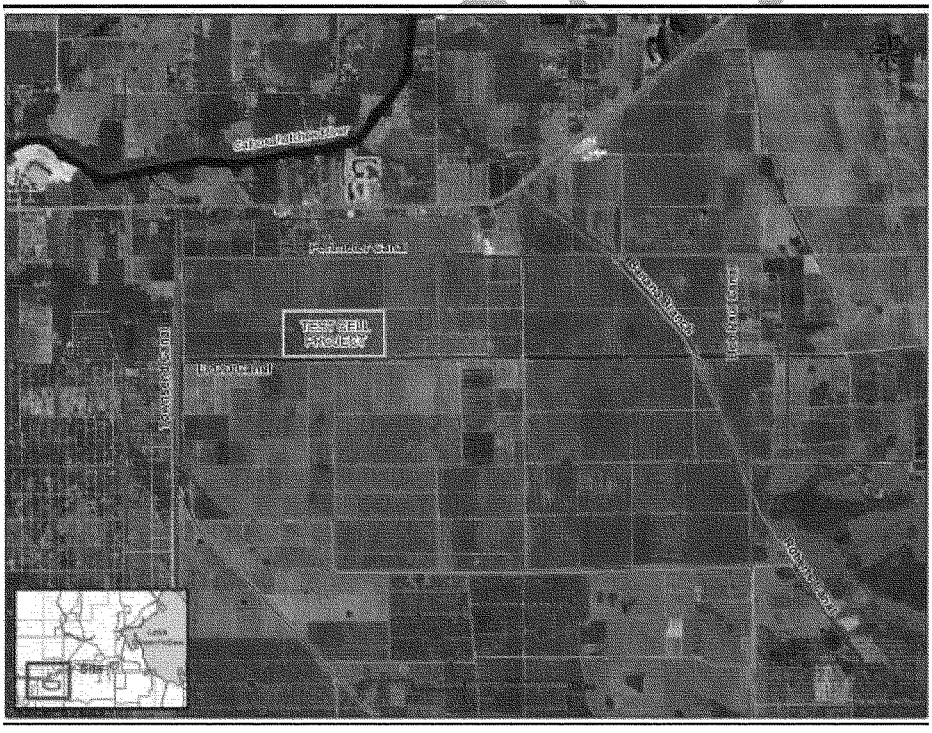


Figure 2: Caloosahatchee River (C-43) West Basin Storage Reservoir Project Site Map

Comparison to CERP Component - Programmatic Regulations for CERP require that one of the alternative plans to be evaluated is the project described in the Final Integrated Feasibility Report and Programmatic Environmental Impact Statement for the Central and Southern Florida Project Comprehensive Review Study (Restudy). The Restudy alternative description for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project cited:

"This feature includes above-ground reservoir(s) with a total storage capacity of approximately 160,000 acre-feet and aquifer storage and recovery wells with a capacity of approximately 220 million gallons per day and associated pre- and post water quality treatment located in the C-43 Basin in Henry, Glades, or Lee Counties. The initial design of the reservoir(s) assumed 20,000 acres with water levels fluctuating up to 8 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design. The initial design of the wells assumed 44 wells, each with the capacity of 5 million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The level and extent of treatment and number of the aquifer storage and recovery wells may be modified based on findings from a proposed aquifer storage and recovery pilot project (U.S. Environmental Protection Agency, 1999)".

The Comprehensive Review Study included two primary structural components focused on improving environmental conditions in the Caloosahatchee River and Estuary: 1) an approximately 160,000 ac-ft reservoir with associated aquifer storage and recovery (ASR) wells and 2) basin runoff backpumping and stormwater treatment facilities. Due to technical uncertainty and implementation issues, the ASR features (Part 2) originally associated with a storage reservoir in the Caloosahatchee Basin will be evaluated and implemented separately. The availability and effectiveness of storing basin runoff for backpumping to the C-43 Canal and Lake Okeechobee will also be further evaluated as part of future CERP updates.

Plan formulation in the Restudy began with a range of components that were screened during the initial phases of formulation. In the initial phase, information gained through a cost effectiveness analysis was joined with information from hydrologic modeling and information gained through previous studies to support best professional judgment in the selection of specific project components. The screening phase aimed to identify which components would be carried forward in the development of alternative comprehensive plans.

Following the initial screening, four alternatives (A-D) were carried through further formulation to arrive at the Selected Plan, also known as D-13R. The plan is composed of forty-nine operational and structural features that are also referred to as components.

For this project, plan formulation efforts initially involved reaffirming that an above-ground storage reservoir, as originally described in the Comprehensive Review Study, is a cost-effective means for achieving the purposes of the project consistent with the goals and objectives of the CERP. After reaffirming that the benefits of the project could be achieved with an above-ground reservoir, formulation efforts focused on optimizing reservoir size and features on lands already acquired for project implementation, combined with a consideration of planning and policy constraints such as the WRDA 2000 Savings Clause.

Selected Plan (Alternative 3B) - The formulation process has identified that Alternative 3C is the best buy plan and should be recommended to be implemented. The difference between Alternative 3C and Alternative 3B is the major pump stations size. Alternative 3C carries with it many uncertainties such as the potential to modify numerous structures downstream of the reservoir thus adding cost and time to the project. This cost and time will ultimately result in a loss of time for the estuary to realize benefits. While Alternative 3B is not a best buy plan it ultimately may be if Alternative 3C needs to be modified to include modifications to downstream features. Alternative 3B is cost effective and implementable while also having the highest score based on the P&G selection criteria.

The recommendation here is to selected Alternative 3B as the selected alternative plan and adaptively monitor and manage the project.

As part of the Phase 2 Project Implementation Report the Project Delivery Team will evaluate if additional pump capacity is required and the feasibility of making modifications to the 1,500 cfs pump station. The design of the Phase 1 Project allows for a future retrofit to add additional pumping capacity (1,500 cfs pump to 3,800 cfs pump) to the reservoir if it is determined necessary under the Phase 2 analysis. This would require the demolition of the old main pumping station and construction/installation of a new pumping station at substantially higher construction cost in order to improve reservoir pumping capacity. Additionally, temporary pumps may need to be installed while the new pumping station is constructed, adding additional costs. The results of the addition pumps will allow the reservoir to capture additional flows from the Caloosahatchee River and to be filled in a shorter period of time, but it would not add any additional volume for water storage.

This decision will be based on real time data collection and engineering and ecological analysis that will be evaluated while Alternative 3B is functioning and benefits are being realized in and around the estuary.

The following is a general description of the location and design of project features. For a detailed description of project features refer to Appendix A of the

DRAFT

PIR/EIS. Although shown in Appendix A, the Selected Alternative Plan does not include construction of culvert structures C43s-16, C43s-17, C43s-18, and C43s-19.

General Plan Description - The Selected Alternative Plan, as shown in Figure 3, consists of a two-cell reservoir with a "normal pool" storage capacity of 170,000 acre-feet. This Selected Alternative Plan comes closest to approximating the Restudy C-43 Reservoir recommended volume of approximately 160,000 acre-feet of storage and is the size evaluated and currently being designed by the SFWMD under their Acceler8 program. The project footprint for the Selected Alternative Plan encompasses approximately 10,492 acres and consists of major features and components to include a two-cell reservoir with armoring, cutoff walls, and embankments. Other features are pump stations, spillways with emergency overflow and vertical lifts, drawdown structures, culverts, canals, earthwork artificial habitat creation, and recreational features. The reservoir design includes a pump station with 1,500 cfs capacity to pump water from the Townsend Canal to fill the Reservoir.

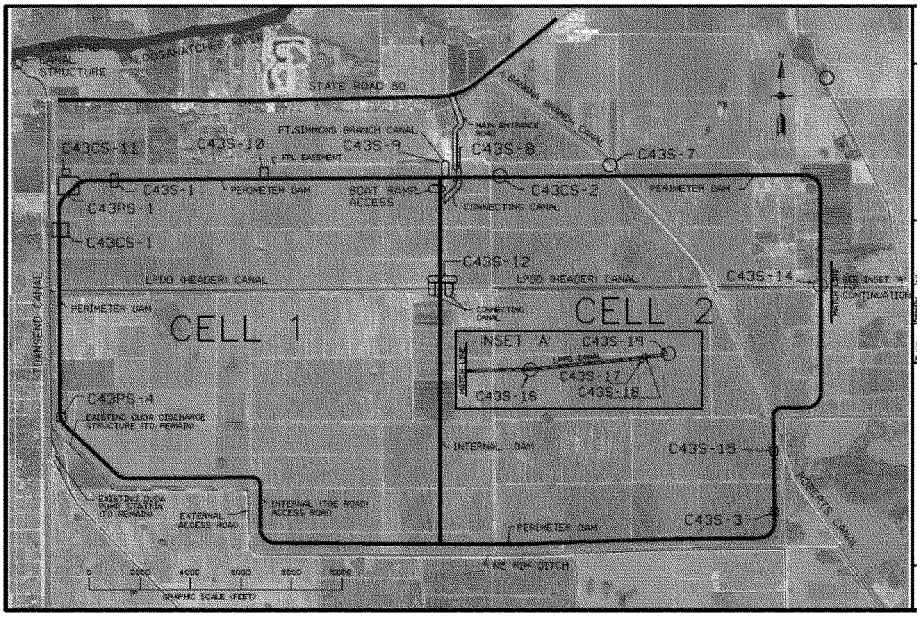


Figure 4: The Selected Alternative Plan

The existing Townsend Canal, located along the west perimeter of the reservoir will serve as the west perimeter canal. The existing disposal mounds along the east side of the Townsend Canal will be removed as part of the project. A drainage culvert will be located on the east perimeter canal connecting the LaBelle Private Drainage District (LPDD) Canal (a.k.a. the Header Canal), which will maintain historical drainage from the Paul Property east of the project. Improvements to or the relocation of the existing weir structure located at the mouth of the Townsend Canal are included. Work to that structure will be done within an existing easement.

The Selected Alternative Plan has a water surface elevation of 42 feet at "normal pool" (NAVD88), with the average depth ranging from 15 to 25 feet. Dam (embankment) heights for the Selected Alternative Plan range from 27 - 38 feet. The maximum water depths and dam heights will occur in Cell 1 due to lower land surface elevations in that cell. The exterior and interior dams are to have a crest width of 14 ft. The side slopes are 3 Horizontal to 1 Vertical (3H:1V). The exterior dams are to be constructed from existing on-site material and have a low permeability core. A graded filter is to be provided on the exterior side of the dam to direct seepage. Soil cement protection would be included on the interior side of all reservoir slope faces. A freeboard of 15 feet was used based on detailed analysis of wind and wave height run-up.

A perimeter canal (seepage canal) is provided on the south, east, and north sides of the reservoir. The existing Townsend Canal will act as a seepage canal on the west side of the reservoir. In addition to seepage collection, the perimeter canal will also convey discharges from the reservoir; convey surface runoff from the south and east of the reservoir including improved drainage for SR29; provide flows to the Crawford Canal, Banana Branch and Fort Simmons Branch; and maintain the surface water elevation in the expanded NE Rim Ditch that provides irrigation for the A. Duda and Sons (Duda) citrus operations, located to the south of the reservoir. A 17 foot cutoff wall along the perimeter of the dam embankment has also been included.

Improvements to the Townsend Canal are based on the necessary capacity to meet maximum pumping requirements to fill the reservoir. Pre-storm and post-storm event flows have been simulated to evaluate flows in the Townsend Canal and other local canals and tributaries. Storm event flows in the Townsend Canal will be decreased over existing conditions with the construction and operation of the reservoir.

Each cell is designed to discharge independently through separate discharge structures. Cell 1 will discharge via the S-1 structure into the Townsend Canal. Cell 2 will discharge via S-8 structure into the perimeter canal. These structures will be designed for incremental operation allowing required flows to

be released to the C-43 Canal during periods of low flow. These structures could also serve as design storm control structures for releases prior to and during a storm event. The storm releases must be balanced with the targeted maximum flow allowed over S-79, which is 4,500 cfs. An emergency spillway with a crest elevation based on retaining the 25 year, 72 hour storm event is to be provided within each cell's discharge structure. The 25 year, 72 hour storm captured in the reservoir would be a "control release" after the storm event in order to restore the water surface to the normal pool elevation while not exceeding the maximum flow of 4,500 cfs at S-79. The final design of the emergency spillway(s) will be in accordance with the requirements of Design Criteria Memorandum 3 (DCM-3).

Within the reservoir, structure S-12 will hydraulically connect the two reservoir cells and is designed to be gated so that either cell can be "isolated" for operational or maintenance purposes. A number of other culverts, weirs, and spillways are included to operate the reservoir and maintain appropriate water levels in existing canals and the perimeter canals.

Major Project Components

Reservoir - The Reservoir is an earthen impoundment consisting of approximately 9,400 acres of interior storage that is to be constructed above the existing ground. It will consist of an approximate 170,000 acre-feet two-cell reservoir. Water will be pumped from the C-43 Canal and into the reservoir by utilizing the existing Townsend Canal and a new pump station (C43PS-1) located in the northwest corner of the project.

Water will be discharged from the reservoir through gravity discharge structures in each cell that discharge into a perimeter canal. Both flows into and out of the reservoir will be controlled by monitoring flows at S-79.

Intake Canal - The existing Townsend Canal will serve as intake canal. The reservoir has been designed so that during storm events flows in the Townsend will not exceed the "pre-existing" condition. Therefore, there will be no negative impacts to the Townsend Canal, SR 80 Bridges, or the existing Flap Gate Weir structure. However, two additional flap gates will be installed in the Weir structure to provide capacity for pumping rates of 1,500 cfs at C43PS-1.

The perimeter canal will serve as a seepage canal and as a means of conveying both surface water runoff and off site flows entering the project. The perimeter canal design includes littoral shelves along the exterior slope that are intended to promote wetland vegetation, fisheries, and recreation activities.

DRAFT

Embankments (Dams) - The perimeter embankment will have an external geometry that includes a 14-foot wide crest and 3 horizontal to 1 vertical sideslopes. Crest elevations have been established at +56.5 feet NAVD for both Cell 1 and Cell 2. The embankment will be constructed largely of random fill, but will also include a low permeability soil-bentonite wall, an internal drain, and upstream slope protection. The soil-bentonite wall will extend from an elevation that is 5 feet above the normal pool elevation to 5 feet below the top of a clay layer which underlies the project site at depths generally in the range of 20 to 25 feet below existing surface grades. A few structures pass through the perimeter embankment. At these locations, the above ground portion of the soil-bentonite wall will be replaced with select fill. A roughly 100 foot wide bench will be raised above the existing ground surface immediately downstream of the perimeter embankment. A perimeter canal is to be located on the outside of the bench.

The separator dam between Cells 1 and 2 will be a homogenous embankment with a crest elevation of +51.4 feet NAVD. It will not include any soil-bentonite wall or internal drain. The separator dam will be covered on both sides with soil-cement. The components of the embankments are described in more detail in the following sections.

Pumping Station C43PS-1 – This pump station will consist of a steel and reinforced concrete structure that will house the main pumps and pumping motors for the project. The structure will be located adjacent to the downstream side of the dam and will have plan dimensions of approximately 200 feet (parallel with the dam) by 100 feet (measured at the intake level). It will have a base slab elevation on the intake side of the structure of -16 feet with respect to the North American Vertical Datum of 1988 (NAVD). The structure bottom will step up to elevation +10 feet NAVD for a distance of about 30 feet in the area between the intake bay and the toe of the dam. The existing surrounding grades at the site of the proposed construction are approximately +16 to +17 feet NAVD.

Pumping Station C43PS-4 – This pump station will provide water to the perimeter canal during dry periods when water cannot be released from Cell 2 of the reservoir due to low reservoir water levels. C43P-S4 will maintain the water level in the perimeter canal, provide water to the Paul Property, and supply water to the Banana Branch and Ft. Simmons Branch.

It will consist of a steel and reinforced concrete structure that will include a "can" type intake. The structure will be located adjacent to the top of bank of the Townsend Canal and will have plan dimensions of approximately 55 feet by 45 feet. It will have a separate intake bay that will have a top of slab elevation of -12 feet with respect to the NAVD. The intake pipes will consist of 3 48-inch diameter steel pipes that connect the intake bay with the vertical cans. Invert

DRAFT

elevations for these pipes will be approximately elevation -10 feet NAVD. The bottom of the can structures will be elevation -20.4 feet NAVD. Surface water levels in the Townsend Canal are expected to range between +3 and -3 feet NAVD. The pumping station floor level will be elevation +10 feet NAVD, and will step up to elevation +19 feet NAVD in the discharge bay. The existing surrounding grades at the site of the proposed construction are approximately +22 to +23 feet NAVD.

Culvert Structure C43s-7 - This culvert structure will provide a hydraulic connection between the perimeter canal and the Banana Branch Canal. It will consist of a 222 foot long double barrel concrete box culvert that rests upon a combined footing with bottom width of approximately 26 feet. The culvert will have an invert elevation of +10 feet with respect to the NAVD. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD. Finished grades above the culvert are expected to be about +22 to +23 feet NAVD.

Culvert Structure C43s-9 - This culvert structure will provide a hydraulic connection between the perimeter canal and the Fort Simmons Branch. It will consist of a 102 foot long double barrel concrete box culvert that rests upon a combined footing with bottom width of approximately 26 feet. The culvert will have an invert elevation of +14 feet with respect to the NAVD. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD. Finished grades above the culvert are expected to be about +21 to +22 feet NAVD.

Culvert Structure C43s-14 - This culvert structure will provide a hydraulic connection between the perimeter canal and the Header Canal. It will consist of a 97 foot long single barrel concrete box culvert that rests upon a footing with bottom width of approximately 15 feet. The culvert will have an invert elevation of +15 feet with respect to the NAVD. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD. Finished grades above the culvert are expected to be about +28 to +29 feet NAVD.

Culvert Structure C43s-15 - This culvert structure will provide a hydraulic connection between the perimeter canal and the Roberts Canal. It will consist of an 86 foot long double barrel concrete box culvert that rests upon a combined footing with bottom width of approximately 26 feet. The culvert will have an invert elevation of +14 feet with respect to the NAVD. The normal water level on the perimeter canal side of the structure will be +19 feet NAVD. Finished grades above the culvert are expected to be about +26 to +27 feet NAVD.

Gated Culvert Structure C43s-3 - This structure will consist of a gated dual culvert that will be situated in the perimeter canal and will control the water

DRAFT

levels in the canal. It will have base dimensions of 65 feet (parallel with the canal) by 25 feet (across the canal). The structure will bottom new elevation +11.5 feet with respect to the NAVD. A concrete tremie seal will be placed between the structure bottom level and elevation +6.5 feet NAVD. The ground surface elevation in the project vicinity is estimated to be +26 feet NAVD. Surface water levels across the structure will be +23 and +19 feet NAVD on the upstream and downstream sides of the structure, respectively. Steel sheet piling will be used to construct wingwalls as needed. A seepage cutoff wall will be set below the upstream edge of the structure. The bottom of the cutoff wall is currently designed at elevation -1.5 feet NAVD.

Gated Spillway Structure C43s-10 - This structure will consist of a gated spillway that will be situated in the perimeter canal and will control the water levels in the canal. It will have a base slab that has plan dimensions of 64 feet (parallel with the canal) by 55 feet (across the canal). The structure will bottom near elevation +2 feet with respect to the NAVD. A concrete tremie seal will be placed between the structure bottom level and elevation -3 feet NAVD. The ground surface elevation in the project vicinity is estimated to be +20 feet NAVD. Surface water levels across the structure will be +19 and +15 feet NAVD on the upstream and downstream sides of the structure, respectively. Steel sheet piling will be used to construct wingwalls and seepage cutoff walls. A seepage cutoff wall will be set below the upstream edge of the structure. The bottom of the cutoff wall is designed to be approximately elevation -8 feet NAVD.

Gated Spillway Structure C43s-11 - This structure will consist of a gated spillway that will be situated in the perimeter canal and will control the water levels in the canal. It will have a base slab that has plan dimensions of 75 feet (parallel with the canal) by 62 feet (across the canal). The structure will bottom near elevation -8 feet with respect to the NAVD. A concrete tremie seal will be placed between the structure bottom level and elevation -13 feet NAVD. The ground surface elevation in the project vicinity is estimated to be +17 feet NAVD. Surface water levels across the structure will be +15 and +3 feet NAVD on the upstream and downstream sides of the structure, respectively. Steel sheet piling will be used to construct wingwalls and seepage cutoff walls. A seepage cutoff wall will be set below the upstream edge of the structure. The bottom of the cutoff wall is designed to be approximately elevation -18 feet NAVD.

Cell 1 Main Outlet Structure C43s-1 - Structure C43S-1 refers to the main operational outlet from Cell 1 to the perimeter canal. It will consist of twin concrete conduits, which will be constructed essentially at existing grade, and will be buried beneath the perimeter dam and oriented perpendicular to the dam. The conduits will each be 10 feet wide and 6 feet high. The outlet will include an intake structure located on the upstream side of the dam, consisting

DRAFT

of a concrete box supported on a reinforced concrete mat foundation. The top of the box has been established at elevation +44 feet with respect to the NAVD. The existing ground elevation in the vicinity of the intake box is estimated to be +17 feet NAVD. The crest of the dam will have an elevation of +55 feet: NAVD. Operational and emergency gates will be located within a control building near the center of the dam. The control works will also be supported on a reinforced concrete mat foundation. The outlet works will discharge to an impact stilling basin located on the downstream side of the dam. The stilling basin will be approximately 26 feet wide and have an invert elevation of +5 feet NAVD. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +15 feet NAVD.

Cell 2 Main Outlet Structure C43s-8 - Structure C43S-8 refers to the main operational outlet from Cell 2 to the perimeter canal. It will consist of twin concrete conduits, which will be constructed essentially at existing grade, and will be buried beneath the perimeter dam and oriented perpendicular to the dam. The box culverts will each be 10 feet wide and 6 feet high. The outlet will include an intake structure located on the upstream side of the dam, consisting of a concrete box supported on a reinforced concrete mat foundation. The top of the box has been established at elevation +29 feet with respect to the NAVD. The existing ground elevation in the vicinity of the intake box is estimated to be +20 feet NAVD. The crest of the dam will have an elevation of +54 feet NAVD. Operational and emergency gates will be located within a control building near the center of the dam. The control works will also be supported on a reinforced concrete mat foundation. The outlet works will discharge to an impact stilling basin located on the downstream side of the dam. The stilling basin will be approximately 26 feet wide and have an invert elevation of +9 feet NAVD. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +19 feet NAVD.

Balancing Outlet Structure C43s-12 - Structure C43S-12 refers to the operational hydraulic connection between Cells 1 and 2. It will consist of triple concrete conduits, which will be constructed essentially at existing grade, and will be buried beneath the internal dam and oriented perpendicular to the dam. The box culverts will each be 10 feet wide and 6 feet high, and will be supported on a reinforced concrete mat foundation. The existing ground elevation in the vicinity of the spillway is estimated to be +21 feet with respect to the NAVD. The top of the internal darn is expected to have a crest elevation of +50 feet NAVD.

Crest Spillway Structure C43cs-1 - Crest Spillway Structure C43CS-l refers to the service spillway from Cell 1 to the Townsend Canal. It will consist of a

DRAFT

concrete conduit, which will be constructed across the perimeter dam and oriented perpendicular to the dam. The conduit will be 12 feet wide. The invert elevation for the conduit will be set at elevation +38 feet with respect to the NAVD. A concrete weir will be set at elevation +42 feet NAVD. The existing ground elevation in the vicinity of the spillway is estimated to be +17 feet NAVD. The crest of the dam will have an elevation of +55 feet NAVD. The spillway will discharge down a concrete lined channel to a stilling basin located on the downstream side of the dam. The stilling basin will be approximately 12 feet wide and have an invert elevation of -7 feet NAVD. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +3 feet NAVD.

Crest Spillway Structure C43cs-2 - Crest Spillway Structure C43CS-2 refers to the service spillway from Cell 1 to the perimeter canal. It will consist of a concrete conduit, which will be constructed across the perimeter dam and oriented perpendicular to the dam. The conduit will be 12 feet wide. The invert elevation for the conduit will be set at elevation +38 feet with respect to the NAVD. A concrete weir will be set at elevation +42 feet NAVD. The existing ground elevation in the vicinity of the spillway is estimated to be +21 feet NAVD. The crest of the dam will have an elevation of +54 feet NAVD. The spillway will discharge down a concrete lined channel to a stilling basin located on the downstream side of the dam. The stilling basin will be approximately 12 feet wide and have an invert elevation of +7 feet NAVD. This portion of the facility will also be supported on a reinforced concrete mat foundation. The downstream water surface elevation at this structure is designed at +19 feet NAVD.

1.3.1.2 Impact of Project Discharges on Public Health, Safety, or Welfare

As described in earlier sections of this report the primary means for restoring the ecosystem involve the creation of project components to store excess runoff from the watershed and control the discharge of excess flows from Lake Okeechobee and the Caloosahatchee Watershed. This storage function is achieved through an impoundment and levee seepage management. Based upon the information provided in this report, the SFWMD has determined the project discharges will not negatively impact public health, safety, or welfare.

1.3.1.3 Availability of Engineering Drawings

Preliminary engineering drawings are available for review in Appendix A of the PIR/EIS. As the project moves through the authorization and design phases, it is anticipated that engineering drawings will be refined. Copies will be provided to the FDEP when available.

1.3.1.4 Summary of Engineering Designs and Evaluations

1.3.1.4.1 Engineering

Pre-Construction Engineering and Design activities will be in accordance with USACE and SFWMD requirements. Preliminary design activities, which include survey and geotechnical investigations as well as cultural resources compliance, commenced in early 2004. Under the State's Acceler8 program, the SFWMD prepared a Basis of Design Report (BODR) for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project (otherwise known in Acceler8 as the C-43 West Storage Reservoir). The BODR includes all engineering assumptions and conceptual designs for each of the projects features. Upon reviewing the BODR, the SFWMD will prepare initial, intermediate and final plans and specifications for construction contract award. All design work will be coordinated and reviewed with the USACE to meet USACE standards and regulations.

The project components that will require engineering design includes levees, pump stations, and water control structures such as weirs and culverts, ditches and canals. These elements can be found in standard engineering designs for surface water management systems for agricultural, commercial and residential projects and flood control projects throughout south Florida. These are also standard elements utilized in many water resource and flood control projects constructed by the USACE. Sound engineering judgment, experience gained from past projects and studies, and other published criteria were utilized in the component design.

Although detailed design work remains to be completed, at this stage it has been determined with reasonable certainty that the project components are feasible based upon standard engineering practices.

1.3.1.4.2 Evaluation Tools

System-wide and sub regional computer models were developed to address watershed hydrology, seepage management and reservoir operations for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. The South Florida Water Management Model (SFWMM) provided the simulated levels for Lake Okeechobee. This system-wide model simulates the water resources system from Lake Okeechobee to Florida Bay. It is used to estimate the hydrologic responses to proposed structural and operational modifications to the water management system in south Florida. The specific details about the system-wide and sub regional models used as evaluation tools as well as the assumptions used and additional modeling can be found in Appendix A of the PIR/EIS.

DRAFT

In formulating and evaluating project alternatives, operational effects of proposed management measures on the existing ecosystem must be considered. To do this, computer simulation models and spreadsheets were used to evaluate the proposed operational criteria for each alternative in terms of its hydrologic influences on potentially affected natural areas.

South Florida Water Management Model (SFWMM) - The most commonly used integrated model in South Florida is the South Florida Water Management Model (SFWMM). The model simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay covering an area of 7,600 square miles with a mesh of 1.61 km (2 miles) by 1.61 km (2 mile) cells. The SFWMM incorporates current or proposed water management protocols and operational rules and has the ability to simulate water management practices and policies that affect urban, agricultural, and environmental water uses in South Florida in one of its major strengths. Since the boundary of the SFWMM does not extend into the C-43 project area, the SFWMM model can only provide boundary conditions at the point where Lake Okeechobee discharges in to the C-43 Canal (S-77). Therefore, a sub-regional model was needed to simulate the hydraulics and hydrology of the project area.

MIKESHE Model - Hydrologic indicators and hydraulic models were used to evaluate potential affects that could occur in the watershed for average wet season water levels (July 1 to October 1), average dry season water levels (April 1 to May 15), and hydroperiods. The MIKESHE modeling platform was used to develop sub-regional models of the C-43 basin to simulate the hydraulics and hydrology for purposes of showing hydrographs and stage duration curves, water level fluctuations and hydroperiods for selected indicator regions within natural areas associated with each of the alternative plans. These modeling results provide a comparisons between Pre-Development, Existing (2000) conditions, 2050 Without Project conditions, and with project conditions for each of the proposed alternatives for the system wide analysis (with CERP) to identify the selected alternative plan (SAP).

Spreadsheet Analyses - As an additional verification of modeling results used in selection of the SAP, a spreadsheet analysis calculated flow data for the S-79 structure for use in a Next Added Increment (NAI) analysis of each alternative to verify environmental benefits achieved by each plan evaluated.

The source of Caloosahatchee River (C-43 Canal) flow data for the spreadsheet analyses for the Existing Conditions Baseline (2000) and Future Without Project Condition (2050 with no-CERP projects in place) is derived from South Florida Water Management Model (SFWMM) version 5.4.2 base model simulation 2000RD, for the Existing Conditions Baseline and 2050RD model simulation for

DRAFT

the 2050 with no CERP projects in place. Below are key assumptions utilized in these analyses and are consistent with this conceptual intent.

- The spreadsheet will take into consideration the ET losses from the reservoir. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, reservoir seepage (assumed to be zero based on results of the C-43 Test Cell Pilot Project – July 2006), ET losses (based on area volume relationship), and reservoir direct precipitation.
- No agricultural or urban water supply deliveries will be supplied by the reservoir. These demands continue to be supplied from Lake Okeechobee or existing groundwater sources.
- The eastern Caloosahatchee Basin (east of the S-78 structure) will not be affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary downstream of S-79, there will be no impacts on the Western Caloosahatchee Basin.

Description and interpretation of all model results including a review of the reliability and accuracy of the assumptions and data used in the in the model, as well as risks and uncertainties associated with their use are described further in Appendix A of the PIR/EIS.

1.3.1.4.3 Discussion of New Technologies or Features with Higher Levels of Uncertainty

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project selected plan relies on existing technologies that have proven to be effective in managing and restoring south Florida's water resources. The USACE has extensive experience and reputable credibility in the construction of the types of features recommended for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. A summary of the project features and associated risks and uncertainties is provided in Table 7.

The risk and uncertainty associated with the construction and operation of these features of the proposed project should be minimal. All features have been designed and constructed through established and applied technology. No experimental design was necessary for any component of the proposed impoundment.

A cutoff wall along the perimeter of the dam embankment is being considered and will be further investigated as the project proceeds to design. For estimating purposes, a 17-foot cutoff wall was included. These use standard technology and should pose minimal risk.

DRAFT

Soil cement protection was included for armoring. This will be further investigated as the team proceeds with the design. Armoring generally uses standard technology and should pose minimal risk.

TABLE 7: SUMMARY OF PROJECT FEATURES AND ASSOCIATED RISK AND UNCERTAINTY

Feature	Risk	Uncertainty
Reservoirs • Armoring • Cutoff Walls • Freeboard	Minimum	Minimum- established and applied technology
Pump Stations	Minimum	Minimum- established and applied technology
Spillways • Emergency Overflow • Vertical Lifts	Minimum	Minimum- established and applied technology
Drawdown Structures	Minimum	Minimum established and applied technology
Culverts	Minimum	Minimum established and applied technology
Canals	Minimum	Minimum- established and applied technology
Earthwork • Filling canals • Plugging culverts	Minimum	Minimum-established and applied technology
Artificial Habitat Creation Oyster substrate	Minimum	Minimum- established and applied technology

A freeboard of approximately 17 feet was used in preparing the rough order of magnitude cost estimates. This value for freeboard was developed by Acceler8 and presented in their March 2006 Draft Technical Memorandum detailing their design assumptions and calculations for freeboard. Based on interagency review of the Draft Memorandum, it is expected that the final freeboard design will be somewhat less than the initial 17 foot assumption. The freeboard design will be further refined in accordance with applicable CERP Design Criteria Memoranda (DCM). These DCMs were developed to provide consistent working level guidance for impoundment design by the Acceler8 teams. The DCMs consolidate and incorporate design criteria from various agency regulations and guidelines including U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, Federal Energy Regulatory Commission, Florida Building Code, and the American Society of Civil Engineers. The DCMs do not supersede Corps of Engineers' regulations. Freeboard designed in compliance with the DCMs, and thusly Corps of Engineers regulations, should result in minimal risk of embankment failure due to overtopping (refer to DCM-2 for additional detail).

Through the Caloosahatchee Watershed plan, lands necessary for the construction, operation, and maintenance of the C-43 West Reservoir have

already been acquired by the SFWMD using funds appropriated to the Department of Interior in Section 390 of the Federal Agricultural Improvement and Reform Act of 1996. As such, there is no uncertainty associated with land availability and acquisition.

1.3.2 Efficiency and Cost Effectiveness

Plan formulation and evaluation for this project focused on management measures and plans developed in prior ecosystem restoration studies (including the Comprehensive Review Study) for the Everglades. All of the prior studies with similar planning objectives (to restore fish and wildlife habitat functions in the remaining Everglades) concluded that additional storage to supplement the regional water management system was needed at the Caloosahatchee River (C-43) West Basin Storage Reservoir Project location, and aboveground impoundments with a seepage management feature were the most cost-effective management measure for creating additional storage.

Cost Effectiveness Analysis - Cost effectiveness analysis begins with a comparison of the costs and outputs of alternative plans to identify the least cost plan for every level of output considered. Alternative plans are compared to identify those that would produce greater levels of output at the same cost, or at a lesser cost, as other alternative plans. Alternative plans identified through this comparison are the cost effective alternative plans. Next, through incremental cost analysis, the cost effective alternative plans are compared to identify the most economically efficient alternative plans. Cost effective plans are compared by examining the additional (incremental) costs for the additional (incremental) amounts of output produced by successively larger cost effective plans. The plans with the lowest incremental costs per unit of output for successively larger levels of output are the "Best Buy" plans. The results of these calculations and comparisons of costs and outputs between alternative plans provide a basis for addressing whether the additional outputs are worth the costs incurred to achieve them.

The cost estimate for the alternatives includes construction, LERRDs (lands, easements, right-of-ways, relocation, and disposal), PED (pre-construction, engineering and design) costs, and construction management. Data for initial construction/implementation, land acquisition, monitoring, and periodically recurring costs for O&MRR&R (operation, maintenance, repair, replacement, and rehabilitation), have been developed through engineering design and cost estimation, and real estate appraisal efforts (See Appendix B of the PIR/EIS for details of data development for cost estimates).

National Economic Development (NED) Costs are expressed in 2007 price levels and are based on costs estimated to be incurred over a 40 year period of analysis.

Costs of a plan represent the value of goods and services required to implement and operate and maintain the selected plan. These costs are included in Table 8 and were used in the cost effectiveness analysis of the alternatives. Based on additional engineering and design that would be performed in the planning, engineering and design phase, Alternative 3C may require modifications to the Townsend Canal and a major road downstream of the impoundments. For this purposes of this planning level cost estimate these costs were not included.

Cost effectiveness and incremental cost analyses were conducted for each of the C-43 alternative plans. The analyses compared the alternative plans' average annual costs against the appropriate average annual habitat unit estimates. The average annual outputs were calculated as the difference between with-plan and without-plan conditions over the period of analysis (through year 2050). CE/ICA was performed using a combination of the following five metrics to represent various ecosystem outputs of the C-43 alternatives:

- Vallisneria
- Oyster
- Seagrass
- EST05
- Extreme Event

Table 8: Cost of Final Array of Alternatives (rounded to the nearest $10,000)

	Alternative 2	Alternative 3B	Alternative 3C	Alternative 4
Cost Component*				
Construction	$285,800,000	$316,900,000	$368,000,000	$464,300,000
S/A	$18,400,000	$20,400,000	$23,700,000	$29,800,000
PED	$23,000,000	$25,500,000	$29,600,000	$37,300,000
Lands	$80,507,000	$80,507,000	$80,507,000	$80,507,000
Initial Cost	$407,707,000	$443,307,000	$501,807,000	$611,907,000
Interest During Construction				
Construction	$26,600,000	$29,500,000	$34,000,000	$43,000,000
Lands	$13,500,000	$13,500,000	$13,000,000	$13,000,000
Total IDC	$40,100,000	$43,000,000	$47,000,000	$56,000,000
Total Project Investment	**$447,807,000**	**$486,307,000**	**$548,807,000**	**$667,907,000**
Average Annual Cost				
Interest & Amortization	**$25,700,000**	**$27,900,000**	**$31,400,000**	**$38,300,000**
Operation & Maintenance	$3,265,000	$3,358,000	$5,267,000	$5,556,000
Total Average Annual Cost	**$28,965,000**	**$31,258,000**	**$36,667,000**	**$43,856,000**

*Note – Final Costs of Selected Alternative Plan will be revised based on additional engineering and design

DRAFT

The total cost of CERP is not included in this cost effectiveness and incremental cost analyses. The cost of the balance of the CERP features, those not included in the C-43 alternatives, is the same for all the alternatives. As such, including it in this analysis does not bring any additional insight or differentiation between alternatives. For this analysis, the difference between the alternatives can be shown through a display of the outputs and costs of each alternative without the cost of the "other CERP" features.

All of the environmental outputs were calculated on an average annual basis to account for the fact that several years may be required for full attainment of the functional capacities to be realized. This was performed for the expected future with and without project habitat units, which were used to calculate the average annual benefits for each ecosystem output. A summary of the average annual lift calculations and average annual costs used in the CE/ICA analysis are provided in Table 9. Alternatives 2, 3B and 3C are all cost effective alternatives. Alternative 3C provides the greatest habitat lift of all the alternatives, and this alternative also has the lowest average cost per unit of output.

Table 9: Results of Cost Effectiveness Analysis

Alternatives	Average Annual Cost ($1,000)	Output	Average Cost Per Output	Cost Effective?
Without Plan	$0	0	N/A	
Alternative 2	$28,965	10,628	$2,725	YES
Alternative 3B	$31,258	12,809	$2,440	YES
Alternative 4A	$43,856	15,907	$2,757	NO
Alternative 3C	$36,667	16,397	$2,236	YES

Note: Freshwater Wetland Habitat Units (HU)
All plans and cost effective plan arrayed by increasing output for each output category.

Incremental Cost Analysis - The initial and final arrays of alternative plans for this project consisted of an aboveground impoundment of varying storage volumes. All other management measures were screened from further consideration as a result of prior studies. Since all of the plans in the final array of alternative plans consisted of the same cost effective management measure, an incremental cost analysis was performed to determine the incremental costs of the benefits produced by the remaining two structural plans.

Incremental cost analysis of the system-wide effects of the final array of plans was performed using IWR Plan software. This analysis was performed for both the next-added (stand-alone) incremental output and the last-added (with-rest-of-CERP) increment output. The output for this analysis was the increase in annual average volume in acre-feet of water retained in the natural system plus

the volume of water stored by the impoundments compared to the future without project condition. The water retention and water storage functions of the project are surrogate metrics for the other environmental outputs affecting the adjacent natural areas (Caloosahatchee River and Estuary).

This analysis is based on and follows guidance from the US Army Corps of Engineers Institute for Water Resources publication, Evaluation of Environmental Investment Procedures Manual, Interim: Cost Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1. Costs are based initially on a rough order of magnitude (ROM) and include PED and construction costs, interest during construction, as well as operations and maintenance costs after construction.

Typically, cost effective plans are arrayed by increasing outputs to clearly demonstrate changes in costs (i.e., increments of cost) and in outputs (i.e., increments of output). For comparison purposes, each cost effective alternative plan is compared to the Without Plan condition to determine which of the alternative plans has the lowest incremental costs per unit of output of all plans. This plan is then considered the first Best Buy plan. After the first Best Buy plan is identified, all larger cost effective plans are compared to the first Best Buy plan in terms of increases in (increments of) cost and increases in (increments of) output. The alternative plan with the lowest incremental cost per unit of output (for all cost effective plans larger than the first Best Buy plan) is then considered the second Best Buy plan.

Table 10 present the results of the incremental cost analysis of the different alternative plans for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project (for the respective ecological zones). The results of the analysis show that there is only one best buy plan for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. From the analysis of incremental cost for all of the alternatives, Alternative 3C provides the greatest Habitat Unit lift while having the lowest cost per unit of output and is considered the First Best Buy for the project.

Average Annual Benefits - The analysis of ecological response times for large, diverse ecosystems is extremely difficult to calculate. For example, when analyzing an estuarine system, certain attributes will have to be examined when predicting the response to changes in salinity. While some species will generally provide responses within a year of salinity change towards normal conditions, others will respond fairly quickly, but are difficult to measure due to changing conditions. To account for this, a linear approach to predict ecological response time was used and it resulted in:

- 80% of the benefits would be realized by 3 years from start of construction,

DRAFT

- 90% within five years after that,
- 100% of the lift would be realized within 10 years of construction.

If nothing was done to improve the conditions in the estuary, the project team determined that the future without condition would experience a gradual improvement for 15 years at which point the ecosystem would stabilize.

Table 10: Results of Incremental Cost Analysis – Cost Effective and Best Buy Plans Arrayed by Increasing Output

	Average Annual Cost ($1000)	Output	Average Cost Per Output ($1,000)	Incremental Average Annual Cost ($1,000)	Incremental Output	Incremental Cost Per Output	Best Buy?
Without Plan	$0	0	N/A	N/A	N/A	N/A	
Alternative 3C	$36,667	16,397	$2,236	$36,667	16,397	$2,236	Best Buy

Cost effectiveness and incremental cost analysis requires a comparison of average annual costs and average annual benefits. In an ecosystem restoration project, the analyses compare the alternative plans' average annual costs against the appropriate average annual habitat unit estimates. The average annual outputs were calculated as the difference between with-plan and without-plan conditions over the period of analysis (through year 2050). Costs used for CE/ICA and outputs used for CE/ICA are displayed in Table 11.

Table 11: Costs and Outputs Used in Cost Effectiveness and Incremental Cost Analyses

	Alternative 2	Alternative 3B	Alternative 3C	Alternative 4
Annual Cost	**$28,965,000**	**$31,258,000**	**$36,667,000**	**$43,856,000**
Average Annual Habitat Units	**10,628**	**12,809**	**16,397**	**15,907**

Note: Values assume system benefits (ecosystem outputs that would accrue to the C-43 study area if rest of CERP is constructed). Values for Alternatives are Differences Between "Without" Plan and "With" Plan (on an average annual basis)

1.4 Determination of Project Consistency with Applicable Laws and Regulations [373.1501(5)(c)]

Section 373.1501(5)(c), F.S. requires the SFWMD to "Determine with reasonable certainty that all project components are consistent with applicable laws and

DRAFT

regulations, and can be permitted and operated as proposed. For purposes of such determination:

1. The district shall convene a preapplication conference with all state and federal agencies with applicable regulatory jurisdiction;
2. State agencies with applicable regulatory jurisdiction shall participate in the preapplication conference and provide information necessary for the district's determination; and
3. The district shall request that federal agencies with applicable regulatory jurisdiction participate in the preapplication conference and provide information necessary for the district's determination."

The following sections form the basis for this determination. Copies of the letters received from agencies with jurisdiction over the various aspects of the project can be found in Annex B of the PIR/EIS.

1.4.1 Pre-application Conference

A pre-application conference was held for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project on March 6, 2007 at the City of LaBelle Civic Center in LaBelle, Florida.

1.4.1.1 Summary of Pre-application Conference

A Pre-application Conference was held on March 6, 2007. The purpose of this meeting was to update the agencies and the public on the schedule for the Project Implementation Report. Although some concern was expressed regarding additional culvert structures requested by Hendry County to assist with local drainage problems, those concerns will be addressed in future detailed design documents, review procedures, and permit processes.

Federal, state and local regulatory agencies attended. Representatives from the following agencies were present:

- U. S. Army Corps of Engineers
- Florida Department of Environmental Protection
- Florida Department of Agriculture and Consumer Services
- Florida Department of Transportation
- South Florida Water Management District

The conference was also open to public, and representatives from the following offices attend:

- Earth Works of Naples

DRAFT

- URS Corporation
- ZFI Engineering and Construction

As a follow up to the Pre-application Conference, each of the agencies was asked in a letter by the District to specify the applicable laws and regulations, and the likelihood that the project components would comply with those laws and regulations. The agencies were also asked to address the following: 1) the applicable permitting requirements administered by that agency; 2) the likelihood of obtaining those permits; 3) other laws administered by the agency which might affect the project; and 4) the likelihood that the projects would comply with those other laws.

In the request, the District acknowledged that the agency responses would be non-binding and non-final agency action, since the Comprehensive Plan components are still undergoing design and review. Nevertheless, the agency responses contribute to the District's reasonable certainty that the project components can be permitted and operated as designed, and will conform to applicable laws and regulations. The FDEP indicated that it did not anticipate any problems with the 373.1501 process, but that determination will be made once the SFWMD submits the 373.1501 State Compliance Report to the FDEP for review. Agency responses are summarized in the following subsections.

The following sections form the basis for this determination. Copies of the letters received from agencies with jurisdiction over the various aspects of the project can be found in the PIR/EIS.

1.4.2 Local Agency Information

All components of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project will need to comply with the Hendry County Land Development Code and all applicable development ordinances. Review of the conceptual design for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project by Hendry County staff indicates that the project will comply, or can be designed to comply with all ordinances and codes administered by the County.

1.4.3 State Agency Information

1.4.3.1 Florida Department of Environmental Protection (DEP)

The Department of Environmental Protection (DEP) has participated actively in the planning and evaluation process directed by the SFWMD and USACE leading to the development of the Comprehensive Plan. Through that process, DEP identified potential permitting obstacles to the implementation of the Comprehensive Plan. DEP will also continue to assign agency staff to work with

DRAFT

the SFWMD and the interagency teams working on ongoing and future detailed planning efforts. Furthermore, to effectively fulfill their responsibilities under the approval process created in s. 373.026(8), F.S. and the criteria for approval listed in s. 373.1501(5), F.S., DEP is continuing to participate with SFWMD staff in the coordination of pre-application conferences and the preparation of information to be submitted to DEP for review and approval. DEP has committed to working with the SFWMD and USACE to issue these permits in a timely manner.

DEP has determined that its Water Quality Standards and Special Projects Program of the Division of Water Resource Management in Tallahassee will have primary responsibility for coordinating their planning and permitting activities associated with CERP components. This will be done in close coordination with the CERP planning and permitting staff in the District Office in Fort Myers.

DEP has reviewed the information presented at the pre-application conferences and have discussed the available information provided to date through the Project Implementation Report process. Based on that review and discussion, it is their initial opinion that with a reasonable degree of certainty, the project components, as currently understood, will be permittable, operable and will comply with relevant laws and regulations.

Achieving water quality standards will be an underlying consideration of the FDEP during the permitting of these project components. FDEP has and will continue to work with the SFWMD and USACE to ensure that surface water discharges and ground water recharge from these components will meet water quality standards and water quality objectives. This position is consistent with both the intent and language of the CERP and the Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) permitting legislation (373.1502, F.S.).

1.4.3.2 Florida Fish and Wildlife Conservation Commission

The FWCC has two areas of regulatory function in the permitting process of the Comprehensive Plan. The first is when construction activities trigger regulations that the FWCC has developed and enforced under Chapter 39 of the Florida Administrative Code. These regulations protect species that the FWCC has designated as endangered, threatened, or of special concern (Chapter 39-027.002 through 39-27.005 of the Florida Administrative Code). These rules protect individuals of listed species, their active nests, their eggs, and their young. The rules do not include habitat protection. The rules would only impact the Comprehensive Plan efforts if the construction or operation activities directly

DRAFT

killed or harmed a listed animal or fish, or if the species were disturbed from their nests such that juveniles were killed.

The second area of permit involvement is an indirect role of commenting when solicited via rules of other agencies that are issuing permits or approvals for projects that have the potential to affect fish and wildlife habitat. The FWCC started this process with information in the CARs found in the Comprehensive Plan documents. SFWMD staff will continue to coordinate with the FWCC to develop satisfactory wildlife-survey methodologies to identify the extent to which listed species may be affected by the individual projects, and if necessary, propose actions to avoid "taking" an individual of a state listed species.

The FWCC has indicated that it supports the goals and concepts of the Comprehensive Plan and anticipates that Caloosahatchee River (C-43) West Basin Storage Reservoir Project is "permittable" pursuant to agency regulations. Furthermore, the FWCC has no indications that it would object to the components being approved via a Comprehensive Everglades Restoration Plan Regulation Act (CERPRA) Permit.

1.4.3.3 Florida Department of State, Division of Historic Resources

The USACE is reviewing information regarding historical properties that might be affected by the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, in compliance with Section 106 of the National Preservation Act of 1966 (PL89-665), as amended in 2000; its implementing regulations (36 CFR Part 800) and the Archeological and Historical Preservation Act of 1974 (PL93-291), as amended.

There are numerous recorded historical properties within Hendry County and there is a possibility that the project may impact known and unknown sites. Investigations to evaluate the cultural resources and high probability areas, which included a literature review, site visit and cultural resource survey resulted in finding no historic or cultural resources were found. This determination was made according to the guidelines established in 36 CFR Part 800 and compliance with Section 106 of the National Historic Preservation Act.

1.4.4 Federal Agency Information

1.4.4.1 U.S. Army Corps of Engineers (USACE)

Based on the current best available information, the proposed project is an integral component of CERP and will be refined and designed, constructed, and cost-shared jointly by the SFWMD and the USACE. As such, the project components should not need federal Clean Water Act 404 permits. However,

DRAFT

should circumstances change to remove this partnership for any of the components and the SFWMD becomes the sole proponent, then 404 permits may be required.

Operation and regulation schedules are to be developed concurrently with the National Environmental Policy Act (NEPA). Each component will be reviewed to assure such compliance, with supplemental NEPA documentation prepared for each component. If the USACE determines during this review that there are no significant impacts for any of the components, the USACE has elected to prepare an Environmental Impact Statement (EIS).

To be eligible for funding, a federal project must comply with all federal laws and regulations. Present understanding is that the final projects will be in complete compliance. The USACE has indicated that based on the present understanding of these project components, the USACE believes that this project will be fully permittable and buildable.

1.4.4.2 U.S. Fish and Wildlife Service (USFWS)

In accordance with Section 7(a)(2) of the Endangered Species Act, the USACE is required to ensure that any action it takes will not jeopardize the continued existence or modify designated critical habitat of federally listed species. The USACE must first make a determination of whether the federal action is "likely to adversely affect" any listed species. If, through informal consultation with the USFWS, the USACE determines that the federal action is "not likely to adversely affect" listed species and the USFWS concurs, then informal consultation is concluded and no further action is required. If the USFWS does not concur with the USACE's determination, the USFWS will request that the USACE enter formal consultation leading to the preparation of a Biological Opinion.

If the USACE determines that the federal action is "likely to adversely affect" listed species, then the USACE will request a Biological Opinion from the USFWS. The USFWS and the USACE then enter formal consultation and the USFWS renders its Biological Opinion.

Additionally, the USACE is required to consult with the USFWS and the appropriate state fish and wildlife agency and seek their views and recommendations on measures to protect, conserve and mitigate for damages to fish and wildlife resources. At this stage of the planning process, the USFWS has provided the USACE with a Planning Aid Report for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project which provides specific recommendations to protect fish and wildlife resources in accordance with the Fish and Wildlife Coordination Act.

DRAFT

The central objective of the Fish and Wildlife Coordination Act (FWCA) is to allow for equal consideration of wildlife resources. Transfer funds have been made available to the USFWS in order to participate in team meetings and workshops scheduled in conjunction with the USACE's planning, implementation, and evaluation process. Funding has also been provided for the USFWS to conduct surveys and investigations necessary to determine impacts of the C-43 project on wildlife resources and to make recommendations to the USACE on measures to prevent loss of or damage to wildlife resources. Recommendations for optimizing opportunities related to the conservation and enhancement of fish and wildlife resources have been provided through the submittal of Planning Aid Letters listed above. A draft CAR has been prepared and is included in Annex A of the PIR/EIS. Additionally, the Florida Fish and Wildlife Conservation Commission (FWC) has been an active participant on this project and have provided a Scoping Letter dated 10 June 2003.

1.4.4.3 Reasonable Certainty that Project is Consistent with Applicable Laws and Regulations and can be Permitted and Operated as Proposed

Based upon these interagency discussions at the Federal, state and local levels, the SFWMD has determined with reasonable certainty that the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is consistent with applicable law and regulations and can be permitted and operated as proposed.

1.5 Reasonable Assurances [373.1501(5)(d)]

Florida Statute s. 373.470(3)(c) states that "Prior to executing a project cooperation agreement with the Corps for the construction of a project component, the District, in cooperation with the Corps shall complete a project implementation report to address the project component's economic and environmental benefits, engineering feasibility, and other factors provided in s 373.1501 sufficient to allow the District to obtain approval under s. 373.026. Each project implementation report shall also identify the increase in water supplies resulting from the project component. The additional water supply shall be allocated or reserved by the District under chapter 373."

Florida Statute s 373.1501(5)(d) states that the SFWMD shall "Consistent with this Chapter, the purpose for the restudy in the Water Resources Development Act of 1996, and other applicable federal law, provide reasonable assurances that the quantity of water available to existing legal users shall not be diminished by implementation of project so as to adversely impact existing legal users, that existing levels of service for flood protection will not be diminished outside the geographic area of the project, and that water management practices will continue to adapt to meet the needs of the restored natural environment."

DRAFT

Key Assumptions for State Compliance Analyses Associated with Reservoir Operations and Spreadsheet Analyses - The conceptual intent of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is that the reservoir will be operated to supply water to the C-43 Canal (Caloosahatchee River) to maintain desirable salinity levels in the Caloosahatchee Estuary System as measured by flows calculated for the S-79 structure. The following are key assumptions utilized in these analyses and are consistent with this conceptual intent.

- The source of Caloosahatchee River (C-43 canal) flow data for the spreadsheet analyses for the Existing Conditions Baseline (2000) is derived from South Florida Water Management Model (SFWMM) version 5.4.2 base model simulation 2000RD.
- The spreadsheet will take into consideration the ET losses from the reservoir. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, reservoir seepage (assumed to be zero based on results of the C-43 Test Cell Pilot Project – July 2006), ET losses (based on area volume relationship), and reservoir direct precipitation.
- No agricultural or urban water supply deliveries will be supplied by the reservoir. These demands continue to be supplied from Lake Okeechobee or existing groundwater sources.
- The eastern Caloosahatchee Basin (east of the S-78 structure) will not be affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary downstream of S-79, there will be no impacts on the Western Caloosahatchee Basin.

The operations of the C-43 reservoir focus on meeting estuary hydrologic restoration targets for the Caloosahatchee Estuary. However, the analyses associated with State Assurances will occur at both the system-wide and project levels to confirm there will be no unexpected impacts to existing legal users of water or significant adverse effects on the level of service for flood protection as a result of the project.

System-wide effects – Defined as the hydrologic effects due to the storage, management, treatment, and delivery of water via the C&SF Project occurring outside the immediate project vicinity. The only basin that will be affected by the project is the Caloosahatchee Estuary. Therefore, there are no System-wide effects on existing legal users or existing levels of flood protection.

Project-level effects – Defined as the hydrologic effects occurring within the immediate project vicinity (e.g., natural areas, wetlands, salinity control) or within the features of the project components (e.g., reservoirs, stormwater treatment areas, wellfield recharge distribution canal).

DRAFT

The SFWMD Acceler8 design process evaluated field conditions at the project reservoir site through geotechnical evaluations which were followed by the construction of test cells. The test cells were constructed to determine the seepage potential of the proposed reservoir and to document local project-level groundwater effects. The embankment of test cell one did not contain a cut-off slurry wall, while the embankment of test cell two did contained a cut-off slurry wall designed to contain seepage. Results of the test cells are presented in the C-43 West Storage Reservoir Test Cell Pilot Project, July 2006. In summary, the groundwater levels within the embankment and seepage rates immediately increased upon filling of test cell one, while test cell two (with a cut-off slurry wall) showed virtually no impact to groundwater levels or in the rate of seepage through the embankment.

In addition, sections 6 and 12 in the C-43 West Basin Storage Reservoir Final Basis of Design Report (SFWMD, April 2006) describe the intended purpose and proposed operations of the perimeter canal. The primary operational intent for seepage management is to maintain the water levels in the perimeter canal to preserve existing groundwater levels and to intercept seepage, if any, from the reservoir.

These project-level, site specific investigations have been used to design a project that will have no adverse effects to the localized surface and ground-water resources adjacent to the project reservoir. In addition, modeling and analyses was conducted using the local reservoir MIKESHE model to assist in the design efforts and to evaluate the affects of the reservoir construction and operations on the area adjacent to the reservoir footprint.

Analyses performed to make these determinations are based in part on simulations produced by the SFWMM for the hydrologic period of record of 1965 through 2000. Details regarding these analyses are included in Annex C of the PIR/EIS.

1.5.1 Water Supply Assurance

This section provides sufficient information "reasonable assurances that the quantity of water available to existing legal users shall not be diminished by implementation of project components so as to adversely impact existing legal users," Section 373.1501(5)(a), F.S. Pursuant to Section 373.219, F.S., existing legal users are those that have a consumptive use permit or are exempt from permitting requirements, such as domestic users.

These assurances require a quantification of the amount of water permitted to all existing legal users and used by exempt users within the Caloosahatchee River (C-43) West Basin Storage Reservoir Project area during the PIR process.

DRAFT

This quantification is determined on a system-wide basis by evaluating flows at S-79 simulated by the SFWMM model simulations of the Existing Conditions PIR Baseline (2000 land use, 2007 permitted demands) without project components to the Existing Conditions PIR Baseline with project components to examine the potential impact of the selected plan on the quantity and quality of water for the existing legal users.

The operations for this project focus on reducing detrimental, excess flows from S-79 and providing supplemental flows across S-79 to the Caloosahatchee Estuary to achieve restoration targets in the estuary. The water supply provided to permitted existing legal users, agricultural and urban demands in the Caloosahatchee Basin, will remain the same as before the project. The project will not affect the regional water management system. Therefore, there will be no system-wide impacts as a result of this project on existing legal users.

At the project level, the existing water levels in the area adjacent to the reservoir will be maintained through the operating levels and control structures of the perimeter canals surrounding the project reservoir. Output of groundwater level simulations using the local reservoir-level MIKESHE model were displayed for eleven locations (each represents a 1,500 ft grid cell) around the reservoir shown in Figure 5. For each location modeled, a groundwater stage duration comparison (see Part 1 Federal Assurances section 3, Figures 2 a-k) shows the groundwater levels at or below the land surface (represented as zero on the figures) and the duration of time for the period of record those levels are maintained for the with and without project conditions.

Location 10 (Figure 6) shows an approximate three foot reduction in groundwater elevations between the "with" and "without" project simulations. This location is adjacent to the Roberts Canal, which functions primarily for drainage, and the perimeter canal, which is held at a lower water elevation between two structures, C-43 S-10 and C-43 S-3, located in the perimeter canal. This reduction in water elevation differences across the project footprint will not affect existing legal users. The results of this groundwater analysis show there are not adverse effects to groundwater levels and, therefore existing legal users will not be affected as a result of the project.

With the project in place, portions of the Roberts Canal and Header Canal will become part of the project footprint. To continue to provide an irrigation source to the Bob Paul property, which in existing conditions pumps irrigation water from the Header Canal (via the Townsend Canal), pump station #3 was included as a project component in the reservoir perimeter canal to pump water to the east to the remaining Header Canal assuring the same volume of water is available compared to existing conditions. The Crawford Canal will still be available to the Bob Paul property for drainage and is not affected by the project.

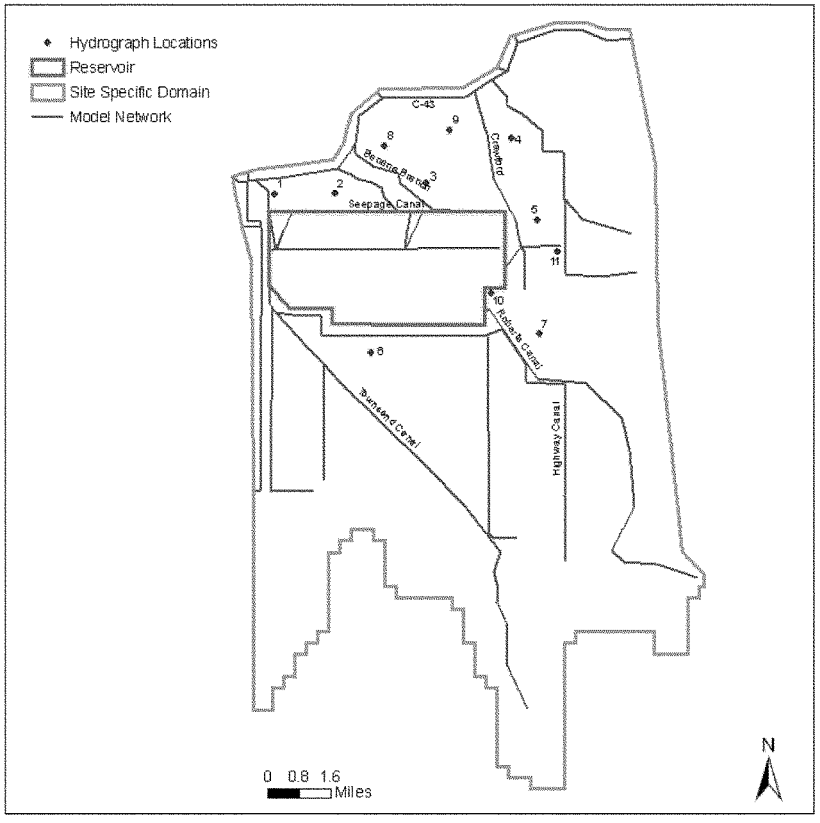


Figure 5: Local Reservoir MIKESHE model boundary outlining the project footprint, local canals and the locations of the simulated groundwater levels for the groundwater hydrographs.

Based on the information contained in this section, the SFWMD is providing reasonable assurances that water supply for existing legal users shall not be diminished through project implementation.

1.5.2 Flood Protection Assurance

An initial analysis of the project's potential impacts on flood protection in the C-43 basin was conducted by reviewing and analyzing the following information:

- Historic stage/discharge relationships;
- Existing groundwater data;
- Canal water surface profiles (with and without the project); and
- Project design and operations;

As a result of this review and analysis, initial recommendations were developed for operational and/or structural changes to the plan necessary to mitigate potential adverse impacts on flood protection associated with project implementation.

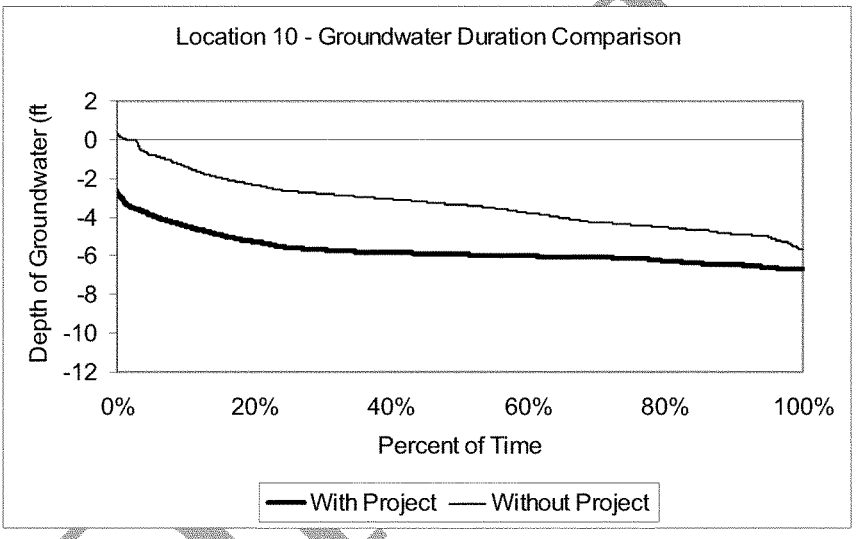


Figure 6: Depth to groundwater level for with project and without project at Location 10

The intent of the level of service analysis for flood protection, required by WRDA 2000 and the CERP Programmatic Regulations as well as Florida State law regarding the implementation of CERP, is to ensure that CERP components do not negatively impact existing levels of service for flood protection.

The operations of this project will not change the operations of the C-43 Canal based on the key assumptions outlined in the Federal Assurances and Savings Clause Analysis, Section 8.4. Therefore, there will be no system-wide effects on flood protection as a result of the project.

Operating levels of the seepage canals and canal structures surrounding the reservoir will be refined to maintain existing groundwater levels adjacent to the

project. In addition, results from the local reservoir-level MIKESHE modeling and the test cell pilot project indicate a boundary slurry wall within the embankment will prevent seepage out of the reservoir and minimize impacts to groundwater levels.

Of the eleven locations (see Figure 5) evaluated using the MIKESHE model, the only location where simulated groundwater elevations increased compared to the without-project conditions was north of the project (Figure 7). Simulated "with project" groundwater elevations increased slightly compared to the "without project" condition. The greatest difference was during the dry period (e.g., 1981) not the wet periods. This minor effect can be addressed through further refinement of perimeter canal control structure operations for the project. The remaining ten locations show no to very little differences in groundwater elevations.

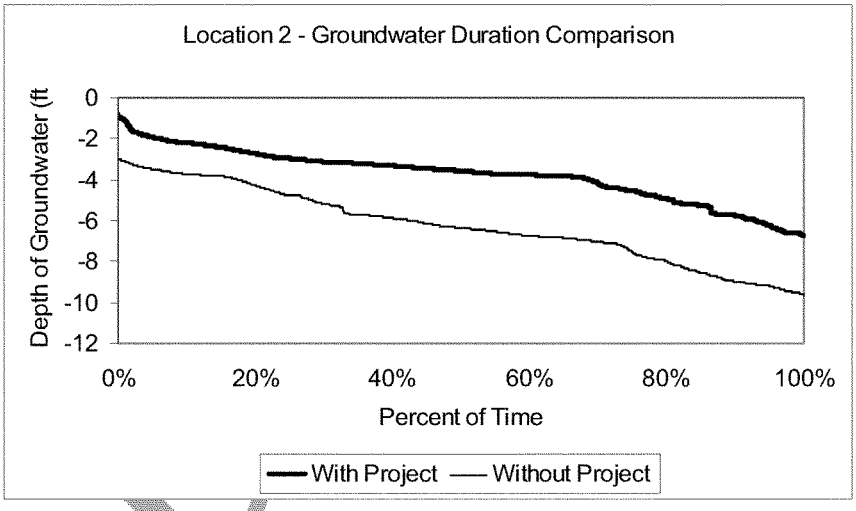


Figure 7: Depth to groundwater level for with project and without project at Location 2

Based upon this information, the SFWMD is providing reasonable assurance through structural and operational modifications that existing levels of service for flood protection will not be diminished through implementation of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project.

Adaptive Management to Meet the Needs of the Restored Natural Environment

Based upon the procedures outlined for the planning process, adaptive water management practices were utilized during the modeling runs and the development of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project selected plan. Along with standard engineering practices and procedures for the detailed design and the establishment of the Restoration Coordination and Verification (RECOVER) process, adaptive water management practices will continue throughout plan implementation. These practices and procedures will ensure that the Caloosahatchee River (C-43) West Basin Storage Reservoir Project will contain the most efficient and cost effective components to meet the needs of the restored natural environment and human environment. The project which is the subject of this report has been a part of past procedures and will be a part of future procedures to maintain this assurance.

Adaptive management (AM) consists of an active strategy for dealing with the considerable uncertainties that characterize management of large natural ecosystems, which are complex and difficult to predict. The overall purpose of AM is to maximize the chance of success and includes methods, such as proactive approaches to dealing with uncertainties, the use of modern ecosystem science and scientific practices, active collaboration, and the use of open, inclusive, and integrative processes.

Five key principles help implement this approach to adaptive management:

1. Anticipate future uncertainties and contingencies
2. Employ science-based approaches to build knowledge
3. Design robust projects that can be adapted to changing conditions
4. Build a shared understanding through collaboration and conflict resolution
5. Reconcile competing objectives to benefit both nature and society

The C-43 project is a component of the CERP, which consists of sixty-eight (68) major components. The uncertainty associated with a program of this magnitude was recognized during the Restudy, which led Congress to address the necessity of AM in the Water Resources Development Act of 2000.

As such, a fundamental implementation principle for CERP is to utilize adaptive assessment and management in order to continually refine and improve the performance of CERP projects so that planned benefits are attained. Incremental revisions of optimal project designs and project operations throughout the planning and implementation process will lead to improved performances. The use of the adaptive assessment policy minimizes the effects

DRAFT

of uncertainty with respect to the effects of CERP projects on the natural system and other water-related needs of the region related to the design and implementation of the CERP.
The measurement of benefits attributable to CERP projects must consider individual outputs as well as system-wide interdependencies among projects. This evaluation methodology applies to hydrologically linked projects that operate optimally in a synergistic fashion. Therefore, until other CERP projects are implemented, some benefits may not be realized. Moreover, interim and long-term impacts will be largely determined by implementation of CERP components and operational strategies. Regional evaluations will be used to improve information necessary to predict and assess shortfalls attributable to sequencing issues versus shortfalls in performance.

The project team considered the uncertainty in the estimation of habitat unit values for the various alternatives and how would ecological outputs respond over time, and how do continued high Lake Okeechobee inflows and runoff volumes affect outputs over time. Consideration of "if" and "when" other CERP components were constructed were also considered in the estimate of ecological outputs, demonstrating the sensitivity of Caloosahatchee Estuary outputs to the construction of other CERP components.

As part of the AM process, careful flow monitoring will occur to evaluate the ability of any implemented features to meet the performance measures. In addition, biological response data will be collected for use in further refining the performance measures, project operations, and system understanding. The next added increment analysis showed that essentially all of the estuary outputs would still be produced by the C-43 Basin project even if other CERP projects were never constructed. This same analysis also indicated that no other alternative performed more cost effectively than the recommended alternative (Alternative 3C) when other CERP project were not constructed. Furthermore, cost effectiveness analysis indicated that the various alternatives were sufficiently separate and distinct so that relatively large changes in either cost or output would be required before an alternative would appear to be the superior.

Coordination with Existing Utilities and Public Infrastructure [373.1501(5)(e)]

Section 373.1501(5)(e), F.S. requires the SFWMD to "Ensure that implementation of project components is coordinated with existing utilities and public infrastructure and that impacts to and relocation of existing utility and public infrastructure are minimized."

1.6.1 Summary of Utilities Within the Project Area

This project is located south of the Caloosahatchee River in a rural area developed in citrus groves east of the City of LaBelle in Hendry County. It is south of State Road 80, a major state road that is designated on the Strategic Intermodal System (SIS). This road serves as a major evacuation and commerce route in and out of Southwest Florida.

There are very few local roads within the project area. These roads will be abandoned and removed as part of the Project.

The only power lines that exist within or immediately adjacent to the Caloosahatchee River (C-43) West Basin Storage Reservoir Project area are local distribution lines that served residential and commercial land uses that have since been acquired for the projects. All the other distribution lines will either be removed or upgraded, once it has been determined which ones need to remain to provide either interim construction and/or permanent operational power for the projects' facilities.

Since telephone lines are co-located with the FPL electrical power lines, removal and relocation of telephone lines due to the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is approximately the same as described above for electrical lines.

1.6.2 Summary of Coordination Efforts with Existing Utilities and Public Infrastructure

Meetings with the other utilities and local governments have been held, as needed, over the years to discuss specific project features and potential impacts on the utility or local government facilities/infrastructure. Follow up meetings will continue to provide an update on project schedules, design analysis to date, and related topics and to discuss actions needed to resolve any remaining issues.

1.7 Increased Water Supply Available from Project [373.470]

1.7.1 State Requirements

Section 373.470, F.S., requires that the PIR identify the increase in water supplies resulting from the project components and that the additional water be allocated or reserved under Chapter 373, F.S.

Identification of water for the natural system is based on the concept of water needed to achieve the benefits of the project and the overarching objective of restoration, preservation and protection of the South Florida Ecosystem. The

DRAFT

water made available for the natural system is the water made available that contributes to meeting hydrologic, water quality, and ecologic targets for restoration of natural systems. In the case of the C-43 Storage Reservoir Project the only inflow basin affected by the project is the Caloosahatchee Estuary. The primary functions of the reservoir are two-fold: 1) to capture excess basin runoff and discharges from Lake Okeechobee during periods of high flow, and 2) to provide an additional source of water to maintain desirable salinity in the Caloosahatchee Estuary during low flow periods. Therefore, the analysis associated with identifying water made available by the project will focus on the project's effects on the Caloosahatchee Estuary.

There will be no water made available for other water related needs by the reservoir and all water made available by the project is for the natural system. The operational assumptions of the C-43 reservoir focus on meeting estuary hydrologic restoration targets for the Caloosahatchee Estuary.

Since the estuarine system is not in need of additional fresh water during wet periods, the analysis of water made available for the natural system focused on the additional water delivered from the reservoir to the C-43 Canal and Caloosahatchee Estuary during low flow periods. A hydrologic target for the natural system (flow at S-79) was utilized to identify the quantity of water that is required to meet estuary restoration objectives, in contrast to water which may be harmful or otherwise not contribute to the estuary restoration targets.

Summary of the Analytical Method Used to Identify Water Made Available - To identify water made available by the project, a simplified spreadsheet analysis of the C-43 Reservoir Project was produced based on the capture of excess flow over S-79, which was derived from the SFWMM simulation of the 2000 base conditions. The spreadsheet analysis evaluated the 2000 condition with and without project and incorporated the operational assumptions.

The spreadsheet analysis is centered on a water budget equation for the reservoir. Equations are based on conservation of mass and relate the inflows to the reservoir and the outflows from the reservoir to the change in storage in the reservoir over some fixed time scale. The spreadsheet calculated the daily change in storage and associated water surface elevation, both of which are considered in determining fill and release operations in subsequent time steps. Then the spreadsheet created an updated flow over S-79 that reflects the changes to the original flow resulting from reservoir fill or release activities.

The focus of the spreadsheet analyses is the modification or adjustments of flow over S-79 with the intent of improving the salinity distribution in the downstream estuary. The spreadsheet however, has no salinity or ecological component and relies on a hydrologic surrogate to infer improved performance.

DRAFT

The hydrologic surrogate used is the flow over S-79 and its ability to achieve, or trend towards, an estuary flow target time series (EST05) which has been demonstrated to be a restoration time series that would result in optimal habitat conditions for several indicator species in the Caloosahatchee Estuary.
In this spreadsheet analyses to identify the variability of water made available by the project for the natural system, inflow volume probability curves will be calculated and presented as total annual cumulative inflow into the Caloosahatchee Estuary. The data presented are the daily numbers summed to yield an annual volume.

As a means to display achieving or trending toward the estuarine salinity targets, EST05, as a whole and quantifying other desirable matches to portions of the restoration flow series, two graphics were generated from the spreadsheet calculations for both the 2000 existing condition "without project" or base condition and the "with project" condition.

1. **Volume probability curves** - Plot of flows in acre feet over S-79 that help meet the EST05 restoration time series for the "with" and "without" project conditions

2. **Water made available by the project** – the increase in water released by the project are described as the percentage of time that flow is less than or equal to the target restoration flow series, EST05, by ranking and plotting the flow over S-79 of the "with" and "without project" conditions.

Volume probability curves - For purposes of identifying the water made available by the project for the natural system, volume probability curves representing total annual cumulative inflows were produced depicting the range of the quantities of water delivered to the Caloosahatchee Estuary through S-79 under all climatic conditions simulated by the period of record. This period includes sufficient climatological variability (including natural fluctuations of water) to be representative of long term hydrologic conditions in the region.

The identification of the water made available in the existing condition and water made available with the project will be determined by comparing the inflow volume-probability curves for the "with" and "without" project conditions. To determine the quantity of water for the natural system in the Caloosahatchee estuary, the EST05 salinity envelope was used to determine the portion of water that is needed, to meet the restoration targets of the estuary. In both the with and without project condition, the quantities of water made available for the estuary as a result of the project will be displayed using volume probability curves.

DRAFT

Water Made Available by the project - After the quantities of water needed to help meet restoration targets have been identified and displayed using volume probability curves, the increase in water made available for the project. The increase in water made available will be derived from annual difference between the 2000 "without" project" condition or the base and the 2000 "with project" condition flows to trend towards the estuarine targets. The results will then be sorted, ranked (from greatest to least), and plotted as a difference curve.

1.7.2 System-Wide Effects

The only basin that will be affected by the project is the Caloosahatchee Estuary. Therefore, there are no System-wide effects.

1.7.3 Caloosahatchee River (C-43) West Basin Storage Reservoir Project Effects

A graphical comparison of how the project trends towards meeting the Caloosahatchee Estuary salinity restoration targets for the "with" and "without" project conditions is shown by the volume probability curves (Figure 7) below. This graphic contains three volume probability curves. The period of record salinity target flows (EST 05) were plotted for comparison of both the "with" and "without" project conditions to show project trends towards meeting restoration targets. The graph displays the relative increase in water made available by the project. It should be noted that the y-axis for this graphic indicates acre-feet per day. A summary of the total water made available by the project is provided in Annex C of the PIR/EIS.

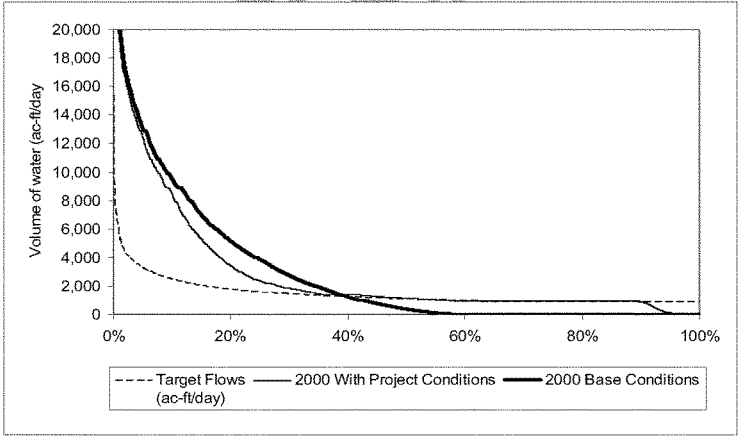


Figure 7: Volume probability curves of water made available for the 2000 Existing Conditions without and with the project

Water Made Available by the Project for the Natural System - The increase in the quantity of the water made available by the project was plotted showing the variability of the water made available for the natural system by the project (Figure 8).

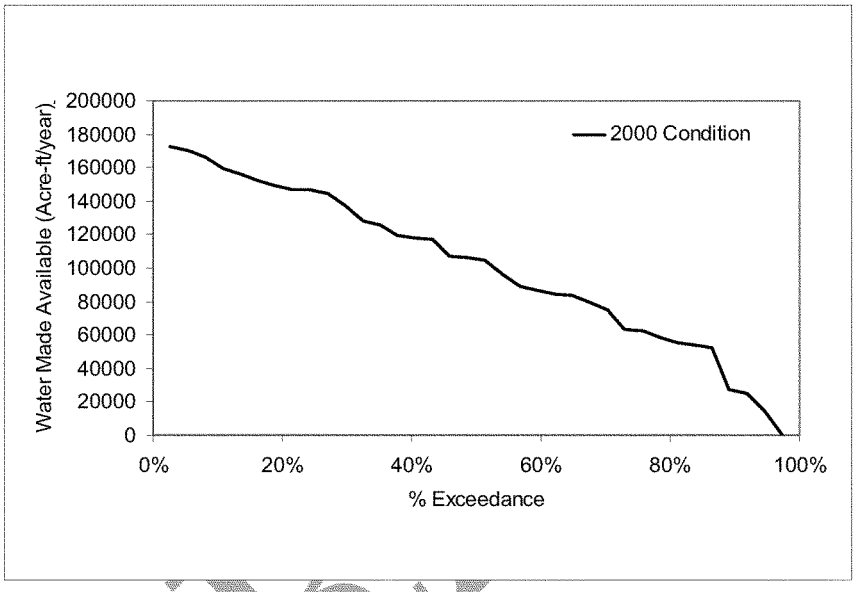


Figure 8: Water made available by the project for the natural system

1.7.4 Water for Other Water-related Needs of the Region

There will be no in water supplied by the project for agricultural and urban needs by the reservoir. All water made available by the project is for the natural system. The operational assumptions of the C-43 reservoir focus on meeting estuary hydrologic restoration targets for the Caloosahatchee Estuary.

ANNEX D
DRAFT PROJECT OPERATING MANUAL AND MONITORING PLAN

This page intentionally left blank

TABLE OF CONTENTS

D.0 DRAFT PROJECT OPERATING MANUAL AND MONITORING PLAN D-1
D.1 PROJECT OPERATING MANUAL D-1
D.1.1 GENERAL PROJECT PURPOSES, GOALS, OBJECTIVES, AND BENEFITS D-1
D.1.2 PROJECT FEATURES D-1
D.1.2.1 Existing Features D-1
D.1.2.2 Proposed Features D-3
D.1.2.3 Removed Features D-7
D.1.3 PROJECT RELATIONSHIPS D-7
D.1.4 MAJOR CONSTRAINTS D-11
D.1.5 STANDING INSTRUCTION TO PROJECT OPERATORS D-11
D.1.6 OPERATIONAL STRATEGY TO MEET PROJECT OBJECTIVES D-11
D.1.6.1 Achieving Natural System Goals, Objectives, and Benefits D-11
D.1.6.2 Flood Damage Reduction D-13
D.1.6.3 Water Quality D-14
D.1.6.4 Water Supply Operations D-15
D.1.6.5 Recreation D-15
D.1.6.6 Fish and Wildlife D-16
D.1.6.7 Navigation D-16
D.1.7 PRE-STORM/STORM OPERATIONS D-16
D.1.8 CONSISTENCY WITH THE IDENTIFICATION OF WATER AND RESERVATIONS OR ALLOCATIONS OF WATER FOR THE NATURAL SYSTEM D-17
D.1.9 CONSISTENCY WITH SAVINGS CLAUSE AND STATE ASSURANCES PROVISIONS D-17
D.1.10 DROUGHT CONTINGENCY PLAN (DCP) D-17
D.1.11 FLOOD EMERGENCY ACTION PLAN D-17
D.1.12 DEVIATION FROM NORMAL REGULATION D-18
D.1.12.1 Emergencies D-18
D.1.12.2 Unplanned Minor Deviations D-18
D.1.12.3 Planned Deviations D-19
D.1.13 RATE OF RELEASE CHANGE D-19
D.1.14 SEEPAGE CONTROL D-19
D.1.15 INITIAL RESERVOIR/STORAGE/TREATMENT AREA FILLING PLAN D-20
D.1.16 NON-TYPICAL OPERATIONS FOR RESERVOIR/STORAGE/ TREATMENT AREA PERFORMANCE D-20
D.1.17 AQUIFER STORAGE AND RECOVERY SYSTEM PLAN D-21
D.1.18 WATER CONTROL DATA ACQUISITION SYSTEM PLAN (WCDASP) . D-21
D.1.19 CONSISTENCY WITH THE ADAPTIVE MANAGEMENT PROGRAM AND PERIODIC CERP UPDATES D-21
D.1.20 INTERIM OPERATIONS DURING CONSTRUCTION D-21
D.1.20.1 Preliminary Operations During Operational Testing and Monitoring Phase (OTMP) D-22

D.1.20.2 Conceptual Description for Transition from the Initial Operating Regime to the Next-Added Increment D-22
D.2 HYDROLOGIC AND METEOROLOGICAL MONITORING AT THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR D-22
D.2.1 Introduction D-22
D.2.2 Stage Monitoring D-23
D.2.3 Flow Monitoring D-23
D.2.4 Groundwater Monitoring D-24
D.2.5 Weather D-24
D.2.6 Structure Monitoring D-24
D.3 ECOLOGICAL MONITORING PLAN D-25
D.3.1 Salinity Monitoring Plan D-26
D.3.1.1 Background D-26
D.3.1.2 Monitoring Objectives D-28
D.3.1.3 Null Hypothesis D-29
D.3.1.4 Monitoring Measures and Targets D-29
D.3.1.5 Monitoring Approach D-30
D.3.1.6 Data Quality D-33
D.3.2 Project Monitoring and Assessment Plan: Water Quality D-33
D.3.2.1 Background D-33
D.3.2.2 Monitoring Objectives D-43
D.3.2.3 Null Hypothesis D-44
D.3.2.4 Monitoring Measures and Targets D-44
D.3.2.5 Monitoring Approach D-46
D.3.2.6 Data Quality D-48
D.3.3 Project Monitoring and Assessment Plan: Oysters D-48
D.3.3.1 Background D-48
D.3.3.2 Monitoring Objectives D-49
D.3.3.3 Null Hypothesis D-49
D.3.3.4 Monitoring Measures and Targets D-50
D.3.3.5 Monitoring Approach D-50
D.3.3.6 Data Quality D-52
D.3.3.7 References D-53
D.3.4 Project Monitoring and Assessment Plan: Submerged Aquatic Vegetation D-53
D.3.4.1 Background D-53
D.3.4.2 Monitoring Objectives D-61
D.3.4.3 Null Hypothesis D-62
D.3.4.4 Monitoring Measures and Targets D-62
D.3.4.5 Monitoring Approach D-64
D.3.4.6 Data Quality D-69
D.3.5 Project Monitoring and Assessment Plan: Fish D-69
D.3.5.1 Background D-69
D.3.5.2 Monitoring Objectives D-71
D.3.5.3 Null Hypothesis D-71
D.3.5.4 Monitoring Measures and Targets D-72

D.3.5.5 Monitoring Approach D-72
D.3.5.6 Data Quality D-75
D.4 WATER QUALITY MONITORING PLAN D-76

LIST OF TABLES

Table D-1: Target Flow Range D-30
Table D-2: Monitoring sites, parameters sampled, monitoring objectives (from Monitoring Objectives section), and the funding source sponsoring the site installation and maintenance. Corps of Engineers (COE), South Florida Water Management District (SFWMD), and Sanibel-Captiva Conservation Foundation (SCCF) D-31
Table D-3: Target frequency distribution of mean monthly flows from S-79 (CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR - Caloosahatchee Estuary Hydrologic Evaluation Performance Measures, 2005). D-37
Table D-4: Suggested limits for the range of chl-a concentration values in a bloom, the number of months a specific range can occur, and the corresponding annual frequency. Non-bloom months are assumed to be < 8 μg/L. D-38
Table D-5: Monitoring sites, parameters sampled, monitoring objectives (from Monitoring Objectives section), and the funding source sponsoring the site installation and maintenance. Corps of Engineers (COE), South Florida Water Management District (SFWMD), Sanibel-Captiva Conservation Foundation (SCCF) and C-43 West Basin Storage Reservoir Project (Project) D-47
Table D-6: Target frequency distribution of mean monthly flows from S-79 (CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR - Caloosahatchee Estuary Hydrologic Evaluation Performance Measures, 2005). D-57
Table D-7: SAV monitoring methods, parameters sampled, monitoring objectives (from Monitoring Objectives section), and the funding source sponsoring the monitoring. Corps of Engineers (COE), South Florida Water Management District (SFWMD), Sanibel-Captiva Conservation Foundation (SCCF) and caloosahatchee River (C-43) West Basin Storage Reservoir Project (Project). D-68

LIST OF FIGURES

Figure D-1: WSE Operational Guidelines D-8
Figure D-2: WSE Operational Guidelines for discharge to the caloosahatchee estuary D-9
Figure D-3: WSE Regulation Schedule D-10
Figure D-4: Map of the Caloosahatchee Estuary, the existing salinity sensors (1 – 7), sensor stations proposed by Sanibel-Captiva Conservation Foundation, and additional sensors supported by the CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR Project. D-28
Figure D-5: Map of Caloosahatchee Estuary area and location of proposed water quality monitoring sensors; staged on existing salinity sensors platforms and at proposed new sites D-35
Figure D-6: Monthly load of total nitrogen from S-79 compared to monthly average flow from the structure D-36
Figure D-7: Chl-a in San Carlos Bay compared with 30-day average flow from S-79 (Franklin Lock and Dam) D-40
Figure D-8: Time series of chlorophyll *a* and dissolved oxygen in bottom water in the upper Caloosahatchee Estuary near Beautiful Island. D-41
Figure D-9: Oyster Sample Locations (IC: Iona Cove, CD: Cattle Dock, BI; Bird Island, KK: Kitchel Key, TB: Tarpon Bay, FL: Future Location) D-52
Figure D-10: Map of Caloosahatchee Estuary area and location of dominant SAV during ideal conditions. Depicted are the proposed SAV sampling sites, using: (1) the traditional manual method deploying divers to measure plants along fixed transects; and (2) hydroacoustic methodology. D-55
Figure D-11: Tape grass (*Vallisneria americana*) shoot density in the upper Caloosahatchee Estuary. Recent data are from the stations monitored by the Sanibel-Captiva Conservation Foundation (Stations 1 and 2 in Figure 7, using manual methods) D-56
Figure D-12: Seagrass coverage at two locations downstream of the Caloosahatchee River (a. Site 7; and b. Site 8-in Figure 7) compared to 60-day average freshwater inflow from S-79 prior to sampling. D-59
Figure D-13: Average seagrass coverage associated with depth during a wide range of freshwater inflow conditions using hydroacoustic sampling methodology at the northern San Carlos Bay station adjacent to Merwin Key (Site 7, Figure 7). D-60
Figure D-14: Percent seagrass coverage at 1.5 meter in San Carlos Bay (Site 7. Figure 7) during a wide range of 30-day average inflow conditions from S-79. ..... D-60
Figure D-15: Example of hydroacoustic mapping coverage at Reach 2B in Iona Cove (Site 5) and Reach 3B in northern San Carlos Bay (Site 7) showing the 10 transects sampled during March and December 1996 and the resulting plant coverage and depth contours. D-67
Figure D-16: Map of Charlotte Harbor sampling area. Zones are labeled A-E, G-H, M and P D-74

D.0 DRAFT PROJECT OPERATING MANUAL AND MONITORING PLAN

D.1 PROJECT OPERATING MANUAL

The main purpose of a draft project operating manual is to describe day-to-day water management operations for essentially all foreseeable conditions affecting the Caloosahatchee River (C-43) West Basin Storage Reservoir project as developed for the Project Implementation Report/Environmental Impact Statement (PIR/EIS) Phase. Modifications to this project operating manual may occur during the remaining project phases (Construction, Operational Testing and Monitoring, and Long-Term Operations and Maintenance). Operating manual preparation is pursuant to Engineering Regulation 1110-2-240 and is in accordance with guidance contained in Engineering Manual 1110-2-3600, Engineering Regulation 1110-2-8156, and CERP Programmatic Guidance Memorandum #5, "Operating Manuals."

The Fill Phase for the reservoir will follow the Initial Reservoir Fill Plan, which will be developed during design and construction.

All elevations referenced in this draft POM are based on the North American Vertical Datum of 1988 (NAVD 1988) unless otherwise noted.

D.1.1 GENERAL PROJECT PURPOSES, GOALS, OBJECTIVES, AND BENEFITS

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to address the declining health of the Caloosahatchee River and estuarine ecosystem by improving water delivery to the estuary. The project will increase the availability of water for the estuarine system during the dry season while reducing excessive high flows during the wet season. This will result in providing a downstream salinity range suitable for a healthy ecosystem that promotes estuarine habitat, increased fish and wildlife populations, and biological diversity.

D.1.2 PROJECT FEATURES

D.1.2.1 Existing Features

(See ***Figure A-1*** of the Engineering Appendix for a map of proposed project features)

1. Structure 77 (S-77). This structure is a reinforced concrete, gated spillway with discharge controlled by four cable-operated vertical lift gates. Operation of the gates is manually controlled. The structure is located on Lake Okeechobee and is the outlet to the Caloosahatchee River (C-43 Canal). The purpose of S-77 is to provide control of regulatory discharge from Lake Okeechobee to the

Caloosahatchee River. In addition, S-77 restricts discharge during floods to levels which will not cause damaging velocities downstream, and passes sufficient discharge during low-flow periods to maintain stages and to satisfy irrigation demands downstream.

Approximately 530 ft west of S-77 is the Moore Haven Lock. The lock serves to facilitate navigation. In addition, the upper gates of the lock also serve as hurricane gates; the structure is designated as Hurricane Gate No. 1 of the Lake Okeechobee levee system.

2. Structure 78 (S-78). This structure is a reinforced concrete, gated spillway with discharge controlled by two cable-operated vertical lift gates and two tainter gates. The structure is located in Glades County, near Ortona, Florida. S-78 is in the existing by-pass channel adjacent to the Ortona Lock. The Ortona Lock is also part of the Lake Okeechobee Waterway. The purpose of S-78 is to maintain optimum upstream water stages in the Caloosahatchee River (C-43 Canal). S-78 also controls discharges during 30 percent standard project flood events without exceeding desirable stages, and passes lake regulatory releases without exceeding desirable stages or velocities.

3. Structure 79 (S-79). This structure is a reinforced concrete, gated spillway with discharge controlled by eight chain-operated vertical lift gates and a reinforced concrete lock with two sets of sector gates. The lock, W.P. Franklin Lock, is located south and adjacent to S-79. The lock is also part of the Lake Okeechobee Waterway. Operation of one of the spillway gates is automatically controlled to ensure the gate is operated in accordance with operational criteria. S-79 is located on the Caloosahatchee River (C-43 Canal) about 30 miles west of S-78 and about 7 miles upstream of the Caloosahatchee Estuary. The purpose of S-79 is to maintain optimum upstream water stages between 2.8 and 3.2 National Geodetic Vertical Datum of 1929 (NGVD) in the Caloosahatchee River (C-43 Canal).

4. Townsend Canal. The canal will serve as an intake and discharge canal to the reservoir. The Townsend canal borders the western side of reservoir cell 1. Currently, the canal has a flap gate weir structure to provide flood conveyance for the citrus operations south of the reservoir. In 2003, SR 80 bridges were replaced which allowed for increased flow in the Townsend Canal. Two additional flap gates will be installed on the flap gate weir structure to provide capacity for pumping rates of 1500 cfs at C43PS-1. In addition, the canal provides irrigation water during the dry season for citrus production on the following properties: Berry Groves, Griffin, and the MG Paul & Duda Property (all in ownership of SFWMD—South Florida Water Management District). Upon completion of construction, proposed pump station, C43-4 will provide water supply to adjacent landowners.

D.1.2.2 Proposed Features

(See ***Figure A-1*** of the Engineering Appendix for a map of proposed project features)

1. Caloosahatchee River (C-43) West Basin Storage Reservoir. This will be a two-celled reservoir designed to contain approximately 170,000 acre-feet of storage. Cell 1 will be located in the western portion of the reservoir; Cell 2 is the eastern portion. The purpose of the reservoir is to improve water deliveries to the estuary, provide for dry season flow, reduce magnitude of wet season high volume flows, restore downstream salinity levels and ensure the availability of water for the natural system needs of the Caloosahatchee Estuary.

2. Pump Station 1(C43PS-1). This will be a 1500 cfs (cubic feet per second) capacity pump station that will provide inflow to Cell 1of the reservoir. C43PS-1 will consist of two 250 cfs pumps and two 500 cfs pumps. C43PS-1 will pump water from the Townsend Canal (intake canal) to the reservoir. All pumps are diesel powered. C43PS-1 will be located in the northwest corner of the reservoir.

3. Perimeter Canal. This canal is adjacent to the reservoir on the south, east, and north sides. The Townsend Canal serves as the "Perimeter Canal" on the west side. The Perimeter Canal will provide the following:
   - Route drainage around both the reservoir and the Roberts Canal
   - Provide water to the Paul property, Banana Branch, and the Fort Simmons Branch
   - Minimize water table impacts to land surrounding the reservoir
   - Collect any seepage from the reservoir

4. Pump Station 4 (C43PS-4). This will be a 195 cfs capacity pump station that will maintain the stage in the Perimeter Canal for seepage control and to maintain pre-project water supply to the neighboring landowners. The purpose of the C43S-4 is for water supply to the neighboring landowners and to maintain the stage in the Perimeter Canal for seepage control. The C43PS-4 site will be adjacent to the southwest corner of the reservoir at the southern limit of SFWMD property. The C43PS-4 discharge will be conveyed to the Perimeter Canal through a conveyance canal paralleling the toe slope of the reservoir embankment.

   The following are assumed for the design of C43PS-4:

   - Normal Dry Season Stage; 0.0 ft
   - Design Low Water Stage: -3.0 ft

- Design High Water Stage: +3.0 ft
- Design Upper Pool Stage: +23.5 ft

5. Perimeter Canal. This canal is adjacent to the reservoir on the south, east, and north sides. The Townsend Canal serves as the "Perimeter Canal" on the west side. The Perimeter Canal will provide the following:
   - Route drainage around both the reservoir and the Roberts Canal. The Roberts Canal/Banana Branch Canal traverses through the Berry Grove and discharges downstream into the Caloosahatchee River. The reservoir bisects the Roberts/Banana Branch Canal; therefore, flow from the Roberts Canal will be re-routed through the perimeter Canal and discharged to the Banana Branch Canal through C43S-7.
   - Provide water to the Bob Paul property to the east, Banana Branch, and the Fort Simmons Branch
   - Minimize water table impacts to land surrounding the reservoir
   - Collect any seepage from the reservoir

6. Discharge Structure 1 (C43S-1). This structure is the main outflow structure for Cell 1. This structure will be located in the northwest corner of the reservoir in Cell 1. C43S-1 will discharge into the northern segment of the Perimeter Canal

7. Discharge Structure 8 (C43S-8). This structure is the main outflow structure for Cell 2. This structure is located in the northwest corner of the reservoir in Cell 2. C43S-8 will discharge into the north Perimeter Canal

8. Uncontrolled Crest Spillway 1 (C43CS-1). This structure is located on the west side of Cell 1 and discharges into the Townsend Canal The purpose of C43CS-1 is to discharge Cell 1 water when Cell 1 water level exceeds 42.0 ft.

9. Uncontrolled Crest Spillway 2 (C43CS-2). This structure is located in the northwest corner of Cell 2, just east of C43S-8. Like C43CS-1, the purpose of C43CS-2 is to discharge Cell 2 water when Cell 2 water level exceeds 42.0 ft.

10. Culvert 12 (C43S-12). This structure is located in the interior berm between Cells 1 and 2 of the reservoir. C43S-12 will convey half the C43PS-1 pump capacity of 1500 cfs. C43S-12 will consist of three 6ft x 10 ft barrels. If one barrel of the structure is out of service the other barrels will convey 750 cfs between the cells .The primary function of the structure is to convey water between the cells and allow the cells to operate independently if necessary. If one of the cells needs to be dewatered for maintenance, C43S-12 may be closed to isolate the cells

11. Culvert 3 (C43S-3). This structure is located in the southeast portion of the Perimeter Canal. C43S-3 will consist of a double-barrel 10 ft x 10 ft box

culvert. One barrel will have an independent intake structure consisting of a 10 ft x 10 ft sluice gate and the other barrel will have a 10 ft x 10 ft weir gate with allowance for a 5 ft high weir opening. The purpose of the weir gate is to maintain a constant water surface elevation of 23.5 ft upstream of C43S-3 and pass the base flow of 28 cfs. The weir gate is capable of passing the peak design flow of 195 cfs which is the flow pumped via C43S-4, plus base flow (seepage) of 28 cfs should the sluice gate be removed for maintenance. This is also true should the weir gate be removed from service. Redundancy was incorporated into the C43S-3 design to allow the peak design flow to pass even if one of the gates is removed from service for maintenance.

12. Spillway 10 (C43S-10). This structure is located on the northern segment of the Perimeter Canal. C43S-10 will be a concrete spillway with one 14 ft x 10ft vertical roller gate and two 10ft x 10ft weir gates to control flow within the Perimeter Canal. Note the design flow received by the Perimeter Canal from the Roberts Canal will be conveyed and discharged into the Banana Branch Canal reaching to C43S-10.

    The Perimeter Canal between C43S-3 and C43S-10 has a varying channel bottom elevation. Tailwater elevation during normal water levels (NWL) at C43S-3 and C43S-10 is 19 ft. During HWL the tailwater at both of these structures is 15.5 ft.

    The vertical roller gate alone, or in combination with the weir gates, is capable of handling the flows required to achieve drawdown. The vertical gate can fully manage the required drawdown discharge with a gate opening of 3.1 ft during NWL conditions. In the event of high water conditions, the gate opening would be approximately 3.6 ft, since the gate is operating under submerged controlled flow conditions.

13. Spillway 11 (C43S-11). This structure is the largest of the Perimeter Canal structures. C43S-11 consists of a reinforced concrete spillway with two 14 ft W x 8 ft H vertical roller gates and two 10 ft x 8 ft weir gates to control flow through the Perimeter Canal, ultimately to the Townsend Canal. Unlike C43S-3, and C43S-10, and C43S-11, has limited redundancy. Should a vertical roller gate be removed from service, the weir gates provide a discharge capacity that is less than normal daily operations.

    The two proposed weir gates, in addition to the vertical roller gates, will be capable of discharging up to the normal daily discharge flow of 500 cfs should a vertical roller gate be removed for service. The weir gates will be set to maintain a water elevation of 15 ft upstream of C43S-11.

14. Culvert 7 (C43S-7). This structure is double barreled with a weir set for normal operations and a gate for larger releases during storm events. This culvert will be constructed to prevent flooding and to maintain historic flows in the Fort Simmons Branch Canal (located north of reservoir) that are necessary to maintain existing environmental conditions.

    C43S-7 is located at the intersection of the upstream end of Banana Branch Canal and the Perimeter Canal. It consists of a double 10 ft x 10 ft box culvert with one sluice gate and one weir gate. The headwater elevation for NWL is 19.25 ft and 20 ft for HWL. Tailwater elevation for NWL is 15.1 ft and 18.5 ft for HWL. With an invert elevation of 12 ft, the HWL conditions are contained within the box culvert height.

15. Culvert 9 (C43S-9). This structure is a double-barreled 6ft W x 6ft H box culvert that conveys flow from the Perimeter Canal to the Fort Simmons Branch Canal which discharges into the Caloosahatchee River. Inlet control used for C43S-9 is a sluice gate and a weir gate. The weir gate is used to allow base flow to pass. The sluice gate is used to pass design flows greater than the base flow. C43S-9 has no redundancy; therefore, maintenance of the sluice gate would require special consideration and must be done during low flow periods. Therefore, both gates must be operational to convey flows greater than base flow.

16. Culvert 14 (C43S-14): This structure is a 10ft W x 6ft H single barrel box culvert with a sluice gate which conveys water from the LPDD Header Canal to the Perimeter Canal to serve the Bryan Paul Property.

    The tailwater elevation for this structure is the tailwater elevation for C43S-10 which is 19 ft for NWL and 20 ft for HWL. HWL flow from the header canal will be contained within the box culvert. The flow regime for discharge from C43S-14 is between ***Submerged Controlled Flow*** and ***Free Controlled Flow*** as tailwater, which is roughly 0.5 ft above the gate sill, and has a limited effect upstream of C43S-14.

17. Culvert 15 (C43S-15): The Roberts Canal/Banana Branch Canal traverses through the Berry Grove and discharges into the Caloosahatchee River. The reservoir bisects the Roberts/Banana Branch Canal; therefore, flow from the Roberts Canal will be re-routed through the Perimeter Canal and discharged to the Banana Canal through C43S-7. The Roberts Canal discharges into the Perimeter Canal downstream of C43S-3. Flow from the Roberts Canal is conveyed through C43S-15 which consists of a double 10 ft x 8 ft box culvert with an independently operated sluice gate and weir gate.

D.1.2.3 Removed Features

There are many small structures within the reservoir footprint that will be removed or demolished. Most of these are small pump stations. Several larger pump stations along the Labelle Private Drainage District (LPDD) Header Canal will also be removed. This includes the 340 cfs Berry Groves No. 1 and No. 2 pump stations that lift water from the Townsend Canal to the Header Canal (the Header Canal bisects, from east to west, the reservoir). However, the Berry Groves No. 1 and No. 2 pump stations in the Header Canal cannot be removed until C43S-4 and the Perimeter Canal are constructed and operational. This is to ensure that a continuous supply of irrigation water can be provided to the Bob Paul Properties.

D.1.3 PROJECT RELATIONSHIPS

Project operations will be dependent upon the stage in the Caloosahatchee River upstream of S-79, Lake Okeechobee, the conditions at S-77, S-78, S-79, and the estuary. All of these locations are affected primarily by seasonal and short-term hydrologic and climatic conditions.

S-77, S-78, and S-79 are operated by the U. S. Army Corps of Engineers (USACE) based on the current Water Control Plan for Lake Okeechobee and Everglades Agricultural Area (USACE, July 2000). The water control plan contains the Lake Okeechobee regulation schedule referred to as WSE (Water Supply and Environmental), and was developed to provide increased operational flexibility, and to optimize environmental benefits with minimal or no impact to competing Lake Okeechobee uses. WSE incorporates tributary hydrologic conditions and climate forecasts into operational guidelines. The WSE regulation schedule is used in conjunction with the Operational Guidelines Decision Tree. Refer to ***Figure D-1*** and ***Figure D-2*** for details.

The WSE schedule has multiple operational Zones (A through E) which correspond to Lake Okeechobee stages throughout the calendar year. (Refer to ***Figure D-3*** for details.) The WSE schedule uses a decision tree that indicates whether or not regulatory releases are required. Discharges at higher lake stages (Zones D and above) are determined based on meteorological forecasts, the effects of climate outlooks on the ecosystems, and review of regional hydrologic conditions. Technical information is provided by an interdisciplinary group of scientists, engineers, and resource managers, while release decisions are made by USACE in accordance with WSE guidelines (USACE 1999). However, the current schedule has required the USACE to deviate on occasion from the WSE. Therefore, in an effort to improve the regulation schedule, an effort to improve the regulation schedule (the Lake Okeechobee Regulation Schedule Study (LORSS)) is currently well underway. A draft Water Control Plan and Environmental Impact Statement was released for public and agency

review in October 2006. A revised draft was released to the public and agency review in July 2007.

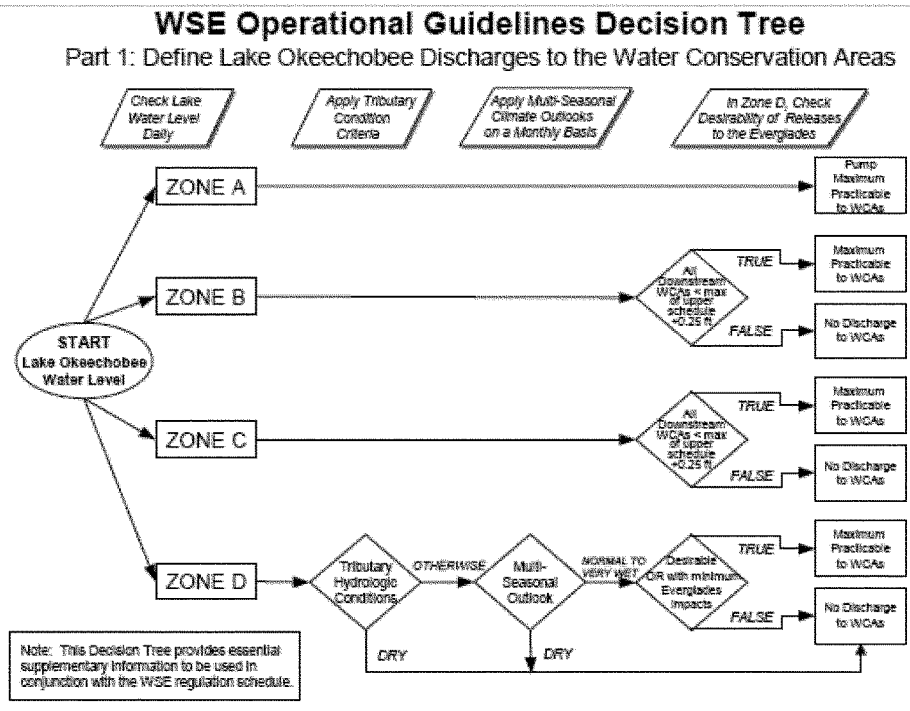


FIGURE D-1: WSE OPERATIONAL GUIDELINES

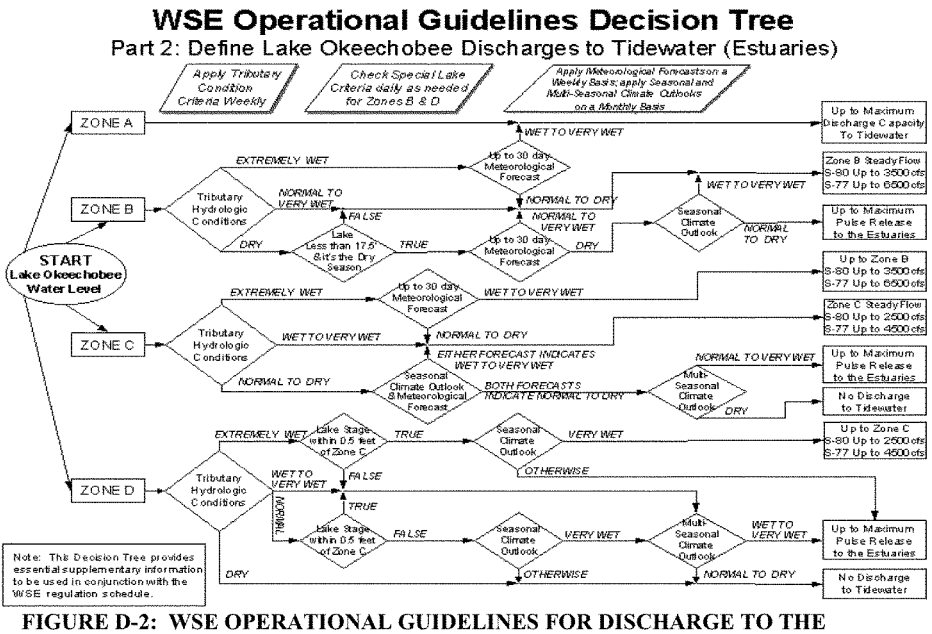
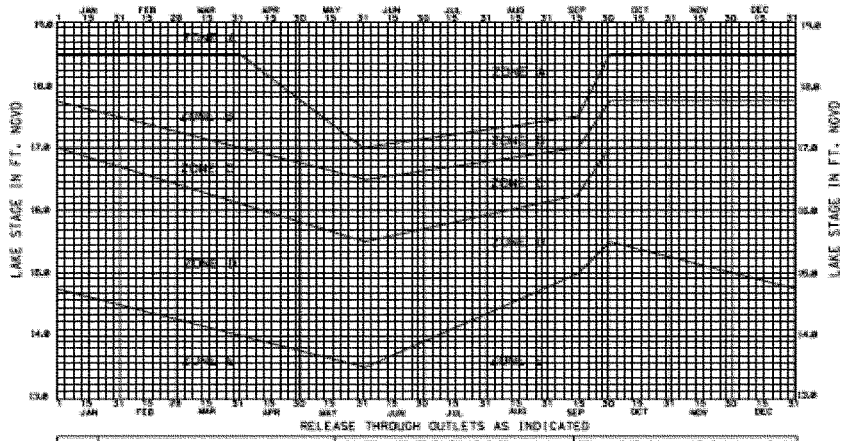


FIGURE D-2: WSE OPERATIONAL GUIDELINES FOR DISCHARGE TO THE CALOOSAHATCHEE ESTUARY

Within the WSE is an Operational Guidelines Decision Tree for discharge to the Caloosahatchee Estuary ***(Figure D-2)***. The range of water released to the Caloosahatchee estuary in the decision tree is from "up to maximum discharge" in the case where the lake is in Zone A of the regulation schedule, and "no discharge to tidewater" when the lake is in Zone D and the tributary conditions are dry. The operational flexibility of the WSE schedule allows for adjustments to be made in the timing and magnitude of Lake Okeechobee regulatory discharges based on conditions in the lake and in the tributary basins, and on extended meteorological and climate outlooks. For example, if the outlook suggests that drought conditions are likely, water might be held in the lake; if the outlook suggests higher than average rainfall, water might be released. The decision criteria in ***Figure D-1*** and ***Figure D-2*** are the starting points from which operational decisions are made. (USACE, 2000).

SFWMD has further defined a process, termed Adaptive Protocols for Lake Okeechobee Operations, for implementing opportunities for operational flexibility that exist in the WSE schedule that address non-regulatory releases of water for fish and wildlife protection and salt water management. The key feature of decisions made under the Adaptive Protocols is balancing water

supply, flood protection, and environmental protection, within the constraints of the approved WSE schedule and Water Control Plan for Lake Okeechobee. The overall purpose of the Adaptive Protocols is to provide information to system operators for greater protection of Lake Okeechobee and downstream ecosystems including the Caloosahatchee Estuary, while continuing to provide a reliable supply of water for agricultural and urban areas that depend on the lake. Adaptive Protocols are proposed to be implemented where the WSE schedule indicates that water must be released from the lake, but does not indicate the exact amount. Adaptive Protocols are also proposed when the Lake Okeechobee Water Control Plan authorizes releases of water from Lake Okeechobee for water supply, fish and wildlife protection, and salt water management (USACE, 2000).



ZONE	AGRICULTURAL CANALS TO WCAs (1,2)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	NORMAL TO WET: UP TO 6500 CFS DRY: UP TO MAXIMUM PULSE RELEASE	NORMAL TO WET: UP TO 3500 CFS DRY: UP TO MAXIMUM PULSE RELEASE
C (3)	MAXIMUM PRACTICABLE RELEASES	WET: UP TO 4500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE	WET: UP TO 2500 CFS NORMAL: UP TO MAXIMUM PULSE RELEASE DRY: NONE
D (3,5)	AS NEEDED TO MINIMIZE ADVERSE IMPACTS TO THE LITTORAL ZONE WHILE NOT ADVERSELY IMPACTING THE EVERGLADES. (SEE NOTE 5.)	VERY WET: UP TO MAXIMUM PULSE RELEASE OTHERWISE: NONE	VERY WET: UP TO MAXIMUM PULSE RELEASE OTHERWISE: NONE
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON 13 SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 23 PROJECTED INFLOW CONDITIONS. RELEASES ARE SUBJECT TO THE GUIDELINES IN THE WSE OPERATIONAL DECISION TREE, PARTS 1 AND 2.
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS.
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES
(5) ONLY WHEN THE WCAs ARE BELOW THEIR RESPECTIVE SCHEDULES

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 9 NOVEMBER 1999

WSE (WITH CLIMATE OUTLOOK)

FIGURE D-3: WSE REGULATION SCHEDULE

D.1.4 MAJOR CONSTRAINTS

1. S-77, S-78, and S-79 Operations. Releases are made in accordance with the Lake Okeechobee operation schedule. In addition, releases are made as required to maintain the optimum tailwater elevation of 11.1 ft. S-78 maintains the upstream stages in the Caloosahatchee River (C-43 Canal). The optimum stage for S-78 is between 10.6 ft and 11.5 ft. If the optimum stages at these structures are exceeded, releases from the reservoir may be reduced until stages are within the optimum range.

2. Caloosahatchee Estuary minimum flows and levels (MFL). The minimum flow is defined as the "limit at which further withdrawal would be significantly harmful to the water resources or ecology of the area. . ." MFL criteria for the Caloosahatchee River are based on maintaining freshwater base flows to the upper reaches of the Caloosahatchee Estuary. This will prevent excessive salinity levels in the estuary from causing significant harm to submerged aquatic vegetation and fish and invertebrate communities. Compliance with the MFL may limit, at times, the amount of water that can be pumped into the reservoir.

D.1.5 STANDING INSTRUCTION TO PROJECT OPERATORS

Once the operational testing and monitoring phase of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is complete, SFWMD will be responsible for the day-to-day water management operations of the newly constructed project features. During normal conditions, the project structures shall be operated in accordance with the approved operating manual (draft and project). Elevations in the plan shall be followed. Deviation from the normal operations will be permitted as stated in Section D.1.12.1. More complete details will be provided in future revisions to the Draft Project Operating Manual in a separate exhibit as stated in CERP Programmatic Guidance Memorandum 5 ("Operating Manuals").

D.1.6 OPERATIONAL STRATEGY TO MEET PROJECT OBJECTIVES

D.1.6.1 Achieving Natural System Goals, Objectives, and Benefits

The Caloosahatchee River is the primary source of water to the Caloosahatchee Estuary. The conceptual intent of the project is for the reservoir to be operated to store excess runoff and discharges from Lake Okeechobee and to deliver water to the Caloosahatchee River (C-43 Canal) based on maintaining desirable salinity levels in the Caloosahatchee Estuary System as measured by flows at S-79.

Early Dry Season (November through January):

- When the flow measured at S-79 is less than 450 cfs and the reservoir water elevation is between 29.0 and 42.0, C43S-8 will be partially opened to allow releases from the reservoir. C43PS-1 will be off.
- When the flow measured at S-79 is less than 450 cfs, and the reservoir water elevation is between 19.2 and 29.0, C43S-8will be opened to allow releases. C43PS-1 will be off.
- When the flow measured at S-79 is greater than 450.0 cfs, and the reservoir water elevation is between 29.0 and 42.0, C43S-1 will be closed, C43PS-1 will begin pumping to the reservoir.

Late Dry Season (February through May):

- When the flow measured at S-79 is less than 450 cfs and the reservoir water elevation is between 29.0 and 42.0. C43S-1 will be opened to allow releases from the reservoir. C43PS-1 will be off.
- When the flow measured at S-79 is greater than 450.0 cfs, and the reservoir water elevation is between 19.2 and 29.0, C43S-1 will be closed, C43PS-1 will begin pumping to the reservoir.

Early Wet Season (June through July):

- When the flow measured at S-79 is less than 450 cfs and the reservoir water elevation is between 29.0 and 42.0, C43S-1 will be opened to allow releases from the reservoir. C43PS-1 will be off.
- When the flow measured at S-79 is greater than 450.0 cfs, and the reservoir water elevation is between 19.2 and 29.0, C43S-1 will be closed, C43PS-1 will begin pumping to the reservoir.

Late Wet Season (August through October):

- When the flow measured at S-79 is less than 450 cfs and the reservoir water elevation is between 29.0 and 42.0, C43S-1 will be opened to allow releases from the reservoir. C43PS-1 will be off.
- When the flow measured at S-79 is greater than 450.0 cfs, and the reservoir water elevation is between 19.2 and 29.0, C43S-1 will be closed, C43PS-1 will begin pumping to the reservoir.

Water management operations outlined above are associated with the traditional/normal understanding of dry and wet season patterns. However, there will be dry and wet periods outside of the traditional seasons in which the water resource will be managed as stated above.

Please note that more detailed operations will be developed for this POM upon following further analyses.

D.1.6.2 Flood Damage Reduction

D.1.6.2.1 Normal and Emergency Operations

Flow in the Perimeter Canal and releases to the Townsend Canal, Fort Simmons Canal, and the Banana Branch Canal are managed using multiple gate and weir structures. These structures are described in Section D.3.2.

The main goal of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is not flood protection. As an incidental benefit, project operations may possibly include reduced flows and stages in the SR 29 Canal during large storm events.

D.1.6.2.2 Hurricane or Tropical Storm Operations

The hurricane season is from 1 June through 30 November. When there are tropical depressions, tropical storms, and/or hurricanes in the Atlantic/Caribbean Basin or Gulf Coast of Florida, the National Hurricane Center (NHC) issues tropical cyclone public advisories, forecast advisories, forecast discussions, and strike probability forecasts. Water Management operations within the Caloosahatchee River (C-43) West Basin Storage Reservoir project area for hurricanes or tropical storms should follow Water Management SFWMD Emergency Preparedness Manual – Suggested Hurricane Operating Procedures, April 2004. The USACE Jacksonville District Emergency Operations Standard Operating Procedures document (CESAJ SOP 500-1-1) should also be consulted for emergency preparedness and actions.

D.1.6.2.3 Storage Area Weir Discharge

The Perimeter Canal structures are C43S-3, C43S-10, and C43S-11. These structures are designed to pass flows along the Perimeter Canal. C43S-3 is a culvert structure and contains both a weir gate and a slide gate. C43S-10 and C43S-11 are gated spillway structures. Both structures have weir gates and roller gate(s). The weir gates for all three structures can be adjusted at each of the structures to provide proper headwater elevations in the Perimeter Canal. The weir gates can be adjusted to at least 5 ft. Although the weir elevations have been established by modeling analyses and will be set at these elevations initially, it is anticipated that adjustments will be required to meet the "field" conditions that will likely change over time, i.e., the adjacent property may be developed as opposed to farmed. For normal day-to-day operations, the weirs will remain at a constant elevation and will pass rainfall events up to the 25-year storms without opening the slide or roller gates. The slide or roller gates will be adjusted by telemetry to allow for discharges that vary based on demands at S-79 and flows during storm events.

D.1.6.2.4 Uncontrolled Discharge

Each cell of the reservoir has an ungated service spillway with a crest elevation 42 ft. C43CS1 is located on the west side of Cell 1 and discharges to the Townsend Canal. C43CS-2 is located just east of C43S-8 in the northwest corner of Cell 2 and discharges to the Perimeter Canal. Both of these spillways consist of a single 50 ft. long weir structure. Any inflows to the reservoir that raise the water level above 42 ft. will discharge from the structure without the use of outlet gates.

D.1.6.3 Water Quality

To minimize the potential for inadvertently causing a water quality problem within the reservoir or downstream, it is important that the operations plan include mechanisms to prevent or minimize potential water quality problems within the reservoir such as thermal stratification, low dissolved oxygen, and algae blooms. Fortunately, some measures to enhance water quality in the reservoir and in the discharge water can be incorporated into future operations with little cost to the project given the reservoir's design. Below is an example list of water quality problems and measures that might be considered to reduce their impact to water quality both within the reservoir and downstream.

1. Measures to Control Thermal Stratification:
   a. Periodic pulse inflows to Cell 1 to disrupt thermal setup in this cell.
   b. Periodic pulse discharges from lower discharge ports to induce mixing of upper and lower water column water. (Combine with upper discharge port discharges to meet DO standards.)
   c. Operation of Cell 1 and Cell 2 semi-independently to transfer water between cells and disrupt thermal setup.
2. Measures to Increase Dissolved Oxygen in Discharge Water:
   a. Discharge from upper port to allow greatest turbulence and re-aeration potential.
   b. Discharge from upper and lower ports to blend high DO water with low DO water.
   c. Install re-aeration mixers to increase DO in reservoir prior to discharge.
3. Measures to Reduce the Impact of Reservoir Algal Production:
   a. Induce mixing of upper photic zone water with lower water to reduce phytoplankton production.
   b. Reduce discharges when reservoir Chl-a exceeds receiving water Chl-a concentration or 11 ug/L.
   c. Installation of aeration devices to reduce algal production
   d. Careful application of algaecides.
   e. Introduction of phytophageous fish or other biological controls to limit phytoplankton.

Some of these example water quality measures may not be necessary, desirable, or perhaps effective. To assist in the development of operational water quality measures, the project includes a water quality monitoring plan for sample collection at the reservoir outfall and downstream in the estuary. Water quality data will be matched with operational information and analyzed to determine which operations schemes provide the best water quality conditions. Once sufficient water quality data is collected, these operational schemes might then be optimized using a reservoir water quality model specifically adapted to this project.

In the event that during operations, the discharge water does not meet water quality standards, the DEP will be notified and the reservoir operations will be modified in an attempt to meet standards. If the operational modifications do not eliminate the standards violation(s), discharges will cease (if this can be done with no threat to human life) and the DEP will be further consulted.

D.1.6.4 Water Supply Operations

The reservoir is within the LaBelle Private Drainage District (LPDD) service area. The LPDD has historically served both the Berry Groves property and the Bob Paul property by pumping water from the Townsend Canal to the Header Canal. Project implementation will transfer an existing legal source of water available to the Bob Paul property from the existing Header Canal to the project's Perimeter Canal. With the project in place, a portion of the Header Canal will become part of the project footprint. To continue to provide an irrigation source to the Bob Paul property, which currently pumps irrigation water from the Header canal and the Crawford canal, C43PS-4 was included in the reservoir perimeter canal to pump water from the reservoir to the east to the remaining Header canal segment, assuring that the same volume of water will still be available. The Crawford Canal will still be available to the Bob Paul property and is not affected by the project. The existing Berry Groves No. 1 and No. 2 pump stations will remain in operation until C43PS-4 and the Perimeter Canal are constructed and operational.

D.1.6.5 Recreation

There are some recreational facilities in or adjacent to the C43BSR. SFWMD intends to allow certain types of recreational use in the impoundments, these plans are currently being prepared (see Appendix H – Recreation Plan). However, there will be no specific operations to provide for recreation.

D.1.6.6 Fish and Wildlife

The reservoir does not have specific water management operations to enhance fish and wildlife resources within project features. Areas of the project that will remain hydrated, even during periods of low water, include the Perimeter Canal and existing drainage/irrigation canals that will remain intact during construction. In addition, features that will enhance fish and wildlife resources are the littoral areas that will be constructed within the Perimeter Canal. However, no special operations will be required for the hydration of these areas. Pre-project flows will be maintained for the Roberts Canal and Banana Branch Canal.

The West Indian manatee is a federally endangered species. Therefore, special considerations will be implemented during design and construction of the project. All pump stations and outfalls will be designed to prevent manatees from entering the system. Because manatees are known to inhabit the Caloosahatchee River (C-43 Canal) and Townsend Canals, special construction precautions will be used to safeguard these animals. Once construction is complete, no special operations will be necessary to protect the manatees.

Construction precautions will be implemented to protect various federally protected species such as the Florida panther, Eastern indigo snake, wood stork, and Audubon's crested caracara. Although no special operations will be necessary for any of these species, operators will be required to follow a set of operational guidelines designed to protect nesting wading birds against severe water rising or lowering which could affect the integrity of the nests.

D.1.6.7 Navigation

The Okeechobee Waterway traverses the state from the Gulf of Mexico to Lake Okeechobee via the Caloosahatchee River (C-43 Canal) and from Lake Okeechobee to the Atlantic coast via the St. Lucie (C-44) Canal. Project operations should not adversely affect maximum or minimum navigational depths in the Caloosahatchee River (C-43 Canal). C43PS-1 will not be operated to deliver water from the Caloosahatchee River (C-43 Canal) to the reservoir when the Caloosahatchee River (C-43 Canal) upstream of S-79 is below 2.8 ft. NGVD. Therefore, operation of the project will not adversely affect navigational on the Okeechobee Waterway.

D.1.7 PRE-STORM/STORM OPERATIONS

If a heavy rainfall is forecast for the Caloosahatchee River (C-43) Basin, the main pump station (C43PS-1) will be placed on standby. If a storm occurs and there is capacity in the reservoir, normal operating conditions will be in effect.

D.1.8 CONSISTENCY WITH THE IDENTIFICATION OF WATER AND RESERVATIONS OR ALLOCATIONS OF WATER FOR THE NATURAL SYSTEM

The operating criteria within this Draft POM are consistent with the operating criteria used to identify the water reservations or allocations for the natural system to be made by the State of Florida in accordance with WRDA 2000. Refer to Annex C for details regarding the assumptions utilized in the technical procedures for identifying water to be reserved or allocated by the State. The project will be operated consistent with the assumptions set forth in Section C.2.1.2 and with the identification of water as set forth in Table C-3 of Annex C.

D.1.9 CONSISTENCY WITH SAVINGS CLAUSE AND STATE ASSURANCES PROVISIONS

The project has been designed to be operated so that there will be no adverse impacts on sources of water at the project (basin) level. Project implementation will transfer an existing legal source of water available to the Bob Paul property from the existing Header Canal to the project's Perimeter Canal. With the project in place, a portion of the Header Canal will become part of the project footprint. To continue to provide an irrigation source to the Bob Paul property, which currently pumps irrigation water from the Header canal and the Crawford canal, C43PS-4 was included in the reservoir perimeter canal to pump water from the reservoir to the east to the remaining Header canal segment, assuring that the same volume of water will still be available. The Crawford Canal will still be available to the Bob Paul property and is not affected by the project. The existing Berry Groves No. 1 and No. 2 pump stations will remain in operation until C43PS-4 and the Perimeter Canal are constructed and operational. The savings clause analysis will be updated to ensure continued compliance with the Savings Clause once the project becomes operational.

D.1.10 DROUGHT CONTINGENCY PLAN (DCP)

During a drought in the Caloosahatchee River (C-43) Basin or project area, operations will be modified in accordance with SFWMD Rules, Chapter 40E-21 F.A.C., Water Shortage Plan.

D.1.11 FLOOD EMERGENCY ACTION PLAN

The Flood Emergency Action Plan will be completed for the C43BSR Project prior to construction completion. The purpose of the Flood Emergency Action Plan is to describe the procedures to be followed in the event of a reservoir failure. The Flood Emergency Action Plan to be developed should be consulted for related emergency preparation and action. Local emergency management offices will be provided copies of the Flood Emergency Action Plan as necessary.

This plan may be used to supplement Hurricane or Tropical Storm Regulations. As outlined in Engineering Regulation 1130-2-530, the Flood Emergency Action Plan shall include:

- A written Emergency Notification Procedure for serious abnormal conditions to provide for the safety of people near the storage area and trigger immediate response for remedial assistance to the levee/water control structure
- A description or list of conditions leading to emergency situations and ways of dealing with them should they occur
- Storage area dewatering procedures
- Levee/water control structure failure inundation maps
- Listing of location, types, and quantity of emergency repair materials and equipment
- Details outlining responsibilities for inspection and execution of emergency repairs
- List of contractors available within a reasonable distance of the project area

D.1.12 DEVIATION FROM NORMAL REGULATION

The USACE, Jacksonville District Engineer is occasionally requested to deviate from the normal regulation of the project. Prior approval for a deviation is to be obtained from the Jacksonville District Office (SAJ) except as noted below. In turn, SAJ will obtain the necessary approvals from the South Atlantic Division (SAD) except as noted below. Deviation requests usually fall into the following categories.

D.1.12.1 Emergencies

Some expected emergencies include drowning and other accidents, failure of project facilities, and flushing of pollutants. Antecedent conditions as well as forecasted storm events may result in SFWMD declaring an Emergency Authorization Order, which would result in an Emergency Deviation. Necessary action under emergency conditions is taken immediately unless such action would create an equal or worse condition. SAJ should be informed as soon as practicable. Written confirmation should be furnished after the incident. SAJ will report these deviations to SAD.

D.1.12.2 Unplanned Minor Deviations

There are unplanned instances where there is a temporary need for a minor deviation from normal regulation, albeit these instances are not considered emergencies. A change in releases is sometimes necessary for construction, maintenance, or inspection. These requested deviations are usually for the

duration of a few hours to a few days. Each request is analyzed on its own merit. Consideration is given to upstream watershed conditions, potential flood threat, conditions of lakes, and possible alternative measures. In the interest of maintaining good public relations the request is typically recognized, providing there are no adverse effects on the overall project regulation for authorized project purposes. Approval for minor deviations will normally be obtained from the Jacksonville District by telephone. A written confirmation will be furnished after the deviation is completed. SAJ will report these deviations to SAD.

D.1.12.3 Planned Deviations

Each circumstance should be analyzed on its own merits. Sufficient data on flood potential, lake and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes, coupled with the USACE district recommendation, will be presented by memorandum, facsimile, or electronic mail to the USACE-SAD for review and approval. In addition, the non-Federal sponsor, the State of Florida (FDEP and SFWMD), and the Department of the Interior should be consulted as part of the process of receiving approval from SAD for the deviation.

D.1.13 RATE OF RELEASE CHANGE

Control structures should be opened and closed gradually. This technique provides an even transition to the new flow regime and minimizes hydraulic effects downstream. Special attention should be given to the maximum gate-opening curve for each structure to ensure the tailwater has a chance to build up before large-scale openings are made.

D.1.14 SEEPAGE CONTROL

The perimeter embankment is designed to include a soil-bentonite wall that is vertically tied into the clay layer that underlies the project site. An internal drain is also designed to gather seepage that passes through the soil-bentonite wall/or through the foundation soils. The internal drain has intermittent discharge pipes that drain to the Perimeter Canal.

Offsite seepage will be monitored using piezometers that are already installed around the perimeter of the reservoir footprint. Groundwater level data is being acquired on a monthly basis and used to establish baseline groundwater elevation conditions. These piezometers will be used during and following construction of, and filling of the reservoir to evaluate the impacts (if any) of the reservoir on the offsite groundwater table conditions. Should the piezometers indicate groundwater mounding occurring offsite, the surface water levels in the Perimeter Canal will be adjusted (lowered). Effects on offsite conditions due to

the lowering of the water table will be monitored and further adjustments will be made on an as-needed basis.

D.1.15 INITIAL RESERVOIR/STORAGE/TREATMENT AREA FILLING PLAN

The Initial Storage Area Filling Plan (ISAFP) is defined as the deliberate impoundment of water to meet project purposes. It is a continuing process as successively higher water levels are attained. The initial reservoir filling is the first test of containing levees and water control structures to perform the function for which they were designed. In order to monitor this performance, the rate of filling will be controlled to the extent feasible to allow as much time as needed for a predetermined monitoring program including the observation and analysis of instrumentation data. Information furnished in the ISAFP will generally be concerned with action that can be taken without a significant impact to project purposes, provided no unsafe conditions are observed. An ISAFP will be developed during design and construction. This plan will include, but is not limited to, the following:

- Preferred filling rate and the available options to control the rate of filling as well as the consequences of operation with the prime objective of controlling the rate of reservoir rise
- The most likely type of problem(s) that may develop during initial filling and the monitoring necessary to detect those problems
- A description of the proposed hydrologic data collection and transmission system and a plan for reading the instruments and evaluating the data with regard to the filling plan
- A plan for inspecting the dam and downstream areas prior to and during filling, including the relationship between frequency of inspection and rate of pool rise
- Instructions for observers on conditions that require immediate attention of personnel authorized to make emergency decisions. Clearly identify who is responsible for decisions and how they can be contacted. Alternative decision makers should be identified
- An emergency plan listing responsibilities, name and/or positions, telephone numbers, page numbers, and radio frequencies to be used
- Water quality requirements, if any, for the initial filling

D.1.16 NON-TYPICAL OPERATIONS FOR RESERVOIR/STORAGE/ TREATMENT AREA PERFORMANCE

Non-typical operations would apply during periods of extreme drought or rainfall. During drought conditions, it may be necessary to pump water more often at lower rates or to release water more slowly from the reservoir.

D.1.17 AQUIFER STORAGE AND RECOVERY SYSTEM PLAN

Not applicable.

D.1.18 WATER CONTROL DATA ACQUISITION SYSTEM PLAN (WCDASP)

The remote automation components installed at the pump station and other structures are the Remote Terminal Unit (RTU) and communication channel to SFWMD control center. Access for the RTU to the control center is via field interface units (FIU). The automation components of all pump stations and structures that will eventually be operated and maintained by SFWMD will conform to SFWMD standards. Equipment used in data acquisition essential to the water control management function will be included in the WCDASP, which will initially be developed during the project design phase. This will include all hardware and software to be used for acquisition, transmission, processing, display, and dissemination of hydrologic meteorology, water quality, and project data for the purposes of supporting the water control goal. This includes, but is not limited to, uninterruptible power supplies, field data collection platforms, and data communication devices and circuits. The WCDASP will also identify the site location of all hardware included in the plan. Hardware referencing and gage reference datum will be determined through coordination with appropriate agencies such as the U.S. Geological Survey (USGS) and SFWMD. The WCDASP will be completed during the plans and specifications phase and will be a subset of the Water Control Data System that is specific to the Caloosahatchee River (C-43) West Basin Storage Reservoir project.

D.1.19 CONSISTENCY WITH THE ADAPTIVE MANAGEMENT PROGRAM AND PERIODIC CERP UPDATES

After long-term operations and maintenance of the CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR Project has been initiated, the project operating manual may be further modified based on operating criteria approved by the USACE and SFWMD resulting from CERP updates and recommendations from the adaptive management of the CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR Project.

D.1.20 INTERIM OPERATIONS DURING CONSTRUCTION

Interim operations will be developed in conjunction with the detailed construction schedule. The interim operations will preserve existing Central and Southern Florida (C&SF) Project authorized purposes and/or achieve the Comprehensive Everglades Restoration Plan (CERP) authorized purposes as identified in the PIR. All interim operations will be conducted to meet the Assurances of Project benefits as set forth in WRDA 2000 and as discussed in the Programmatic Regulations and the Guidance Memoranda.

D.1.20.1 Preliminary Operations During Operational Testing and Monitoring Phase (OTMP)

Preliminary operations for the OTMP will be developed in conjunction with the plan for the OTMP. Operations will be conducted to meet the Assurances of Project benefits as set forth in WRDA 2000 and as discussed in the Programmatic Regulations and the Guidance Memoranda.

D.1.20.2 Conceptual Description for Transition from the Initial Operating Regime to the Next-Added Increment

Analysis of project benefits performed for plan formulation, selection, and justification indicates that there will be no significant difference between next-added incremental operations and the Initial Operating Regime. For this project, water management operations as described for the Initial Operating Regime would be expected to remain in effect if no other CERP projects affecting the regional water management system were to become operational.

D.2 HYDROLOGIC AND METEOROLOGICAL MONITORING AT THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR

D.2.1 Introduction

The purpose of this document is to provide a summary of the approach to be used for monitoring and control of the CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR and associated gated structures; spillways and culverts. This document will address measure points and methods, as well as telemetry to transfer measured data to pump station One (C43PS-1) and ultimately to the South Florida Water Management District (SFWMD) SCADA System at Gun Club Road.

The parameters to be monitored include the following:

- Reservoir level
- Perimeter and branch canal levels
- Water flows discharging from the reservoir cells and within the perimeter and branch canals
- Gate positioning and control
- Embankment monitoring
- Ambient conditions

Two data collection systems will be used:

- Motorola MOSCAD and MOSCAD-L RTU
- Campbell Scientific CR-1000 datalogger

Each data collection system will utilize independent radio telemetry networks. Details related to the communication type, licensed versus spread spectrum radios, are yet to be determined. All Motorola applications will be powered from a 120-volt ac power source. Campbell Scientific applications will utilize solar cells and battery power storage because of their remote locations.

All data collected will be transmitted to the C43PS-1 site microwave tower. The Motorola data will be stored on the telvent SCADA server located in the C43PS-1 control room. The Campbell Scientific data will be stored in the LoggerNet® Server in the microwave shelter. All data will be available to the C43PS-1 SCADA system and to the district SCADA system via the district microwave network.

D.2.2 Stage Monitoring

The reservoir water level will be measured using submersible pressure transducer type devices. This will allow level measurements in addition to the district's standard Balluff rod-type linear transducer. Reservoir level measurements not associated with gated structures will input into a Campbell Scientific datalogger due to standalone type of measurement. Reservoir level measurements associated with gated structures will be input into the site Motorola MOSCAD RTU with other site parameters. Upstream and downstream levels will be measured at all gated structures.

Canal water level will be measured using district standard Balluff rod-type linear transducers. The level measurements will be associated with gated structures and thus input into the site Motorola MOSCAD RTU with other site parameters. Upstream and downstream levels will be measured at all gated structures.

Stage measurements will be taken every 15 minutes by electronic equipment. For redundancy, a staff gage will be read.

D.2.3 Flow Monitoring

Water flow discharge from each of the reservoir cells will be measured independently. Flow measurement is expected to utilize level measurements within the intake structure and the gate well, and calculated based on the known fixed area of the flooded channel between to two level measurement locations. The exact method of flow measurement still needs to be determined. Flow measurement within the Perimeter Canal and branch canals will be calculated using level measurements and gate positioning.

D.2.4 Groundwater Monitoring

During the preliminary stages of exploration work (i.e. 2004), fifteen clusters of piezometers were installed along the proposed perimeter embankment alignment in order to provide information related to groundwater levels for design purposes. Each of these clusters consists of three 2-inch diameter Schedule 40 PVC well screens that are flush joint coupled to a riser pipe of similar composition. The well screens were set at depths corresponding to above, within and below the clay layer, and are designated A, B, and C, respectively. Each piezometer installation includes a sand pack surrounding the screened interval, and the borehole annulus was grout sealed above the sand pack to ground level.

In 2006, an additional 22 clusters of piezometers were installed in areas outside of the proposed reservoir footprint, adjacent to its north, south, and east sides. These piezometers were installed to enable monitoring of background groundwater levels before, during and after construction and filling of the reservoir, and to assess the hydrologic impacts of filling of the C43BSR on regional hydrogeology. Each of these additional clusters includes two piezometers similar to those described above, with one screened above the clay layer and one below it. In addition, there are two USGS piezometers, and one Lee County piezometer that are located west of the proposed reservoir footprint.

D.2.5 Weather

One or more weather stations measuring rain amount, wind speed and direction, barometric pressure, temperature and relative humidity will be placed around the reservoir area. The data will be collected using a Campbell Scientific CR-1000 data logger at each weather station location. Logged data will be transmitted as indicated above.

D.2.6 Structure Monitoring

Motorola MOSCAD RTU. Each sample at each selected gated structure will be deposited in a separate bottle. Samples will be manually collected weekly and lab tested for phosphorus content.

Gated structure roller gates, sluice gates, slide gates, and weir gates will be monitored for position using external potentiometer devices, where applicable and input into the area Motorola MOSCAD, MOSCAD-L RTUs. Fully open and fully closed gate position signals received from either the gate positioning electric actuator or gate assembly installed limit switch will also be input into RTU. Remote manual control of gate positioning will be available from the C43PS-1 and locally at the gated structure building. Gated structures with one

or two gates will implement the Motorola MOSCAD-L RTU, while gated structures with three or more gates will use the full Motorola MOSCAD RTU.

D.3 ECOLOGICAL MONITORING PLAN

The purpose of the ecological component of this monitoring plan is to make recommendations for monitoring to RECOVER and to provide enough detail of these recommendations to enable RECOVER to develop appropriate scopes of work for each component, if necessary, and to determine when adaptive management would be needed related to the project. This plan proposes the addition of 3 water quality stations, 2 salinity stations, and additional oyster sampling sites as new reefs are built, to current monitoring efforts.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project is the first part of the Basin Storage Reservoir (BSR) and Aquifer Storage and Recovery (ASR) component as identified in the Restudy. It is authorized as one of the initial projects for implementation under Section 601(b) (2) (C) of the Water Resources Development Act (WRDA) 2000. The reservoir has been designed for water supply benefits, some flood attenuation, to provide environmental water supply deliveries to the Caloosahatchee Estuary, and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary.

This section represents a monitoring plan for the Caloosahatchee Estuary and is a component of a larger project level monitoring program. This program establishes the framework for measuring project level responses, determines how well the project is meeting its goals and objectives, and identifies opportunities for improving the operation of the reservoir where needed.

The monitoring program has 3 objectives:

1. Establish baseline variability for each of the performance measures prior to project implementation;
2. Determine the status of and trends in the performance measures during and following project implementation;
3. Detect responses of the ecosystem to changes resulting from the project.

This plan consists of a minimal set of estuarine performance measures necessary to determine the success of the project as identified by a team of local scientists and water resource managers. It includes the objectives of the monitoring component, monitoring measures and targets for each performance measure, and a recommended monitoring approach. Also incorporated, where enough information is known, are triggers for adaptive management.

This monitoring plan is intended to address concerns related to downstream estuary impacts and benefits related to changes in freshwater inflows, water quality, and salinity due to project implementation. It was developed for the Caloosahatchee River (C43) West Basin Storage Reservoir Project Implementation Report (PIR) document. The PIR development phase has requirements for sections detailing monitoring and adaptive assessment methods for the recommended alternative. This monitoring plan is to be implemented prior to project start up and will be adhered to for a duration of the time during operation (post construction) sufficient to determine if there has been project impacts. Changes to the plan may occur in the future, commensurate with analysis of the monitoring data to date, funding limitations, and the need for adaptive management.

Modification of this monitoring plan will be determined by the needs of the project. This plan may be changed to reflect any future design changes, permit requirements and/or may be terminated according to permit expiration dates or changes to the project objectives. The plan will be reviewed and/or modified annually or more frequent if necessary, to reflect new requirements and updates regarding the parameters sampled and the expected duration of monitoring.

It is a recommendation of the C43 West Basin Reservoir Part I Project Delivery Team that the following plan be implemented by RECOVER and incorporated into their adaptive management strategy for South Florida.

D.3.1 Salinity Monitoring Plan

This salinity monitoring plan is intended to help address concerns related to downstream estuary impacts and benefits related to changes in freshwater inflow and salinity due to project implementation.

D.3.1.1 Background

Freshwater inflow and salinity vary naturally in an estuary and exert a profound influence on the survival and distribution of estuarine organisms, especially early life history stages and sessile benthic organism. However, excessive variation in salinity can maintain estuarine biota in a constant sate of flux between those favoring high salinity and those lower salinity. Proper management of water entering the estuary via the S-79 structure (***Figure D-4***) is the predominant requirement for a healthy Caloosahatchee Estuary, because the volume of freshwater passing through S-79 from the watershed and Lake Okeechobee overwhelms any other source. Environmental research and modeling, conducted mostly since 1985, has been employed to determine the optimum range and distribution of freshwater inflow from S-79 that protect key biota. This distribution of target flows ensures a complete range of salinities from freshwater to marine conditions along the longitudinal gradient of the

estuary, providing salinities that remain stable within geographical zones of the estuary that support the organisms within these zones.

A shift from the current undesirable, often extreme flow and salinity conditions, to maintaining the target flows and related estuarine salinity gradient can not be achieved without: (1) implementing the portion of the Comprehensive Everglades Restoration Plan (CERP) that reduces Lake Okeechobee releases; and (2) the building and operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir project. Therefore, as a component of the CERP effort and C-43 West Basin Storage Reservoir (BSR) Project, monitoring freshwater discharge from the Lake and S-79, as well as salinity in the estuary are necessary to determine if project flow and salinity targets are achieved; the cause for under achievement; and if adaptive management is required (e.g., changes in operations of project reservoirs). The available of inflow and location specific salinity information also is required for assessing the level of beneficial impacts of CERP and the Caloosahatchee River (C-43) West Basin Storage Reservoir project on key species and ecosystem components within their preferred range (e.g., oysters). Therefore, the guidance contained in this document will assist in maintaining consistency in sampling locations, parameter lists and frequencies as well as provide documentation of the project scope and an ongoing historical perspective.

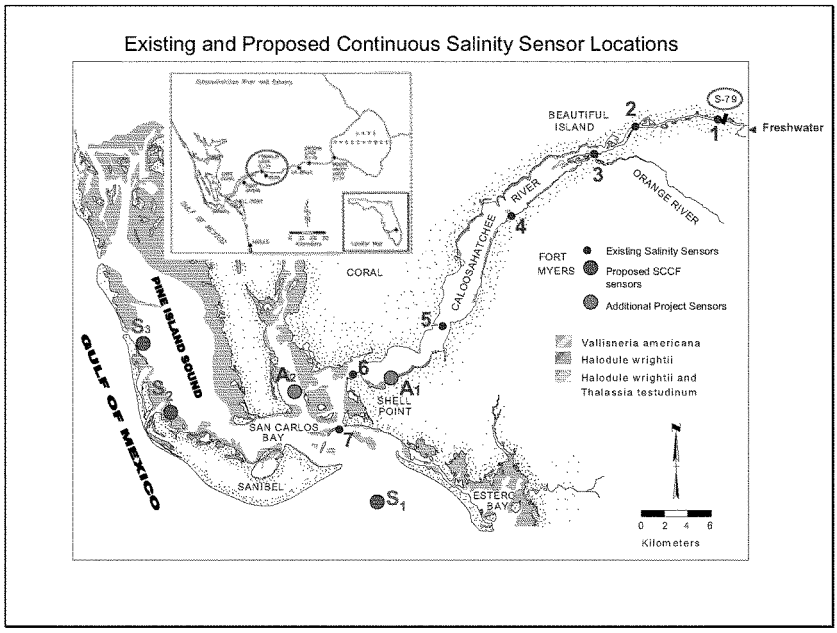


FIGURE D-4: MAP OF THE CALOOSAHATCHEE ESTUARY, THE EXISTING SALINITY SENSORS (1 – 7), SENSOR STATIONS PROPOSED BY SANIBEL-CAPTIVA CONSERVATION FOUNDATION, AND ADDITIONAL SENSORS SUPPORTED BY THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT.

D.3.1.2 Monitoring Objectives

1. (a) Compare the discharge distribution from S-79 to the Caloosahatchee River (C-43) West Basin Storage Reservoir target distribution; and (b) determine if the source of the variation is due to basin rainfall runoff and Lake Okeechobee Releases, as well as the influence of Caloosahatchee River (C-43) West Basin Storage Reservoir operations.
2. Collect salinity information along the downstream gradient of the estuary with sufficient frequency to detect annual and season change for comparison to pre-project conditions.
3. Determine if the low flow target for the project is sufficient and the associated salinity criteria in the upper estuary are achieved for protection of *Vallisneria americana*. Provide short term and long term operation recommendations based on the monitoring information.
4. Provide salinity information useful for the seagrass monitoring plan to determine if the salinity target for supporting seagrass in the lower Caloosahatchee River and San Carlos Bay are being achieved. Again,

provide short term and long term operation recommendations based on the monitoring information collected in the seagrass region.

5. Provide salinity information useful for the oyster monitoring plan to determine if the salinity target for supporting oysters near Shell Point is being achieved. Provided short term and long term operation recommendations based on the monitoring information collected in the oyster region.
6. Adequately collect salinity information throughout the estuary that enables the construction of salinity and computation hydrodynamic models, which allows the: (a) estimation of daily salinity throughout the estuary for understanding impacts to key species during non-sampling days of biotic indicators; (b) the determination of internal cause of salinity variation not related to project influence or discharges from S-79 (e.g., influence of freshwater from Gator Slough on salinity in the Matlacha Pass and San Carlos Bay); and (c) salinity model comparison of pre-project spatial and temporal patterns with new model output during project operation.
7. Address the null hypothesis stated below that is intended to asses the success of the project.

D.3.1.3 Null Hypothesis

The general null hypothesis - As a result of the operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir, there are no beneficial changes in freshwater inflows from S-79, nor improvement in the resulting downstream salinity, related to (a) the historic longitudinal salinity gradient and valued ecosystem habitat locations; (b) historic season salinity patterns; and (c) variation in salinity within distinct estuarine zones of the estuary.

D.3.1.4 Monitoring Measures and Targets

1. Monitoring Measure: Freshwater discharge through S-79, S-77 and from Caloosahatchee River (C-43) West Basin Storage Reservoir.

Target:

TABLE D-1: TARGET FLOW RANGE

Discharge Range (cfs) from S-79	Percent Distribution Of Flows From S-79
0 to 450	0%
450 to 500	42.8%
500 to 800	31.7%
800 to1500	19.2%
1500 to 2800	5.6%
2800 to 4500	0.7%
>4500	0%

Adaptive Management Trigger: (1) Long term - If operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir does not result in a significant increase toward achieving the above flow targets, thus satisfying the null hypothesis; and (2) Short Term (real time) - When there is a significant decrease in estuarine health or threat of adverse impacts related to flow from the Caloosahatchee River (C-43) West Basin Storage Reservoir (e.g., algae blooms in the upper estuary or insufficient delivery of water to achieve the MFL).

2. Salinity along a downstream gradient of the estuary and correlated freshwater inflow.

Target: Sufficient temporal and spatial salinity information to assess positive change regarding reduction in salinity variability and achieving the salinity targets as required for submerged aquatic vegetation, oyster, and fish (as specified in their respective monitoring plans).

Adaptive Management Trigger: (1) Long term - If operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir and it's related flow alterations does not result in: (a) significant decrease in salinity variability; and (b) stabilization in desirable salinity ranges along the estuary's downstream gradient and within valued ecosystem habitats, thus satisfying the null hypothesis; and (2) Short Term (real time) – (a) impending violation of the MFL rule and associated salinity criteria; and (b) adverse immediate impacts to estuarine biota as a result of the operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir

D.3.1.5 Monitoring Approach

Daily freshwater discharge from S-79 and the Lake Okeechobee structure at Moore Haven are measured by the Corp of Engineers and posted electronically on COE and South Florida Water Management District (SFWMD) web sites. This information is part of normal operation and therefore no additional Caloosahatchee River (C-43) West Basin Storage Reservoir project cost is required.

A network of continuous salinity sensors is required to meet the above monitoring objectives. The data from the sensors should be collected at the frequency and location necessary to support future modeling with minimum uncertainty and provide the salinity information necessary for other species and VEC monitoring efforts. ***Table D-2*** identifies each sensor site (as indicated in ***Figure D-4***), its monitoring objective (from above 6), and the expected funding sponsor of the site.

The existing sensors (soon to be 1-7) collect salinity every 15 minutes at 20% and 80% of the water depth. These are considered permanent sensors, most of which have long term data sets beginning in 1992 (source of pre-project data). These sensors have been critical in the development of salinity models and should be maintained at their current operation capacity to provide data for future modeling efforts related to assessing project change. The information from most of these sensors are used as part of the daily operation of the Corp of Engineers and SFWMD and available to provide short term and long term project feed back. The cost to maintain these sensors should be minimal to the Caloosahatchee River (C-43) West Basin Storage Reservoir project. The locations of S-sites are also identified in ***Figure D-4***. These sensors should be similar in operation as the existing 7. The cost for supporting the S-site sensors is being considered by the Sanibel-Captiva Conservation Foundation.

TABLE D-2: MONITORING SITES, PARAMETERS SAMPLED, MONITORING OBJECTIVES (FROM MONITORING OBJECTIVES SECTION), AND THE FUNDING SOURCE SPONSORING THE SITE INSTALLATION AND MAINTENANCE. CORPS OF ENGINEERS (COE), SOUTH FLORIDA WATER MANAGEMENT DISTRICT (SFWMD), AND SANIBEL-CAPTIVA CONSERVATION FOUNDATION (SCCF)

Monitoring Site and Parameters	Objective(s) Addressed	Funding Sponsor
S-77 (Moore Haven) & S-79 (Franklin Dam)	1a -Compare flow from S-79 to project target 1b - Determine if any change in S-79 flow due to basin or lake.	COE & SFWMD
1 - Salinity, temperature & water level	Null Hypothesis -Provide/Protect oligohaline zone.	SFWMD
2 - Salinity & temperature	Null Hypothesis -Provide/Protect oligohaline zone.	SFWMD
3- Salinity & temperature	3 - Determine if low flow salinity criteria achieved to protect tape grass (monthly average <10ppt). -Support short term operation and long term adaptive management needs. 6a - Estimation of salinity during non-	SFWMD

	sampling days for key biota (VECs)	
4- Salinity & temperature	3 - Determine if low flow salinity criteria achieved to protect tape grass (monthly average <10ppt). -Critical MFL measurement station. -Support short term operation and long term adaptive management needs	SFWMD
5 - Salinity & temperature	4 -Support seagrass monitoring, and meets target salinity for area (>15 ppt)	SFWMD
6 - Salinity, temperature & water level	4 -Support seagrass monitoring, and meets target salinity for area. 5 - Support oyster monitoring, and meets target salinity for area (> 5ppt) -Support short term operation and long term adaptive management needs. 6a - Estimation of salinity during non-sampling days for key biota (VECs)	SFWMD
7 - Salinity & temperature	4 -Support seagrass monitoring, and meets target salinity for area (>25ppt). -Support short term operation and long term adaptive management needs. 6a - Estimation of salinity during non-sampling days for key biota (VECs).	SFWMD
S1- Salinity & temperature	4 - Support seagrass monitoring	SCCF
S2 - Salinity & temperature	4 - Support seagrass monitoring -Support short term operation and long term adaptive management needs.	SCCF
S3 - Salinity & temperature	4 - Support seagrass monitoring	SCCF
A1 - Salinity & temperature	4 -Support seagrass monitoring, and meets target salinity for area (>20 ppt). -Support short term operation and long term adaptive management needs. 6a - Estimation of salinity during non-sampling days for key biota (VECs)	CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
A2 - Salinity & temperature	4 -Support seagrass monitoring 6a - Estimation of salinity during non-sampling days for key biota (VECs). 6b - Salinity variation due to non-project sources.	CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR
All Sensors	2 - Detect desired seasonal, annual, and spatial change along the downstream gradient. 6c -Salinity model to compare w/ pre-op.	

The locations of additional sites are proposed in ***Figure D-4***, along with their suggested priority ranking. These A-site sensors should be similar in operation as the existing 7. The majority of the cost for these additional sensors will probably be funded by the Caloosahatchee River (C-43) West Basin Storage Reservoir project, with possible support from other CERP sources and RECOVER.

Sensors 1 -7 provide real time data, with live access available to restricted SFWMD staff. These sites, the S-sites, and the proposed A-sites should also provide similar real time data. The information from all sites should be required to have broader access for scientist conducting research and analysis.

D.3.1.6 Data Quality

Routine samples and routine quality control samples are collected in accordance with the Florida Department of Environmental Protection (Department) Quality Assurance Rule, 62-160.200 and 62-160.320, F.A.C. and the District Field Sampling Quality Manual (FSQM). Applicable sections of the FSQM include auto-sampler collection methods; field test methods; and quality control procedures. Corrective actions for data not meeting the quality objectives may be taken as outlined in the Quality Assurance Systems Requirement (QASR).

D.3.2 Project Monitoring and Assessment Plan: Water Quality

This water quality monitoring plan is intended to help address concerns related to downstream estuary impacts and benefits related to changes in freshwater inflow and associated water quality due to project implementation.

D.3.2.1 Background

Quality of water is a major factor of influence as to the degree which an estuary may successfully sustain the diverse biological communities and habitats within its boundaries. Estuaries provide an area of dynamic chemistry where substances are naturally deposited. Freshwater, in the process of flowing from the land to the sea, transports a wide range of materials, that when coupled with internal estuarine dynamics of circulation, nutrient flux, sediment type, and resuspension, results in each estuary being unique in its appearance and ability to support biological activity and the nature of that activity. Therefore, among aquatic ecosystems, estuaries are uniquely complex systems, since they act as sinks for substances delivered in freshwater flows, possess mixing and flow patterns controlled by the ebb and flow of tide and tidal-influence, and exhibit interrelated chemistries connecting atmosphere, water and sediment. Key water quality characteristics of concern for the Caloosahatchee considered by this Monitoring Plan are nitrogen and phosphorus nutrients, algal bloom dynamics, dissolved oxygen regime, water color, suspended solids, and water clarity;

however, these characteristics are inter-related and cannot be adequately or properly evaluated except within the context of their interdependencies in delineating acceptable from unacceptable water quality conditions. This monitoring plan is accordingly constrained to consider water quality from the perspective of sustainable and desirable estuarine ecological response; that is water quality requirements of valued ecosystem components and habitats addressed in the other Caloosahatchee River (C-43) West Basin Storage Reservoir Project Monitoring Plans for submerged aquatic vegetation (SAV), fisheries, oysters, and the soft-bottom benthos. With that said, the purpose of this Monitoring Plan is to define Caloosahatchee River (C-43) West Basin Storage Reservoir project expectations regarding water quality improvements brought about by implementation of CERP and this Project, and to provide a tool with which to evaluate and assess those improvements. Other state and local efforts, e.g. the State's Total Maximum Daily Load (TMDL) program, are expected to compliment and supplement this Project and the larger CERP effort, thus affording additional improvements in water quality; however, implementation of these efforts, including effective agricultural and urban Best Management Practices (BMPs) are outside the purview of this project and CERP and are not addressed by this monitoring plan.

Extensive development of the Caloosahatchee watershed has changed the source and character of water entering the estuaries, from a historical drainage pattern dominated by wetland and forested land uses to that of urban and agricultural stormwater runoff. The modifications inherent in the original Central and Southern Florida (C&SF) Project resulted in increases in quantity and rate of water entering the estuaries. These modifications also served to extend the expanse of the estuaries' drainage basins to include Lake Okeechobee. The combined effect of changes in land use, expansions in acreage drained, and the manner in which water is delivered to the estuaries has resulted in varying degrees of degradation of water quality.

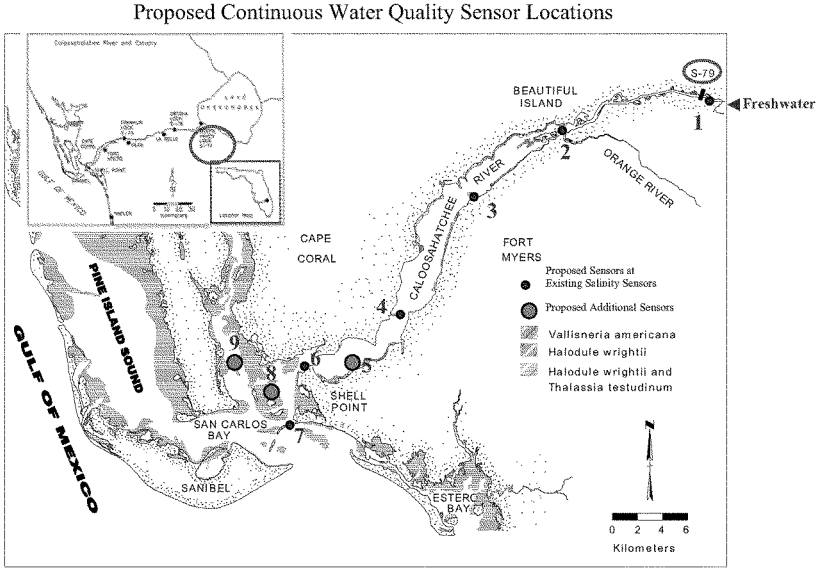


FIGURE D-5: MAP OF CALOOSAHATCHEE ESTUARY AREA AND LOCATION OF PROPOSED WATER QUALITY MONITORING SENSORS; STAGED ON EXISTING SALINITY SENSORS PLATFORMS AND AT PROPOSED NEW SITES

Efforts currently underway to retain, re-direct, treat, or otherwise better control water deliveries holds the promise of ameliorating excess nutrient loading, reducing sediment and turbidity causing conditions, improving water clarity, and decreasing intensity and frequency of algal blooms. Otherwise, judiciously managing water will result in improved estuarine water quality. For example, freshwater inflow through S-79 is directly related to the amount of total nitrogen entering the estuary (***Figure D-6***). This relation also holds for other primary constituents, including phosphorus and water color. The loading and flow together thereby effects parameter concentration in the estuary, distance downstream of influence, and the amount of change in related parameters like chlorophyll (algae), water clarity and dissolved oxygen (D.O.).

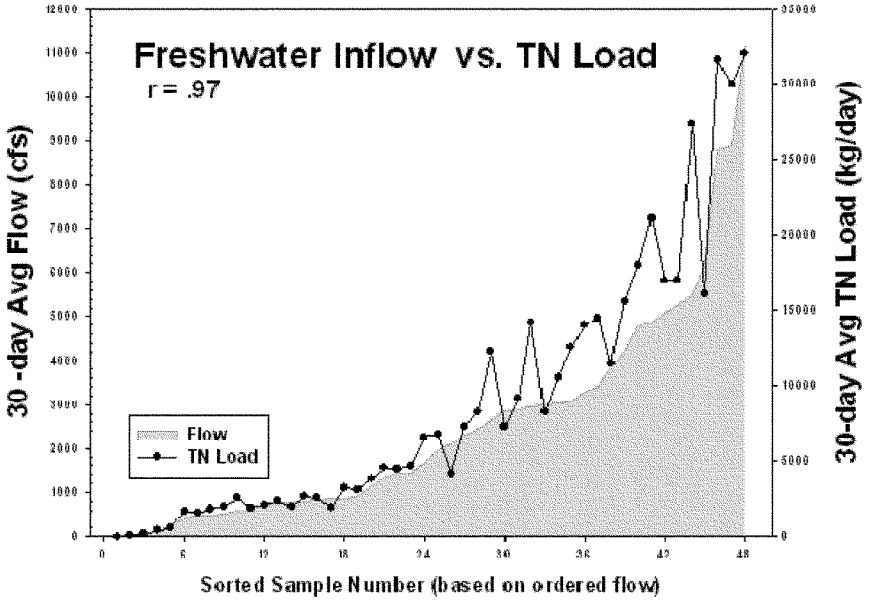


FIGURE D-6: MONTHLY LOAD OF TOTAL NITROGEN FROM S-79 COMPARED TO MONTHLY AVERAGE FLOW FROM THE STRUCTURE

Figure D-6 serves to indicate not only that parameter loading of constituents is strongly related to flow volume, but also the concentration of the constituents upstream - in the water being discharged to the estuary. However, for many constituents, loading and subsequent water quality downstream will greatly improve if the S-79 inflow targets are achieved (***Table D-3***). For example, if 75% of the flows are within the 450-800 cfs range, and almost all flows are less than 2,800 cfs, than the load to the estuary will be restricted to the very low end of ***Figure D-6***.

Provisional analysis indicates that flows in the range of 450-800 cfs per month will equate to ~ a average 2000 kg/day (2 metric tons/day = 60 metric tons month), flows of 2,800 cfs will produce an average TN load of 10,000 kg/day (10 metric tons/day, 300 mt/month), and 4,500 cfs per month correlates to about 14,000 kg/day (14 mt/day, 420 mt/30days).

TABLE D-3: TARGET FREQUENCY DISTRIBUTION OF MEAN MONTHLY FLOWS FROM S-79 (CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR - CALOOSAHATCHEE ESTUARY HYDROLOGIC EVALUATION PERFORMANCE MEASURES, 2005).

Discharge Range (cfs) From S-79	Percent Distribution Of Flows From S-79
0 to 450	0%
450 to 500	42.8%
500 to 800	31.7%
800 to1500	19.2%
1500 to 2800	5.6%
2800 to 4500	0.7%
>4500	0%

Based on ***Figure D-6***, discharges at S-79 contain 70 to 80 percent of the nutrient load delivered to the Caloosahatchee Estuary. Waste load allocation studies conducted over twenty years ago in the Caloosahatchee Estuary by the Florida Department of Environmental Regulation (DeGrove 1981) concluded that the estuary had reached its nutrient loading limit as indicated by elevated chlorophyll α and depressed dissolved oxygen levels. Janicki (2003) determined that nitrogen loads were more responsible for degraded water quality in the estuary than phosphorus, and calculated that achieving an annual average chlorophyll-a concentration of 11 ug/l would require reducing the nitrogen load at S-79 to less than 190 metric tons/month (average of 6.3 mt/day) during the dry season, 350 tons/month during the wet season (average 11.7mt/day), and an annual cumulative load less than 3000 U.S. tons per year (2721 mt/year, average 7.45 mt/day). Recent estimates of average load (Crean and Irican 2005) indicate that on average (1993-2003) 2,905 and 233 U.S. tons of total nitrogen and total phosphorus, respectively, enter the estuary annually, with nitrogen loads in excess of 3000 U.S. tons occurring 30 to 40% of the time.

The Janicki recommendation for nitrogen loading to maintain a chl-a of 11ug/l is for the entire estuary, which would serve to keep the estuary from violating the state impaired water rule (also 11 ug/l). However, the estuary chl-a concentration varies between segments of the estuary. Doering and Chamberlain (2005) found current median chl-a in 4 section of the estuary (upper, mid, lower estuary above Shell Pt, and in San Carlos Bay) were 10.7ug/l, 12.7ug/l, 5.3ug/l, and 4.2ug/l, which were usually below the goal used by Janicki. Doering and Chamberlain (2005) determined that the seagrass targets listed in the SAV Monitoring Plan were associated with chl-a concentrations of below 4.6 in the lower estuary, and 4.0 in San Carlos Bay, which also is close to the Charlotte Harbor National Estuarine Program's chl-a target to promote seagrass growth to 2 meters in San Carlos Bay. Doering and Chamberlain (2005) further correlated a nitrogen load of 186-192 mt/month (2230-2310 mt/year) at S-79 with the chl-a goals for seagrass downstream. Therefore, Janicki's estimate for the dry season

should be promoted all year. Doering and Chamberlain (2005) ended their analysis by indicating that a chlorophyll a concentration of 5 ug/l in San Carlos Bay corresponds to an Estuary-wide average of 8.3 ug/l. Given the variability, this compares well with the standards/rule based value of 11 ug/l.

The Florida Impaired Waters Rule (IWR) states that an estuary is impaired if the annual mean chlorophyll concentration is greater than 11 µg/L. Even though the current median values identified in the previous paragraph exceed 11ug/l only in the mid-estuary, the average chl-a is greater than 11ug/l throughout the upper, middle, and into the lower estuary. Therefore, maintaining current nutrient dynamics of loading, concentrations, and bloom frequency that allows monthly chl-a values to fluctuate at their current highly variable concentrations will result in the denigration of the estuary and its continued designation as an impaired water body.

Since the IWR is calculated on an annual average basis, then one approach to determine a target for allowable bloom frequencies is to ascertain the number of months that average chl-a values above 11 µg/L can occur and not cause the estuary to be designated as an impaired water body. This approach is summarized in ***Table D-4***. This premise assumes that the average chl-a value during the non-bloom months is < 8 µg/L, which is the expected median value for the area upstream of Shell Pt. when nitrogen loading is reduced to the suggested target of 190 mt/month discussed above.

TABLE D-4: SUGGESTED LIMITS FOR THE RANGE OF CHL-A CONCENTRATION VALUES IN A BLOOM, THE NUMBER OF MONTHS A SPECIFIC RANGE CAN OCCUR, AND THE CORRESPONDING ANNUAL FREQUENCY. NON-BLOOM MONTHS ARE ASSUMED TO BE < 8 µG/L.

Range of Chl-a (µg/L)	Allowable # of Months	Annual bloom frequency (Allowable Months/12)100
>50	0	0%
30-50	1	9%
23-29	2	17%
18-22	3	25%
17-18	4	33%
11-16	5	42%
< 5: Upper and Mid-Estuary	Minimum = 4 months	Minimum = 33%
< 5: Lower estuary	Minimum = 7 months	Minimum = 60%

A review of the data found that the maximum frequency of months that exceeded 20 µg/L has been about 20 percent, which is within the table values. However,

the current maximum frequency of monthly values above 11 µg/L has only been about 40 percent. Therefore, to suggest that 100% is allowable to avoid an IWR designation may actually result in a decline of water quality conditions. In this same spirit, the existing frequency of chl-a values of < 5 µg/L in the upper and middle estuary is about 35%, which should be promoted as a good chl-a target. In the lower estuary, the minimum desirable frequency of 5 µg/L jumps to 60%. Including these minimum frequency targets in ***Table D-4*** will help preserve existing condition important for seagrass.

As discussed above, keeping the upper and mid-estuary from being designated impaired water bodies will further promote chl-a values of < 5 µg/L in the seagrass areas (lower estuary and San Carlos Bay). Also as indicated above target flows between 450 and 800 cfs account for 75% of the total distribution When flows are < 800 cfs, chl-a has historically been < 5 µg/L (***Figure D-7***). Therefore, achieving the hydrologic targets should help meet the chlorophyll goals as well as the nutrient loading target. Although, it should be noted that chl-a values in San Carlos Bay that exceed 5 µg/L may be unconnected with nutrient loading or chlorophyll values upstream, in part because of the occasional impacts of "red tide" on this area. Red tide originates in Gulf waters and may move inshore when oceanographic conditions are favorable.

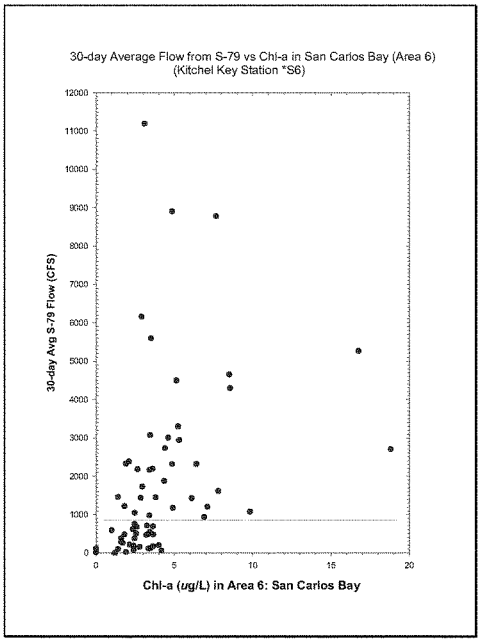


FIGURE D-7: CHL-A IN SAN CARLOS BAY COMPARED WITH 30-DAY AVERAGE FLOW FROM S-79 (FRANKLIN LOCK AND DAM)

High concentrations of chlorophyll a in surface waters can be associated with low concentrations of dissolved oxygen in bottom waters (0.5 m above bottom) in the Caloosahatchee on short time scales of weeks (Doering and Chamberlain (2005). Such an instance is depicted in ***Figure D-8***. The crash of a chlorophyll a bloom coincided with a rapid decline in oxygen in bottom waters during the month of June 2000. On longer time scales, the high concentrations of chlorophyll a may be associated with lower oxygen concentrations one or two months in the future. Establishing a maximum chl-a bloom target of 50 µg/L in the upper and middle estuary will help protect against sub standard D.O. as depicted in ***Figure D-8***.

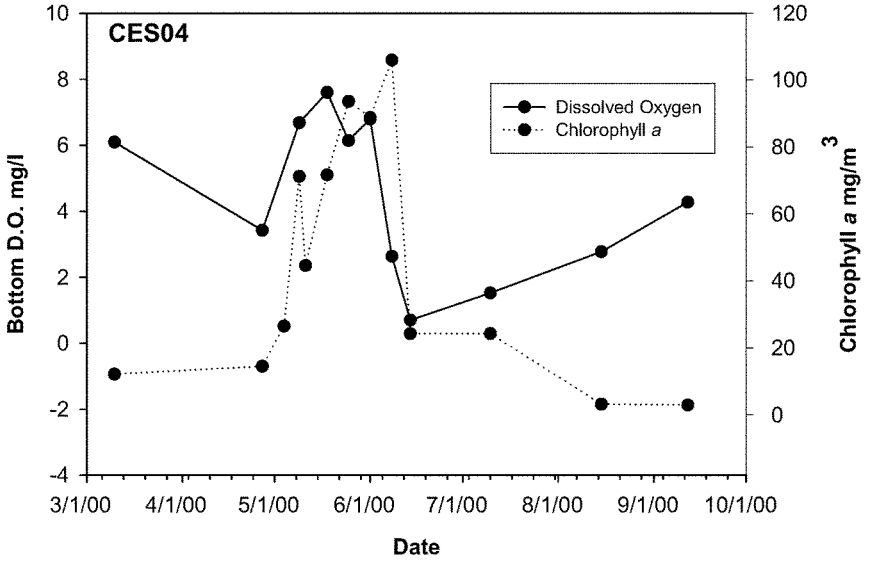


FIGURE D-8: TIME SERIES OF CHLOROPHYLL *A* AND DISSOLVED OXYGEN IN BOTTOM WATER IN THE UPPER CALOOSAHATCHEE ESTUARY NEAR BEAUTIFUL ISLAND.

In general, the D.O. goal is to improve or maintain suitable conditions for establishment and maintenance of healthy, well-balanced biological communities. Bottom dissolved oxygen regime is most meaningful as regards to biological response and success. Jordan et al. (1992) developed dissolved oxygen targets for the Chesapeake Bay for the protection of desirable species of fish, mollusks and crustaceans. These targets recommended that dissolved oxygen is greater than or equal to 1.0 mg/l at all times everywhere in the water column; dissolved oxygen never falls within 1.0-3.0 mg/l for longer than 12 hours every 48 hours; monthly mean dissolved oxygen is greater than 5.0 mg/l at all times above the pycnocline (above the wedge of saltier water that typically exists as a function of tides); and dissolved oxygen is always greater than 5.0 mg/l in spawning and nursery areas.

The targets recommended by Jordan are supported by the conclusions of other researchers that report low dissolved oxygen (DO) concentrations even in the water column can increase mortality, reduce growth rates and alter the distribution and behavior of aquatic organisms (Diaz and Rosenberg 1995, Breitburg 2002, U.S. EPA 2002, 2003). Mortality can occur rapidly from short-term exposure (less than 6 to 12 hours) to low oxygen concentrations (Breitburg 2002). Continuous exposures to even moderate reductions in DO can

substantially reduce growth rates of both fishes and invertebrates (for review see U.S. EPA 2000); best evidence of this is from aquaculture studies – for example, Davis (1990) reports that DO is the most critical aspect of water quality for red drum, *Sciaenops ocellatus*, and that growth reduction is apparent when DO levels drop below 4 mg/L. However, many species exhibit behavioral responses (e.g., blue-crab migrations, Bailey and Jones 1989, as cited by Tomasko 1997, etc.) that allows them to avoid not only lethal oxygen concentrations but also those that would require greatly increased ventilation and reduce growth. Emigration leading to reduced densities of fishes can begin at oxygen concentrations approaching 3 to 4 mg/l (Diaz and Rosenberg 1995, Breitburg 2002, U.S. EPA 2003). Consequently, habitat loss due to depressed DO can be far greater than if based on concentrations thought to be lethal. Although the breakpoint for hypoxia and community change in the benthos was considered to be 2 mg DO/l, a study by Ritter and Montagna (1999) suggest it may occur at 3 mg DO/l. Impacts from hypoxia induced community change can lead to altered sedimentary processes (e.g., bioturbation, etc.) and, as a consequence, altered geochemistry (Diaz and Rosenberg 1995). Habitat squeeze from low DO can interrupt seasonal migrations for spawning or of organisms seeking optimal temperatures. Because they are limited in their behavioral avoidance, eggs and larvae can be more vulnerable to low DO (Breitburg 2002). Moreover, in many species, eggs and larvae have higher DO requirements than adults (Breitburg 2002; for tolerances of red drum larvae, see Miller et al. 2002, for newly set (3-4 days) eastern oysters *Crassostera virginica*, see Osman and Abbe, 1994; as cited in U.S. EPA, 2000).

U.S. EPA (2003) adopted a number of dissolved oxygen criteria (for various designated uses and temporal applications) including, but not limited to, the following: 1) a criterion minimum concentration (CMC = 1-day mean concentration) of 2.3 mg/l to protect juvenile and adult survival in open-water, 2) a criterion continuous concentration (CCC = 30-day mean) of 5 mg/l to protect against adverse effects on growth of larval, juvenile and adult fish and shellfish in tidal habitats (>0.5 ppt salinity) and, 3) an instantaneous minimum concentration of 1.7 mg/l to protect the survival of eggs and larvae in deep water. The most rigorous criteria adopted was a 7-day mean concentration of 6 mg/l for the protection of survival and growth of larval and juvenile fish in tidal-freshwater habitats (< 0.5 ppt), which was based on information contained in U.S. EPA (1998).

In summary, if achieved, the current State water quality standard appears to a good general target for the Caloosahatchee, which would be protective for Class II or III marine waters. This standard includes a 24-hour average ≥ 5.0 mg/L; instantaneous minimum [as indicated by pre-dawn concentrations] ≥ 4.0 mg/l (≈ FAC 62-302.530 (31).
The need to establish suitable Chl-a targets in the estuary related to SAV is due to the impact that increased phytoplankton can have on water clarity. Other

water quality constituents also influence water clarity, including water color and total suspended solids. These parameters are either directly related to freshwater inflow (i.e., color) or indirectly (Chlorophyll and TSS). However, limiting flow to the targets in ***Table D-3*** will promote SAV as depicted in ***Figure D-10*** and in the SAV Monitoring Plan. Therefore, the establishment of additional water clarity targets will be best served by identifying the actual light requirements of SAV species and monitoring to determine if requirements are achieved. Current median values of secchi disk depth are 1.0m near *Vallisneria americana* (tape grass) beds in the upper estuary, 1.1 – 1.3m adjacent to the Halodule wrightii (shoal grass) beds in the lower estuary, and 1.4m in San Carlos Bay. Improvement in freshwater inflows should also improve these secchi measurements, such that variability in measurement decreases and the current median values trend toward the 25 percentile, instead of the median.

In addition to secchi depth measurements, direct monitoring of light using photosynthetic radiation (PAR) sensors should become standard practice. Traditionally, these this type of sensor has been used deployed through the water column during site sampling to determine light attenuation. However, researchers have estimated the amount of light required by specific SAV species to survive, including tape grass and shoal grass. The minimum average daily bottom light (ADBL) measured in the PAR spectrum of 400-700 nanometers is about 20 microEinsteins (uE = micromoles/m2/sec). ADBL is based on daily light reaching the bottom during the entire 24 hour day (not just daylight or peak light periods). During high salinity conditions (>9.5 ppt) when the plant is stressed, about 100 uE represents plant saturation. When salinity is < 9.5 ppt, 100 uE represents about 60-70% saturation, which doesn't occur until ADBL reaches about 390 uE. ADBL exists for shoal grass can also be divided into stressed environments like in Iona Cove, and more desirable areas as in San Carlos Bay. Minimum ADBL in Iona Cove area is about 50-60 uE, with 50 and 100% saturation equal to about 140 and 220-275 uE , respectively. In San Carlos Bay, the minimum, 50% and 100% levels of ADBL equates to about, 75-100uE, 150-175, and 325 uE, respectively.

D.3.2.2 Monitoring Objectives

The Caloosahatchee River (C-43) West Basin Storage Reservoir project is authorized as one of the initial projects for implementation under Section 601(b)(2)(C) of the Water Resources Development Act (WRDA) 2000. To clarify the intent of WRDA 2000, projects in the category of this Caloosahatchee River (C-43) West Basin Storage Reservoir project must not attain their primary quantity performance objectives by degrading water quality. Therefore, it is not the goal of this project to improve water quality in the estuary, but the project also can't degrade water quality. The targets discussed earlier act as benchmarks for desirable water quality trends if change is detected. As discussed earlier, improvement in water quality is expected from controlling water quantity.

Other state and local efforts, for example the State's Total Maximum Daily Load program (TMDL), are expected to compliment and supplement this Project and the larger CERP effort, thus affording additional improvements in water quality; however, implementation of these efforts, including effective agricultural and urban Best Management Practices (BMPs) are outside the purview of this Project and CERP in this region and are not addressed by this Monitoring Plan Determining if the "no degradation" of water quality requirement is achieved depends on monitoring and evaluating estuarine water quality commensurate with the project operation, with the following objectives:

1. Compare water quality during project operation with the historic data sets described by Doering and Chamberlain (2005) and new monitoring information prior to operation to determine if there is a change in nutrient loading. To assist this effort, compare project related water quality and nutrient loading with similar seasonal conditions when freshwater inflows would have been equal to non project flow.
2. Compare historic chl-a data as explained in Doering and Chamberlain (2005) with new monitoring data collected during project operation, to determine if there is a change in chl-a concentration and blooms within the same regions.
3. Compare D.O. as described above for other parameters.
4. Monitor water clarity by secchi disk reading and PAR measurements at SAV habitats. Compare variability in these parameters as discussed above for the other parameters.
5. Using the same monitoring approaches as discussed above, compare concentrations of TN, inorganic nitrogen, TP, inorganic P and color. If change is detected, determine if it is it toward decreasing concentrations.
6. Addresses the null hypothesis stated below that is intended to assess the success of the project.

D.3.2.3 Null Hypothesis

The general null hypothesis - As a result of the operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir, there will be a statistically significant degradation in current water quality condition, compared to – (a) historic water quality samples along the estuary's longitudinal gradient and at valued ecosystem habitat locations; (b) historic seasonal water quality patterns; and (c) variation in water quality within distinct estuarine zones of the estuary.

D.3.2.4 Monitoring Measures and Targets

1. Monitoring Measure: Mean monthly flows from S-77, the Caloosahatchee River (C-43) West Basin Storage Reservoir, as well as flows and loading from S-79.

Target: Reduction in current mean monthly flows from S-79 toward achieving the Project target flows (***Table D-3***) should also equate to a reduction in nutrient loading. The target nutrient loading from S-79 is 190 mt/month. Review of historical data indicates that flows < 2000 cfs will achieve this loading target. Therefore, as flows trend toward that of project target, reduction in loading variability should occur, and eventually 95% of monthly loading will be < 190 mt.

Adaptive Management Trigger: Significant increase in average monthly and annual loading as a result of project operation.

2. Monitoring Measure: Phytoplankton production as estimated by chlorophyll-a.

Target: As a result of the reduction in loading and freshwater inflows, phytoplankton production will decrease as measured by chl-a concentrations and variability. Ultimately, upon Project build-out with other CERP components in place, chl-a values are expected to average below 5 ug/l in the Iona Cove area and < 4 ug/l in San Carlos Bay. The target average chl-a in the remainder of the upstream areas of the estuary is 8 ug/l. As project completion precedes, reduction in chl-a variability should occur as monthly chl-a values approach the targets. Phytoplankton bloom frequency should diminish with a target to be less than the frequencies listed in ***Table D-4***.

Adaptive Management Trigger: Increase in chl-a, especially upstream associated achieving minimum flow targets. Increase in bloom frequencies and chl-a concentrations that negative impacts the estuary's IWR standing.

3. Monitoring Measure: Dissolved Oxygen.

Target: D.O. should be the same as state standards, such that 24-hour average D.O. is ≥ 5.0 mg/L and instantaneous minimum [as indicated by pre-dawn concentrations] is ≥ 4.0 mg/l (≈ FAC 62-302.530 (31).

Adaptive Management Trigger: Increase in the violation occurrence of Florida's D.O. standards.

4. Monitoring Measure: Turbidity (Secchi).

Target: Variability in secchi readings should not decline below the current median values of 1.0 m in the tape grass area, 1.2 m in Iona Cove, and 1.4 in San Carlos Bay. It should tend toward the 25 percentile as project operation approaches the target flows. In addition, ADBL in the tape grass area should be > 20 UE and average > 100 uE at 1.0 meters (MLLW). ADBL in Iona Cove should exceed 70 uE and average 150 uE at 1.0 m. In San Carlos Bay, the

minimum ADBL should exceed 80 uE and average at least 150 uE at 1.5 m (MLLW).

Adaptive Management Target: Project operation that causes: (a) secchi measurements and variability to decline below the above stated current median values; and (b) a decline in PAR below current median values.

5. Nutrients (inorganic nitrogen, total phosphorous, inorganic phosphorous) and Color.

Target: Concentrations of TN, inorganic nitrogen, TP, inorganic P, and color should detect a decrease in concentrations compared to the data sets described and evaluated by Doering and Chamberlain (2005) and any new data collected as outlined in this monitoring plan prior to project operation.

Adaptive Management Trigger: Increase in concentrations of TN, inorganic nitrogen, TP, inorganic P, and color compared to the data sets described and evaluated by Doering and Chamberlain (2005) and any new data collected as outlined in this monitoring plan prior to project operation.

D.3.2.5 Monitoring Approach

Daily freshwater discharge from Lake Okeechobee and S-79 are measured by the Corp of Engineers and posted electronically on COE and SFWMD web sites. This information is part of normal operation and therefore no additional Caloosahatchee River (C-43) West Basin Storage Reservoir project cost is required. Salinity information will be provided by the network of continuous sensors described in the Salinity Monitoring Plan and additional information collected concurrent to SAV monitoring.

Standard method of water quality sampling (grab samples) are too expensive and have such a high variability, that the results would probably be unable to detect change until many years of sampling are completed. This type of monitoring also is inappropriate for sampling on the sub-daily basis required to address the above objectives.

Currently, RECOVER is testing in situ instruments (Microlab) capable of automatically sampling nitrogen, phosphorous, and other parameters at a pre-set frequencies. These instruments, coupled with other in-situ instruments to monitor D.O. and PAR and reflectance (measure of Chl-a) are necessary.

***Figure* D-5** identifies locations where instruments should be located. To meet Objective 1 and Target 1, a Microlab will be required to sample nitrogen at 20% and 80% of the water depth twice daily. Microlab instruments will also be

required at sites 2, 3, 4, 5, and 8 to sample nitrogen, TP, inorganic P, estimate chl-a and color (if possible) twice daily to meet Objective 2 and 5. Dissolved oxygen sensors and data logger will be required at 205 and 80% of the depth at stations 2, 3, 4, and 5, in order to electronically record D.O. at 30 minute intervals to address Objective 3 and 5. Finally, a submerged PAR sensor should be located at 1.0 m at station 2, 3, and 5, as well as at 1. 5 m at station 8 and 9; recording PAR every 30 minutes to meet Objective 4 and address Target 4. An additional instrument should be established at the Ft. Myers Service Center to record natural variation in air PAR as a reference to observed changes in the submerged sensors. In addition to the instrument measurements, a secchi disk depth measurement (Objective 4) should be taken at each station when instruments are cleaned and calibrated.

TABLE D-5: MONITORING SITES, PARAMETERS SAMPLED, MONITORING OBJECTIVES (FROM MONITORING OBJECTIVES SECTION), AND THE FUNDING SOURCE SPONSORING THE SITE INSTALLATION AND MAINTENANCE. CORPS OF ENGINEERS (COE), SOUTH FLORIDA WATER MANAGEMENT DISTRICT (SFWMD), SANIBEL-CAPTIVA CONSERVATION FOUNDATION (SCCF) AND C-43 WEST BASIN STORAGE RESERVOIR PROJECT (PROJECT)

Monitoring Site and Parameters	Objective(s) Addressed	Funding Sponsor
S-79 (Franklin Dam)	Compare flow from S-79 to project target	COE
1 – Total Nitrogen (TN upstream side of S-79)	1- Determine daily loading (TN concentration X flow)	New platform & sensors – SCCF or Project
2 – TN, inorg N, TP,inorg P, Chl-a, color, turbidity, D.O.	2 - Compare Chl-a conc., trends, and blooms freq. 3 - Compare D.O conc and diurnal fluctuation 4 - Compare PAR levels and tape grass requirements 5 - Compare N, P, color, and turbidity & trends	-Existing SFWMD Platform -Sensors: SCCF or Project
3 - TN, inorg N, TP,inorg P, Chl-a, color, turbidity, D.O., PAR	2 - Compare Chl-a conc., trends, and blooms freq. 3 - Compare D.O. conc and diurnal fluctuation 4 - Compare PAR levels and tape grass requirements 5 - Compare N, P, color, and turbidity & trends	-Existing SFWMD Platform -Sensors: SCCF or Project
4- TN, inorg N, TP,inorg P, Chl-a, color, turbidity, D.O	2 - Compare Chl-a conc., trends, and blooms freq. 3 - Compare D.O. conc and diurnal fluctuation 5 - Compare N, P, color, and turbidity & trends	-Existing SFWMD Platform -Sensors: SCCF or Project
5 - TN, inorg N, TP,inorg P, Chl-a, color, turbidity, D.O., PAR	2 - Compare Chl-a conc., trends, and blooms freq. 3 - Compare D.O. conc , diurnal fluctuation, and oyster requirement 4 - Compare PAR levels and seagrass requirements 5 - Compare N, P, color, and turbidity & trends	-Existing Platform (?Salinity M Plan) -Sensors: Project
6 – D.O.	3 - Compare D.O. conc , diurnal fluctuation, and oyster requirements	-Existing SFWMD Platform -Sensor: Project
7 - TN, inorg N, TP,inorg P, Chl-a, color, turbidity,	2 - Compare Chl-a conc., trends, and blooms freq. 5 - Compare N, P, color, and turbidity & trends	-Existing SFWMD Platform -Sensors: SCCF or Project
8 - TN, inorg N, TP,inorg P, Chl-a, color, turbidity	2 - Compare Chl-a conc., trends, and blooms freq. 5 - Compare N, P, color, and turbidity & trends	SCCF
9 - TN, inorg N, TP,inorg P,	2 - Compare Chl-a conc., trends, and blooms freq.	-Existing Platform

Chl-a, color, turbidity, D.O., PAR	3 - Compare D.O. conc and diurnal fluctuation 4 - Compare PAR levels and seagrass requirements 5 - Compare N, P, color, and turbidity & trends	(?Salinity M Plan) -Sensors: Project
10 - TN, inorg N, TP,inorg P, Chl-a, color, turbidity, D.O., PAR	2 - Compare Chl-a conc., trends, and blooms freq. 3 - Compare D.O. conc and diurnal fluctuation 4 - Compare PAR levels and seagrass requirements 5 - Compare N, P, color, and turbidity & trends	SCCF
11 - TN, inorg N, TP,inorg P, Chl-a, color, turbidity, D.O.,PAR	2 - Compare Chl-a conc., trends, and blooms freq. 3 - Compare D.O. conc and diurnal fluctuation 4 - Compare PAR levels and seagrass requirements 5 - Compare N, P, color, and turbidity & trends	SCCF

D.3.2.6 Data Quality

Routine samples and routine quality control samples are collected in accordance with the Florida Department of Environmental Protection (Department) Quality Assurance Rule, 62-160.200 and 62-160.320, F.A.C. and the District Field Sampling Quality Manual (FSQM). Applicable sections of the FSQM include auto-sampler collection methods; field test methods; and quality control procedures. Corrective actions for data not meeting the quality objectives may be taken as outlined in the Quality Assurance Systems Requirement (QASR).

D.3.3 Project Monitoring and Assessment Plan: Oysters

This oyster monitoring plan is intended to help address concerns related to downstream estuary impacts and benefits related to changes in freshwater inflow and salinity due to project implementation.

D.3.3.1 Background

The eastern oyster is a bivalve in the family Ostreidae. It is important both commercially and recreationally in fisheries along the Atlantic and Gulf of Mexico coasts of North America. It requires a proper substrate and suitable salinity conditions for existence. Due to its sedentary nature, the eastern oyster is susceptible to undesirable natural and artificial environmental changes, as well as pollution within its habitat. Environmental disruptions are responsible for reducing oyster populations and their traditional habitats (Cake 1983).

In the Caloosahatchee Estuary, oysters have been identified as a Valued Ecosystem Component (VEC). Oysters are natural components of southern estuaries and were documented to be abundant in the system. The eastern oyster is important for providing reef habitat that serves as areas of concentration (Wells 1961. Bahr and Lanier 1981) and as food for numerous estuarine species including gastropod mollusks, polychaete worms, decapod crustaceans, various boring sponges, fish, and birds, including the endangered oyster catcher. The eastern oyster is the dominant species in the oyster reef community. There may be over 40 species of macrofauna living in oyster beds with the total number of species exceeding 300 (Wells, 1961; Ingle & Smith,

1956; Woodburn, 1965; McDonald, 1982; Peters, 1981; Meyer, 1994; Tolley, 2006).

Implementation of the C43 West Basin Reservoir Project expects to restore hydrology in the Caloosahatchee Estuary by reducing the number of low and high flow water delivery events. It is anticipated that if flows are restored to more natural conditions then there should be an improvement of recruitment and survivorship of the eastern oyster (*Crassostrea virginica*).

There is an existing RECOVER monitoring program for the eastern oyster (*Crassostrea virginica*) in the Caloosahatchee Estuary. This program began collecting data in January 2004.

D.3.3.2 Monitoring Objectives

1. Continue long term monitoring of oysters (*Crassostrea virginica*) in the Caloosahatchee Estuary.
2. Determine if the restoration of beneficial patterns of freshwater inflow, salinity and water quality to the Caloosahatchee Estuary will achieve the expected distribution, community structure and viability of oysters.
3. Examine the effects of variation in salinity on oyster condition and health.
4. Identify areas suitable for the development and therefore potential restoration of oyster reefs.
5. Create additional monitoring stations at newly assembled reefs, as they are constructed, in order to track
6. Addresses the null hypothesis stated below that is intended to assess the success of the project.

D.3.3.3 Null Hypothesis

The general null hypothesis - As a result of the operation of the CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR, there are either detrimental impacts to the oyster community, or no changes in the estuarine oyster population, related to – (a) the base line conditions established from years of sampling prior to reservoir operation in a variety of habitats and salinity zones along the downstream gradient of the estuary.

Determining if the null hypothesis is true depends on monitoring oysters and at least salinity commensurate with the project operation, by:

1. Comparing populations and health with historic data sets;
2. Assessing trends in oyster populations and health during project operation to determine the direction of change

3. Comparing current project related flows and oyster populations and health with similar seasonal conditions when freshwater inflows would have been equal to non-project flow.

D.3.3.4 Monitoring Measures and Targets

1. Monitoring Measure (monthly): *Perkinsus marinus* prevalence. *Perkinsus* infection is measured on a scale of 0 to 5 with five being the highest infestation of the parasite.

Target: *Perkinsus marinus* prevalence is less than 1.

Adaptive Management Trigger: When prevalence becomes a 3 or higher, additional freshwater should be released to lower salinity in the lower estuary.

2. Monitoring Measure (monthly): Spat Recruitment (May- October).

Target: 5 spat per shell per month

Adaptive Management Trigger: When there is less than 5 spat per shell for two or more consecutive months flows should be decreased to reduce the number of larvae being flushed from the system.

3. Monitoring Measure: Density of Live Oysters.

Target: Greater than 200 living oysters per m^2 at identified sample locations.
Adaptive Management Trigger: When there are less than 100 live oysters per m^2 water flow should be adjusted to provide optimum salinities in the lower estuary.

4. Monitoring Measure: Condition Index of Oysters (CI). CI measures the general health of the oyster and generally ranges from 0 to 8 with 8 being the best.

Target: CI changes seasonally but should not be less than 2.5.
Adaptive Management Trigger: A CI less than one indicates poor oyster health usually resulting in lack of food. If the CI falls below 2 flows should be adjusted to increase primary and secondary productivity in the estuary.

D.3.3.5 Monitoring Approach

A long term oyster monitoring program based on previous studies and existing monitoring will be carried out in the Caloosahatchee Estuary. The program will utilize existing methodologies and sampling locations for consistency and will incorporate existing data as baseline for a comparison to project condition.

Continued post construction monitoring will allow tends to be identified once the project becomes functional. Additional sampling locations will be established as new reefs are constructed.

Twice a year (summer, winter) one 100 m transects (parallel to shore) will be established at seven stations (***Figure D-9***). Each transect will be subdivided into seven (7) 20 m long portions (0-20, 20-40, 40-60, 60 – 80, 80 – 100) On each sampling date, 5 – 1 m2 quadrats will be placed randomly along each transect (n=5 quadrats per transect, 1 quadrat with each 20 m portion, n = 10 quadrats per site,). For each quadrat, the following measurements will be determined.

- Percent Adults Live versus Dead: Count and record the number of live adult oysters and the number of dead adult oysters within the 1 m^2 quadrat.
- Adult sizes (Live versus Dead): Measure and record the maximum length of all adult oysters (both dead and alive) within the 1 m^2 quadrat. Be sure to distinguish between the two.
- Water Depth: Measured to the nearest centimeter at the center of each of the 1 m^2 quadrats; measured from water surface; report in meters (m).
- Spat Recruitment: Oyster spat recruitment will be conducted at each oyster monitoring station using old adult oyster shells strung together with a weighted galvanized wire. Three shell strings will be deployed at the site each month. A shell string will consist of 12 oyster shells, each 5.7-7.5 cm long with a hole drilled in the center and oriented inner surface down, when suspended off the bottom. Oyster spat settlement will be monitored monthly (March – October) by counting the number of spat settled on the underside of strung shells.
- Juvenile Oyster Growth and Survival: Four hundred hatchery raised juvenile oysters (10 mm-20 mm) will be deployed at all sampling locations in 0.5 mm wire-mesh bags. Fifty randomly selected oysters will be measured to the nearest 0.1 mm every month from each location for 24 months. Beginning year 3, 250 more juvenile oysters in wire mesh bags will be deployed at each site to examine the effects of high freshwater releases and resulting low salinities on juvenile oysters. Similar to year 1 and 2, growth of juvenile oysters will be measured monthly. The effect of predation on oyster survival will be determined by placing juvenile oysters in open vs. closed cages.
- Oyster disease prevalence and intensity: 15-20 oysters / sampling location will be monitored monthly for disease prevalence and intensity of the oyster pathogen *Perkinsus marinus*.

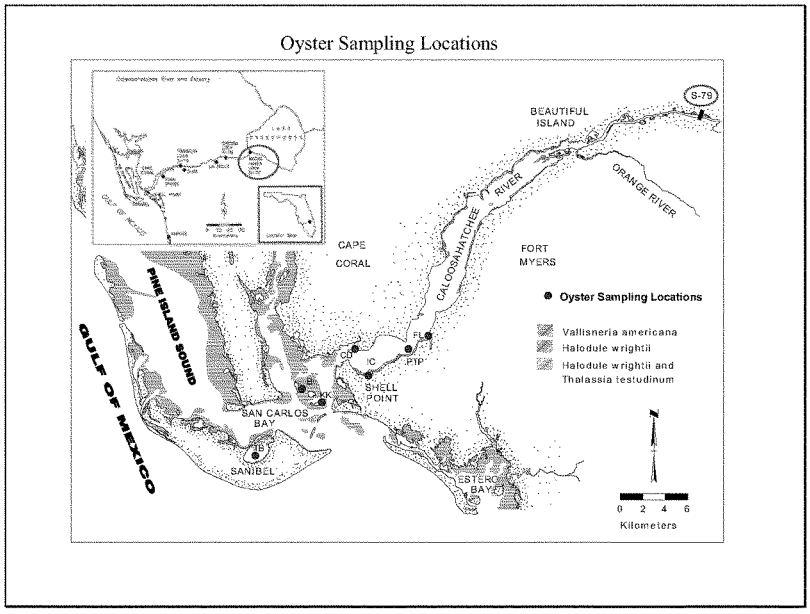


FIGURE D-9: OYSTER SAMPLE LOCATIONS (IC: IONA COVE, CD: CATTLE DOCK, BI; BIRD ISLAND, KK: KITCHEL KEY, TB: TARPON BAY, FL: FUTURE LOCATION)

Concurrent with sampling schedule, the Contractor shall obtain vertical profiles of dissolved oxygen, salinity, temperature, pH, and conductivity using standard electronic sensors calibrated to manufacturer's specifications. Contractor must meet and follow the minimum requirements in the FDEP field Sampling SOPs for field testing (FT), field documentation (FD), and field quality control (FQ). Depth intervals shall be surface and bottom if the depth is greater than 1 m. A log of pre-calibration and post-calibration checks along with records of yearly maintenance of the instruments cables and sensors should be kept. Copies of these logs must be submitted with each data submission. Water depth, weather conditions (i.e. cloudy, windy etc.), time of day and tidal stage will be recorded (low, high, ebbing, flooding).

D.3.3.6 Data Quality

Routine samples are collected in accordance with RECOVER guidelines and published standards regarding monitoring oysters.

D.3.3.7 References

Bahr, B. M., and W. P. Lanier. 1981. The ecology of intertidal oyster reefs of the south Atlantic: a community profile. US Fish and Wildlife Service, Office of Biological Services, Washington, D.C., FWS/OBS-81/15.

Cake, E.W., Jr. 1983. Habitat suitability index models: Gulf of Mexico American oyster. U.S. Fish Wildl. Ser.FWS/OBS-82/10.57. 37p.

Ingle, R.M. and F.G.W. Smith. 1956. Oyster culture in Florida. Florida Board of Conservation, Educational Series 5, 25 pp.

McDonald, J. 1982. Divergent life history patterns in the co-occurring intertidal crabs Panopeus herbstii and Eurypanopeus depressus (Crustacea: Brachyura: Xanthidae). Marine Ecology Progress Series 8:173-180.

Meyer, D.L. 1994. Habitat partitioning between the xanthid crabs *Panopeus herbstii* and Eurypanopeus depressus on intertidal oyster reefs (Crassostrea virginica) in southeastern North Carolina. Estuaries 17:674-679.

Peters, K.M. 1981. Reproductive biology and developmental osteology of the Florida blenny, Chasmodes saburrae (Perciformes: Blenniidae). Northeast Gulf Science 4:79-98.

Tolley, S.G., and A.K. Volety. 2005. The role of oysters in habitat use of oyster reefs by resident fishes and decapod crustaceans. Journal of Shellfish Research. 24: 1007-1012.

Wells, H.W. 1961 The fauna of oyster beds with special reference to the salinity factor. Ecol. Monogr. 31:239-266.

Woodburn, K.D. 1965. Clams and oysters in Charlotte County and vicinity. Florida Board of Conservation, no. 62-12, 29 pg.

D.3.4 Project Monitoring and Assessment Plan: Submerged Aquatic Vegetation

This submerged aquatic vegetation monitoring plan is intended to help address concerns related to downstream estuary impacts and benefits related to changes in freshwater inflow and salinity due to project implementation.

D.3.4.1 Background

Submerged aquatic vegetation (SAV) is important economically and ecologically, serving as major structural elements in estuarine and coastal waters. They provide food, habitat, and refuge to invertebrates, birds, marine turtles,

mammals, and many marine recreationally and commercially targeted fishes during some stage of their life cycle. In addition to being important constituents of coastal food webs, SAV also stabilize sediments, inhibit their re-suspension, sequester atmospheric carbon, and export carbon to other systems, improve water transparency, trap and cycle nutrients, and protect shorelines through wave energy attenuation (Duarte 2002). Because of these extensive ecosystem services, SAV ecosystems are among the most significant on the planet.

By definition, SAV includes both marine and freshwater aquatic angiosperms as well as macroalgal species. Native macroalgal species (attached and drift) are desirable constituents of estuaries, though an overabundance of these taxa may be detrimental to angiosperms (Onuf 1996).

In the Caloosahatchee estuarine system, five seagrass species are found, including the uncommon presence of *Halophila decipiens* (paddle grass) and *Halophila engelmannii* (star-grass) in San Carlos Bay area. *Halodule wrightii* (shoal grass) and *Thalassia testudinum* (turtle grass) are the dominant two species in San Carlos Bay (3), with *Syringodium filiforme* (manatee grass) also contributing to the lush beds in lower Pine Island Sound (***Figure D-10)***. Their density, coverage, and depth increases with distance from the river, while population variability decreases. Only shoal grass is found upstream of Shell Point. The dominant freshwater species of concern is *Vallisneria americana* (American wild celery - tape grass). One brackish water species *Ruppia maritima* (widgeon grass) is also found in the upper and middle section of the estuary upstream of Shell Point, but is uncommon and usually ephemeral.

Although there are species-specific variations, generally speaking SAV distributions are limited by four environmental factors: light, salinity, temperature, and nutrients (Dennison et al. 1993; Kemp et al. 2004). In the Caloosahatchee, studies have documented that SAV distribution and subsequently its functionality, is strongly related to limits on their physiological response to salinity and light. Except at the distribution margins, plant location in the estuary generally depends on salinity, while growth characteristics controlling plant height and depth strongly relates to light attenuation within salinity tolerant zones.

Submerged Aquatic Vegetation and Sampling Locations

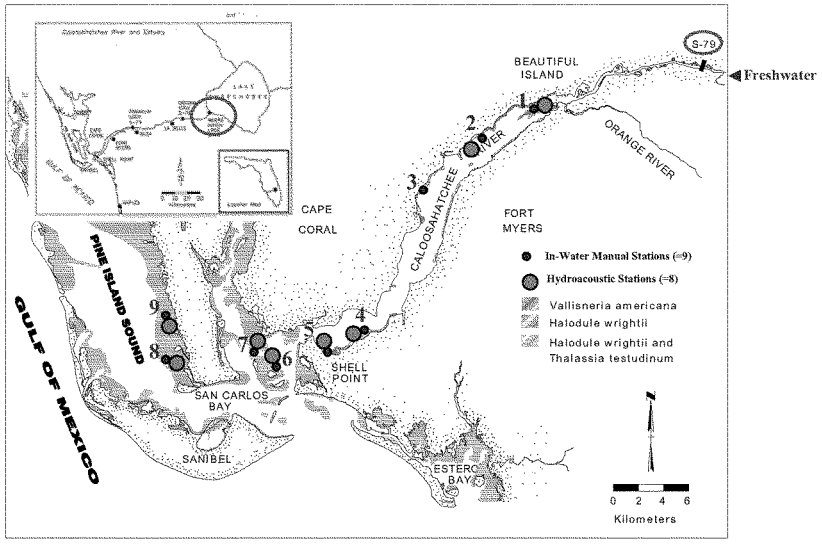


FIGURE D-10: MAP OF CALOOSAHATCHEE ESTUARY AREA AND LOCATION OF DOMINANT SAV DURING IDEAL CONDITIONS. DEPICTED ARE THE PROPOSED SAV SAMPLING SITES, USING: (1) THE TRADITIONAL MANUAL METHOD DEPLOYING DIVERS TO MEASURE PLANTS ALONG FIXED TRANSECTS; AND (2) HYDROACOUSTIC METHODOLOGY.

Superimposed upon this physiologically based template are a variety of factors, such as impacts via grazing (Lewis 1986). The relationship between SAV and herbivores is not well understood. The West Indian Manatee (*Trichechus manatus*) is among the few vertebrate grazers utilizing SAV as the main source of their diet although grass carp (*Ctenopharyngodon idella*) too have been documented as having an affect on freshwater SAV species (Hestand and Carter, 1978). Large herbivores such as manatees may graze destructively (Lefebvre et al. 2000) and thus inhibit the recovery of the SAV by disturbing their rhizospheric components when removing the photosynthetic leaves (Thayer et. al., 1984). The gaps created by grazing within the SAV habitat may alter the functionality and subsequently the value of the SAV habitat by increasing landscape heterogeneity and thus influencing both floral (may initiate succession) and faunal relationships.

Tape grass disappeared from the upper estuary sampling area following the 2000-2001 draught when salinity exceeded the plants tolerance limits. Despite

the return of the plant to the area and favorable salinity conditions, plant recovery to the pre-drought density (***Figure D-11***) and canopy height have not been sustained, possibly in part because the diminished plants have not been able to compete with the rate of grazing.

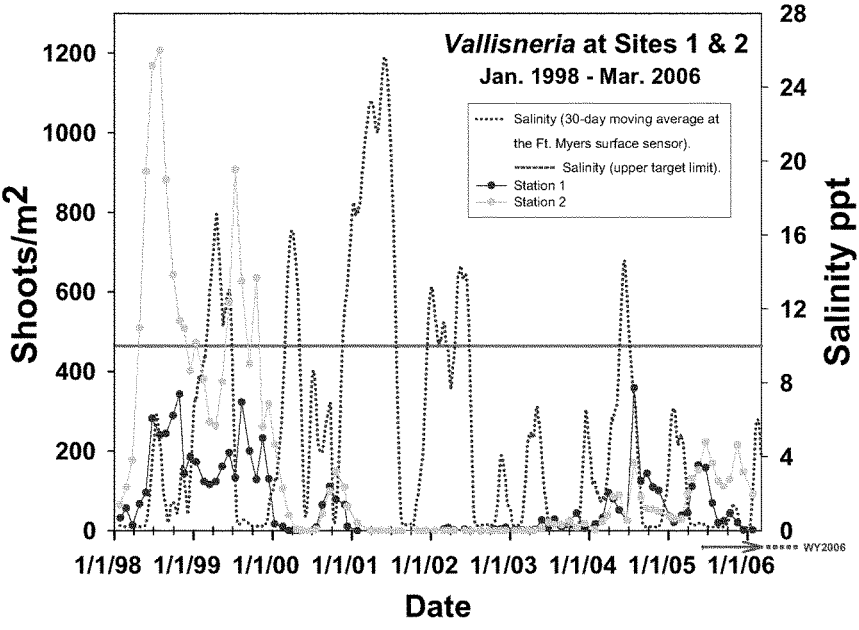


FIGURE D-11: TAPE GRASS (*VALLISNERIA AMERICANA*) SHOOT DENSITY IN THE UPPER CALOOSAHATCHEE ESTUARY. RECENT DATA ARE FROM THE STATIONS MONITORED BY THE SANIBEL-CAPTIVA CONSERVATION FOUNDATION (STATIONS 1 AND 2 IN FIGURE 7, USING MANUAL METHODS).

Pursuant to the requirements of "Florida Water Resources Act," the South Florida Water Management District established minimum flows and levels (MFLs) for freshwater inflow entering the Caloosahatchee Estuary via the Franklin Lock and Dam (structure S-79). The minimum flow is defined as" the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area" (section 373.042(1), F.S.). For purposes of establishing minimum flows, significant harm is defined as a loss of water resource functions that takes more than two years to recover. The minimum flow criterion is linked to the concept of protecting valued ecosystem components from significant harm. An MFL rule, has been established in the Caloosahatchee Estuary (SFWMD 2003 and 2005), whereby an exceedance occurs during a 365 day period, when: (a) A 30-day average salinity concentration exceeds 10 parts per thousand at the Ft. Myers salinity station

(measured at 20% of the total river depth from the water surface at a location of latitude 263907.260, longitude 815209.296; or (b) A single, daily average salinity exceeds a concentration of 20 parts per thousand at the Ft. Myers salinity station. Exceedance of either (a) or (b), for two consecutive years is a violation of the MFL. The intent of the rule is to maintain *Vallisneria* habitat that will support both estuarine and juvenile marine organisms. Currently, the Rule identifies a minimum mean monthly flow of 300 cfs is required to be delivered to the estuary between the months of November – March (dry season) in order to not reach the salinity exceedance limits. More recent modeling and field studies indicate that a flow of 450 cfs is more appropriate to avoid exceedance during periods of low rainfall and freshwater inflows. This low flow limit is reflected in the target S-79 flow distribution identified within Caloosahatchee River (C-43) West Basin Storage Reservoir - Caloosahatchee Estuary Hydrologic Evaluation Performance Measures (2005 – ***Table D-6***).

TABLE D-6: TARGET FREQUENCY DISTRIBUTION OF MEAN MONTHLY FLOWS FROM S-79 (CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR - CALOOSAHATCHEE ESTUARY HYDROLOGIC EVALUATION PERFORMANCE MEASURES, 2005).

Discharge Range (cfs) From S-79	Percent Distribution Of Flows From S-79
0 to 450	0%
450 to 500	42.8%
500 to 800	31.7%
800 to1500	19.2%
1500 to 2800	5.6%
2800 to 4500	0.7%
>4500	0%

The variability, timing, frequency, and volume of freshwater inflows effect salinity fluctuations, which in turn, can restrain SAV distribution and growth rates. For example, Montague and Ley (1993) found that SAV biomass was directly proportional to salinity, with biomass decreasing as salinity variation increased. As discussed above, in the upper estuary, naturally occurring tape grass will not survive prolonged periods of elevated salinity. The seagrass *Halodule wrightii* can persist in areas with higher variation in salinity than other seagrass, thus this species maintains a minimum presence upriver of Shell Point. *Thalassia testudinum* and *Syringodium filiforme* will not tolerate

prolonged periods of reduced salinity as a result of manipulated water release, and are located only in areas with relatively low variation in salinity. Regardless of the seagrass species, the frequent release of large volumes of freshwater from S-79 commonly results in freshening of the river to a point that downstream euryhaline SAV species are negatively impacted (***Figure D-12***). Achieving the target flow distribution (***Table D-6***) will reduce the occurrence of excessive discharges and maintain salinity variability in a range more supportive of SAV throughout the longitudinal gradient of the estuary.

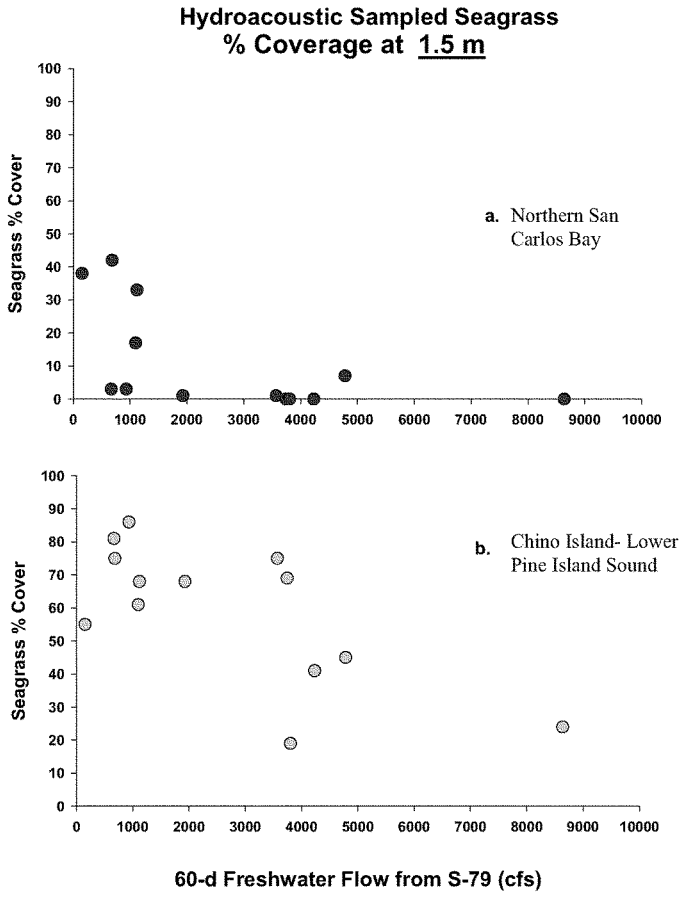


FIGURE D-12: SEAGRASS COVERAGE AT TWO LOCATIONS DOWNSTREAM OF THE CALOOSAHATCHEE RIVER (A. SITE 7; AND B. SITE 8-IN FIGURE 7) COMPARED TO 60-DAY AVERAGE FRESHWATER INFLOW FROM S-79 PRIOR TO SAMPLING.

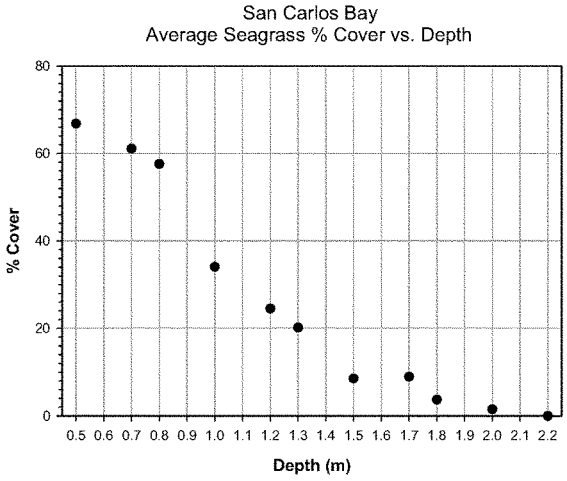


FIGURE D-13: AVERAGE SEAGRASS COVERAGE ASSOCIATED WITH DEPTH DURING A WIDE RANGE OF FRESHWATER INFLOW CONDITIONS USING HYDROACOUSTIC SAMPLING METHODOLOGY AT THE NORTHERN SAN CARLOS BAY STATION ADJACENT TO MERWIN KEY (SITE 7, FIGURE 7).

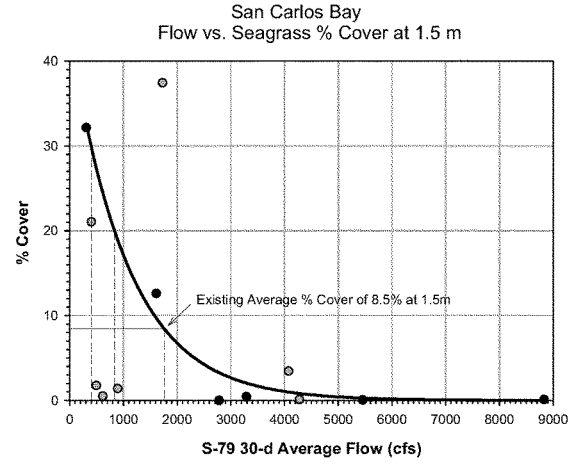


FIGURE D-14: PERCENT SEAGRASS COVERAGE AT 1.5 METER IN SAN CARLOS BAY (SITE 7. FIGURE 7) DURING A WIDE RANGE OF 30-DAY AVERAGE INFLOW CONDITIONS FROM S-79.

An exponential decay regression line is fitted to the subset of flows (bold points). Drop lines are provided from the existing 8.5% average coverage and the

expected improved coverage of 20% and 30% when flows approach the dominant target range of 450-800 cfs (***Table D-6***).

Seagrass are distributed along a depth gradient and when conditions of salinity and light are good, seagrass can extend to over 2 meters depth in San Carlos Bay (***Figure D-13***). Both salinity and light are influenced by freshwater inflow and impact the percent cover of seagrass along its depth range (***Figure D-9***). For example, when flows are within the target flow range (***Table D-6***), seagrass percent cover at 1.5 meter can be > 30% (***Figure D-14***).

D.3.4.2 Monitoring Objectives

1. Quantify SAV throughout the expected impacted area, so to: (a) Compare the discharge distribution from S-79 to the target SAV goals identified below; (b) Determine if the source of the variation is due to basin rainfall runoff or Lake Okeechobee Releases; (c) assess if SAV changes are consistent with expected values compared to salinity and water quality; and (d) where possible, relate changes in SAV to operation of project reservoir.
2. Determine tape grass coverage as it relates to (a) the 30-day moving average salinity $\leq$ 10 ppt during the dry season at the Ft. Myer's continuous salinity sensor (at 20% of water depth), such that salinity in the Beautiful Island area remains <10 ppt, in order to maintain a continuous population of tape grass in the area between the Ft. Myers U.S 41 northbound bridge and Beautiful Island (Sites 1 and 2, Figure 1), with a minimum bottom coverage of 20% to 1 meter (MLLW) and blade length $\geq$ 10 cm; and (b) take remedial action to address over grazing by herbivores that may prevent attaining this goal.
3. Determine shoal grass coverage upstream of Shell Pt. as it relates to the occurrence of average monthly salinity <15 ppt at the Cape Coral Bridge sensor. Salinity $\geq$20 ppt is promoted downstream of Peppertree Pt., in order to maintain: (a) continuous shoal grass coverage in the area immediate downstream of Peppertree Pt. (Site 4, Figure 1); and (b) continuous shoal grass coverage $\geq$ 30% in Iona Cove (Site 5) to 1 meter water depth (MLLW) with an average blade length $\geq$ 10 cm.
4. Determine changes in aerial seagrass coverage as it relates to the maintenance of average monthly salinity $\geq$ 30 ppt at the Sanibel Causeway (measured by the near surface continuous sensor), with a goal of increasing restoring seagrass coverage by 38% in the San Carlos Bay area circa Harris et al. 1983 aerial survey.
5. Determine average seagrass coverage per water depth, with a goal of maintaining a coverage of $\geq$ 30% at 1.5 m in mid-San Carlos Bay (Site 6 and 7), and $\geq$ 20% at $\geq$ 1.75 meters, with blade length $\geq$ 10 cm.
6. Determine average seagrass coverage per water depth in lower Pine Island Sound, with a goal of maintaining a coverage of $\geq$ 65% at 1.5 m.

7. Determine seagrass species composition, with a goal of maintaining annual shoal grass and turtle grass percent composition in San Carlos Bay and Pine Island Sound (Sites 6, 7, 8, and 9) at levels normally associated with S-79 monthly average flows of ≤1,000 cfs, as measured between 0.5 –1.0 meters depth.
8. Compare historical SAV coverage, density, and blade length data at all sites with similar data collected during project operation, with a goal of detecting an increase in the average amount of each of these metrics, as well as a reduction in their variability (annual, between seasons, and within seasons).
9. Addresses the null hypothesis stated below that is intended to assess the success of the project.

D.3.4.3 Null Hypothesis

The general null hypothesis - As a result of the operation of the C-43 West Basin Storage Reservoir (BSR), there will be no beneficial changes in freshwater inflows from S-79, nor improvement in estuarine SAV populations, related to – (a) recent area wide population data (positive trend of increasing area coverage); (b) historic seasonal SAV patterns; and (c) variation in SAV within distinct estuarine zones of the estuary.

Determining if the null hypothesis is true depends on monitoring SAV and related water quality commensurate with the project operation. To meet these demands the following SAV monitoring measures and targets are identified.

D.3.4.4 Monitoring Measures and Targets

1. Monitoring Measure: Average Seagrass Coverage

Targets: Maintain average seagrass coverage of > 30% at 1.5 m in mid-San Carlos Bay (Site 6 and 7), and > 20% at > 1.75 meters, with blade length > 10 cm.

Maintain average seagrass coverage of > 65% at 1.5 m in lower Pine Island Sound.

Maintain annual shoal grass and turtle grass percent composition in San Carlos Bay and Pine Island Sound (Sites 6, 7, 8, and 9) at levels normally associated with S-79 monthly average flows of <1,000 cfs, as measured between 0.5 –1.0 meters depth.

Improvement seagrass coverage, density, and blade length at all sites as indicated by an increase in the average amount of each of these metrics, as well

as a reduction in their variability (annual, between seasons, and within seasons).

Adaptive Management Trigger: (1) Long term - When there is no significant increase toward achieving the above monitoring measures within any of the geographic reference locations, thus satisfying the null hypothesis as per the condition described above; and (2) Short Term (real time) - When there is a significant decrease (or threat of adverse impacts) in the current monitoring measures as a result of project operation compared to no action (reservoir operation) or not implementing an improved operation scenario (considering other resources).

2. Monitoring Measure: SAV recovery and protection linked to meeting 30 Day Moving Average Salinity goals.

Targets: Achieve the MFL salinity criteria by augmenting freshwater releases to maintain a 30-day moving average salinity < 10 ppt during the dry season at the Ft. Myer's continuous salinity sensor (at 20% of water depth), such that salinity in the Beautiful Island area remains <10 ppt, in order to maintain a continuous population of tape grass in the area between the Ft. Myers U.S 41 northbound bridge and Beautiful Island (Sites 1 and 2, ***Figure D-15***), with a minimum bottom coverage of 20% to 1 meter (MLLW) and blade length > 10 cm. Limit the occurrence of average monthly salinity <15 ppt at the Cape Coral Bridge sensor, so salinity >20 ppt is promoted downstream of Peppertree Pt., in order to maintain: (a) continuous shoal grass coverage in the area immediate downstream of Peppertree Pt. (Site 4, ***Figure D-15***); and (b) continuous shoal grass coverage > 30% in Iona Cove (Site 5) to 1 meter water depth (MLLW) with an average blade length > 10 cm.

Maintain an average monthly salinity > 30 ppt, as measured at the Sanibel Causeway near surface continuous sensor, in order to regain historical seagrass coverage lost in the San Carlos Bay area, with a goal of increasing coverage by 38% to circa Harris et al. 1983 aerial survey.

Adaptive Management Trigger: (1) Long term - When there is no significant increase toward achieving the above recovery goals within any of the geographic reference locations, thus satisfying the null hypothesis as per the condition described above; and (2) Short Term (real time) - When there is a significant decrease, threat of adverse impacts, or loss in recovery gains for tape grass, shoal grass upstream of Shell Pt, or the area wide coverage in San Carlos Bay as a result of project operation compared to no action (reservoir operation) or not implementing an improved operation scenario (considering other resources).

D.3.4.5 Monitoring Approach

Daily freshwater discharge from Lake Okeechobee and S-79 are measured by the Corp of Engineers and posted electronically on COE and SFWMD web sites. This information is part of normal operation and therefore no additional Caloosahatchee River (C-43) West Basin Storage Reservoir project cost is required. Salinity information will be provided by the network of continuous sensors described in the Salinity Monitoring Plan and additional information collected concurrent to SAV monitoring. Water quality data also will be provided by additional sensors (see Water Quality Monitoring Plan) and concurrent measurements of important parameters.

If low tape grass coverage, density, or blade length is attributed to over grazing, then determine the species responsible and take remedial action, especially if grazing is by introduced species, like grass carp. The District is planning to investigate grazing problems and potential remedial actions, depending on the extent of the problem, the species responsible, their pervasiveness, their dependency on tape grass, and their sensitivity to water quality conditions.

Monitoring SAV to determine if the above objectives and targets are achieved requires three methodologies are employed. Each approach provides progressively more detail, but also increasingly sacrifices total area covered. Each method has inherited limitations, but when coupled together in this monitoring plan, will provided: accurate (low uncertainty) long term information for addressing the above targets and monitoring objectives; as well as provide short term feed back for changing project component operation.

Continuation of aerial photography will be required to determine if seagrass coverage is trending upward, toward achieving objective 4. Overflights are the only tested method that provides a system wide approach. A minimum of 3 flights will be required to detect a change and probably more than 5. Currently, flights are made every 2 years. Flights should be flown as late in the year (April-June) as possible to view plants within the growing season. Delays past June run the risk of missing the flight window because of wet season cloud cover and poor water clarity from runoff. Species distinction is not possible with this method, percent coverage is qualitative, and the viewing depth is limited based on water clarity. Also, very low coverage and plant density can not be detected.

Figure D-15 indicates the current location of in-water manual sampling. This is a traditional approach that requires divers to hand measure/collect plants contained in quadrants randomly placed along permanent transects. Each station consists of two 100 meter transects parallel to shore and two perpendicular transects that do not necessary reach the edge of the bed at each station. Five, 1.0 m2 quadrants, are measured per transect each month. This method provides precise quantitative estimates of species density in each

quadrant, regardless of the plant size and coverage. Sampling and information collected should at a minimum follow the guidelines being developed by RECOVER for manual SAV monitoring. Limitations to this method are sample size for the amount of staff time required (5 quads/4 transects and a sample size, n = 4 per visit monthly?). Therefore, the ability to detect change is limited by sample variability and each estimate represents only a small area. Thus patchiness (areas of increased or depressed coverage) can bias the results.

Hydroacoustic methodology has been used since 1996 (baseline) in the Caloosahatchee Estuary to detect seasonal and annual change in seagrass coverage and plant height (***Figure D-15***). This method provides an approach that fits between the total area coverage provided by remote aerial photography and the manual, site specific approach. Hydroacoustic sampling is conducted at the locations indicated in ***Figure D-15*** and is generally in close proximity to the manual method stations. Thus, water quality impacts to SAV can be considered the same for both methods. Hydroacoustic sampling design consists of 10 transects, usually hundreds of meters long, with some extending well beyond the plant depth at each station. Like the manual method, this approach is not restricted by the time of year, water and weather conditions, or number of sampling events. However, currently, sampling is conducted three times per year during the growing season between March and September. While the sample boat transverses the transect at about 2.5 knots, a digitized sample and GPS position is recorded with total plant coverage, canopy height, and bottom depth every 0.5 second, which is equivalent to every 0.5-1.0 meter. This translates to an extremely large quantitative sample size with large area coverage during a short on-site time commitment (1-2 hours). Therefore, the ability to detect change is greater then the manual method and more quantifiable than remote photography, at least for the area covered. Limitations include the inability to: distinguish species; detect plants in very low density; or when plants are shorter than 5-7 cm.

Each method is uniquely suited to address at least one objective and assist on others. ***Table D-7*** identifies each sampling method, the monitoring objective(s) of the eight identified above that the method will address, and the expected funding sponsor for each method. As indicated above, only remote aerial photography can adequately address Objective 4, and it can also contribute to confirming Objectives 3a and 8. Manual sampling is the only method able to address Objective 7, but it can contribute to objectives 2, 3, and 8. The manual method will also be critical for comparison to hydroacoustic results, especially when morphometrics decline toward the limits of hydroacoustic detection. The hydroacoustic is best suited for addressing Objectives 2, 3b, 5, 6 and also is important for evaluating Objective 8.

The results of all three SAV methods should be compared to: the salinity and water quality measured during time of collection; and the salinity and water

quality collected as specified by their respective monitoring plans. This comparison should delineate their influence on SAV related to the operation of the reservoir and help explain SAV changes if detected. If and when water quality targets discussed in the Water Quality Monitoring Plans are approached, then is there the expected positive SAV responses.

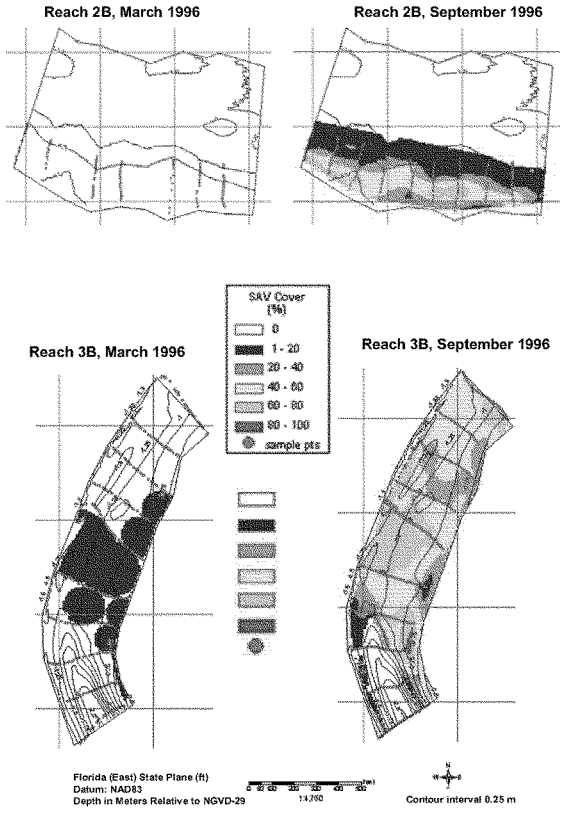


FIGURE D-15: EXAMPLE OF HYDROACOUSTIC MAPPING COVERAGE AT REACH 2B IN IONA COVE (SITE 5) AND REACH 3B IN NORTHERN SAN CARLOS BAY (SITE 7) SHOWING THE 10 TRANSECTS SAMPLED DURING MARCH AND DECEMBER 1996 AND THE RESULTING PLANT COVERAGE AND DEPTH CONTOURS.

TABLE D-7: SAV MONITORING METHODS, PARAMETERS SAMPLED, MONITORING OBJECTIVES (FROM MONITORING OBJECTIVES SECTION), AND THE FUNDING SOURCE SPONSORING THE MONITORING. CORPS OF ENGINEERS (COE), SOUTH FLORIDA WATER MANAGEMENT DISTRICT (SFWMD), SANIBEL-CAPTIVA CONSERVATION FOUNDATION (SCCF) AND CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT (PROJECT).

Monitoring Method and Information Source	Objective(s) Addressed	Funding Sponsor
Flow from S-77 :Moore Haven & S-79: Franklin Dam	1a -Compare flow from S-79 to project target 1b - Determine if change in S-79 flow due to basin or Lake. 1c and d- Is detected changes due to altered flow from basin or Lake Okeechobee?	COE & SFWMD
Salinity and Water Quality (from respective Monitoring Plans)	1 - Influence of project on water quality and salinity and their influence on SAV. Are SAV and water condition targets valid or need to be changed?	SFWMD, SCCF and Project
1 – Aerial Photography	4 – Increase San Carlos bay Coverage and regain lost 38%.	SFWMD or Project
2 – Hydroacoustic Method (General SAV % cover, depth of occurrence, and canopy height)	1c and d- Detect SAV changes related to salinity and water quality and Project. 2 – Detect change in tape grass: meeting targets? 3 – Ground truth aerial photography and verify related trends. 4 – Detect change in Iona Cove *Halodule*: meeting targets? 5 – Detect change in San Carlos Bay SAV: targets? 8 – Improve SAV throughout estuary at historical locations and reduce variability.	SFWMD
3- In Water, manual method	1 - Ground truth/ verify Hydroacoustic sampling results & and measure plant too low in density & height trends. Use method to sample months not using Hydroacoustic method. 2 – Detect change in tape grass: meeting targets? 3 – Ground truth aerial photography and verify related trends. 4 – Detect change in Iona Cove *Halodule*: meeting targets? 7 – Maintain SAV species composition in San Carlos Bay.	SCCF, funded by SFWMD/Project

D.3.4.6 Data Quality

Routine samples are collected in accordance with RECOVER guidelines and published standards regarding monitoring SAV.

D.3.5 Project Monitoring and Assessment Plan: Fish

This fish monitoring plan is intended to help address concerns related to downstream estuary impacts and benefits related to changes in freshwater inflow and salinity due to project implementation.

D.3.5.1 Background

Estuaries are among the richest environments in the world. They provide a range of habitats for a diverse population of aquatic life; acting as a nursery for some species; and providing important physical and water quality conditions for permanent residents and temporary users, including over 75% of the commercially harvested marine fish and shellfish in Florida. An estuary is not an estuary without freshwater inflow, which provides: (1) input of nutrients and organic matter as the building block for an adequate food supply to higher trophic levels, including fish; (2) protection from predation by more mature life stages that can't tolerate lower salinity or can't find prey in naturally turbid estuarine waters; (3) a range of salinity conditions available for a variety of organisms with different requirements for growth and development; and (4) the regulation of larval transportation and retention. Within healthy estuaries are a variety of habitats, including submerged aquatic vegetation, oysters, mangroves, and a range of salinity zones that overlay these habitats which fulfill the various life stage requirements of a diverse population of fish.

Therefore, freshwater inflow and salinity in an estuary exerts a profound influence on the survival and distribution of fish, especially early life history stages. However, excessive variation in salinity can maintain estuarine biota in a constant state of flux between those favoring high salinity and those lower salinity. At the extreme, appropriate salinity conditions do not last long enough for some fish species to complete their life cycle and the estuary can become devoid of some self-sustaining populations. Therefore, changes to the salinity envelope in the Caloosahatchee will have the least detrimental effect if salinity shifts are more gradual and extreme rapid changes are avoided.

Estuarine populations of stenohaline fishes are most sensitive to atypical salinity regimes as either larvae (spotted seatrout), juveniles (tropical reef fish: yellowtail, lane and mutton snapper) or adults (spawning spotted seatrout and common snook). Therefore the timing and severity of salinity fluctuations becomes an important factor in reproduction and growth. Euryhaline fish populations that often associate with oligohaline habitats show a positive

association with increased freshwater flows relative to food availability (ex. feeding adult common snook).

Soft sediment (mud) fish communities have a positive association with healthy fine sediments, mud and their benthic animal communities as a food source (primarily gerreids, mugilids and engraulids) and habitat source (gobioid fishes). Benthic soft sediment invertebrate communities support one of the largest biomass components of indigenous Caloosahatchee fish communities. On the contrary, abiotic fine sediments ("muck") do not support this same soft sediment (mud) fish community and can create a bottom devoid of life often accompanied by anoxic conditions.

Healthy oyster bed habitat is essential for the survival of oyster dwelling fish. For example, population dynamics in *Gobiosoma bosc* (Gobiidae) is influenced by: (1) oyster reef structure; (2) live vs. dead oyster reef structure; (3) age and degradation/deterioration of oyster reef systems. *Gobiosoma bosc* plays a major trophic role in northern estuaries due to: its high production of ichthyoplankton; and its major role as an important vertebrate species directly associated with oyster reefs as critical habitat for feeding and spawning sites. *Gobiosoma bosc* is a major prey item for planktivorous fishes, chaetognaths, ctenophora, and as an adult it is prey for juvenile gray snapper *Lutjanus griseus*.

Estuarine seagrass and nearshore hard bottom dependent populations of juvenile tropical reef fish (lutjanids, serranids, scorpeanids, gobiids, blenniids and labrisomids) show a positive relationship with salinity, ex. higher densities at higher salinities. Spawning populations of seagrass and reef associated marine/mesohaline/polyhaline fish species are most affected by atypical (aseasonal) reduced salinities during their spawning period.

The Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute's Fisheries-Independent Monitoring (FIM) program is a long-term program designed to monitor the relative abundance of fishery resources in Florida's major estuarine, coastal, and reef systems. The monitoring approach has been employed in the Caloosahatchee Area since 2004. FIM program was developed to: 1) address the critical need for effective assessment techniques for an array of species and sizes of fishes, turtles, and selected invertebrates; 2) provide timely information for use in management plans; and 3) monitor trends in the relative abundance of fishes and select invertebrates in a variety of estuarine and marine systems throughout Florida. In addition to the primary goals of describing long-term trends in fishery abundance and size distribution related to fishery management, FIM data have been useful for preparing species inventories for major estuaries throughout Florida, documenting habitat and dietary needs for a variety of estuarine fishes and invertebrates, displaying geographic information on fish distribution and primary nursery areas, and assessing the implications of water resource management to estuarine fish

communities. The data generated from this type of program provides resource managers with high-quality information on fish communities that may be useful when gauging the effects of natural and anthropogenic disturbances and changes in water quality and quantity (Coull 1985; Wolfe et al., 1987), related to programs like the Caloosahatchee River (C-43) West Basin Storage Reservoir.

In Fiscal year 2008, the SFWMD is planning to fund evaluation of the first 3 years of monitoring (2004-2007) to assess its ability to detect change related to freshwater inflow. Based on the evaluation, the program's sampling design may be refocused. For example, future monitoring may concentrate more effort in upstream areas and valued ecosystem habitat (such as submerged aquatic vegetation), where the greatest impacts and ability to detect change is expected. This may require the addition of fixed station for sampling vegetated and non vegetated areas, similar to efforts used by Mote Marine Laboratory (Brad Robbins, MML: 2nd contract's Final Report, expected 4th quarter 2007).

D.3.5.2 Monitoring Objectives

1. Continue long term monitoring of fish populations in the Caloosahatchee Estuary.
2. Quantify fishery in a variety of habitats and salinity zones throughout the expected impacted area of the estuary.
3. Determine changes related to the operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir.
4. Provide long term and short term feed back for adaptive management and future project requirements.
5. Address the null hypothesis stated below that is intended to assess the success of the project.

D.3.5.3 Null Hypothesis

The general null hypothesis - As a result of the operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir, there are either detrimental impacts to the fish community, or no changes in the estuarine fish population, related to – (a) the base line conditions established from years of sampling prior to reservoir operation in a variety of habitats and salinity zones along the downstream gradient of the estuary.

Determining if the null hypothesis is true depends on monitoring fish and at least salinity commensurate with the project operation, by:

1. Comparing populations with historic data sets;
2. Assessing trends in fish populations during project operation to determine the direction of change; and

3. Comparing current project related flows and fish populations with similar seasonal conditions when freshwater inflows would have been equal to non-project flow.

D.3.5.4 Monitoring Measures and Targets

1. Monitoring Measure: Statistical significant change (compared to preoperational data) in fish species composition, abundance per species, size of individuals, or other population morphometrics (e.g., diversity).

Target: No Change or a statistically significant increasing trend in desirable fish monitoring measures at fixed or random sampling sites along the estuary's downstream salinity gradient and at existing SAV and oyster sampling locations.

Adaptive Management Trigger: When there is an unnatural (undesirable) significant decrease in monitoring measures within any salinity zone or habitat because of project operation, thus satisfying the null hypothesis as per condition 3 described above.

D.3.5.5 Monitoring Approach

Daily freshwater discharge from S-79 and the Lake Okeechobee structure at Moore Haven are measured by the Corp of Engineers and posted electronically on COE and South Florida Water Management District (SFWMD) web sites. This information is part of normal operation and therefore no additional Caloosahatchee River (C-43) West Basin Storage Reservoir project cost is required. It will be available to compare fishery catches with daily freshwater inflow form these two structures. The information from the network of continuous salinity sensors (and water quality sensors if desired) is available (see Salinity and Water Quality Monitoring Plans) to meet the above monitoring objectives and make the required comparisons to determine the cause of any detected population changes.

The FIM program uses a stratified-random sampling design. The study area is divided into six bay zones (A-E and G) and three riverine zones (H, M, and P; ***Figure D-16***). Funding to date by RECOVER allowed the expansion of sampling into Zones E, G, and H since 2004. Zones E and G encompass the southern portion of Charlotte Harbor, including parts of Matlacha Pass, Pine Island Sound, and San Carlos Bay. Zone H extends from the mouth of the Caloosahatchee River upstream approximately 23 nm to the Franklin Lock. The zones are divided into 1-nm2 grids that are randomly selected for sampling each month. Sampling grids are stratified by habitat and depth, thereby identifying the gear types that could be used in those areas. A total of 71 samples are collected each month as part of the FIM expansion into lower Charlotte Harbor

and the Caloosahatchee Estuary (twenty-three 21.3-m Caloosahatchee River seines, seven Caloosahatchee River trawls, twenty 21.3-m bay seines, ten 183-m haul seines, and eleven bay trawls; see below for gear descriptions).

A multi-gear approach is used to collect data on fishes and select invertebrates from a wide range of habitats and life history stages. A 21.3-m center bag seine with a mesh size of 3.2 mm is used to collect young-of-the-year and juvenile fishes in shallow areas (≤1.8 m); a 6.1-m otter trawl with a 3.2 mm mesh liner is used to collect young-of-the-year, juvenile, and adult fish in deep water (1.0-7.6 m); and a 183-m haul seine with a mesh size of 38.1 mm is used to collect sub-adult and adult fish in shallow water (≤2.5 m) along shorelines.

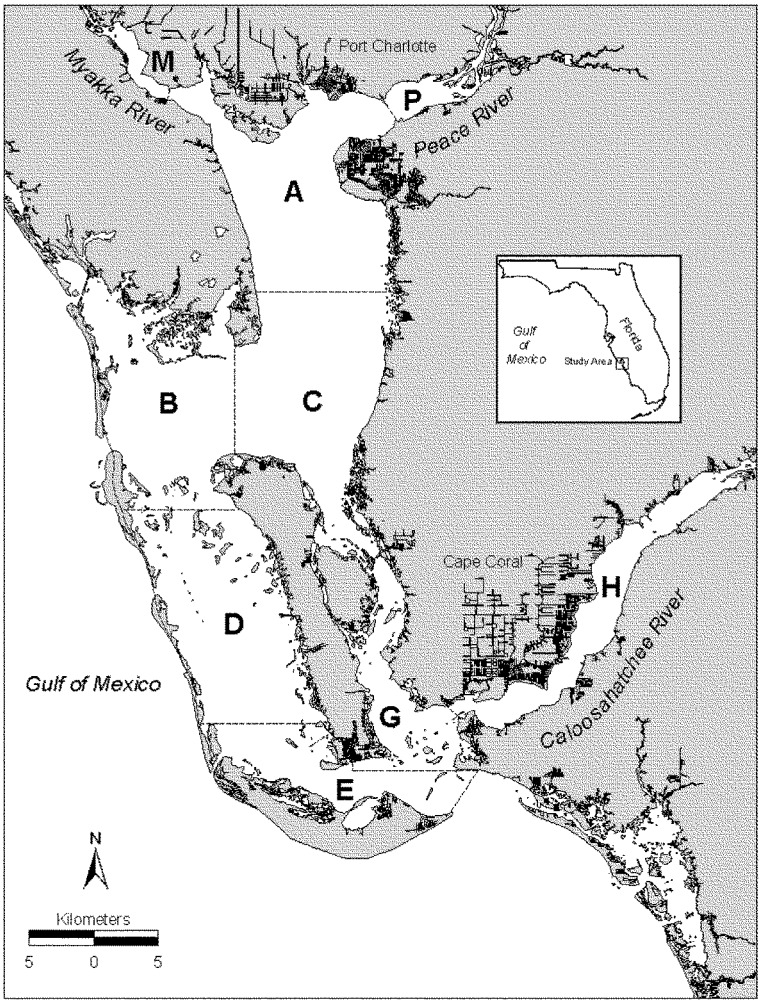


FIGURE D-16: MAP OF CHARLOTTE HARBOR SAMPLING AREA. ZONES ARE LABELED A-E, G-H, M AND P

Several different techniques are used, depending on habitat, to stratify the samples collected with the various gears. The 21.3-m center bag seine is deployed in one of two ways. The bay seine technique is used to sample shallow areas of the estuary and is pre-stratified by the presence or absence of bottom vegetation, or the presence of a shoreline. The river seine technique is used to

sample the shorelines of the rivers. Samples collected with 183-m haul seines are pre-stratified by the presence or absence of overhanging shoreline vegetation. Further sampling details are described in the FIM program's Procedure Manual.

Environmental data consisting of water chemistry, habitat characteristics, and physical parameters such as tidal conditions are recorded for each sample. The sample work-up technique was similar for all collected samples, regardless of gear type or sampling regime. All fishes and select invertebrates captured in net collections are identified to the lowest practical taxonomic level, counted, and measured (standard length for teleosts, precaudal length for sharks, disc width for rays, carapace width for crabs, and post-orbital head length for shrimp). Animals are then released except for representative samples of each taxon (for laboratory confirmation of field identifications) and samples required for specific research projects.

D.3.5.6 Data Quality

A detailed explanation of the standard sample work-up for data collection and program quality assurances are described in the FIM program's Procedure Manual. The taxonomic nomenclature in this report follows the American Fisheries Society's Common and Scientific Names of Fishes (Nelson et al., 2004).

D.4 WATER QUALITY MONITORING PLAN

C-43 WEST STORAGE RESERVOIR PROJECT
WATER QUALITY MONITORING PLAN

This page intentionally left blank

TABLE OF CONTENTS

1.0 INTRODUCTION AND BACKGROUND 3
1.1 Active Mandates and Permits 3
1.2 Project Objectives 4
1.3 Duration 4
1.3.1 Initiation Conditions 4
1.3.2 Modification or Termination Conditions 4
2.0 GEOGRAPHIC LOCATION 5
2.1 Regional Area 5
2.2 Sampling Locations 7
2.3 Access and Authority 8
3.0 FIELD ACTIVITIES 8
3.1 Parameter and Frequency Rationale 8
3.1.1 Baseline Monitoring 8
3.1.2 Routine Operational Monitoring 10
3.2 Project Specific Guidelines 10
3.3 Sampling Procedures 10
3.4 Field Testing Procedures 10
3.5 Field Quality Control Requirements 11
3.6 Autosampler Collection 11
3.7 Sample Submission 12
4.0 DATA QUALITY OBJECTIVES 12
4.1 Data Uses 12
4.2 Data Quality 12
4.3 ANALYTICAL PARAMETERS 12
4.4 Completeness Targets 13
5.0 DATA AND RECORDS MANAGEMENT 13
5.1 Data Deliverables 13
5.2 Data Storage 13
6.0 REVISIONS AND MODIFICATIONS 14
7.0 MONITORING COSTS 14
8.0 REFERENCES 14
9.0 APPROVALS 15

LIST OF TABLES

Table 1: Surface Water Quality Monitoring Stations 8
Table 2: C43 Baseline Projects in South Florida Water Management District Database (DBHYDRO) 9
Table 3: Routine Operational Monitoring – Auto-sampler, Grab Sample and Insitu Collection 10
Table 4: Field Analytical Collection Parameters 11
Table 5: C43 West Storage Reservoir Autosampler Collection Stations 13

LIST OF FIGURES

Figure 1: Project Location Map 6
Figure 2: Project Features 7

APPENDIX

Appendix 1: Mercury and Toxics Monitoring Program for the C43 West Storage Reservoir Project 16

WATER QUALITY MONITORING PLAN

1.0 INTRODUCTION AND BACKGROUND

This document serves as a reference for monitoring of various matrices (water sediment and fish) for the C-43 West Storage Reservoir (C43) Project. The C43 includes an above ground reservoir with a total storage capacity of approximately 170,000 acre-feet located in the C-43 Basin of Hendry County.

The purpose of this feature is to capture C-43 Basin runoff and releases from Lake Okeechobee which will reduce peak flows to the Caloosahatchee Estuary, provide flood attenuation and increase regional water supply benefits.

The C-43 West Storage Reservoir is intended to improve the timing of environmental deliveries to the Caloosahatchee Estuary, including reducing the damaging flood releases from Lake Okeechobee. Though water quality improvement is not a project purpose, there is the potential for the reservoir to provide benefits from long-term nutrient removal. The long-term downstream average of various nutrients (i.e.: phosphorus and nitrogen) could be decreased as a result of the storage reservoir and other Comprehensive Everglades Resoration Program (CERP) projects affecting the basin.

The guidance contained in this document will assist in maintaining consistency in sampling locations, parameter lists and frequencies as well as provide documentation of the project scope and an ongoing historical perspective.

1.1 Active Mandates and Permits

The C-43 Project is authorized as one of the initial projects for implementation under Section 601(b) (2) (C) of the Water Resources Development Act (WRDA) 2000. This water quality monitoring plan meets the requirements outlined in the CERP Guidance Memorandum (CGM) 023.01: Water Quality Considerations for the Project Implementation Report (PIR) Phase (CGM 023, dated March 1, 2004), CGM 42.00: Toxic Substances Screening Process – Mercury and Pesticides (CGM 42.00, dated September 17, 2005) and CGM 040.00: Project Level Water Quality and Hydrometeorologic Monitoring and Assessment (CGM 040, dated May 25, 2004). These guidance memoranda address water quality considerations necessary for the formulation, evaluation, and design of project alternatives during the PIR development. This monitoring plan (Plan) will also be modified, if necessary, to be compliant with any future water quality certification conditions.

To clarify the intent of WRDA 2000 with respect to attaining Everglades water quality restoration objectives, CGM 023 establishes three categories of CERP projects (Category A, B or C). For a Category C project, design development does not include water quality improvement features or specifically reference water quality improvements as a criterion to be addressed during design. Category C

components will not have performance measures for water quality improvement and are not required to have evaluation criteria for comparing the water quality improvement of alternatives. The C-43 meets the CGM definition of a Category C project.

1.2 Project Objectives

The monitoring stations described in this document were established to satisfy requirements of the CERP PIR. This Plan will provide an outline for quantifying water quality, measure constituents of interest (i.e.: phosphorous and nitrogen) **in surface water entering and leaving the project area and measure, and evaluate pollutant sources**. As a Category C component, this project does not include water quality improvement features; however, it is anticipated the project will reduce pollutant loading into downstream receiving water bodies through the attenuation of surface flows and reduction of associated pollutant loads prior to discharge.

1.3 Duration

1.3.1 Initiation Conditions

This Plan was initiated by the Water Quality Monitoring Division and technical review provided by staff of the Environmental Resource Assessment Department of the South Florida Water Management District (SFWMD). Development of this Plan is required by the Project Management Plan (PMP) and for the development of the PIR document, due in August 2007. The PIR development phase has requirements for sections detailing the water quality monitoring and adaptive assessment methods for the recommended alternative. This Plan is to be implemented at the project start date and will be adhered to for the length of time the project is operational. Changes to the plan may occur in the future as the project nears completion as outlined in the following Section.

1.3.2 Modification or Termination Conditions

Modification of the Plan will be determined by the needs of the project as it nears the estimated completion date of 2011. This Plan may be changed to reflect any future design changes, permit requirements and/or may be terminated according to permit expiration dates or changes to the project objectives. The Plan will be reviewed and/or modified annually or more frequently if necessary, to reflect new requirements.

2.0 GEOGRAPHIC LOCATION

2.1 Regional Area

The Caloosahatchee River forms the major basin to the west of Lake Okeechobee. The Caloosahatchee River watershed includes an area of approximately 550,900 acres in parts of Lee, Glades, Charlotte and Hendry counties. Existing agriculture in the C43 Basin is dominated by citrus production with a smaller production of vegetables, rice and sod.

Physiographically, the site lies in the Sandy Flatlands region of South Florida which is characterized by surficial marine sand (consisting of predominantly unconsolidated sand and sandy marl containing abundant marine mollusks) with deposits of organic soils accumulated in fresh-water environments.

The C-43 Project is located just south of the Caloosahatchee River midway between Lake Okeechobee to the east and Fort Myers to the west. In general it will be surrounded predominately by agricultural interests, though as the value of agricultural land increases, urban development adjacent to the reservoir is likely in the future. A site map showing the site of the C-43 West Storage Reservoir Project, its setting within South Florida and the location of other CERP/ACCELER8 features in the region is shown in Figure 1.

The Townsend Canal, located west of the project outline (see Figure 2) provides an open channel connection to the Caloosahatchee River. Drainage across the property discharges to the Caloosahatchee River via Fort Simmons Branch, Bedman Flowing Creek and Roberts Canal via Banana Branch Canal.

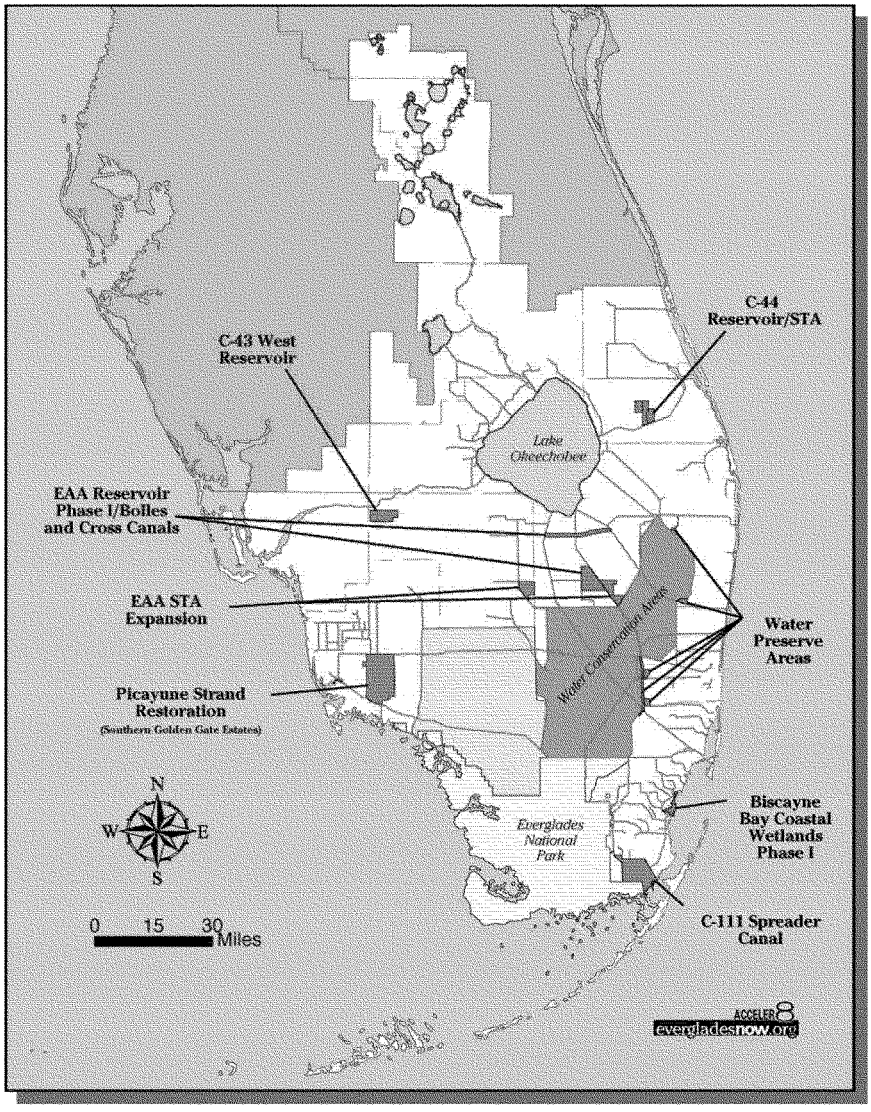


FIGURE 1: PROJECT LOCATION MAP

2.2 Sampling Locations

Monitoring will be designed to provide compliance with applicable state and federal surface water criteria. Project features are shown in Figure 2.

Sampling stations will be registered in the SFWMD Laboratory Information Management System (LIMS). Table 1 provides information on each proposed monitoring location. The locations of the monitoring stations (in addition to structures that will not be monitored for water quality) are depicted on the map in Figure 2, with the exception of interior stations. These stations (possibility of multiple interior stations within each cell-TBD) will be used for surface water monitoring.

Since the project is in the early stages of development, monitoring locations may change depending on the final construction plans and permits.

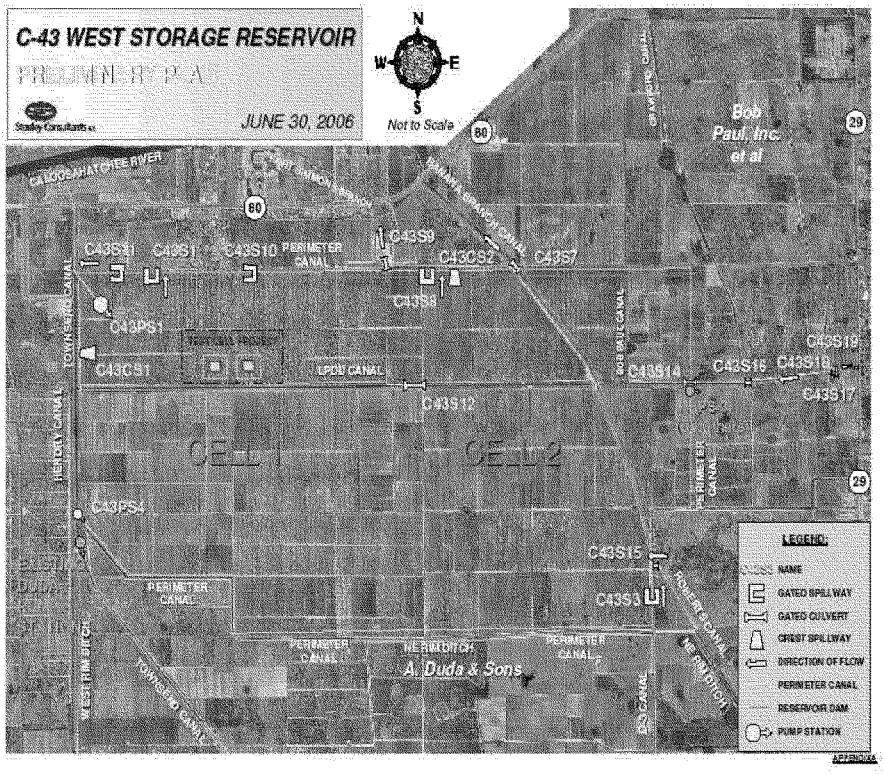


FIGURE 2: PROJECT FEATURES

TABLE 1: SURFACE WATER QUALITY MONITORING STATIONS

Site Name	Latitude	Longitude	Description
C43PS1	TBD	TBD	Cell 1 Inflow Pump Station
C43S1	TBD	TBD	Gated spillway; outflow from cell 1 to Perimeter Canal
C43S8	TBD	TBD	Gated spillway; outflow from cell 2 to Perimeter Canal

2.3 Access and Authority

The Project will be accessed from Route 80 which runs parallel along the Caloosahatchee River. Monitoring stations within the project will be accessed along the system of levees that surround the reservoir.

3.0 FIELD ACTIVITIES

3.1 Parameter and Frequency Rationale

3.1.1 Baseline Monitoring

SFWMD has been conducting water quality monitoring in the Caloosahatchee River and in the Caloosahatchee River estuary for a number of years. These surface water samples have been analyzed for multiple constituents and at various frequencies. Caloosahatchee River data are compiled in the SFWMD's DBHYDRO database under project codes X, CR and PEST. Data collected in the Caloosahatchee River estuary are compiled in the SFWMD's DBHYDRO database under project codes CESWQ. There are other agencies that also collect surface water quality data in this region (i.e. Lee County and Charlotte Harbor National Estuary Program) that may be relevant to the project as baseline data. These agencies would have to be contacted for access to their databases.

Surface water, groundwater and sediment samples also are being collected as part of the C43 Test Cell Project by Wetland Solutions, Inc. Sampling stations are located within the test cells and the Header canal that provides water to the test cells, as well as stations located in the Townsend Canal and Roberts Canal. The data collection for the C43 Test Cell Project are expected to continue until May 2007 and all data associated with this project will be accessible in the DBHYDRO database under project code C43RES. Refer to Table 2 for a complete listing of project names, stations, parameters and frequency of collection of projects that are relevant as baseline data for this project.

TABLE 2: C43 BASELINE PROJECTS IN SOUTH FLORIDA WATER MANAGEMENT DISTRICT DATABASE (DBHYDRO)

Project Name	Stations	Parameters Collected	Frequency of Collection
CR	S78, S79, CR-00.2T, CR-04.8T	ALK, MG, SIO2, CA, NA, SO4, CL, NH4, TEMP, COLOR, NO2, TKN, COND, NOX, TPO4, DO, OPO4, TSS, K, PH, TURB	Bi-monthly
X	S77	ALK, CL, NH4, TEMP, COLOR, NO2, TKN, COND, NOX, TPO4, DO, OPO4, TSS, PH MG, SIO2, CA, NA, SO4, TDS, TOTFE, K	Bi-weekly/Monthly Quarterly
CESWQ	CES02, CES03, CES04, CES05, CES06, CES07, CES08, CES09, CES10, CES11 CES01 CES01, CES03, CES04, CES06	CHLA TPO4, TN, CHLA CHLA, CHLA2, COLOR, NO2, NO3, NOX, NH4, TKN, TN, TOC, TPO4, OPO4, SILICATE, TSS, TURBIDITY	Release Release Monthly
C43RES	Surface Water - C43TC1, C43TC2, C43RC1, C43RC2 Groundwater – PZ01A, PZ13A, PZ14A, PZ15A, PZ16A, PZ17A, PZ18A, PZ19A, PZ20A, PZ21A Soil–C43TC1-Z1,C43TC1-Z2, C43TC1-Z3, C43TC2-Z1, C43TC2-Z2, C43TC2-Z3	ALKA, CHLA, CL, COLOR, NH4, NOX, OPO4, SO4, TDPO4, TKN, TOTAL, TOTAS, TOTCA, TOTCU, TOTZN, TPO4, TSS, TURB, VSS, Ametryn, Atrazine, Bromacil, Norflurazon, Simazine TDS, CA, SO4, CL, TP, TDPO4, OPO4, TKN, NH4, NOX, TOTAL, TOTAS, TOTCU, TOTFE, TOTZN BULK DENSITY, CALCIUM, TOTFE, TOTAL, TKN, TOC, TP, TS, ORGANIC P FRACTION, Ametryn, Atrazine, Bromacil, Norflurazon, Simazine	Monthly (except RC1 & RC2) 3X's during test cell operation Quarterly 2X's during test cell operation
PEST	S79, CR33.5T, S78, S235	Chlorinated acids, Organochlorine compounds, Organophoshporus and Nitrogen compounds, Urea and Other pesticides	Quarterly for Surface Water, Bi-annually for Sediment

3.1.2 Routine Operational Monitoring

Monitoring objectives and requirements for the operational phase of the C43 will depend largely on permit requirements and the final design and operational plan for the project area, and will include the following:

Flow proportional auto-samplers will be installed at one inflow and two outflow stations. Auto-samplers will be visited once per week regardless of flow in order to maintain data integrity. Grab sampling at the inflow and outflow stations of both cells will occur bi-weekly during flow events or monthly if no flow, for nutrients and other parameters listed. Autosampler and grab surface water samples will be collected as detailed in Table 3.

TABLE 3: ROUTINE OPERATIONAL MONITORING – AUTO-SAMPLER, GRAB SAMPLE AND INSITU COLLECTION

Location	Collection Method	Matrix	Frequency	Parameter
C43PS1, C43S1, C43S8	Autosampler	Water	Weekly	TPO4, TKN, NOX
C43PS1, C43S1, C43S8	Grab	Water	Biweekly if flowing or monthly	NOX, TKN, NH4, TPO4, OPO4, TURB, Sulfate, Alkalinity, Chl-a
C43PS1, C43S1, C43S8	In situ	Water	Biweekly if flowing or monthly	Temperature, PH, Conductivity, Dissolved Oxygen

3.2 Project Specific Guidelines

In general, grab samples are collected at a depth of 0.5 m in canals. When collecting a sample at a structure, samples are generally collected on the upstream side.

3.3 Sampling Procedures

Sample collection for this project shall follow the procedures and requirements found in the Field Sample Collection Procedures Section of the District's *Field Sampling Quality Manual* (FSQM).

3.4 Field Testing Procedures

Field testing procedures shall follow the procedures and requirements found in the Field Testing Section of the District's FSQM. Table 4 below describes the field parameters collected for this project. The table shows only the most commonly used parameters.

TABLE 4: FIELD ANALYTICAL PARAMETERS COLLECTION

Parameter	Resolution	Accuracy
DO	0.01 mg/L	0-20 mg/L, +/- 0.2 mg/L
Conductivity	0.001 mS/cm	+/- 0.5% of reading +0.001 mS/cm
Temp	0.01° C	+/- 0.15°C
pH	0.01 unit	+/- 0.2 unit

3.5 Field Quality Control Requirements

Field quality control requirements shall follow the procedures found in the Quality Control Section of the District's FSQM.

3.6 Autosampler Collection

TP04, TKN and NOX samples will be collected by autosamplers at the stations identified in Table 3. Flow-proportional autosamplers (ACF) will be located at all stations and are programmed to collect discrete aliquots at a frequency based on flow. That frequency is determined by a "trigger volume" established through the protocols created by Abtew and Powell (2004). The discrete bottles will be pre-acidified and composited on a weekly basis and analyzed for the above parameters. Refer to Table 5 for setup detail on the autosamplers to be installed at the inflow/outflow stations.

Due to the unique configuration of the discharge structures, C43S1 and C43S8, the autosamplers will be located in the stilling wells which operate the final gate controls for discharge from each structure. The height of the gate-wells are too great for an autosampler to lift samples, so submersible pumps will be installed in each gate-well. The submersible pumps will pump a continuous flow of water to the top of the levee where an autosampler will draw aliquots when triggered. The submersible pumps will operate only when flow is occurring within each discharge culvert.

TABLE 5: C43 WEST STORAGE RESERVOIR AUTOSAMPLER COLLECTION STATIONS

Station	Flow	Aliquot Volume (mL)*	Refrigerated Yes or No	# of Bottles	Intake Type *fixed or float*	Intake Elev *(if fixed)*
C43PS1	Yes	TBD	No	TBD	Fixed	TBD
C43S1	Yes	TBD	No	TBD	Fixed	N/A
C43S8	Yes	TBD	No	TBD	Fixed	N/A

**aliquot volume may be increased for seasonal sampling to ensure adequate volume for sample analysis.*

3.7 Sample Submission

Following completion of sample collection for each sampling trip, the samples are transported in coolers with wet ice at 4° Celsius to the laboratory for analysis. Samples are submitted to the laboratory on the same day as collection or via courier for delivery the following day. Samples are submitted according to the requirements outlined in the District's FSQM. If samples are submitted to other than the District's in house laboratory, the laboratory must be currently under contract with the District. If services can not be provided by a contract laboratory, an alternate laboratory can be used but the alternate laboratory must receive written approval from ERA's Quality Assurance Administrator prior to sample submittal.

4.0 DATA QUALITY OBJECTIVES

4.1 Data Uses

The data will be used to fulfill project purposes and to comply with monitoring requirements of an operational permit.

4.2 Data Quality

Surface water samples, including in-situ testing and field quality control samples are collected in accordance with the Florida Department of Environmental Protection (FDEP) Quality Assurance Rule, 62-160.200 & 62-160.320, Florida Administrative Code (F.A.C.) and the District FSQM. Applicable sections of the FSQM include, but are not limited to field sample collection procedures, decontamination procedures, field testing and quality control requirements. Data are qualified in accordance with the *District Chemistry Laboratory Quality Manual.* Data not meeting the quality objectives are qualified using standard FDEP qualifier codes (F.A.C. 62-160), in accordance with the FSQM data validation and reporting section.

4.3 Analytical Parameters

Tables 3 in Section 3.1.2 and Tables 2 and 3 in Appendix 1, identify all parameters in the project. All analytical work is to be conducted by a NELAC-certified laboratory following NELAC and EPA Standard Methods for which the laboratory is approved. For field analytical methods (pH, specific conductance, temperature and dissolved oxygen) refer to Section 6 of the District's FSQM.

.

4.4 Completeness Targets

For each project, monitoring parameters and frequencies will be registered in LIMS and DBHYDRO. This process aids in the creation of header sheet templates, quality assurance and determining completeness. Completeness targets, meaning the number of samples successfully collected and analyzed, are set at 95% annually for this project.

5.0 DATA AND RECORDS MANAGEMENT

After the data validation process, all data are maintained so that end users can retrieve and review all information relative to a sampling event. Field notes are maintained on an internal server either by scanning actual field note pages or by uploading narratives from field computers path to server. All analytical data and field conditions are sent to a database (DBHYDRO) for long-term storage and retrieval.

The collecting agency shall maintain records of field notes and copies of all records relative to the chain of custody and analytical data. It is the responsibility of the collection agency to maintain both current and historical method and operating procedures so that at any given time the conditions that were applied to a sampling event can be evaluated. Upon completion of the project, the collecting agency shall provide all original field notes to the District's Water Quality Management District (WQMD) for permanent archival.

Records shall be maintained for the life of the project and five years thereafter, in a manner that will protect the physical condition and integrity of the records. Storage shall follow the District's records storage procedure. Access to archived methods shall be through designated records custodian. Corrections of data or records shall follow the District SOP's.

5.1 Data Deliverables

The laboratory data shall be submitted to the District in a DBHYDRO compatible format. The laboratory shall evaluate the data in accordance with the data quality objectives stated in the FSQM. All data submittals shall conform to existing District guidelines or other format as requested by the District.

5.2 Data Storage

After the data validation process, all data are maintained so that end users can retrieve and review all information relative to a sampling event. Field notes are maintained on an internal server either by scanning actual field note pages or by uploading narratives from field computers \\ha2-fs1\kb_wqm\fieldnotes\. All analytical data and metadata are sent to a database (DBHYDRO) for long-term storage and retrieval.

6.0 REVISIONS AND MODIFICATIONS

[This section is left for future changes as they are made and should be referenced throughout the document as revisions occur. Sections should be added chronologically. As revisions are made a note should be made in the corresponding section of the plan.]

Date	Section	Page Number(s)	Change From	Change To	Reason

7.0 MONITORING COSTS

The monitoring costs (including analytical and data management) associated with this Monitoring Plan have been estimated at costs of $610,952 for the initial year and $603,198 for each subsequent operational year. These costs are based upon Fiscal Year 2007 estimates with a 3% annual inflation factor applied.

8.0 REFERENCES

9.0 APPROVALS

Monitoring Plan

For

Project C43 Storage Reservoir

Prepared by:
Water Quality Monitoring Divsion, South Florida Water Management District

Linda Crean, Water Quality Monitoring Division Director	Date
David Struve, Water Quality Analysis Division Director	Date
Julianne LaRock, Water Quality Assessment Division Director	Date
Ming Chen, Quality Assurance Administrator	Date

APPENDIX 1

Mercury /Toxics Monitoring Program for the C43 West Storage Reservoir Project

Introduction:

Appendix 1 follows the guidelines of CGM-42, which includes the flexibility to adapt the guidelines to a reservoir (vs. an STA). However, the language in CGM-42 is specific to the phases of startup and operation of an STA. The C43 Reservoir differs from an STA in that there is no flow-through type of operation. The Reservoir will be filled during the wet season when there is an excess of water in the Caloosahatchee basin and emptied when there is less than 450 cfs discharge at S79. Water depths in the Reservoir when full will average about 20 ft with a maximum depth of 25 ft.

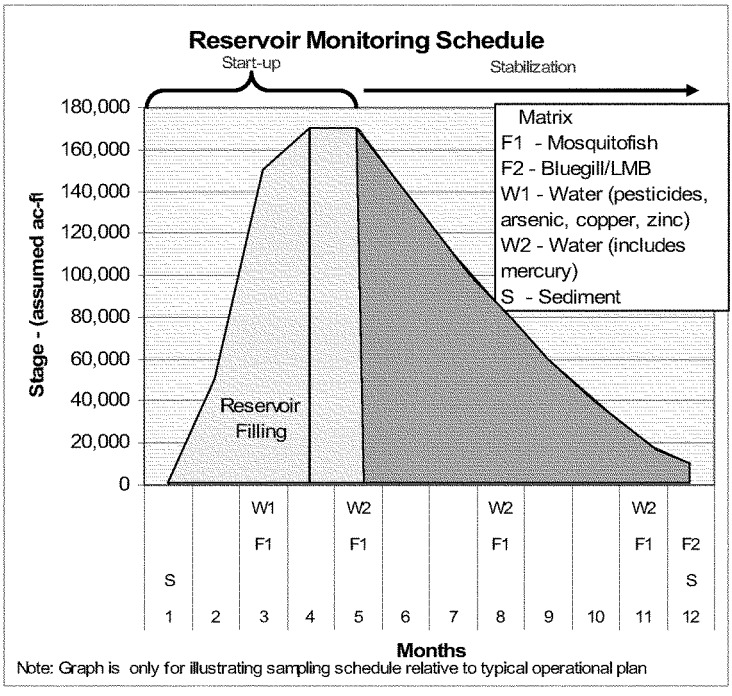
Part of the monitoring regime includes sediment sampling, which at full depths is not reasonable or productive. Therefore, sediment sampling will be conducted prior to filling the reservoir and again following seasonal discharge assuming that pool levels are low enough to collect sediment cores.

Sediment sampling will also take into account the variability in site conditions which will be experienced following construction. The removal of surface soils during construction of the reservoir will be necessary in some areas to use as borrow material to construct the levee surrounding the reservoir. Exposed parent soils will be left after removal of the borrow material. Organic soils may be stockpiled or spread. In addition, the former land-use of the site was primarily citrus, therefore tree removal operations may leave disturbed soil profiles across much of the storage area, but volunteer growth of grasses and brush may fill in during the construction period. It is necessary that sediment sampling locations characterize the sampling site conditions for accurate data interpretation.

Regarding the pesticide parameters required for analysis in fish, sediment and water as outlined in this monitoring plan, the list was reduced from what is historically analyzed in those matrices (usually all of the compounds in an analytical group - i.e. chlorinated (phenoxy acid) herbicides (3 parameters), urea herbicides and imidacloprid (3 parameters), ogranophosphorus and nitrogen pesticides (32 parameters) and organochlorine pesticides (40 parameters)). The Florida Department of Environmental Protection is now able to analyze distinct analytes within an analytical group which assists in reducing the data management aspect of monitoring.

The current recommended pesticide analytical list (chlordane – gamma, chlordane – alpha, endrin and ethion – as well as arenic, copper and zinc) is based on historical data as well as the site assessment performed for this location.

Sampling of the soil, fish, and water matrices follow a schedule that is attuned to the reservoir operations. The following diagram illustrates the intent of the planned schedule.



A1. Initial Start-up Monitoring Prior to Discharge

The District shall initiate start-up monitoring prior to discharge as follows:

A1.1 Mosquitofish

i) When construction of the reservoir is complete, the District shall notify the Department and, within one month of the initial filling of reservoir, collect mosquitofish from four locations within each cell of the reservoir to total at least 100 fish per cell. Physically composite them into one (spatially-averaged) sample per cell of the reservoir for THg analysis (note, a single aliquot should be analyzed per composite). Additionally, mosquitofish (to total at least 100 fish) will be collected from a single site located in the receiving water downstream from the project and analyzed for THg (site to be located in Townsend Canal between C43PS1 and the Caloosahatchee River. Refer to Figure 2 for site location). This downstream site is located in a canal with flow velocities that will allow for a resident population. The data for the downstream site will serve as a baseline for any future evaluations of potential impacts to the receiving waters. Sampling described

above will continue quarterly after the initial collection during the period water is being pumped into the reservoir (usually during the wet season from July to November).

ii) The District shall provide the Department with the results of the first collection of mosquitofish as well as the appropriate action levels for comparison (90% upper confidence level of the basin-wide average or the 75th percentile concentration for the period of record for all basins). If tissue-concentrations from each cell of the reservoir are below the 90% upper confidence level of the basin-wide average or below the 75th percentile concentration for the period of record for all basins (if basin-specific data are lacking); after concurrence from the Department, the District may initiate discharge from the reservoir and routine monitoring for that cell of the reservoir (for details on routine monitoring, see below).

However, if Hg concentration in any of the mosquitofish composites from within the reservoir exceed one of the above referenced action levels, the District shall immediately (within 14 days of receiving quality assured data from the laboratory) collect a sample(s) to confirm the exceedance(s). In addition, the District shall consult with the Department to determine the most appropriate course of action and obtain authorization to initiate discharge from the reservoir. At a minimum, the course of action will include implementation of Tier 2 Expanded Monitoring and Risk Assessment by the District during initial reservoir discharge (e.g. collection of monthly mosquitofish within each cell of the reservoir and at the downstream location at a minimum). Additional details on expanded monitoring are provided below and in "A Protocol for Monitoring Mercury and Other Toxicants" dated January, 2006 and subsequent revisions (hereafter referred to in this document as the "Protocol"). The recommended course of action may also include additional measures as determined to be appropriate. When results of expanded monitoring demonstrate concentrations in each cell of the reservoir has decreased to acceptable levels (below action levels referenced above) and the concentrations at the downstream site are not significantly elevated above baseline levels, the District shall notify the Department and request that the monitoring revert back to Tier 1 routine monitoring.

Additionally, these tissue samples will be analyzed and assessed for bio-accumulative toxicants other than mercury identified in Table 1.

A1.2 Sediment

To expand on baseline data detailed in Section 3.1.1, monitoring of sediment within the reservoir prior to flooding will be conducted. Each cell will be divided into four quadrants, and a sediment sample will be collected in the centroid of each quadrant and one sample collected in the middle of the cell (5 samples collected per cell). In addition, sediment cores will be collected at one downstream site in the receiving water (site to be located in Townsend Canal between C43PS1 and the Caloosahatchee River). Sediment samples will be analyzed for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), total iron (TFe), chlordane-alpha, chlordane-gamma, endrin, ethion, arsenic, copper and zinc (parameters of concern as outlined in the environmental site assessments). The results from this sampling will provide a baseline for future data collection to be compared against.

Upon the initial discharge from reservoir at lowest stage (after the initial filling), sediment cores will be collected from five representative locations within each cell of the reservoir (providing water levels are low enough to allow normal sediment core collection without use of specialized equipment). Each cell will be divided into four quadrants, and a sample will be collected in the middle of each quadrant and one sample collected in the middle of the cell. In addition, sediment cores will be collected at one downstream site in the receiving water (site to be located in Townsend Canal between C43PS1 and the Caloosahatchee River).

At each location or site, a minimum of three cores (number of cores in excess of three will be determined by amount of sediment required for analysis) from the 0-to-4 cm horizon are to be collected and composited as a single sediment sample.

To serve as baseline for future comparison, if future conditions warrant follow-up sampling of sediments (i.e., if Tier 2 were triggered), sediment samples will be analyzed for THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe). To allow for possible future analysis, remaining material from each sediment sample will be archived separately for the maximum hold time allowable for the specified parameter list.

Additionally, these sediment samples will be analyzed and assessed for the following toxicants other than mercury identified in Table 1.

A1.3 Water

Although bio-accumulative toxicants, in particular mercury, will be monitored and assessed prior to discharge based on tissue concentrations, because of the concern for potential acute toxicity, water will be collected from immediately upstream of inflows (station **C43PS1**) and outflows (stations **C43S1, C43S8**) of the project and analyzed for toxicants other than mercury as discussed below.

Selection of Toxicants Other Than Mercury

The following information sources have been reviewed for data regarding this project: Environmental Site Assessment Phase I or II or III for various properties located in the project area. Based on this review, the parameters identified in Table 1 will be analyzed in each of the specified matrices.

Table A1. Parameter list of toxicants other than mercury that will be analyzed in specified matrix.

Analyte	Surface Water	Sediment	Fish tissues
Chlordane - alpha	✓	✓	✓
Chlordane - gamma	✓	✓	✓
Endrin	✓	✓	✓
Ethion	✓	✓	✓
Arsenic	✓	✓	✓
Copper	✓	✓	✓
Zinc	✓	✓	✓

The District shall provide the Department with the results of these analyses as well as the appropriate action levels for comparison. If the following criteria are met for a given flow way or cell, the District may initiate reservoir discharge and routine monitoring for that flow way or cell (for details on routine monitoring, see below).

- If ambient mosquitofish do not demonstrate excessive bioaccumulation that exceeds a critical tissue benchmark used to establish SQAGs or in site-specific risk assessments;
- If concentrations in sediments do not exceed an effects-based, numerical sediment quality assessment guideline (SQAGs for sediment dwelling organisms, MacDonald Environmental Sciences Ltd.and USGS, 2003);
- If concentrations in sediments do not exceed an established bio-accumulative based SQAG, if available (MacDonald Environmental Sciences Ltd. and USGS, 2003), a action level reported in the ESA or a level that was determined to be critical in a site-specific risk assessment;
- If water-column concentrations do not exceeded a WQS in Chapter 62-302, F.A.C.

However, if one of the above referenced action levels are exceeded, the District shall immediately (within 14 days of receiving quality assured data from the laboratory) collect a sample(s) to confirm the exceedance(s). In addition, the District shall consult with the Department to determine the most appropriate course of action and obtain authorization to initiate reservoir discharge from that cell or flow way. At a minimum, the course of action will include implementation of Tier 2 Expanded Monitoring and Risk Assessment by the District during initial flow-through operations. The recommended course of action may also

include additional measures as determined to be appropriate. When results of expanded monitoring demonstrate concentrations in each flow way has decreased to acceptable levels (below action levels referenced above), and the concentrations at the downstream site are not significantly elevated above baseline levels, the District shall notify the Department and request that the monitoring revert back to Tier 1 routine monitoring.

Refer to Table A2 for a summary of initial start up monitoring described above.

Table A2. Summary of Initial Start Up Monitoring Prior to Discharge

Matrice	Frequency	Location	Parameters
Mosquitofish	Initial filling of reservoir than quarterly (when water is pumped into reservoir during wet season: July to November). The same sampling regime will be followed when discharge occurs from reservoir (usually during dry season: January to May).	4 locations (along perimeter of levee) within each cell and one downstream location	THg, chlordane-alpha, chlordane-gamma, endrin, ethion, arsenic, copper, zinc
Sediment	Post construction, prior to filling	5 locations within each cell of the reservoir and one downstream location	THg, MeHg, moisture content, total organic carbon (TOC), total sulfur (TS), and total iron (TFe), chlordane-alpha, chlordane-gamma, endrin, ethion, arsenic, copper, zinc
Sediment	After initial discharge at lowest stage	5 locations within each cell of the reservoir and one downstream location	Same as above
Water	Initial filling of reservoir than quarterly (when water is pumped into reservoir during wet season: July to November). The same sampling regime will be followed when discharge occurs from reservoir (usually during dry season: January to May).	C43PS1, C43S1, C43S8	Chlordane – alpha, chlordane – gamma, endrin, ethion, arsenic, copper, zinc

A2. Monitoring During Stabilization Period

The District shall initiate monitoring after initial discharge and during the stabilization period as follows:

A2.1 Tier 1: Routine Monitoring During Stabilization Period

A2.1.1. Water

On a quarterly basis, an unfiltered surface water sample (n = 1) shall be collected in accordance with Chapter 62-160, F.A.C., at the inflow (station C43PS1) and immediately upstream of the outflows (stations C43S1, C43S8) from the project (see map of project shown in Figure 2). These samples will be analyzed for THg, MeHg, and sulfate (the latter not to be duplicative if listed as a parameter under routine monitoring described elsewhere in the general monitoring plan).

Based on the discussion above regarding toxicants other than mercury, a surface water sample will be collected quarterly at the inflow (station C43PS1) and immediately upstream of the outflows (stations C43S1, C43S8) and analyzed for the parameters listed in Table 1 under surface water.

In addition, flow will be monitored at the inflow and outflow to allow for load estimation to and from the project (it should be recognized that quarterly sampling would allow for only rough estimation of loads).

This data set will be assessed to determine if outflow concentrations exceed WQS, and whether annual outflow loads of analytes are significantly greater than inflow loads, including atmospheric loading; load estimates will include confidence intervals that describe uncertainty in measures of flow and concentration (e.g., field and analytical precision) and resulting from interpolation (note: assessment protocol to be negotiated with permitting authority). Failure to satisfy these assessment measures would trigger Tier 2 Expanded Monitoring and Risk Assessment (see below).

Because of differences in the anticipated time frames under which sedimentary release are thought to occur (i.e., relative to MeHg that may have time lag associated with changes in biogeochemistry and microbial methylation driven by water quality, especially in sandy soils), monitoring for other toxicants would cease after one year if action levels are not exceeded within that time.

A2.1.2. Fish Tissues

Samples of fish from multiple trophic levels will be collected from cell of the reservoir and from a single downstream site in the receiving water of the project (Figure 2). Specifically, mosquitofish collections will be made in a similar fashion and continue on a quarterly basis from all sites that were sampled prior to discharge (see above; for rationale for the selection of this and other species listed below, see the Protocol). On an annual basis, bluegill (n should be greater than or equal to 5) should be collected and individually analyzed as whole-

fish. Because this site contains habitat that is expected to support largemouth bass and because recreational harvesting is likely in the future, bass will also be collected (n should be greater than or equal to 5) and a fillet from each individual analyzed. For the reasons discussed in the Protocol, collections should target bluegill ranging in size from 102 to 178 mm (i.e., 4 to 7 inches) and largemouth bass ranging in size from 280 to 330 mm (i.e., 11 to 13 inches); however, other lepomids (first priority being given to spotted sunfish) or sizes are to be collected if efforts fail to locate targeted fish. These samples will be analyzed for THg and other toxicants listed in Table 1 under tissues.

Assessment

To detect and minimize any adverse effects as early as possible (and to provide a basis for identifying adaptive management options, if deemed necessary), the results of this monitoring will be assessed based on the criteria and time table described under Phase 2-Tier 1 in the Protocol (specifically, A Protocol for Monitoring Mercury and Other Toxicants and appendices, as approved at the time of the assessment). Monitoring results will be provided to the Department in accordance with the reporting requirements identified in Section 4.

Refer to Table A3 for a summary of routine monitoring during stabilization described above.

Table A3. Summary of Routine Monitoring During Stabilization

Matrice	Frequency	Location	Parameters
Water	Quarterly	C43PS1, C43S1, C43S8	THg, MeHg, sulfate, Chlordane – alpha, chlordane – gamma, endrin, ethion, arsenic, copper, zinc
Mosquitofish	Quarterly	4 locations (along perimeter of levee) within each cell and one downstream location	THg, chlordane-alpha, chlordane-gamma, endrin, ethion, arsenic, copper, zinc
Bluegill, largemouth bass (n=5)	Annually	4 locations (along perimeter of levee) within each cell and one downstream location	THg, organochlorine chlordane-alpha, chlordane-gamma, endrin, ethion, arsenic, copper, zinc

A2.2 Tier 2: Expanded Monitoring and Risk Assessment During Stabilization Period

In accordance with the Protocol, if Tier 1 data exceed the action levels identified under Phase 2 – Tier 2 Expanded Monitoring and Risk Assessment, the District shall notify the Department and after obtaining the Department's concurrence, shall expand monitoring and undertake all necessary steps consistent with the Protocol.

A3. Operational Monitoring Following the Stabilization Period

The monitoring plan and associated data will be re-evaluated on a regular basis beginning after year-1 for other toxicants and after year-3 for mercury species to determine if criteria specified in the Protocol are being satisfied. Based on that assessment, and with the concurrency of the Department, monitoring and assessment efforts may be reduced (as identified in Phase 3-Tier 1 Operational monitoring of the Protocol) or eliminated all together at the project level to be subsumed by regional monitoring (as identified in Phase 3-Tier 3 Operational monitoring). However, if monitoring reveals anomalous conditions as described under Phase 3-Tier 2, the District shall expand monitoring and undertake all necessary steps under Phase 3 – Tier 2 Expanded Monitoring and Risk Assessment.

A4. Reporting Requirements

The permittee shall notify the Department immediately if monitoring data indicate that any of the action levels are exceeded. In addition, the permittee shall submit to the Department, as part of the annual South Florida Environmental Report, the results of the monitoring as defined above, including the following:

i. Comparison of inflow and discharge concentrations with state water quality criteria;
ii. Comparison of inflow and outflow loads and concentrations for total mercury, methylmercury, and other toxicants; and
iii. Comparison of data with appropriate action levels.

This page intentionally left blank.

ANNEX E
RECOVER REPORTS

This page intentionally left blank

TABLE OF CONTENTS

E.0 REPORTS PROVIDED BY RECOVER TO SUPPORT THE PLAN E-1
E.1 INTRODUCTION AND PURPOSE OF THE EVALUATION E-1
E.2 PROJECT BACKGROUND AND GENERAL DESCRIPTION OF ALTERNATIVE PLANS E-1
E.2.1 Project Goals and Objectives E-1
E.2.2 Project Background E-2
E.2.3 General Description of Alternative Plans E-3
E.3 EVALUATION METHODOLOGY AND INFORMATION CONSIDERED E-4
E.4 CONSISTENCY WITH THE COMPREHENSIVE PLAN E-5
E.5 SYSTEM-WIDE PERFORMANCE OF ALTERNATIVE PLANS E-6
E.5.1 Caloosahatchee Estuary E-6
E.5.1.1 Low Flow Events (<450 cfs) E-7
E.5.1.2 Flow Distribution at S-79 ..... E-10
E.5.1.3 Moderate and Extreme High Flow Events E-13
E.5.1.4 LO Regulatory Releases E-15
E.5.1.5 Ecological Impact for the Caloosahatchee Estuary E-15
E.5.2 Water Supply, Flood Damage Reduction, and Saltwater Intrusion E-16
E.5.2.1 Caloosahatchee East Basin E-16
E.5.2.2 Caloosahatchee West Basin E-17
E.5.2.3 Suggestions for further investigation E-18
E.5.3 Interaction with Other Projects E-19
E.5.4 Ability of Project Alternatives to Address Planning and Scientific Uncertainties (CERP Adaptive Management) E-19
E.5.4.1 Scientific Uncertainty E-19
E.5.4.2 Planning Uncertainties E-20
E.6 OPPORTUNITIES FOR ALTERNATIVE PLAN IMPROVEMENTS AND OTHER CONSIDERATIONS E-20
E.7 CONCLUSIONS E-21
E.8 REFERENCES E-22

LIST OF TABLES

Table E-1: Summary of caloosahatchee River (C-43) West Basin storage reservoir Project Alternative Plans E-4
Table E-2: Summary of Caloosahatchee River (C-43) West Basin storage reservoir Project Objectives and Corresponding CERP Objectives E-6
Table E-3: Summary of CERP System-Wide Performance Measure NE-3 Predictive Targets E-7
Table E-4: Mean Monthly Flow Events <450 cfs at the S-79 Structure October to July E-9
Table E-5: Mean Monthly Distribution of Flows From S-79 ..... E-10
Table E-6: Mean Weekly Distribution of Flows From S-79 ..... E-10
Table E-7: Summary of Moderate and Extreme High Mean Monthly Flows E-13
Table E-8: East Caloosahatchee (S-78 Basin) Summary (1000 ac-ft) E-17

Table E-9: West Caloosahatchee (S-79 Basin) Summary (1000 ac-ft) E-18

LIST OF FIGURES

Figure E-1: Number of Mean Monthly Flow Events Less than 450 cfs October to July E-9
Figure E-2: Distribution of Mean Monthly Flows Less Than 450cfs E-9
Figure E-3: Mean Monthly Flows at S-79 within the Desirable 450-2800 cfs Flow Range E-11
Figure E-4: Mean Weekly Flows at S-79 within the Desirable 450-2800 cfs Flow Range E-11
Figure E-5: Seasonal Mean Monthly Flows within the Desirable 450-2800 cfs Flow Range E-12
Figure E-6: 30-Day Moving Average S-79 Flows June 1982 to June 1983 ..... E-14

E.0 REPORTS PROVIDED BY RECOVER TO SUPPORT THE PLAN

E.1 INTRODUCTION AND PURPOSE OF THE EVALUATION

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project Team has identified their final array of alternative plans and requested that Restoration Coordination and Verification (RECOVER) conduct a system-wide evaluation of the alternative plans being considered. The role of RECOVER is to organize and apply scientific and technical information in ways that are most effective in supporting the objectives of the Comprehensive Everglades Restoration Plan (CERP or Comprehensive Plan). One of the primary missions of RECOVER is to work with the project team to evaluate and maximize the contribution made by each project to the system-wide performance of the CERP. The RECOVER Evaluation Team (ET) is charged with the responsibility of conducting system-wide evaluations.

The ET is an interagency and interdisciplinary scientific and technical team charged with developing and using performance measures for evaluating alternative plans developed for project implementation reports (PIRs). The purposes of system-wide evaluations are to (1) inform the project team of the compatibility of proposed project alternative plans with regional CERP restoration goals and performance expectations; (2) determine the performance of each alternative plan toward meeting system-wide goals and objectives through the use of system-wide performance measures, project performance measures, and best professional judgment; (3) identify improvements for project performance that would improve its system-wide performance, and (4) provide decision-makers required information regarding system-wide performance expectations of specific projects.

The type of RECOVER evaluations may vary depending on the applied tools, new information that may have become available, the project's relationship to the Central and Southern Florida (C&SF) Project, or the project implementation schedule. In the case of hydrologically isolated projects, RECOVER may not be able to rely on regional modeling results for their evaluations. For these projects, the scope of RECOVER's evaluations may be limited to reviewing project-level model results and applying best professional judgment.

E.2 PROJECT BACKGROUND AND GENERAL DESCRIPTION OF ALTERNATIVE PLANS

E.2.1 Project Goals and Objectives

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project is part of the CERP as authorized by the Water Resources Development Act (WRDA) 2000 (U.S. Congress 2000). The goal of the Caloosahatchee River (C-43) West Basin

Storage Reservoir Project is to capture Caloosahatchee River (C-43) Basin runoff and releases from Lake Okeechobee. The project's primary purpose will be to provide environmental water supply deliveries to the Caloosahatchee Estuary and water quality benefits to reduce salinity and nutrient impacts of runoff to the estuary. The objectives of this project, as identified in the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Feasibility Scoping Meeting Documentation (USACE and SFWMD 2005) are as follows:

- Improve the quantity, timing, and distribution of freshwater flows to the Caloosahatchee Estuary by capturing runoff from the Caloosahatchee Basin and Lake Okeechobee releases.
- Improve water quality in the Caloosahatchee Estuary by reducing nutrient inflows from the Caloosahatchee Basin.
- Improve salinity balance in the Caloosahatchee Estuary for estuarine organisms. Reduce the spatial extent and duration of occurrences of extreme low and high salinities.
- Improve the spatial extent and functional quality of habitat for estuarine biota.
- Increase plant and animal diversity and abundance, particularly increasing the spatial extent of SAV.
- Conserve and protect water resources to ensure sustainability of economic and natural resources.
- Ensure availability of ground and surface water supplies for environmental resources while protecting existing legal sources of water for agricultural and urban uses.
- Maintain existing level of service for flood protection in the project area.
- Provide recreational, tourism, and environmental education opportunities.

E.2.2 Project Background

The overall purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project can best be understood in terms of its contribution and relationship to the overarching purpose of restoring the South Florida ecosystem. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project will contribute to South Florida ecosystem restoration through features to increase the availability of water for the natural environment (i.e., the Caloosahatchee Estuary) to enable a more natural salinity regime for the estuary. By mitigating low flows to the estuary during the dry season (November-May) and extreme high flows during the wet season (June-October), natural salinity ranges suitable to improve habitat suitability and increase biological diversity will be established. Additional water made available by the project could supply urban and agricultural users.

The Caloosahatchee River (C-43) West Basin Storage Reservoir is intended to capture local basin runoff and Lake Okeechobee (LO) regulatory releases. The reservoirs will be used to attenuate flood conditions in the local basin, provide estuarine water deliveries, and potentially reduce nutrient impacts of runoff to the estuaries (USACE and SFWMD 1999). Through additional information development performed for the Initial CERP Update (ICU), it was determined that land-use and runoff calculations performed for the Caloosahatchee River (C-43) basin during the Restudy grossly overestimated the amount of runoff available in the local basin, while underestimating the urban and agricultural water demands. In addition to these updates, the low flow target to maintain acceptable salinities in the Caloosahatchee Estuary were updated from 300 cfs to 450 cfs, and deliveries from Lake Okeechobee were capped at Restudy-like levels. The combination of all these changes had the unintended consequence of requiring more environmental water deliveries from a system now producing less local runoff and shouldering increased agricultural and urban demand, while being unable to increase the amount of water supplied by Lake Okeechobee. Cost estimates for potential solutions to the above-listed problems were estimated to exceed the cost containment cap for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. Consequently, the C-43 BSR Project was split into two separate PIRs. The first PIR, termed Caloosahatchee River (C-43) West Basin Storage Reservoir Project, consists of a separable western storage reservoir at the Berry Groves site to address the needs of the lower Caloosahatchee River (C-43) basin and the Caloosahatchee Estuary. This PIR will primarily address estuarine freshwater flows and will only incidentally address water quality effects regarding sedimentation during reservoir retention. A subsequent PIR, consists of the remaining reservoirs identified in the original project, primarily addressing the needs of the upper Caloosahatchee River (C-43) basin, including water quality issues within the basin. The Caloosahatchee River (C-43) West Basin Storage Reservoir project is on a compressed timescale to coordinate with SFWMD Accelerate Program activities prior to the projected beginning of construction in June 2007. It will include formulation, evaluation, and justification of the separable western storage reservoir while acknowledging that the project is a part of a more comprehensive plan for the Caloosahatchee River (C-43) Basin.

E.2.3 General Description of Alternative Plans

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project identified their final array of project alternative plans. Each alternative plan that is being considered includes a reservoir to store and release water to the estuary. The configurations and operational plans that make up the final suite of alternative plans are detailed in ***Table E-1***.

TABLE E-1: SUMMARY OF CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT ALTERNATIVE PLANS

Alternative Name	Reservoir			Pump Size (cfs)	Operating Scheme
	Size (acres)	Depth (ft)	Storage Capacity (ac-ft)		
Alt2	10,000	10	100,000	1500	PIR
Alt3a	10,000	17	170,000	1500	A8
Alt 3b	10,000	17	170,000	1500	PIR
Alt 3c	10,000	17	170,000	3800	PIR
Alt 4	10,000	22	220,000	3800	PIR

E.3 EVALUATION METHODOLOGY AND INFORMATION CONSIDERED

This section outlines the methodology used by RECOVER to conduct its system-wide evaluation of alternative plans. It also describes the modeling and technical information considered by RECOVER to evaluate the potential system-wide effects of the project. RECOVER's analyses of the information presented and implications to the system are presented in later sections of this report.

Because the Caloosahatchee River (C-43) West Basin Storage Reservoir Project is essentially outside the spatial resolution and domain of the South Florida Water Management Model (SFWMM), the MIKESHE model was developed and used to dynamically simulate the entire land phase of the hydrologic cycle within the Caloosahatchee River (C-43) basin. Because the MIKESHE model and the SFWMM are not dynamically linked, the two models operate separately. Essentially, the Caloosahatchee River (C-43) West Basin Storage Reservoir Project receives a set volume of water from the SFWMM boundary based on the planning assumptions modeled in the 2050RD condition. The MIKESHE model then uses these boundary conditions and models the individual alternative plans for the western reservoir. The MIKESHE daily output for the S-79 structure was used to evaluate the project's performance using the CERP system-wide performance measure NE-3: Caloosahatchee salinity envelope (http://www.evergladesplan.org/pm/recover/recover_docs/et/ne-03.pdf).

Because the SFWMM essentially provides a pass-off volume of water to the MIKESHE model to manage within the local basin, conditions within the rest of the system remained unchanged based on changes in alternative plans. For this reason, RECOVER focused its evaluation on the project's performance within the Caloosahatchee Estuary, and worked in conjunction with the project's environmental sub-team to apply the hydrologic performance measure and interpret habitat suitability indices (HSI) output developed by the project team. RECOVER conducted its evaluation based on the following SFWMM and MIKESHE scenarios:

- 2000 Existing Condition using revised deliveries to the Caloosahatchee basin (2000RD)
- 2050 Future without CERP Condition using revised deliveries to the Caloosahatchee basin (2050RD)
- 2050 Future without Project (FWO) Condition using the MIKESHE model (2050FWO)
- 2050 Future Condition with each alternative in place with the rest of CERP using the MIKESHE model (Alt2, Alt3a, Alt3b, Alt3c, and Alt 4)

RECOVER recognizes that the West Basin Storage Reservoir Project Team will likely perform additional model runs during refinement of their alternatives leading up to their alternative formulation briefing. When available, RECOVER will review these additional model results and provide modified and/or additional comments to the Project Team on alternative plan performance where appropriate.

E.4 CONSISTENCY WITH THE COMPREHENSIVE PLAN

The planning objectives developed for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project are generally consistent with the objectives of the Comprehensive Plan (USACE and SFWMD 1999). The planning goal of this project is to address the declining health of Caloosahatchee River and Estuary ecosystems by improving water deliveries to the estuary to reduce excessive high flows during wet season and increase the availability of water for the estuarine system during the dry season to provide a salinity range that is suitable for a healthy ecosystem that promotes estuarine habitat, increased fish and wildlife, and biological diversity. After estuarine system needs are met, any additional water could supply urban and agricultural needs. The twelve objectives developed for the Project presented in ***Table E-2*** directly correspond to specific CERP goal(s) contained in the Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement (USACE and SFWMD 1999).

TABLE E-2: SUMMARY OF CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT OBJECTIVES AND CORRESPONDING CERP OBJECTIVES

CERP Goal: Restore ecologic values by increasing habitat and functional quality and improving native plant and animal species abundance and diversity
West Basin Storage Reservoir Project Objectives:
▪ Improve the quantity, timing, and distribution of freshwater flows to the Caloosahatchee Estuary by capturing runoff from the Caloosahatchee Basin and Lake Okeechobee releases.
▪ Improve water quality in the Caloosahatchee Estuary by reducing nutrient inflows from the Caloosahatchee Basin.
▪ Improve salinity balance in the Caloosahatchee Estuary for estuarine organisms. Reduce the spatial extent and duration of occurrences of extreme low and high salinities.
▪ Improve the spatial extent and functional quality of habitat for estuarine biota.
CERP Goal: Enhance economic values and social well being
West Basin Storage Reservoir Project Objectives:
▪ Conserve and protect water resources to ensure sustainability of economic and natural resources.
▪ Ensure availability of ground and surface water supplies for environmental resources while protecting existing legal sources of water for agricultural and urban uses.
▪ Maintain existing level of service for flood protection in the project area.
▪ Provide recreational, tourism, and environmental education opportunities

E.5 SYSTEM-WIDE PERFORMANCE OF ALTERNATIVE PLANS

The following sections summarize performance of the project alternatives using the methodology described in Section E.3 of this report.

E.5.1 Caloosahatchee Estuary

RECOVER's review of alternative plans focused on freshwater discharges from the Caloosahatchee River (C-43 canal) at the S-79 structure. Based on these analyses, the project will provide substantial benefits to the area.

The CERP system-wide Caloosahatchee Estuary salinity envelope performance measure, NE-3, targets a mean monthly inflow between 450 and 2800 cfs during all months, with a low flow target of no months during October to July when the mean monthly inflow from the Caloosahatchee watershed, as measured at S-79, falls below a low flow limit of 450 cfs and the high flow target is no months with mean monthly flow greater than 2800 cfs, as measured at the S-79, from Lake Okeechobee regulatory releases in combination with flows from the Caloosahatchee River (C-43) basin. These predictive performance targets are summarized in ***Table E-3***. A reduction in the number of low flow and high flow events and a reduction in the frequency and duration of high and low flow events is required to show improvement over the base conditions.

TABLE E-3: SUMMARY OF CERP SYSTEM-WIDE PERFORMANCE MEASURE NE-3 PREDICTIVE TARGETS

Performance Metric	Target
Low Flow Events	
Mean monthly flow at S-79 <450 cfs (July-October)	0
Number of consecutive months mean monthly flow at S-79 < 450cfs	Alternative with fewest consecutive months is best
Number of consecutive years with mean monthly flows at S-79 < 450 cfs	Alternative with fewest consecutive years is best
S-79 Flow Distribution	
Percent of mean monthly flows at S-79 450-800 cfs	75%
Percent of mean monthly flows at S-79 800-2800 cfs	25%
Moderate and Extreme High Flow Events	
Mean monthly flows at S-79 > 2800 cfs	0 (especially March-October)
Mean monthly flows at S-79 > 4500 cfs	0 (especially March-October)
Lake Okeechobee Regulatory Releases (measured at S-77RG)	
Number of days with LO regulatory releases	0
Daily volume of LO regulatory releases	0
Total volume of LO regulatory releases	0

E.5.1.1 Low Flow Events (<450 cfs)

The target of no flows less than 450 cfs especially between October and July has been found to be ecologically significant to valued ecosystem components (VECs) within the estuary, primarily for submerged aquatic vegetation (SAV) and the American oyster. The health of these VECs is crucial to maintaining the ecological structure and function of the estuary by providing food, living space, and foraging sites for other naturally occurring estuarine species (RECOVER 2006). Performance between October and July, corresponding to the dry season, is especially important to the health and stability of SAV communities within the estuary. An important upper estuarine feature is the freshwater-brackish submerged grass, *Vallisneria americana* (tape grass), which when present is located near the shoreline in the upper estuary to a depth of about 1.0 m (Hoffacker et al. 1994; Chamberlain and Doering 1998). *Vallisneria americana* is the dominant type of SAV in the upper Caloosahatchee Estuary and occurs in well-defined beds in shallow water. *Vallisneria americana* is thought to be an important habitat for a variety of freshwater and estuarine invertebrate and vertebrate species, including some commercially and recreationally important fishes (Bortone and Turpin 1999). Additionally, it can serve as a food source for the Florida manatee. *Vallisneria americana* is more sensitive to low freshwater flows and high salinities than the most common higher salinity grasses in the Caloosahatchee Estuary such as shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*). During times of extended low flow conditions, when salinity is too high, *Vallisneria*

americana becomes very sparse and can disappear completely (Chamberlain et al. 1995; Doering et al. 2002; SFWMD 2000). By reducing or eliminating low flow events, high salinities are reduced supporting greater *Vallisneria americana* beds and their associated ecological function.

Volety et al. (2003) has demonstrated the importance of the American oyster (*Crassostrea virginica)* as a VEC in the Caloosahatchee Estuary. A greater abundance of decapods and fishes are associated with clusters of live oyster compared to dead-articulated clusters, while the structure provided by both living and dead oyster shells supports a greater abundance than no shells. Species richness and dominance are higher for samples with oyster clusters (dead or live) compared to controls with no oyster shell. While high flow events (i.e., low salinities) are more detrimental to oysters than low flow events (i.e., high salinities), extended low flows can negatively impact oysters by making them prone to disease and predation. Low flow events will increase salinities in areas normally associated with lower salinity, and result in the migration of marine predators and pests. Oyster spat that recruit to downstream areas will also be exposed to higher salinity and heavy predation pressure resulting in very little survival (Volety et al. 2003). Infection by the oyster pathogen, *Perkinsus marinus*, increases during higher salinity and temperature conditions. Field studies by Volety et al. (2003) determined that the prevalence of infection is high when salinities are high due to low flow. Reducing or eliminating low flow events with short pulses of freshwater inflow can greatly benefit oyster populations by killing predators, such as the southern oyster drill and the whelk and reducing *Perkinsus marinus* infection.

Each of the alternatives evaluated demonstrates a decrease in the number of months when flows through the S-79 structure are less than 450 cfs between October and July (***Figure E-1***). These decreases range from 8% of the period of record (POR) for Alt2 to 21% of the POR for Alt3c and Alt4 (***Table E-4***). With regard to the target for this metric, 0% of the POR, alternatives Alt3c and Alt4 perform best. When the monthly distribution of these events is evaluated, differences among the alternatives' performance is more easily observed. By focusing on the heart of the dry season, between March and June, the differences among alternatives becomes apparent. While the largest decreases in damaging low flow events during this time period occur under alternatives Alt3c and Alt4, alternatives Alt2 and Alt3a do not show substantial decreases over the FWO condition (***Figure E-2***).

TABLE E-4: MEAN MONTHLY FLOW EVENTS <450 CFS AT THE S-79 STRUCTURE OCTOBER TO JULY

	Number of Events	Percent POR
Target	0	0%
2050FWO	42	39%
Alt2	33	31%
Alt3a	32	30%
Alt3b	30	28%
Alt3c	19	18%
Alt4	19	18%

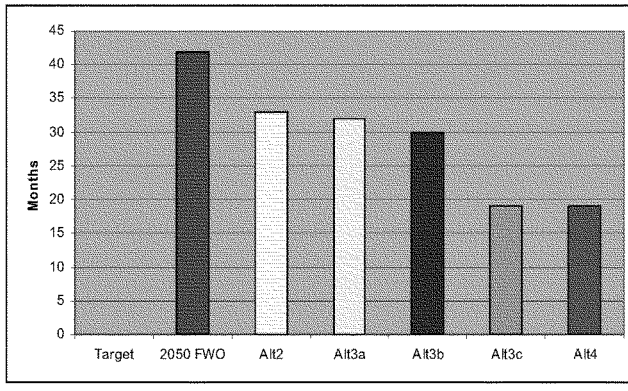


FIGURE E-1: NUMBER OF MEAN MONTHLY FLOW EVENTS LESS THAN 450 CFS OCTOBER TO JULY

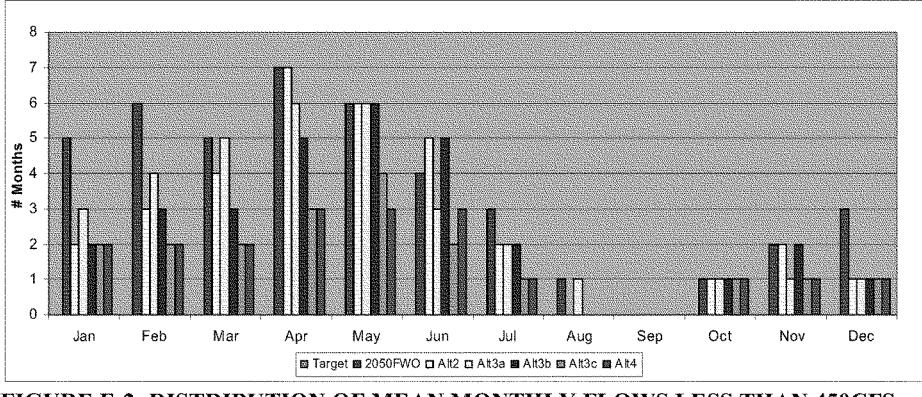


FIGURE E-2: DISTRIBUTION OF MEAN MONTHLY FLOWS LESS THAN 450CFS

E.5.1.2 Flow Distribution at S-79

The target of 75% of S-79 flows between 450-800 cfs and most of the remaining inflow between 800-2800 cfs is important for protecting and restoring estuarine resources while promoting species abundance and diversity (RECOVER 2006). Each of the alternatives increases the number of months where flow is within the desired envelope (***Table E-5*** and ***Figure E-3***). Alternatives Alt3c and Alt4 provide the greatest percentage of time within the desired flow envelope at 82% of the POR. RECOVER also evaluated the alternatives' performance based on mean weekly flows through the S-79 structure. Using this method, the ranking of alternative performance remained unchanged with alternatives. Alt3c and Alt4 again provide the best performance at 82% and 84% of the POR respectively ***Table E-6*** and ***Figure E-4.***

TABLE E-5: MEAN MONTHLY DISTRIBUTION OF FLOWS FROM S-79

	450-800 cfs	800-2800 cfs	%POR in Desired Envelope
Target	75.0%	25.0%	100.0%
2050FWO	25.0%	25.9%	50.9%
Alt2	42.6%	25.0%	67.6%
Alt3a	51.9%	15.7%	67.6%
Alt3b	45.4%	24.1%	69.4%
Alt3c	55.6%	26.9%	82.4%
Alt4	55.6%	26.9%	82.4%

TABLE E-6: MEAN WEEKLY DISTRIBUTION OF FLOWS FROM S-79

	450-800 cfs	800-2800 cfs	%POR in Desired Envelope
Target	75.0%	24.6%	99.6%
2050FWO	23.7%	21.8%	45.5%
Alt2	44.9%	23.1%	67.9%
Alt3a	47.9%	16.2%	64.1%
Alt3b	50.4%	24.4%	74.8%
Alt3c	59.4%	22.9%	82.3%
Alt4	60.7%	23.1%	83.8%

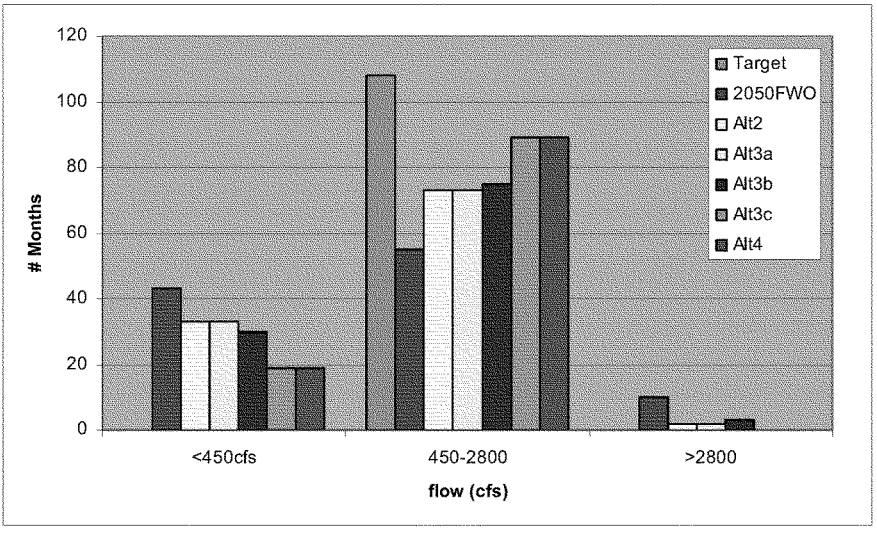


FIGURE E-3: MEAN MONTHLY FLOWS AT S-79 WITHIN THE DESIRABLE 450-2800 CFS FLOW RANGE

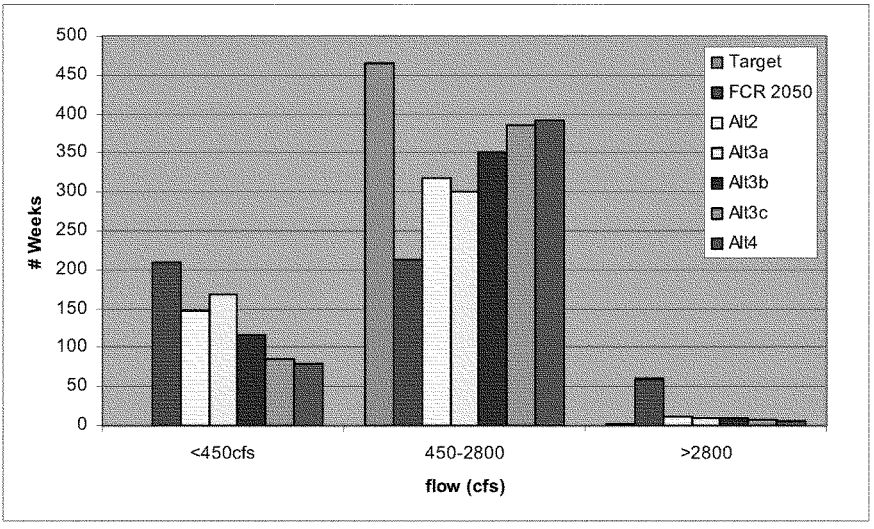


FIGURE E-4: MEAN WEEKLY FLOWS AT S-79 WITHIN THE DESIRABLE 450-2800 CFS FLOW RANGE

To understand any additional improvements in flow distributions, RECOVER evaluated the changes in seasonal flow distributions for mean monthly flows. The increases in the number of desirable flows that occur during the March-October period have been identified as most beneficial to indicator species communities in the Caloosahatchee Estuary with regard to SAV and juvenile oyster recruitment and survival. As with the previous analyses, Alt3c and Alt4 provide the largest increase in the number of months with flows within the desired envelope (***Figure E-5***).

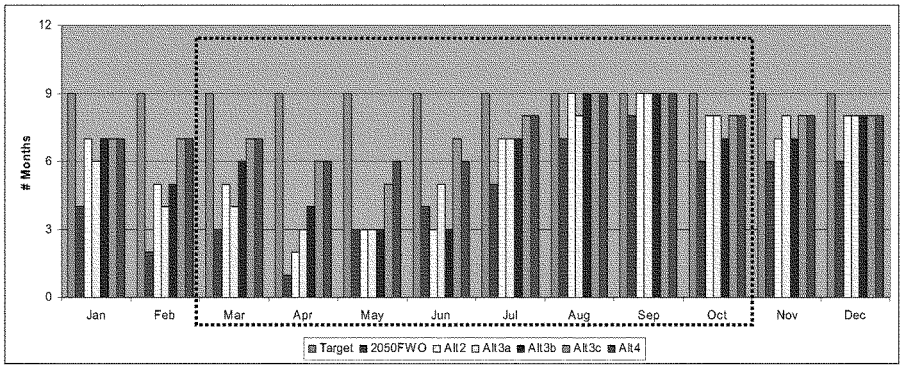


FIGURE E-5: SEASONAL MEAN MONTHLY FLOWS WITHIN THE DESIRABLE 450-2800 CFS FLOW RANGE

E.5.1.3 Moderate and Extreme High Flow Events

Moderate and extreme high flow events in the Caloosahatchee Estuary (>2800 cfs and >4500 cfs, respectively) directly impact estuarine salinities and ecosystem indicators such as the American oyster and SAV. Reduction in these high volume releases, especially during the period from March to October, may lead to decreases in mass mortality (salinity < 3 ppt) as well as poor spat production and excessive valve closure (salinity < 14ppt) in the oyster population (RECOVER 2006). Oysters are particularly susceptible to high flows that drastically lower salinity levels during the spawning season. One key component of spawning success is the requirement of salinities of approximately 7.5 ppt or greater (Sellers and Stanley 1984, Volety et al 2003). High flow events (flows > 2800 cfs, i.e., lower salinities) have a much greater impact on oysters than low flow events (i.e., higher salinities) as these inhibit reproduction and recruitment. This is exacerbated as oyster life spans are short and the effects of missed spawning opportunities prevent restoration of healthy populations. Optimum oyster ranges for physiological purposes, food abundance, and stenohaline predator avoidance is 10 to 20 ppt (Mazzoti et al. 2005). These salinities and flows have been corroborated by monitoring at S-79 structure where monthly flow volumes of 87.2 to 196 thousand ac-ft create salinities of less than 7.5 ppt. These flow volumes equate to mean monthly flows of 2800 cfs.

All alternatives measurably reduce the number of months and number of consecutive months where high flow events occurred. All alternatives substantially reduced the number of months with flows greater than 2800 cfs and completely eliminated flows greater than 4500 cfs, creating favorable conditions for the American oyster. Alternatives Alt3c and Alt4 provided the best performance and eliminated all flows greater than 2800 cfs (***Table E-7***).

TABLE E-7: SUMMARY OF MODERATE AND EXTREME HIGH MEAN MONTHLY FLOWS

Alternative	Months 2800-4500 cfs	Percent Change	Months >4500 cfs	Percent Change
Target	0		0	
2050FWO	7		3	
Alt2	2	-71%	0	-100%
Alt3A	2	-71%	0	-100%
Alt3B	3	-57%	0	-100%
Alt3C	0	-100%	0	-100%
Alt4	0	-100%	0	-100%

Note: Percent change indicates difference between the modeled alternative and the 2050 FWO condition.

To demonstrate the additional differences among alternative plans in preventing moderate high flow events (2800 cfs – 4500 cfs) a 30-day moving average of S-79

structure flows was evaluated. In most cases there is little difference between alternatives, however if attention is directed at the June 1982 to March 1983 time frame, differences among the alternative plans are apparent. To provide more resolution, ***Figure E-6*** depicts these 30-day moving averages during this critical period. For those alternatives without additional pumping and reservoir capacity (i.e. alternatives Alt2 and Alt3B), daily flows frequently exceeded 3000 cfs and in some cases exceed 10,000 cfs. When these high daily flows are converted to 30-day moving average flows, differences among the alternative plans can be discerned. Note that the 30-day moving average for flows through the S-79 structure exceed 3000 cfs for alternatives Alt2 and Alt3B during June of 1982, October of 1983, and March of 1983. Flows that exceed the moderate high flow criteria do not occur for alternatives Alt3C and Alt4. The larger pumping capacity and increased reservoir depth for these alternatives effectively prevent high flows to the estuary from the S-79 structure. From an ecological perspective, these high flows occur during oyster spawning windows. This protracted period of low salinity would have interrupted the oyster spawning cycle, potentially killing adult oysters, as well as spat that had set earlier in the season. As daily flows exceed 8,000 cfs mortality to reefs of adult oysters would also be expected to occur. These high flows also occur during the growing season for the SAV *Halodule wrightii*, which would inhibit growth.

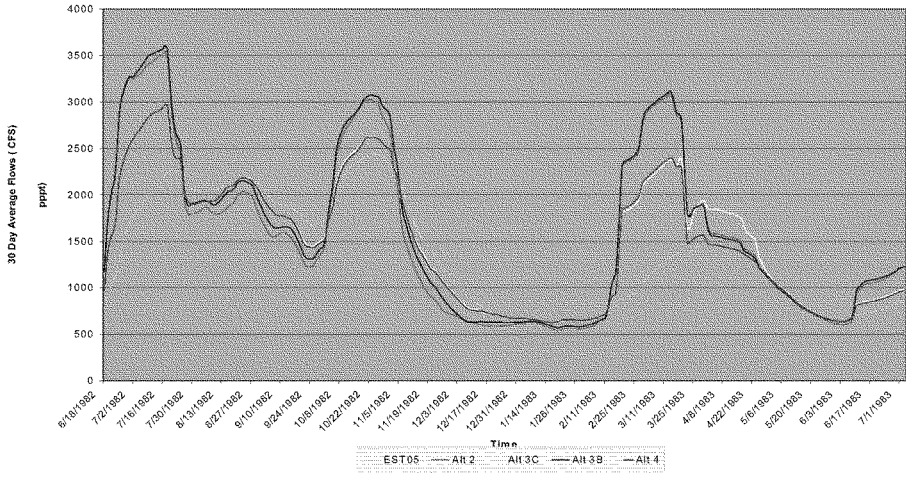


FIGURE E-6: 30-DAY MOVING AVERAGE S-79 FLOWS JUNE 1982 TO JUNE 1983

Periods of low salinity shorter than 30-days also impact oyster and *Halodule wrightii* health, therefore an analysis was conducted on a shorter time scale to

determine if more low salinity episodes were prevented through implementation of the alternative plans. For this analysis a two-week moving average was employed over the POR. Four events were identified when salinities were expected to drop below 3ppt based on flows greater than 2800 cfs: October 1979, July 1982, October 1982, and March 1983. These four episodes of low salinity did not occur for alternatives Alt3C and Alt4, but did occur for alternatives Alt2 and Alt3B. Impacts to estuarine oyster communities would have occurred in late 1979 thereby affecting the 1980 spawning season. After less than two years of recovery, three more episodes would occur in 1982 and early 1983. This would have compromised recovery of oysters in the Caloosahatchee Estuary system. If the MIKESHE period of record is representative of a longer time scale, then these episodic low salinity events could provide chronic and cyclic destruction of the oyster and *Halodule wrightii* communities. The additional pumping capacity and storage provided by alternatives Alt3C and Alt4 clearly improve ecological conditions within the estuary.

E.5.1.4 LO Regulatory Releases

Because the volumes of water provided by SFWMM boundary conditions into the MIKE-SHE model were fixed and did not vary based on the alternative plans, there was no change in the number or frequency of LO regulatory releases to the Caloosahatchee Estuary. The ability of the alternative plans to mitigate the LO regulatory releases that did occur is demonstrated through the substantial reduction or moderate high flow events (2800-4500 cfs) and the complete elimination of extreme high flow events (>4500 cfs).

E.5.1.5 Ecological Impact for the Caloosahatchee Estuary

The alternatives show a measurable reduction in low flow events due to the project and will provide significant benefit to the VECs tape grass (*Vallisneria americana)* and American oyster (*Crassostrea virginica).* A reduction in the low flow events eliminates high salinities, which has greatly reduced *Vallisneria americana* beds in the Caloosahatchee Estuary in the past (Chamberlain et al. 1995; Doering et al. 2002; SFWMD 2000). This reduction of high salinity conditions will lead to more extensive *Vallisneria americana* beds and greater ecological function in the Caloosahatchee Estuary. A reduction in low flow events eliminates high salinities that will benefit oyster populations by killing predators, such as the southern oyster drill and the whelk and reducing *Perkinsus marinus* infection (Volety et al. 2003). This reduction in high salinities not only decreases predation and disease, it also diminishes predation pressure on oyster spat, allowing greater recruitment.

In addition to the reduction in low flow events, the reduction of high flow events and the reduction in the duration of the high flow events due to the project will provide significant benefits to the area. When S-79 discharges exceed 4000 cfs,

salinities drop below 3 ppt upstream of Shell Point which can limit population survival and abundance of oysters in this region (Volety et al. 2003). A greater abundance of decapods and fishes are associated with clusters of live oyster compared to dead oyster clusters, while the structure provided by both living and dead oyster shells support a greater abundance than no shells (Volety et al. 2003). Therefore, the reduction of high flow events, which reduces low salinity events affecting oysters, will lead to increased diversity and abundance of estuarine fauna, one of CERP's primary goals.

E.5.2 Water Supply, Flood Damage Reduction, and Saltwater Intrusion

The severity and duration of water restrictions when drought levels exceed a 1-in-10 condition need to be reviewed to determine the full extent of predicted water supply impacts in the Caloosahatchee River (C-43) basin. To perform a review based on Supply-Side Management (SSM), raw or post-processed data that will allow the determination of monthly demand volume, number of days per month with cutbacks (demands not met), and volume of cutbacks (demand not met) per each month is required. Since this data is not readily available from MIKESHE output, annual average volumes (AAV) were evaluated. It is important to note that the average annual number will not allow for a determination of differences in alternative performance regarding water supply deliveries.

The results for agricultural and urban domestic self-supply in the Caloosahatchee River (C-43) basin indicate that "demands not met" dominate the model results and urban domestic self-supply for groundwater predicts over 90% of demand is not met. At this time, it is not possible for RECOVER to determine whether disparities between AAV demand and supply are a result of model assumptions/operations or accurately reflect the demands of urbanization within the basin. The following RECOVER evaluation presents performance based on the available model outputs and suggests additional areas of investigation for water supply analysis.

E.5.2.1 Caloosahatchee East Basin

A significant difference does not occur between the 2050FWO and the environmental target (EST05) for agricultural surface water and groundwater AAV demands (***Table E-8***). Only alternative Alt3a exhibits better performance for surface water AAV deliveries to agricultural users than the other alternatives and Alt3A matches the volume of surface water delivered in the 2000 base condition. All alternatives appear to slightly increase groundwater AAV agricultural demand over the 2050FWO without significant differences in performance. The agricultural groundwater AAV demand for all alternatives exceeds the AAV demands in the 2000 base condition.

All future planning conditions and alternatives are almost identical regarding surface water and groundwater AAV for urban self-supply (i.e., local irrigation-type wells). It appears the model presumes surface water will not be used for domestic supply in the future. The 2000 base condition does show a surface water demand of 800 ac-ft/year and a groundwater demand of 19,000 ac-ft/year for urban self-supply in the Caloosahatchee east basin.

TABLE E-8: EAST CALOOSAHATCHEE (S-78 BASIN) SUMMARY (1000 AC-FT)

	Irrigation and Domestic Self-supply AAV DEMAND				Irrigation AAV SUPPLY				AAV DEMAND NOT MET			
	Agriculture		Urban		Agriculture		Urban		Agriculture		Urban	
	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW
2000Base	142.4	1.7	0.8	18.6	130.7	1.0	0.8	0.6	11.7	0.7	0.0	18.0
2050FWO	146.7	17.9	0.0	51.9	134.8	8.8	0.0	1.8	12.0	9.1	0.0	50.1
EST05	146.8	18.0	0.0	52.0	133.4	8.9	0.0	1.8	13.4	9.0	0.0	50.1
Alt2	147.4	20.2	0.0	52.2	126.8	10.7	0.0	1.9	20.6	9.5	0.0	50.3
Alt3A	148.3	20.1	0.0	52.7	130.2	10.6	0.0	1.9	18.0	9.5	0.0	50.9
Alt3B	147.4	20.3	0.0	52.2	126.8	10.7	0.0	1.9	20.6	9.5	0.0	50.3
Alt3C	147.3	20.3	0.0	52.2	126.8	10.8	0.0	1.9	20.4	9.5	0.0	50.3
Alt 4	147.3	20.3	0.0	52.2	127.3	10.7	0.0	1.9	20.0	9.5	0.0	50.3

E.5.2.2 Caloosahatchee West Basin

Agricultural AAV provided via surface water is significantly different for 2050FWO and EST05, but groundwater is only slightly different (***Table E-9***). The target deliveries to the estuary appear to reduce the surface water available for agricultural supply in the western basin. Alternative Alt3A exhibits substantially better agricultural AAV deliveries and is the only alternative providing as much AAV delivered to agriculture as the 2050FWO. Alternatives Alt3C and Alt4 provide the next highest volume of agricultural AAV and Alt2 and Alt3B are both similar in AAV to EST05 and provide the lowest AAV deliveries to agricultural users. The alternatives do not differ significantly for groundwater AAV regarding demands not met for agricultural users. Alternative Alt3A has a slightly lower volume of groundwater AAV deliveries that is offset by higher surface water AAV deliveries in the basin. Alternative Alt3A resembles the 2050FWO and the other alternatives resemble the EST05.

Surface water and groundwater AAV demands for domestic self-supply do not differ significantly between 2050FWO and EST05. All of the alternatives show increased surface water AAV demand over the 2000 base condition and the 2050FWO. Alternative Alt3A has a slightly lower surface water AAV demand. All alternatives are practically identical regarding groundwater AAV demand for urban users. Adjusting for the predicted demands not met, the alternatives

provide approximately 10% more AAV than the 2050FWO and approximately 20% less AAV than the 2000 base condition.

TABLE E-9: WEST CALOOSAHATCHEE (S-79 BASIN) SUMMARY (1000 AC-FT)

	Irrigation and Domestic Self-supply AAV DEMAND				Irrigation AAV SUPPLY				AAV DEMAND NOT MET			
	Agriculture		Urban		Agriculture		Urban		Agriculture		Urban	
	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW	SW	GW
2000Base	87.7	61.2	1.1	42.4	65.7	17.9	0.8	13.4	22.0	43.3	0.3	29.0
2050FWO	61.3	54.0	6.2	118.3	52.5	18.9	2.9	9.8	8.8	35.2	3.3	108.6
EST05	56.5	58.9	6.2	118.5	34.8	20.0	2.9	9.8	21.6	38.9	3.3	108.7
Alt2	55.3	59.4	8.6	125.3	33.7	20.1	4.1	10.6	21.6	39.3	4.5	114.7
Alt3A	61.1	53.5	8.4	124.5	53.7	18.7	4.1	10.5	7.4	34.8	4.3	114.0
Alt3B	56.0	58.6	8.6	125.2	36.0	20.0	4.1	10.6	20.0	38.7	4.5	114.6
Alt3C	57.6	57.0	8.5	125.0	41.5	19.7	4.2	10.5	16.2	37.3	4.3	114.4
Alt 4	57.9	56.7	8.5	125.0	42.5	19.6	4.1	10.6	15.5	37.2	4.3	114.4

E.5.2.3 Suggestions for further investigation

The following section presents some insight and questions that might be considered during further investigation of water supply metrics within the Caloosahatchee River (C-43) basin:

- The data requested for a SSM-type water supply review might help determine discrepancies not apparent in AAV data.
- The 2050FWO, EST05, and alternative plans all exhibit increased groundwater demands over the 2000 base condition for urban users and appear to be the governing factor in increased demand not met.
- Why does the East Caloosahatchee 2000 base agricultural AAV provided seem to match the current understanding of the basin, while the West Caloosahatchee 2000 base AAV provided seems decreased from on the ground observations? What are the differences in how the two sub-basins are modeled?
- If the model results are predicting correctly, could the environmental deliveries require so much from the system that less water is available for consumptive use? The inconsistencies between the modeled 2000 base and on the ground conditions indicate issues with modeling assumptions/operations for groundwater in the basin.
- Why do the alternatives add 12,000 ac-ft/year to consumptive use demands above the amount predicted in the 2050 Bases? Most of this is added in the West Caloosahatchee Urban demands – but there are indications of smaller additions throughout.

E.5.3 Interaction with Other Projects

While each CERP project is considered as a stand-alone component, it is important to remember that the interactions among projects will ultimately determine CERP's restoration success for the South Florida ecosystem. With this in mind, RECOVER sought to understand how surrounding projects might interact with the Caloosahatchee River (C-43) West Basin Storage Reservoir project to maximize system benefits. The primary projects identified include Aquifer Storage and Recovery (ASR), Lake Okeechobee Watershed (LOW) Project, and the Lake Okeechobee Regulation Schedule (LORS). While the West Basin Storage Reservoir Project is able to capture and re-release many of the high flow events that result during the wet season in order to better mimic the natural salinity patterns of the estuary, the LOW Project and LORS will clearly impact the amount of water that travels to the estuary in the wet season. Coordination of these projects will be necessary to alleviate high lake stages to maintain littoral zone health while maximizing utilization of the reservoirs in the LOW Project and the Caloosahatchee River (C-43) West Basin Storage Reservoir project to mitigate high flows in the wet season and supplement low flows during the dry season. Additionally, the advent of ASR, or similar storage option, will help to store additional water to ensure that local water supply needs are met. The combined effect of these projects, LOW and LORS reducing the number of moderate and extreme high low events and the Caloosahatchee River (C-43) West Basin Storage Reservoir project providing water to the estuary during the dry season, are expected to meet estuary restoration goals.

E.5.4 Ability of Project Alternatives to Address Planning and Scientific Uncertainties (CERP Adaptive Management)

As with other ecosystem restoration projects throughout the nation, every potential restoration action carries with it an amount of uncertainty and risk. In the case of the Caloosahatchee River (C-43) West Basin Storage Reservoir project, this uncertainty has been identified and project alternatives have been formulated to address and alleviate those uncertainties. In general, uncertainties related to large-scale restoration can be categorized as scientific uncertainties and planning uncertainties.

E.5.4.1 Scientific Uncertainty

The environmental response corresponding to a specific action is uncertain; this is scientific uncertainty. With regard to the Caloosahatchee (C-43) West Basin Storage Reservoir project, there is little uncertainty that more natural salinity patterns in the estuary will improve habitat for desirable indicator species (SAV, oysters, and estuarine fishes) if the timing and distribution of flows meets seasonal targets. It is expected that obtaining more natural flow regimes will benefit target species populations directly by decreasing extreme salinity fluxes.

There is, however, uncertainty regarding the exact water quality benefits provided by the proposed project and the extent of secondary benefits to the broader estuarine community. The HSIs developed by the project team demonstrate the benefits to given species within the estuary over the FWO condition; however they do not demonstrate large differences among the alternative plans. The inability to reveal these differences may be an artifact of model sensitivity, or may indicate that the estuary ecology is benefited over the range of alternative plans evaluated. At this time, the scientific evidence is not available to support one of these theories over the other. Given the scientific uncertainties mentioned, it will be necessary for future scientific findings regarding the resiliency of species indicators and effects on total estuarine health to be incorporated in project operations. Additionally, in order for the project to quantify the total benefits resulting in the estuary post-implementation, activities will need to include associated monitoring and assessment activities at appropriate spatial and temporal scales to provide feedback to the predictive tools (i.e., HSIs) developed during the planning of this project.

E.5.4.2 Planning Uncertainties

The largest planning uncertainty facing the Caloosahatchee River (C-43) West Basin Storage Reservoir team is the project's affect on agricultural and urban water supply in the western Caloosahatchee River (C-43) basin. Initial modeling results indicate that additional investigation is warranted to determine the exact impacts to water supply in this region. A related issue is the cap on water deliveries from LO to the Caloosahatchee River (C-43) basin to Restudy-like levels. The CERP A Refinement currently being conducted by the System Planning and Operations Team (SPOT) is investigating the effects to LO if water deliveries are raised to 2000 levels. The results of this investigation will be presented to CERP decision-makers to determine whether revisions to the stated policy are warranted, and are outside the scope of the project team's planning effort.

E.6 OPPORTUNITIES FOR ALTERNATIVE PLAN IMPROVEMENTS AND OTHER CONSIDERATIONS

As part of the responsibilities given to RECOVER, this section presents suggested improvements to the alternative plans, which, where possible, are intended to improve the project's performance or enhance benefits to the natural system. These suggested improvements to the alternative plans should be considered by the project during the design of the final plan or reevaluation of alternative plans when appropriate.

Two primary opportunities to improve project performance have been identified. First, the project team should strive to optimize operations to coordinate with

other storage features such as ASR, the LOW Project, and the LORS in order to increase benefits to LO (i.e., fewer deviations from the LO stage envelope) and the Caloosahatchee Estuary (i.e., fewer regulatory releases, especially during sensitive periods for key indicator species). Second, the project team should further investigate water supply issues within the Caloosahatchee basin, with specific emphasis on urban groundwater demands within the western basin. RECOVER will remain available to participate in these investigations.

E.7 CONCLUSIONS

RECOVER's system-wide evaluation indicates that all of the project alternative plans improve estuary health over the FWO Project Condition by altering hydrology to achieve a more natural salinity pattern within the estuary. Alternative plans Alt3C and Alt4 provide the most benefits to the estuary by reducing the number of damaging high and low flows to the greatest extent at both the monthly and weekly scale. The project alternative plans are likely to have the following effects compared to the future without project condition:

- Increasing the period of time during which flows from the S-79 structure fall within the desirable flow envelope for the Caloosahatchee Estuary
- Decreasing the frequency and duration of low flows to the Caloosahatchee Estuary via S-79
- Decreasing the frequency and duration of moderate and extreme high flows to the Caloosahatchee Estuary via S-79
- Decreasing level of service for water supply in the LOSA and LECSA for frequency, duration, and severity of cutbacks

In conjunction with other CERP and non-CERP projects within neighboring basins, the Caloosahatchee River (C-43) West Basin Storage Reservoir project is expected to reach CERP system-wide restoration goals for the frequency and duration of moderate and extreme high flow events, and to meet CERP restoration targets for flow distributions to the estuary up to 84% of the time. Given the cumulative effects of project benefits, the coordination of the Caloosahatchee River (C-43) West Basin Storage Reservoir project with other CERP project is even expected to provide additional benefits than those that are currently able to be documented using available ecologic and hydrologic models.

E.8 REFERENCES

Bortone, S.A., and R.K. Turpin. 1999. Tape grass life history metrics associated with environmental variables in a controlled estuary. In: Bortone, S.A. (ed). Seagrasses: Monitoring, Ecology, Physiology, and Management. CRC Press, Boca Raton, Florida, pp. 65-79.

Chamberlain, R. H. and P.H. Doering. 1998. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach, p. 121-130. *In* S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington, D.C.

Chamberlain, R.H., D.E. Haunert, P.H. Doering, K.M. Haunert, and J.M. Otero. 1995. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary, Florida. Technical report, South Florida Water Management District, West Palm Beach, Florida.

Doering, P.H., R.H. Chamberlain, and D.E. Haunert. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. *Estuaries* 25 (1343-1354).

Hoffacker, V.A. 1994. Caloosahatchee River submerged grass observation during 1993. W. Dexter Bender and Associates, Inc. Letter-report and map to Chip Meriam, SFWMD.

Mazzoti, F. J., Pearlstine, L. G., Barnes, T., Volety, A. K., Irvin, D., and A. M. Weinstein. 2005. Stressor response models for the Eastern oyster, Crassostrea virginica. JEM Technical Report 2005-01. Final Report to the U. S. Geological Survey. University of Florida, Ft. Lauderdale Research and Education Center, Fort Lauderdale, FL. 14 pages.

RECOVER 2006. CERP System-wide Performance Measures. Restoration Coordination and Verification Team, c/o U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL, and South Florida Water Management District West Palm Beach, FL.

SFWMD. 2000. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary. South Florida Water Management District, Florida.

Sellers, M.A, and J.G. Stanley. 1984. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic) - - American oyster. U.S. Fish and Wildlife Service. FWS/OBS-82/11.23. U.S. Army Corps of Engineers. TR EL-82-4. 15 pp.

USACE and SFWMD. 1999. Central and Southern Florida Project Comprehensive Review Study Final Integrated Feasibility Report and Programmatic Environmental Impact Statement, U.S. Army Corps of

Engineers Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

USACE and SFWMD. 2005. C-43 Basin Storage Reservoir Project Feasibility Scoping Meeting Documentation. U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

U.S. Congress 2000. Water Resources Development Act 2000. Public Law 106-541, 106th U.S. Congress, Washington, D.C.

Volety, A.K., S.G. Tolley, and J.T. Winstead. 2003. Effects of seasonal and water quality parameters on oysters (Crassostrea virginica) and associated fish populations in the Caloosahatchee River: Final contract report (C-12412) to the South Florida Water Management District. Florida Gulf Coast University, Ft. Myers, Florida.

This page intentionally left blank.

ANNEX F
COASTAL ZONE MANAGEMENT PROGRAM
CONSISTENCY EVALUATION
AND
SECTION 404(B)(1) EVALUATION

This page intentionally left blank

TABLE OF CONTENTS

F.0 COASTAL ZONE CONSISTENCY AND SECTION 404(B)(1) EVALUATIONS F-1
F.1 FLORIDA COASTAL ZONE MANAGEMENT PROGRAM FEDERAL CONSISTENCY EVALUATION PROCEDURES F-1
F.1.1 Chapter 161, Beach and Shore Preservation F-1
F.1.2 Chapters 186 and 187, State and Regional Planning F-1
F.1.3 Chapter 252, Disaster Preparation, Response and Mitigation F-1
F.1.4 Chapter 253, State Lands F-1
F.1.5 Chapters 253, 259, 260, and 375, Land Acquisition F-2
F.1.6 Chapter 258, State Parks and Aquatic Preserves F-2
F.1.7 Chapter 267, Historic Preservation F-2
F.1.8 Chapter 288, Economic Development and Tourism F-3
F.1.9 Chapters 334 (Transportation Administration), 335 (State Highway System), 338 (Intrastate Highway System and Toll Facilities) and 339 (Public Transportation) F-3
F.1.10 Chapter 370, Saltwater Living Resources F-3
F.1.11 Chapter 372, Living Land and Freshwater Resources F-4
F.1.12 Chapter 373, Water Resources F-4
F.1.13 Chapter 376, Pollutant Spill Prevention and Control F-4
F.1.14 Chapter 377, Oil and Gas Exploration and Production F-4
F.1.15 Chapter 380, Environmental Land and Water Management F-5
F.1.16 Chapter 388, Arthropod Control F-5
F.1.17 Chapter 403, Environmental Control F-5
F.1.18 Chapter 582, Soil and Water Conservation F-5
F.2 CLEAN WATER ACT SECTION 404(B)(1) EVALUATION F-6

This page intentionally left blank

F.0 COASTAL ZONE CONSISTENCY AND SECTION 404(B)(1) EVALUATIONS

F.1 FLORIDA COASTAL ZONE MANAGEMENT PROGRAM FEDERAL CONSISTENCY EVALUATION PROCEDURES

F.1.1 Chapter 161, Beach and Shore Preservation

The intent of the coastal construction permit program established by this chapter is to regulate construction projects located seaward of the line of mean high water and which might have an effect on natural shoreline processes.

Response: The proposed plans and information will be submitted to the state in compliance with this chapter. No work is proposed seaward of the mean high water line in beach areas.

F.1.2 Chapters 186 and 187, State and Regional Planning

These chapters establish the State Comprehensive Plan that sets goals that articulate a strategic vision of the State's future. Its purpose is to define in a broad sense, goals and policies that provide decision-makers directions for the future and provide long-range guidance for an orderly social, economic and physical growth.

Response: The proposed project has been coordinated with various Federal, State and local agencies during the planning process. The proposed project would achieve the goals of this chapter by contributing to a long-range master plan for south Florida's water resources, which would support the continued orderly social, economic and physical growth of the region.

F.1.3 Chapter 252, Disaster Preparation, Response and Mitigation

This chapter creates a state emergency management agency, with the authority to provide for the common defense; to protect the public peace, health and safety; and to preserve the lives and property of the people of Florida.

Response: This statute is not applicable to this project.

F.1.4 Chapter 253, State Lands

This chapter governs the management of submerged state lands and resources within state lands. This includes archeological and historical resources; water resources; fish and wildlife resources; near shore reefs; beaches and dunes; submerged grass beds and other benthic communities; swamps, marshes and other wetlands; mineral resources; unique natural features; submerged lands; spoil islands; and artificial reefs.

Response: The proposed project would make a positive contribution to preserving cultural, water, fish and wildlife, wetland and estuarine resources. The proposed project would comply with the intent of this chapter.

F.1.5 Chapters 253, 259, 260, and 375, Land Acquisition

This chapter authorizes the state to acquire land to protect environmentally sensitive areas.

Response: The property proposed for this project is already in public ownership. The proposed project would comply with the intent of this chapter.

F.1.6 Chapter 258, State Parks and Aquatic Preserves

This chapter authorizes the state to manage state parks and preserves. Consistency with this statute would include consideration of projects that would directly or indirectly adversely impact park property, natural resources, park programs, management or operations.

Response: The Caloosahatchee River and Estuary are at the head of a vast estuarine and marine ecosystem that includes aquatic preserves managed by the State of Florida (e.g., Matlacha Pass, Estero Bay, and Pine Island Sound Aquatic Preserves), the Charlotte Harbor National Estuary Program, and the J. N. Ding Darling National Wildlife Refuge (NWR) Complex which includes the Caloosahatchee, Matlacha Pass, Pine Island, and Island Bay NWRs; along with numerous other state and local parks and recreation areas. The aquatic preserves are also outstanding Florida water bodies. The proposed project would improve the timing and delivery of water to the Caloosahatchee River which will have a positive effect on these areas. The proposed project would comply with the intent of this chapter.

F.1.7 Chapter 267, Historic Preservation

This chapter establishes the procedures for implementing the Florida Historic Resources Act responsibilities and for implementing the Section 106 of the National Historic Preservation Act of 1966, as amended; and the National Environmental Policy Act of 1969, as amended.

Response: Cultural resource surveys have been completed for the Caloosahatchee River (C-43) West Basin Storage Reservoir. Three isolated prehistoric artifacts, one isolated historic artifact, one prehistoric archeological site (8HN129), and four modified historic buildings were identified. All except the prehistoric archeological site were determined to lack integrity and determined not eligible for listing on the National Register of Historic Places, the prehistoric archeological site (8HB129) is located near the edge of the

proposed project and will be avoided by project design. The USACE has determined that the project will not affect historic properties eligible for listing on the National Register of Historic Places. The Florida State Historic Preservation Officer concurred with this determination (Florida State Department of Historic Preservation numbers 2004-8676 and 2006-07757). The project will be consistent with the goals of this chapter.

F.1.8 Chapter 288, Economic Development and Tourism

This chapter directs the state to provide guidance and promotion of beneficial development through encouraging economic diversification and promoting tourism.

Response: The proposed project would achieve the goals of this chapter by contributing to a long-range master plan for South Florida's water resources, which would support economic diversification and tourism.

F.1.9 Chapters 334 (Transportation Administration), 335 (State Highway System), 338 (Intrastate Highway System and Toll Facilities) and 339 (Public Transportation)

These chapters authorize the planning and development of a safe, balanced and efficient transportation system.

Response: No public transportation systems would be impacted by this project.

F.1.10 Chapter 370, Saltwater Living Resources

This chapter directs the state to preserve, manage and protect the marine, crustacean, shell and anadromous fishery resources in state waters; to protect and enhance the marine and estuarine environment; to regulate fishermen and vessels of the state engaged in the taking of such resources within or without state waters; to issue licenses for the taking and processing products of fisheries; to secure and maintain statistical records of the catch of each such species; and to conduct scientific, economic, and other studies and research.

Response: The proposed project is consistent with the goals of this chapter. Implementation of the project will provide direct positive impacts on saltwater resources within the Caloosahatchee Estuary by attenuation of freshwater flows during the wet season, provision of freshwater flows during the dry season, and improvement of the salinity balance. This will benefit seagrass, oysters, fisheries, and wildlife.

F.1.11 Chapter 372, Living Land and Freshwater Resources

This chapter establishes the Game and Freshwater Fish Commission (now called the Florida Fish and Wildlife Conservation Commission) and directs it to manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions that provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits.

Response: The project will have a long-term beneficial effect on freshwater aquatic life and wild animal life within the Caloosahatchee River through attenuation of high flows during the wet season and provision of flows during the dry season. The proposed project is consistent with the intent of this chapter.

F.1.12 Chapter 373, Water Resources

This chapter provides the authority to regulate the withdrawal, diversion, storage, and consumption of water.

Response: The non-federal sponsor for this project is the South Florida Water Management District, which is the state agency responsible for implementing this statute. Coordinated planning has been done with this agency to ensure compatibility with established policies. The project is consistent with the goals of this chapter.

F.1.13 Chapter 376, Pollutant Spill Prevention and Control

This chapter regulates the transfer, storage, and transportation of pollutants and the cleanup of pollutant discharges.

Response: The contract specifications will prohibit the contractor from dumping oil, fuel, or hazardous wastes in the work area and will require that the contractor adopt safe and sanitary measures for the disposal of solid wastes. A spill prevention plan will be required.

F.1.14 Chapter 377, Oil and Gas Exploration and Production

This chapter authorizes the regulation of all phases of exploration, drilling, and production of oil, gas, and other petroleum products.

Response: This project does not involve the exploration, drilling, or production of gas, oil or petroleum product and therefore, this chapter does not apply.

F.1.15 Chapter 380, Environmental Land and Water Management

This chapter establishes criteria and procedures to assure that local land development decisions consider the regional impact of proposed large-scale development on natural systems.

Response: The proposed project includes development of the site for an above-ground reservoir with pump stations and other related features. Operation of the reservoir would benefit and the Caloosahatchee River Region by reducing the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuary system. The project also helps to maintain a desirable minimum flow of fresh water to the estuary during dry periods. These two primary functions help to moderate unnatural changes in salinity which is extremely detrimental to estuarine communities. The project is consistent with the intent of this chapter.

F.1.16 Chapter 388, Arthropod Control

This chapter provides for a comprehensive approach for abatement or suppression of mosquitoes and other pest arthropods within the state.

Response: The project would not further the propagation of mosquitoes or other pest arthropods.

F.1.17 Chapter 403, Environmental Control

This chapter authorizes the regulation of pollution of the air and waters of the state by the Florida Department of Environmental Regulation (now a part of the Florida Department of Environmental Protection).

Response: An Environmental Impact Statement addressing project impacts has been prepared and will be reviewed by the appropriate resource agencies including the Florida Department of Environmental Protection. Environmental protection measures will be implemented to ensure that no lasting adverse effects on water quality, air quality, or other environmental resources will occur. Water Quality Certification will be sought from the State prior to construction. The project complies with the intent of this chapter.

F.1.18 Chapter 582, Soil and Water Conservation

This chapter establishes policy for the conservation of state soil and water through the Department of Agriculture. Land use policies will be evaluated in terms of their tendency to cause or contribute to soil erosion or to conserve, develop, and utilize soil and water resources both onsite or in adjoining

properties affected by the project. Particular attention will be given to projects on or near agricultural lands.

Response: Project construction and implementation will include appropriate erosion control plans and measures to ensure compliance with the intent of the chapter.

F.2 CLEAN WATER ACT SECTION 404(B)(1) EVALUATION

1. Project Description

a. Location.

The study area consists of the proposed project site, the Caloosahatchee River (C-43 Canal), Caloosahatchee Estuary, and the affected drainage basins. The study area extends approximately 70 miles from Lake Okeechobee to the lower Charlotte Harbor Basin at San Carlos Bay. The Caloosahatchee River watershed constitutes the northern portion of the SFWMD Lower West Coast planning area. The Caloosahatchee River watershed covers an area of 1,125,000 acres in parts of Lee, Glades, Charlotte, and Hendry Counties. The watershed can be further subdivided into seven drainage basins based on their hydrologic characteristics, hydrologic control features, and topography. Moving from east to west these basins are the C-21, East Caloosahatchee, West Caloosahatchee, Orange River, S-236, Telegraph Swamp, and the Tidal Caloosahatchee Basin.

The Caloosahatchee River watershed (or C-43 Basin) drains an area of about 1,758 square miles and was originally a shallow meandering river. Prior to human disturbance, water moved slowly from the uplands and wetlands to the river and then downstream to the estuary. The population of the four counties that make up the Caloosahatchee River Basin was 630,000 in 2000 and is expected to nearly double to 1,220,000 by 2050. Major land uses in the area include agriculture (dominated by citrus, sugar cane, vegetables, sod, and cattle production), urban and municipal development, and natural areas.

b. Alternatives Considered and Rejected

Both structural and non-structural management measures were developed to ensure the achievement of an overall CERP goal that the proposed project would provide environmental restoration benefits as outlined in the Restudy. In order to develop and select a plan that will reasonably maximize ecosystem restoration benefits while addressing the water supply issues and opportunities in the basin, restoration of estuarine and riverine health were sought by improving hydrologic conditions. This could be done by evaluating two objectives: providing additional water to augment low or no flows over S-79 during the dry season/dry periods and reducing damaging peak flows by providing adequate storage during

high flow conditions. The following measures were identified and subsequently screened for the reasons identified in parenthesis:

- Restoration of natural areas (few locations able to provide significant natural storage)
- Stormwater treatment areas (does not help meet the goals and objectives of the project)
- Backpumping with stormwater treatment (potentially insufficient water supply; does not meet the goals and objectives of the project)
- Aquifer storage and recovery (lack of information on this technology; pilot projects currently researching this possibility)

The above analysis of management measures reaffirmed that above ground reservoir storage areas along with operations of the reservoir(s) met the goals and objectives as outlined in the Restudy. The final array of alternatives for this project were then developed using the Restudy alternative as a starting point. The final array of alternatives included:

- Alternative 1 – no action
- Alternative 2 – 100,000 ac-ft reservoir with 1500 cfs pumping capacity
- Alternative 3B – 170,000 ac-ft reservoir with 1500 cfs pumping capacity
- Alternative 3C – 170,000 ac-ft reservoir with 3800 cfs pumping capacity
- Alternative 4A – 220,000 ac-ft reservoir with 3800 cfs pumping capacity

A benefits analysis and CE/ICA were performed, as well as other factors considered as discussed in Section 5 of the attached PIR/EIS, which resulted in Alternative 3B as the preferred alternative.

c. General Description.

The recommended plan for the C-43 West Storage Reservoir would consist of approximately 10,700 acres (approximately 10,480 acres of fee and 20 acres of perpetual channel easement. Approximately 200 additional acres will be required on a temporary basis during project construction for staging areas). This includes an above-ground reservoir with two cells totaling approximately 9,400 acres providing a normal maximum storage capacity of approximately 170,000 acre-feet surrounded by an embankment and perimeter canals. Major features of the recommended plan include the following:

- External (dam) embankments varying in height between 32 and 37 ft. above existing grade;
- Soil-Bentonite slurry walls within and beneath the external embankments;

- An internal (dam) embankment separating the two cells with an approximate height of 31 ft. above existing grade ;
- An inflow pump station consisting of diesel-powered pumps with a total pumping capacity of 1,500 cfs;
- A perimeter canal;
- A perimeter canal pump station consisting of electric-powered pumps with a total pumping capacity of 195 cfs;
- Numerous spillways, culverts, perimeter canal structures, an internal cell balancing structure, and outlet structures;

d. Authority and Purpose.

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project was authorized by Section 601 the Water Resources Development Act (WRDA) of 2000, Public Law 106-541. The purpose of the project is to capture and store excess regulatory releases from Lake Okeechobee; capture and store excess Caloosahatchee River (C-43) basin storm-water run-off; provide environmental benefits for a better salinity balance in the downstream Caloosahatchee Estuary by attenuating high flows in the wet season and releasing essential flows during the dry season; provide groundwater recharge; provide some water supply for irrigation needs, and environmental and urban demands and prevention of saltwater intrusion.

e. General Description of Dredged or Fill Material.

(1) General Characteristics of Material: Fill material for the embankments will be dredged and excavated material that will be removed within the immediate project area. The material will consist primarily of poorly-graded sand and clayey sand above the limestone rock layer.

(2) Quantity of Material: Approximately 4,500,000 cubic yards of material would be excavated to construct the perimeter canal and suitable excavated material will be used to construct the embankments.

(3) Source of Material: The fill material will be material removed *in situ* during excavation of the perimeter canal, but mainly from excavating the upper few feet of material over several hundred feet from within the reservoir interior.

f. Description of the Proposed Discharge Site.

(1) Location: The fill material will be used to construct the perimeter embankments and internal levee between Cell 1 and Cell 2. Any excess material excavated or dredged or material that is unsuitable for levee construction will be spread throughout the interior reservoir.

(2) Size: The project area is approximately 10,700 acres in size (approximately 10,480 acres of fee and 20 acres of perpetual channel easement. Approximately 200 additional acres will be required on a temporary basis during project construction for staging areas). The project would consist of 16.3 miles of perimeter embankment with an adjacent 14.7 miles of perimeter canal and an interior embankment to divide the reservoir into two cells. The perimeter canal would have a top width of approximately 110 feet, bottom width of 10 feet, and the side slopes would be 1 Vertical on 2.5 Horizontal (1V:2.5H). Dam height of the perimeter embankment would vary from 32 feet to 37 feet with a crest width of 14 feet. The reservoir would be approximately 9,400 acres in size with a storage capacity of 170,000 acre feet and average water depth ranging from 17 feet to 19 feet.

(3) Type of Site: The disposal site is developed as a citrus grove and includes a dense network of irrigation and drainage ditches and canals that serve the groves. Additionally there are wetlands scattered throughout the grove.

(4) Type of Habitat: Citrus groves, row crops and improved pasture with scattered cypress and mixed wetland hardwoods flank the project area to the north, east, and south. The area to the north of the project site also contains some low-density residential areas. Forested uplands (parceled into low-density residential lots, various stages of development) such as pine flatwoods, longleaf pine-xeric oak, sand pine, and xeric oak are adjacent to the west of the project. At a landscape level, the C-43 West Storage Reservoir Project is surrounded by a matrix of agricultural, forested, and wetland land covers with pockets of urban land use. Urban areas are present to the southwest and northeast of the project area with small parcels along the Caloosahatchee River. Regions to the northwest and southeast of the project area are generally undeveloped.

The project site is an active citrus grove. Upland habitats associated with the grove include citrus trees, grove maintenance roads, small berms, brush piles, and other features related to citrus grove operations. There are no natural upland areas within the project site. The project site includes approximately 994.53 acres of jurisdictional Waters of the United States in the form of canals/ditches and/or wetlands. As a result of the recommended plan, most of the site would be converted to an above-ground reservoir with attendant features and would primarily consist of open water habitat after construction. Jurisdictional areas impacted as a result of the project include 899.59 acres of man-made ditches and canals which serve as irrigation and drainage conveyances for the citrus operation and 125 acres of wetlands.

(5) Timing and Duration of Discharge: Project construction is scheduled to begin in 2008 under the SFWMD Acceler8 program (pending receipt of all required permits and authorizations) and take approximately 3 years to complete.

g. Description of Disposal Method. Conventional earth moving equipment would be used during construction to excavate the perimeter canal including Townsend Canal improvements. Excavated material will be placed adjacent to the perimeter canal to construct the embankment, using only suitable excavated material.

2. Factual Determinations

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope: The perimeter embankment includes a 14-foot wide crest, with the soil cement protection, and 3 horizontal to 1 vertical side slopes. Crest elevations have been established at +57 NAVD88 for both Cell 1 and Cell 2, respectively. The embankment would be constructed largely of random fill, but would also include a low permeability soil-bentonite (SB) slurry wall, an internal drain, and upstream soil cement slope protection. The SB slurry wall would extend from an elevation 5 feet above the normal pool elevation to 5 feet below the top of a clay layer which underlies the project site at depths generally in the range of 20 to 25 feet below existing surface grades. The interior dam between Cells 1 and 2 would be a homogenous embankment with a crest elevation of +50 NAVD88. It would not include any SB wall or internal drain. The side slopes of the separator dam would be covered on both sides with soil-cement.

(2) Sediment Type: The material to be excavated and used as fill includes a combination of sand, clayey sand, silty sand, and some fine sediments.

(3) Dredge/Fill Material Movement: Suitable material excavated from the perimeter canal will be used to construct the earthen embankment. Any excess material or material not suitable for levee construction would be spread throughout the interior of the reservoir. There will be no deposition of material in unconfined waters where it would be subject to movement.

(4) Physical Effects on Benthos: Existing benthic organisms within the footprint of the levees would be covered by fill material.

b. Water Circulation, Fluctuation and Salinity Determination.

(1) Water Column Effects: During dredging operations to widen the existing Townsend Canal the water column would become temporarily more turbid. The

use of turbidity curtains may be required to confine the turbidity to the immediate vicinity of dredging.

(2) Current Patterns and Circulation: Dredging would not affect current patterns or circulation. Construction of the embankments would not affect current patterns or circulation.

(3) Normal Water Level Fluctuations and Salinity Gradients: Construction activities would not affect normal water level fluctuations and salinity gradients. Implementation of the project would reduce the number and severity of events where harmful amounts of freshwater from basin runoff and Lake Okeechobee releases are discharged into the estuary system. The project also helps to maintain a desirable minimum flow of fresh water to the estuary during dry periods. These two primary functions help to moderate unnatural changes in salinity which is extremely detrimental to estuarine communities.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site: Construction of the embankment would require deposition of fill over wetlands permanently converting these areas to upland sites. Temporary increases in suspended particulates can be expected during construction at the embankment fill sites as well as the dredging location in the Townsend canal. All appropriate measures to reduce and contain turbidity will be employed so state Water Quality Standards would not be violated.

(2) Effects on Chemical and Physical Properties of the Water Column: In general, any short-term impacts to water quality associated with construction of the project will be ameliorated by construction sequencing, best management practices for erosion and sedimentation control and monitoring during construction. Longer-term impacts to water quality associated with the operation of project features will be addressed through operational monitoring and adaptive management actions, if potentially adverse affects are observed or predicted.

(a) Light penetration: During dredging operations there would be a temporary reduction in light penetration in the immediate vicinity of dredging. Once construction is completed, light penetration is expected to return to pre-construction levels.

(b) Dissolved Oxygen: During dredging operations there could be a temporary reduction in the dissolved oxygen content in the water column in the immediate vicinity of dredging. Once construction is completed, dissolved oxygen is expected to return to pre-construction levels.

(c) Toxic Metals, Organics and Pathogens: No toxic metals, organics, or pathogens would be released by project construction. Reservoir operations will also incidentally improve water quality in the Caloosahatchee Estuary, since some of the nutrient-laden runoff and lake water will be stored in the reservoir, allowing for the settling of nutrients and other pollutants within the reservoir cells prior to delivery to the estuary.

(d) Aesthetics: During construction, visual aesthetics would be negatively impacted. After completion, aesthetics would improve once new vegetation becomes established.

(3) Effects on Biota:

(a) Primary Productivity and Photosynthesis: Disposal of excavated materials would adversely affect wetlands within the project footprint destroying vegetation and smothering biota. The perimeter canals are being designed to include littoral shelves within the corners and along some of the canal banks. These shelves will be colonized by wetland, emergent plant species. The reservoir footprint will likely be too deep to support any wetland vegetation except during drawdowns, but floating vegetation may colonize the reservoir.

(b) Suspension/Filter Feeders: During dredging operations there would be a temporary increase in turbidity and possibly a decrease in suspension/filter feeders due to construction activities. This temporary increase in turbidity will be short-term and should not have any long-term negative impact on these highly fecund organisms. These organisms would return to current levels after construction is completed.

(c) Sight Feeders: During dredging operations there would be a temporary increase in turbidity and possibly a decrease in sight feeders due to construction activities. No significant impacts on these organisms are expected as the majority of sight feeders are highly mobile and can move outside the affected area. These organisms would return to current levels after construction is completed.

d. Contaminant Determinations.

Currently the SFWMD has restricted the use of copper on the site and plans to conduct all required corrective actions as recommended by the U.S. Fish and Wildlife Service (USFWS) prior to initiating any construction. Deposited fill material would not introduce, relocate, or increase contaminants. Dredging of the Townsend Canal is limited to side slopes for widening; therefore, material on the bottom of the canal which may contain toxic materials would not be dredged.

e. Aquatic Ecosystem and Organism Determinations.

(1) Effects on Plankton: No adverse affects on plankton are expected. Long-term effects on plankton should be beneficial with an improvement of salinity balance in the Caloosahatchee Estuary.

(2) Effects on Benthos: A temporary decrease in benthos in the project area may occur during widening of the Townsend Canal. It is expected that the benthos would return to current levels after construction is completed. Effects to benthos outside the project area are not anticipated.

(3) Effects on Nekton: Small forage fish may be displayed during construction; however, these effects are short-term. The project provides deepwater habitat within the reservoir, including refugia (created by embankment excavation and from existing agricultural ditches) for fish and other aquatic animals during extremely dry periods. Long-term effects to fish in the Caloosahatchee Estuary should be beneficial as a result of the project operation and subsequent improvement in salinity balance, attenuation of peak flows, and provision of flows during the dry season.

(4) Effects on the Aquatic Food Web: No adverse impacts on aquatic organisms are anticipated. A relatively minor temporary effect on the aquatic food web due to construction activities is anticipated; however, this effect is short-term. Long-term effects to aquatic food web as a result of operation should be beneficial through improving the salinity balance in the downstream Caloosahatchee Estuary for oysters, seagrasses, and wildlife.

(5) Effects on Special Aquatic Sites:

(a) Hardground and Coral Reef Communities. There are no hardground or coral reef communities within the project footprint. Oysters once flourished within the Caloosahatchee Estuary but with damaging pulse freshwater flows and lack of suitable substrate populations have declined. With the addition of hard substrate attenuation of high flows, oyster reef/recruitment would occur as a result of project implementation.

(b) Sanctuaries and Refuges. The Caloosahatchee River and Estuary are at the head of a vast estuarine and marine ecosystem that includes aquatic preserves managed by the State of Florida (e.g., Matlacha Pass, Estero Bay, and Pine Island Sound Aquatic Preserves), the Charlotte Harbor National Estuary Program, and the J. N. Ding Darling National Wildlife Refuge (NWR) Complex which includes the Caloosahatchee, Matlacha Pass, Pine Island, and Island Bay NWRs; along with numerous other state and local parks and recreation areas. The aquatic preserves are also outstanding

Florida water bodies. Improvement of the timing and delivery of water to the Caloosahatchee River will have a positive effect on these areas.

(c) Wetlands. The project site includes 125 acres of jurisdictional wetlands. The wetland communities include mixed wetland hardwoods, willow and elderberry, exotic wetland hardwoods, cypress, wetland shrub, and freshwater marsh. As a result of the project, all onsite wetlands would be eliminated. Adverse impacts include destruction of wetland habitat and adverse affects to the biological productivity of wetlands ecosystems by smothering, by dewatering, by permanently flooding, or by altering substrate elevation or periodicity of water movement. Through implementation of CERP, the quality, quantity, timing, and delivery of water to the south Florida ecosystem will be improved. This coupled with the increase in spatial extent of protected wetland acreage in the region will offset adverse impacts to wetlands associated with project implementation. The current design of the reservoir perimeter canal includes approximately 109 acres of wetland i.e., littoral habitat within the corners and along some of the canal banks.

(d) Mud Flats. Mud flats are present within the Caloosahatchee Estuary but none would be adversely impacted by the project. Regulation of the timing of water delivered to the estuary may benefit mud flats by returning inundation patterns toward natural system targets and ameliorating rates of erosion and accretion.

(e) Vegetated Shallows. Vegetated shallows are present in the Caloosahatchee River and Estuary but none would be adversely impacted as a result of the project. Excessive variation in discharges and salinity to the Caloosahatchee River and Estuary result in a flux of biota from those favoring higher salinities to those favoring lower salinities. As a result of project implementation, the timing and delivery of water to the Caloosahatchee River and salinity balance would be improved. This would sustain a variety of species of freshwater, estuarine, and marine submerged aquatic beds that once flourished historically.

(f) Riffle and Pool Complexes. There are no riffle and pool complexes within the study area.

(6) Threatened and Endangered Species: Formal consultation with the USFWS for the Florida panther, Audubon's crested caracara, and eastern indigo snake is ongoing and a Biological Opinion that the project will not jeopardize the existence of these species is anticipated. The CERP Band 1/Acceler8 projects will collectively provide for the preservation and restoration of approximately 100,492 acres in the panther core area, including 59,294 acres in the Primary Zone and 41,198 acres in the Other Zone. These "core area" lands include the majority of home ranges of the current population of the Florida panther. This

includes over 548,000 panther habitat units (PHUs) that can be used to offset the loss of panther habitat anticipated as a result of conversion of the citrus grove lands within the project footprint to open water. Additionally, the USACE has determined that the implementation of this project will either benefit, or not adversely affect, a number of other endangered and/or threatened species in the project area or areas affected by the project. Informal consultation remains open with the USFWS and the National Marine Fisheries Service. Special protection measures will be implemented during construction to minimize impacts to any listed species present.

f. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination: The dredged material will not cause unacceptable changes in the mixing zone water quality requirements as specified by the State of Florida's Water Quality Certification permit procedures. No adverse impacts related to depth, current velocity, direction and variability, degree of turbulence, stratification, or ambient concentrations of constituents are expected from implementation of the project.

(2) Determination of Compliance with Applicable Water Quality Standards: The project would comply with Federal and State water quality standards.

(3) Potential Effects on Human Use Characteristics:

(a) Municipal and Private Water Supply: No municipal or private water supplies would be adversely impacted by the implementation of the project. The reservoir may provide a source for water supply during the dry season once environmental deliveries have been made.

(b) Recreational and Commercial Fisheries: Construction activities would not significantly affect recreational or commercial fisheries.

(c) Water Related Recreation: No recreation resources would be adversely affected by the project.

(d) Aesthetics: During construction, the visual appearance of the new impoundment and levees may be somewhat unattractive. The levees would be grassed to prevent erosion and help blend them into the landscape background as unobtrusively as possible. The existing landscape characteristics would be replaced with views of levees and open water within the impoundment areas.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves: There are no such

designated areas present within the area proposed for construction of project features. Aquatic preserves and NWRs comprise the downstream area that will be positively affected by project implementation.

g. Determination of Cumulative Effects on the Aquatic Ecosystem

The implementation of CERP is anticipated to convert large areas within the Caloosahatchee River basin, the Everglades Agricultural Area, and around Lake Okeechobee to reservoirs for increasing water storage for the overall gain and long-term benefit of the regional system. This will cause some adverse consequences to agricultural land uses - permanently removing tens of thousands of acres from agricultural production. These impacts may be felt locally and/or regionally as the economic base derived from agriculture is incrementally reduced relative to other sectors of the economy. As these features occur disparately across the landscape within different hydrologic basins, and as distinct units rather than multiple features within a single watershed, they will not likely result in a significantly detrimental cumulative effect.

The overall benefit to the regional system is expected to be far greater than the localized adverse effects. The restoration of hydrology of the greater Everglades ecosystem and the increase in spatial extent of protected wetland acreage in the region will produce extensive cumulative beneficial effects. These beneficial effects are expected to substantially outweigh the cumulative adverse effects produced by the aquatic ecosystem alterations that may be necessary to construct some of the project components.

h. Determination of Secondary Effects on the Aquatic Ecosystem

There will be no adverse secondary impacts on the aquatic ecosystem as a result of the construction. During construction the site will be contained enclosing the construction areas with sedimentation barriers. Erosion will be controlled by compaction of soils, construction of ditches, and embankments, maintenance of relatively flat grades, and other appropriate erosion control techniques. Sedimentation will be controlled during construction by use of sediment controls basins and traps, filter berms, straw bales, etc. Although construction will likely include several mobilizations associated with the perimeter canal and embankment, impacts will localized and wildlife will able to utilize undisturbed portions of the site, particularly the interior. An ecological and water quality monitoring plan would be implemented during and after construction and specific environmental commitments, engineering and design commitments, and operational commitments will be incorporated to avoid, minimize, and/or mitigate for adverse effects.

Implementation of this project would beneficially affect the aquatic ecosystem in the Caloosahatchee Estuary by regulating the timing and delivery of water. Through attenuation of peak flows during the wet season, providing essential flows during the dry season, and improving the salinity balance, oyster, seagrass, and wildlife will benefit.

3. Findings of Compliance or Non-Compliance with the Restrictions on Discharge

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. No practicable alternative exists which meets the study objectives that does not involve discharge of fill into waters of the United States.

c. No practicable alternative exists which would have less adverse impact on the aquatic ecosystem which does not also have other significant adverse environmental consequences

d. The discharge of fill materials will not cause or contribute to violations of any applicable State water quality standards for Class III waters. The discharge operation would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

e. The placement of fill materials in the project area will not jeopardize the continued existence of any species listed as threatened or endangered or result in the likelihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended.

f. The placement of fill materials will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values will not occur.

g. On the basis of the guidelines, the proposed disposal site for the discharge of fill and/or dredged material is specified as complying with the requirements of these guidelines.

This page intentionally left blank.



US Army Corps
of Engineers®

Jacksonville District



South Florida Water
Management District

112th Congress, 1st Session – – – – – – – – – – – – House Document 112–20

CALOOSAHATCHEE RIVER (C–43) WEST BASIN STORAGE RESERVOIR PROJECT

COMMUNICATION

FROM

THE CHIEF ENGINEER, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

PART 2 of 2

MAY 6, 2011.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

CALOOSAHATCHEE RIVER (C–43) WEST BASIN STORAGE RESERVOIR PROJECT
PART 2 OF 2

112th Congress, 1st Session – – – – – – – – – – – – House Document 112–20

CALOOSAHATCHEE RIVER (C–43) WEST BASIN STORAGE RESERVOIR PROJECT

COMMUNICATION

FROM

THE CHIEF ENGINEER, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND FINAL ENVIRONMENTAL IMPACT STATEMENT

PART 2 of 2



MAY 6, 2011.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

---

U.S. GOVERNMENT PRINTING OFFICE

66–224 WASHINGTON : 2011

US Army Corps of Engineers ®
Jacksonville District

Central and Southern Florida Project
Comprehensive Everglades Restoration Plan

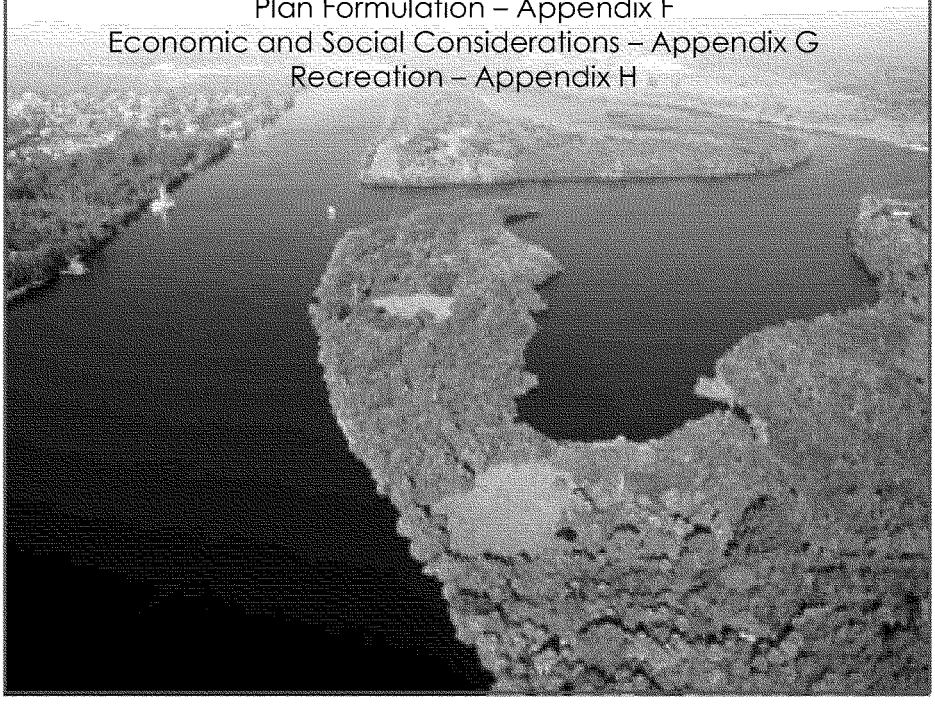
Caloosahatchee River (C-43) West Basin Storage Reservoir Project

Final Integrated Project Implementation Report

Volume 4: Final Appendix Engineering – Appendix A

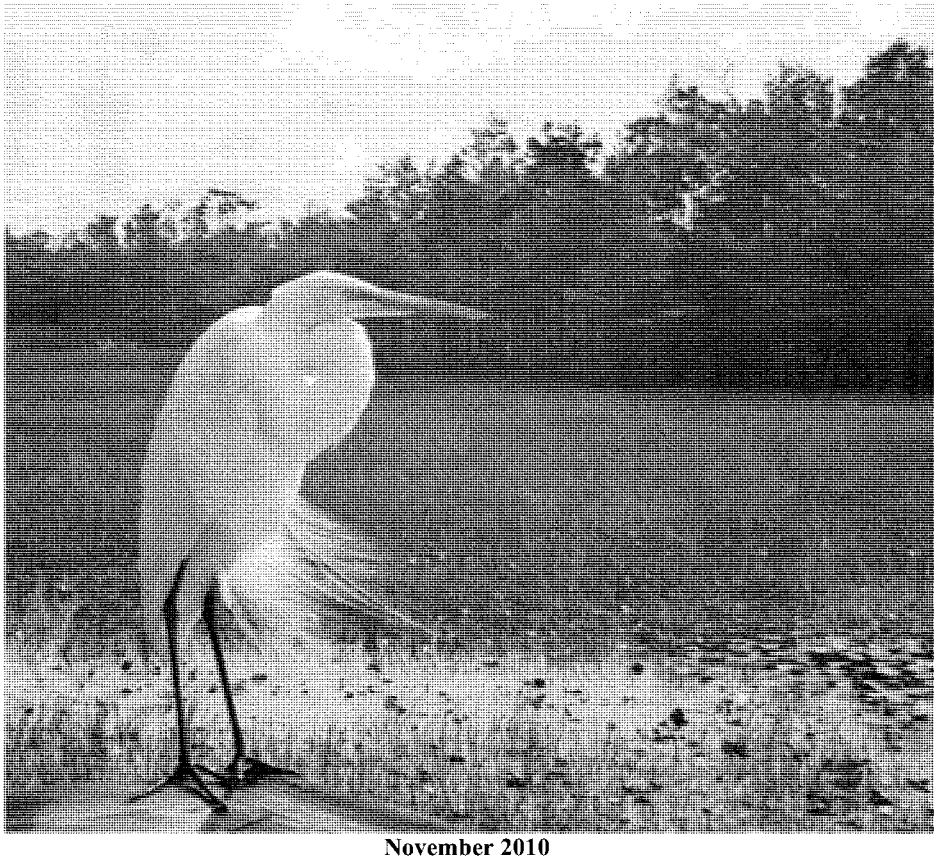
and

Volume 5: Final Appendices
Cost Estimates – Appendix B
Environmental Information – Appendix C
Real Estate – Appendix D
Agency / Public Coordination – Appendix E
Plan Formulation – Appendix F
Economic and Social Considerations – Appendix G
Recreation – Appendix H



CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE EVERGLADES RESTORATION PLAN
FINAL CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT
IMPLEMENTATION REPORT

FINAL APPENDIX
ENGINEERING – APPENDIX A



November 2010

This Report Contains [5] Volumes

You Are Here

Volume 1 – Main Report – November 2010
- Addendum A
- Addendum B
- Executive Summary
- Section 1 – Introduction
- Section 2 – Existing Conditions/Affected Environment
- Section 3 – Future "Without Project" Condition
- Section 4 – Identification of Problems and Opportunities
- Section 5 – Formulation of Alternative Plans
- Section 6 – Environmental Effects of the Selected Alternative Plan
- Section 7 – The Selected Alternative Plan
- Section 8 – Plan Implementation
- Section 9 – Summary of Coordination, Public Views, and Comments
- Section 10 – Recommendations
- List of Report Preparers
- Index
- Glossary of Terms
- Acronyms
- References

Volume 2- Annex – September 2007
- Annex A – FWCA and Endangered Species Act Compliance

Volume 3 – Annexes – September 2007
- Annex B – NEPA Information
- Annex C – Analyses Required by WRDA 2000 and State Law
- Annex D – Draft Project Operating Manual and Monitoring Plan
- Annex E – Reports Provided by RECOVER to Support the PIR
- Annex F – CZM Consistency and 404(b)(1) Evaluations

Volume 4 – Appendices – November 2010
- Appendix A – Engineering

Volume 5 – Appendices – November 2010
- Appendix B – Cost Estimates
- Appendix C – Environmental Information
- Appendix D – Real Estate
- Appendix E – Agency / Public Coordination
- Appendix F – Plan Formulation
- Appendix G – Economic and Social Considerations
- Appendix H – Recreation

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C43) WEST BASIN STORAGE RESERVOIR

FINAL APPENDIX

Engineering – Appendix A

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

SOUTH FLORIDA WATER
MANAGEMENT DISTRICT

November 2010

This page intentionally left blank.

APPENDIX A
ENGINEERING

This page intentionally left blank

TABLE OF CONTENTS

A.0 ENGINEERING A-1
A.1 GEOTECNHICAL STUDIES A-1
A.1.1 General A-1
A.1.1.1 Background A-1
A.2 GEOLOGY A-3
A.2.1 Regional Geology A-3
A.2.1.1 Pleistocene-Holocene Series A-4
A.2.1.2 Pliocene Series A-4
A.2.1.3 Miocene Series A-4
A.2.1.4 Oligoeene Series A-5
A.2.1.5 Soils A-5
A.2.1.6 Aquifers A-5
A.2.2 Local Geology A-5
A.3 PRELIMINARY GEOTECHNICAL ENGINEERING EVALUATION A-9
A.3.1 Evaluation of Subsurface Soil and Rock Conditions A-9
A.3.2 Seepage Evaluation A-10
A.3.2.1 General Description and Background A-10
A.3.2.2 Cases Analyzed A-10
A.3.2.3 Seepage Analysis Results A-11
A.3.3 Slope Stability Analyses A-12
A.3.3.1 General Description and Background A-12
A.3.3.2 Case Analyzed A-12
A.3.3.3 Design Requirements A-13
A.3.3.4 Slope Stability Analysis Results A-13
A.3.4 Settlement Analyses A-14
A.3.5 Dewatering for Structures A-14
A.3.6 Other Foundation and General Construction Considerations for Structures A-15
A.4 HYDROLOGIC MODELING A-15
A.4.1 Regional Modeling A-17
A.4.1.1 SFWMM Boundary Condition Simulations A-17
A.4.2 Sub-Regional Modeling–MIKESHE A-19
A.4.3 Estuary Salinity Modeling A-21
A.4.3.1 CH3D A-21
A.4.3.2 Salinity Regression Model and Spatial Interpolator A-21
A.4.3.3 Simulation Period A-22
A.4.4 Model Certification, Description of Models, and Modeling Assumptions A-24
A.4.4.1 Model Certification Process A-24
A.4.4.2 Models Used, Model Criteria, Status of Certification A-26
A.4.4.3 Hydrologic Modeling Application for Modeling of Alternatives A-33
A.4.5 Hydrology and Hydraulics (H&H) Considerations for Embankments and Canals A-36
A.4.5.1 General A-36
A.4.5.2 Embankment A-37
A.4.5.3 Slope Protection A-38

A.4.5.4 Perimeter Canal A-38
A.4.5.5 Construction Materials A-38
A.4.5.6 Construction Access A-39
A.4.5.7 Perimeter Road and Ramps A-39
A.4.5.8 Pump Station C43-PS-1 ..... A-39
A.4.5.9 Pump Station C43PS-4 ..... A-39
A.4.5.10 Water Control Structures A-40
A.5 EMBANKMENTS AND CANALS A-55
A.5.1 General A-55
A.5.2 Proposed Plan A-55
A.5.3 Civil Site Work A-56
A.5.3.1 Site Preparation A-56
A.5.3.2 Site Access/Entrance Road A-56
A.5.3.3 Townsend Canal Channel Improvements A-56
A.5.3.4 Disposal/Borrow A-58
A.5.4 Embankments A-58
A.5.4.1 Random Fill A-59
A.5.4.2 Select Fill A-59
A.5.4.3 Soil–Bentonite Wall A-60
A.5.4.4 Drainage Blanket A-60
A.5.4.5 Soil Cement A-61
A.5.4.6 Bench A-61
A.5.4.7 Seeding and Sodding A-61
A.5.5 Relocations A-61
A.5.6 Operations and Maintenance A-61
A.5.6.1 General A-61
A.5.6.2 Inspection A-62
A.5.6.3 Estimated Annual Costs A-62
A.5.6.4 O&M Manual A-62
A.5.7 Quantities and Cost Estimates A-62
A.6 MECHANICAL AND ELECTRICAL DESIGN A-63
A.6.1 Mechanical Design A-63
A.6.1.1 Pump Station General Information and Size Criteria A-63
A.6.1.2 Pump Station PS-1 ..... A-64
A.6.1.3 Pump Station PS-4 ..... A-67
A.6.1.4 Gates A-68
A.6.2 Electrical Design A-69
A.6.2.1 Pumping Stations A-69
A.6.2.2 Other Structures A-71
A.6.2.3 Instrumentation Design A-73
A.7 CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR STRUCTURES A-74
A.7.1 C43PS-1 - 1500 cfs Pump Station A-74
A.7.1.1 General Description A-74
A.7.1.2 Substructure A-75
A.7.1.3 Superstructure A-75

A.7.1.4 Siphon Break and Saxophone Discharge Structures A-76
A.7.1.5 Service Bridge A-76
A.7.1.6 Trash Screen Bridge A-76
A.7.1.7 Fuel Oil Containment A-76
A.7.1.8 Stoplogs A-77
A.7.1.9 Design Load Criteria A-78
A.7.1.10 Materials A-80
A.7.1.11 Design Standards A-80
A.7.2 C43PS-4 - 195 cfs Pump Station A-81
A.7.2.1 General Description A-81
A.7.2.2 Codes and Standards A-81
A.7.2.3 Loads and Design Criteria A-82
A.7.2.4 Stability A-83
A.7.2.5 Reinforced Concrete Design A-83
A.7.3 Water Control Structures A-84
A.7.3.1 Culverts A-84
A.7.3.2 C43S-7- Gated Double Barrel Box Culvert A-84
A.7.3.3 C43S-9 - Gated Double Barrel Box Culvert A-84
A.7.3.4 C43S-14 - Gated Single Barrel Box Culvert A-85
A.7.3.5 C43S-15- Gated Double Barrel Box Culvert A-85
A.7.4 Perimeter Canal Structures A-85
A.7.4.1 C43S-3- Double Barrel Gated Culvert A-85
A.7.4.2 C43S-10 - Three Bay Reinforced Concrete Spillway A-86
A.7.4.3 C43S-11 - Four Bay Reinforced Concrete Spillway A-86
A.7.5 Main Outlet Structure A-87
A.7.5.1 General A-87
A.7.5.2 C43S-1 and C43S-8 - Gated Outlet Structures A-87
A.7.5.3 C43S-12 Triple Conduit Cell Balancing Structure A-92
A.7.5.4 C43CS-1 and C43CS-2 Crest Spillway Structures A-95
A.8 REFERENCES A-101
A.9 ENGINEERING PLATES A-102
A.10 TECHNICAL MEMORANDUM FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR SPREADSHEET MODEL AND WATER BUDGET ANALYSIS and APPLICATION OF SPREADSHEET MODEL TO EVALUATION OF C-43 STORAGE RESERVOIR PROJECT ALTERNATIVES A-125
A.11 TECHNICAL MEMORANDUM FOR SPILLWAY DESIGN A-261
A.12 FINAL TECHNICAL MEMORANDUM–C-43 WEST STORAGE RESERVOIR FREEBOARD ANALYSIS AND RECOMMENDATIONS . A-275
A.13 TECHNICAL MEMORANDUM - TOWNSEND CANAL IMPACTS FOR VARIOUS PUMPING SCENARIOS AT C43PS-1 .....A-505

LIST OF TABLES

Table A-1: GeneralizedEmbankment and Subsurface profile and estimated hydraulic conductivity values A-10
Table A-2: Summary of seepage analysis results A-11
Table A-3: Shear strength parameters A-12
Table A-4: Differences Between the 2000B2 and 2000RD Model Runs A-18
Table A-5: Differences Between the 2050B2 and 2050RD Model Runs A-18
Table A-6: Differences Between the CERP1 and CERP1RD Model Runs A-19
Table A-7: Model Runs for use in SAP Selection A-34
Table A-8: Differences between Existing Condition Runs (2000B2 Simulation and 2000RD Simulation) A-35
Table A-9: Differences between Future Without Project Condition Runs (2050B2 Simulation and 2050RD Simulation A-35
Table A-10: Differences between Future with CERP Condition runs (CERP1 Simulation and CERP1RD Simulation) A-36
Table A-11: Required Freeboard Heights A-37
Table A-12: Spillway Information A-53
Table A-13: Caloosahatchee River (C-43) West Basin storage reservoir Pump Station Information A-64
Table A-14: Allowable Live Loads A-78
Table A-15: Recommended Hydraulic Grade Line A-79
Table A-16: Soil Lateral Loading Criteria A-80
Table A-17: Structure Nomenclature A-100

LIST OF FIGURES

Figure A-1: Boundary of Site A-2
Figure A-2: Borings and Cross-Sections Locations A-6
Figure A-3: Northern Geologic Cross Section, East – West A-7
Figure A-4: Southern Geologic Cross Section, East – West A-8
Figure A-5: Seepage analysis output A-12
Figure A-6: Slope stability output A-14
Figure A-7: Caloosahatchee (C-43) West Basin Storage Reservoir PIR Model Relationships A-16
Figure A-8: Caloosahatchee Estuary Salinity Regression Model and Spatial Interpolator A-22
Figure A-9: Annual Rainfall Inputs for C-43 MIKESHE Model A-24

A.0 ENGINEERING

A.1 GEOTECNHICAL STUDIES

A.1.1 General

A.1.1.1 Background

The C-43 West Storage Reservoir Area, Berry Grove Site, is located near the town of Labelle in northwestern Hendry County, Florida. The Reservoir is just a couple of miles South of State Road 80 and approximately two miles west of State Road 29. The property is owned by the South Florida Water Management District under a leasing agreement with Jack M. Berry, Inc. for agricultural farm land use.

A.1.1.1.1 Purpose

The purpose of the geotechnical exploration was to develop subsurface information concerning the site from data associated with core borings and test cell construction. This information will be used to evaluate the suitability of the subsurface soils and rock in order to support a water storage reservoir. The reservoir is expected to provide 170,000 acre-feet of water with approximate normal pool depth approaching 17 feet. The reservoir is also expected to cover approximately 11,000 acres of land use. The topography of the area is variable with respect to land surface however, overall the relief is generally considered flat. The topography also contains three major arterial canals that transport water for the purpose of irrigation and attenuation of Caloosahatchee Basin runoff waters. Two of the three canals, Roberts and Townsend lie along the eastern and western perimeters of the study area, respectively. The Header Canal also called the LPDD Canal, transects the entire reservoir area and its use is primarily to cross-feed water between the Roberts and/or Townsend Canals. The potential reservoir will contain several gates and pump stations to improve water deliveries throughout the Basin. ***Figure A-1***, shows a site location map, and the proposed reservoir limits.

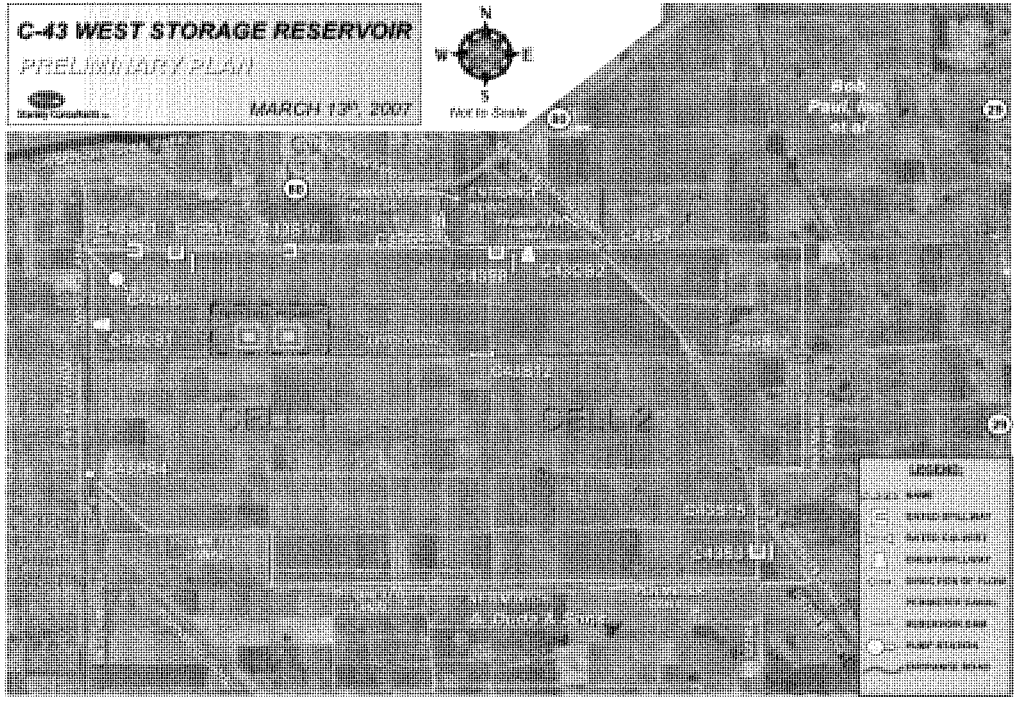


FIGURE A-1: BOUNDARY OF SITE

1602

A.2 GEOLOGY

A.2.1 Regional Geology

The Caloosahatchee River Drainage Basin of both Collier and Hendry Counties, which lies within the physiographic region denoted as the Sandy Flatlands or Gulf Coastal Lowlands, is characterized by terraced plains. These terraced plains largely control the topography of the area that extends northward into Glades and Charlotte Counties, westward to the Gulf of Mexico, and southward into Monroe County. The sands were deposited as three marine terraces: Talbot, Pamlico, and Silver Bluff, all of which were produced during the Pleistocene Epoch. The Talbot terrace ranges from 25 to 42 feet above sea level and is considered the highest in elevation within the subject area. The Pamlico terrace ranges between eight to 25 feet above sea level, and the Silver Bluff terrace, the lowest in elevation; is less than 10 feet above sea level and gradates toward the western seaboard. The deposits were formed during the Pleistocene Era when sea level rose and fell in response to the advance and retreat of the continental ice sheets. When sea level is relatively stationary for long periods, shoreline features develop. In southwest Florida the Pleistocene deposits are represented by the Anastasia Formation (a coquinoid limestone, sand and clay), alternating marine and freshwater limestone consisting of mollusks, interbedded clays, and sands of the Ft. Thompson Formation, Caloosahatchee Formation (shell hash limestone and clay), and the Hawthorn Group sediments.

Rock units range in age within the Caloosahatchee River Basin study area from Recent to Miocene to Oligocene. Formations and groups discussed in this report include (from land surface) the Ft. Thompson Formation, Tamiami Formation (which includes the Bonita Springs Marl and Pine Crest Sand members), the Hawthorn Group (which consists of the Peace River Formation within the upper unit and Arcadia Formation belonging to the lower Hawthorn Group sediments), and, to a lesser extent, the early Oligocene Series of the Suwannee Limestone.

Since its inception in 1907, the Florida Geological Survey (FGS) has gathered data on Florida karst (sinkholes, caves, springs, etc.). FGS published Special Publication 29, entitled, "Karst in Florida" and included a Map Series 110, which explain sinkhole types, their distribution, and development. Sinkholes form in karst terrain principally from the collapse of surface sediments into underground cavities in the limestone bedrock. Slightly acidic ground water slowly dissolves cavities and caves in the limestone over a period of many years. (source: http://www.dep.state.fl.us/geology/geologictopics/sinkhole.htm)

The C-43 project area is not prone to sinkhole activities. Regionally the area is classified by the USGS as Area II where sinkholes are few and typically formed of shallow and small diameter. Locally and as a site specific, the overburden over the limestone consists of plastic clay with low permeability. This clay

impedes downward movement of groundwater and hence retards the development of solution cavities in underlying limestone. Areas underlain by relatively impervious clays are generally not affected by sinkholes. Therefore, it is expected that there is a low risk of sinkhole development at the C-43 project.

A.2.1.1 Pleistocene-Holocene Series

In the western part of the Caloosahatchee River Basin study area lies a thin veneer of undifferentiated Holocene/Pleistocene-age sediment that extends from land surface to approximately 10-feet below land surface. The Pamlico sands/Ft. Thompson Formation also occur at land surface in specific areas and is breached by either the Pliocene-age green dolosilts of the Bonita Springs Marl Member or the middle to late Pliocene-age beds of the Pinecrest Sand Member, consisting of mixed shell assemblage, both of which belong to the Tamiami Formation.

A.2.1.2 Pliocene Series

The rocks above the Tamiami Formation vary throughout the planning area, but within the Tamiami Formation two locally identifiable members are of particular interest. The Bonita Springs Marl identified by Missimer (1984) within the locale of the Bonita Springs area is the lowermost member of the Tamiami Formation. The Marl is a discontinuous deposit of unconsolidated sand, green dolosilts, and lime mud matrix. The member is considered a confining unit to the Holocene–Pliocene sediments and the water table aquifer. The Ochopee Limestone (Hunter (1968), is described as a light gray calcarenite with white fossiliferous limestone within the type section of the study area.

In overview, the Tamiami Formation within the Caloosahatchee River Basin is characterized by a fossiliferous sandy limestone. In northern Hendry and southern Glades counties the formation is thin and difficult to distinguish from the younger biogenic limestone of the Ft. Thompson Limestone and Caloosahatchee Marl. The Tamiami Formation is thickest in southern Hendry County. It thins to the north and west, pinching out in Glades County.

A.2.1.3 Miocene Series

Rocks of Miocene age in the planning area belong to the Hawthorn Group. The Hawthorn Group is divided into an upper clastic sequence and a lower carbonate sequence. The Peace River Formation is a siliclastic stratum, composed primarily of greenish-gray phosphatic silts interbedded with coarse sand and sandstones. The formation also consists of interbedded quartz sand, clays, and minor carbonates. The siliclastics comprise more than two-thirds of the formation. The lower carbonate sequence is the Arcadia Formation and is described as phosphatic dolomite, composed of poorly to moderately indurated phosphatic micrites, very pale orange, poorly sorted, fossiliferous, clayey, and

sandy. The base of the Hawthorn Group occurs at the contact between the Suwannee Limestone of the Oligocene Series and the Lower Hawthorn/Tampa Limestone. The top of the Hawthorn Group is identified by the first occurrence of a continuous greenish-gray dolosilts. In Hendry County the top of the Hawthorn Group occurs at a poorly consolidated sand or sandy silt beneath a biogenic limestone of the Tamiami Formation.

A.2.1.4 Oligocene Series

Rocks of Oligocene age in the planning area belong to the Suwannee Limestone. The Suwannee Limestone is generally fossiliferous, yellow to pale orange, moderately indurated, very porous calcerenite interbedded with sandy phosphatic limestones and dolomites. The formation varies in thickness from 50 feet to more than 150 feet. It lies within the Floridan Aquifer System and is considered the main source of irrigation within the Glades County area.

A.2.1.5 Soils

The soils of the Caloosahatchee River Basin are dominated by somewhat poorly drained sandy soils. These soils are considered recent deposits of limestone origin, underlain by marl and or limestones. South of the river and in the coastal area the soil consists of poorly drained sands and organic muck and peat. They are very poorly drained soils underlain by marl and limestone.

A.2.1.6 Aquifers

Three major aquifers or producing zones and three confining beds have been identified within this sequence of rocks for the study area. The upper surficial aquifer consists of sands, shells, and limestones, within the sediments of the Ft. Thompson and Tamiami Formations that are Holocene- Pliocene age, respectively. This aquifer and the lower Tamiami/Ochopee Aquifer are separated by the Bonita Springs Marl confining unit. Below the lower Tamiami aquifer lies another confining unit of the Miocene age sediments, Upper Peace River confinement. The Sandstone aquifer is sandwiched between the Upper Peace River and Basal Peace River confining unit.

The lower Hawthorn/Tampa producing zone (which includes the basal part of the lower Hawthorn aquifer of Sproul et al., 1972) and the Suwannee aquifer are considered parts of the Floridan Aquifer System. At this time, these aquifers are not considered for this portion of the study.

A.2.2 Local Geology

The local geology within the Caloosahatchee River (C-43) West Basin Storage Reservoir site is described based on the compilation and analysis of 92 core

borings. The borings ranged in depth from 15 feet to 150 feet below the existing ground surface. ***Figure A-2*** is a point-coverage map that shows the location of core borings within the West Storage Reservoir Area (Berry Grove Site). In addition, ***Figure A-2*** shows two transect lines (cross-sections) that strike in the East and West direction for both the northern and southern extent of the study area. These transects were used to develop general geologic cross sections within the Caloosahatchee (C-43) West Basin Storage Reservoir Area. ***Figure A-3*** shows a generalized geologic cross section that strikes East and West direction within the northernmost perimeter of the reservoir. Whereas, ***Figure A-4*** shows a generalized geologic profile that also strikes East and West but for the southern perimeter of the reservoir.

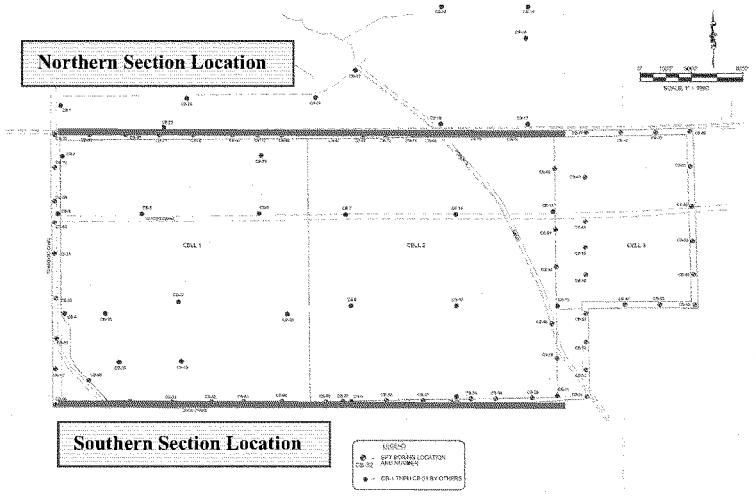


FIGURE A-2: BORINGS AND CROSS-SECTIONS LOCATIONS

This data combined with data obtained from the excavation of two test cells within the West Storage Reservoir site indicate that in general the subsurface conditions are suitable for the proposed project. The spacing of the borings ranged between 4,000 to 6,000 feet. The subsurface materials found within the borings generally consisted of relatively clean sands, clayey sands, and sandy clays. A layer of relatively clean sands, undifferentiated sediments, was found at the ground surface and extended to depths of 4 to 10 feet. In a few borings, some surficial clean sands extended to 20-feet below land surface. A minor sequence of limestone deposit (Ochopee Limestone) which thickens toward the eastern portion of the study area as shown in ***Figure A-3***, lie just beneath the clean sands to depths of approximately 20 to 25 feet. However where the limestone is absent, most of the borings indicate clayey sands exist beneath the

surficial clean sands to depths as far down as 40 feet or more. The subsurface zones beneath these layers generally are comprised of siliclastic sands and sandstones that make up the Peace River Formation to depths of approximately 100 feet below grade. The basal phosphatic clays are referred to as the Hawthorn Group sediments and no other core borings penetrated beyond these depths.

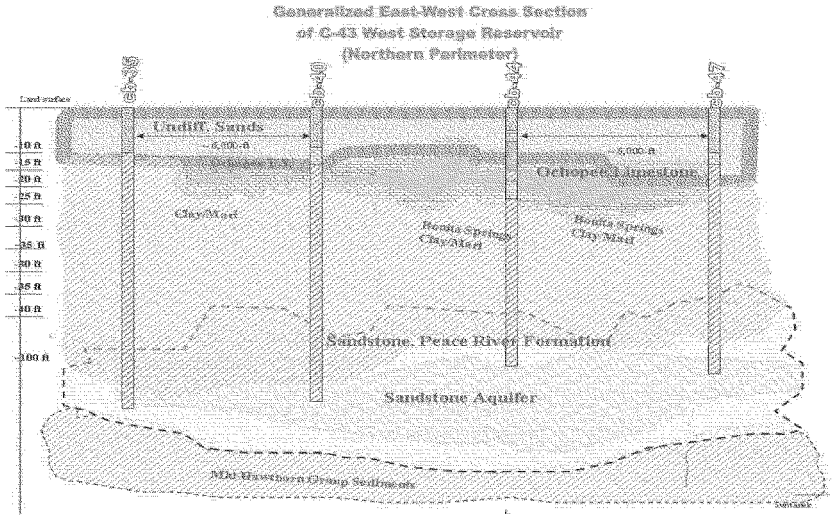


FIGURE A-3: NORTHERN GEOLOGIC CROSS SECTION, EAST – WEST

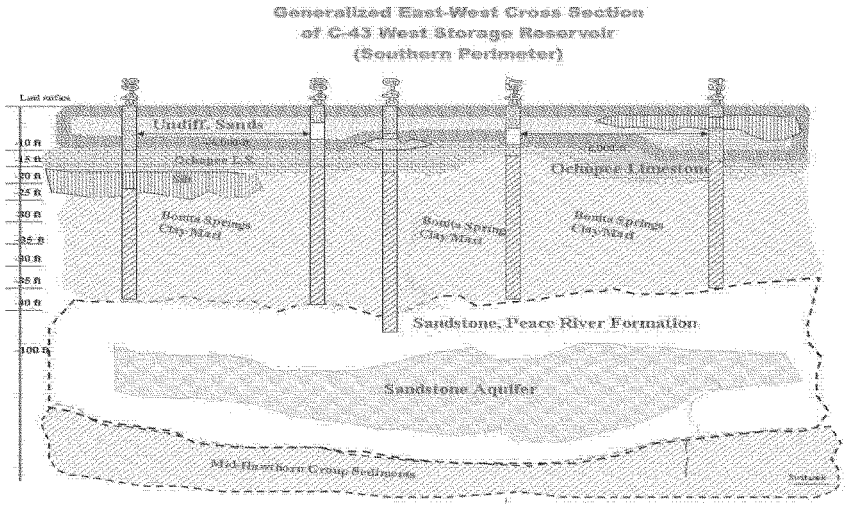


FIGURE A-4: SOUTHERN GEOLOGIC CROSS SECTION, EAST – WEST

A.3 PRELIMINARY GEOTECHNICAL ENGINEERING EVALUATION

Preliminary geotechnical engineering evaluation was performed for the planned reservoir project at the Berry Grove site. The geotechnical engineering evaluation performed was based on the geotechnical data available from the project site. The geotechnical engineering evaluation performed included evaluation of the subsurface conditions, seepage analyses, and slope stability analyses. Details of the geotechnical evaluation performed are presented below.

A.3.1 Evaluation of Subsurface Soil and Rock Conditions

Based on the available geotechnical data at the Berry Grove site, the area generally appears to be suitable for the construction of the new reservoir. This is primarily due to the presence of relatively shallow silty and clayey deposits within the site that will behave as seepage barrier or retardant and will assist in containing the reservoir stored water.

As mentioned earlier, the subsurface conditions encountered at the Berry Grove site consist of a surficial layer of sands with isolated zones of silty sand material. This sandy deposit varies in thickness from 1 to 15 feet. Below this sandy deposit, a layer of interbedded zones of silty sand, clayey sand, sandy clay, and sandy silt materials was encountered. This layer varies in thickness from 1 to about 20 feet. Below this sand/silt/clay mix deposit, limestone material was generally encountered with a thickness ranging from 2 to 12 feet, with isolated areas where the limestone deposit was thicker than 30 feet: boring CB-51 near Roberts Canal along the southern half of the eastern boundary. Some of the borings performed did not encounter the limestone material indicating the absence of limestone at these locations. Below the limestone material and until boring termination depths, clayey deposits were encountered. These clayey deposits mainly consist of sandy silt, sandy clay, and clayey sand materials.

The surficial sandy deposit is suitable for use in embankment construction. However, due to presence of shallow groundwater at the site, it is anticipated that the majority of the suitable fill material will be saturated. Therefore, during design and construction, dewatering of proposed borrow areas will be required and the material excavated may require reworking to make it suitable for compaction.

In addition based on the preliminary subsurface investigations, the limestone material encountered at the site appears to be relatively soft and may be excavated by conventional equipment such as backhoes. Blasting of the limestone may not be necessary based on the limited data available and field observations during test cells construction activities.

The underlying clays are not suitable for use in embankment construction. However, the clayey material could be used for the soil bentonite cut-off wall construction. These clayey/silty materials will be saturated and will require significant drying and reworking if used in construction. As mentioned earlier, the underlying silty/clayey zone will assist in retarding the under seepage flow and is a good geologic sequence to cut-off (minimize) outwards seepage.

A.3.2 Seepage Evaluation

A.3.2.1 General Description and Background

The SEEP/W computer program was used to perform the seepage analyses. The SEEP/W is a two-dimensional finite element computer program. The SEEP/W program was developed by Geo-Slope International Ltd.

A simplified 2-dimensional subsurface profile was developed for the Berry Grove site that utilized available core boring data obtained from the site. Hydraulic conductivity values used in the seepage model were obtained from available published data, pump test analyses, and other available laboratory test data. Due to the variability of the hydraulic conductivity data available, the hydraulic conductivity values used in the analyses were generally based on average values, engineering evaluation and correlations, and best professional judgment. The simplified subsurface profile including the hydraulic conductivity values used in the seepage analyses are presented in ***Table A-1*** below.

TABLE A-1: GENERALIZEDEMBANKMENT AND SUBSURFACE PROFILE AND ESTIMATED HYDRAULIC CONDUCTIVITY VALUES

Layer No.	Material Type	Average Estimated Depth (ft)	K (ft/day)
1	Upper Sand	0 - 7	20
2	Upper Sand/Silt/Clay Deposit	7 - 11	15
3	Limestone	11 - 15	25
4	Lower Sand/Silt/Clay Deposit	15 - 21	1.0
5	Sandy Clay/ Fat Clay	> 21	0.05
6	Embankment Fill	----	20
7	Core Zone	----	0.1

A.3.2.2 Cases Analyzed

For the final PIR, the cross-section analyzed utilized an embankment cross-section that is similar to the Acceler8 design. Acceler8 is a cooperative parallel design effort between SFWMD and USACE, whereby the SFWMD produces plans and specs in parallel with the USACE PIR planning process. The cross-section analyzed utilized a 12-foot wide crest and 3:1 (H:V) side slopes. The normal pool elevation was assumed to be at elevation 42 feet corresponding to 170,000 acre-feet storage volume. Outside the exterior embankment, the water

level within the adjacent canal was assumed to match the existing ground water level.

A cut-off wall was also modeled in the seepage analysis extended about 5 feet into the lower clay/silt deposit zone, with approximate depth of 20 feet below the existing ground surface. The top of the cut off wall was assumed to be at elevation of 47 feet, similar to the A8 design. The thickness of the cut-off wall was assumed to be 3 feet. A chimney drain and a blanket drain were also included in the analysis. The chimney drain was located about 40 feet from the cut-off wall, downstream side, and was extended to elevation 43 feet.

A.3.2.3 Seepage Analysis Results

Results of the seepage analyses performed are summarized in ***Table A-2*** below.

TABLE A-2: SUMMARY OF SEEPAGE ANALYSIS RESULTS

Case	Estimated Total Seepage ($ft^3/d/ft$)	Estimated Seepage Into Canal* ($ft^3/d/ft$)	Estimated Seepage Collected by the Blanket ($ft^3/d/ft$)
Pool Level @ Elev. 42' with a cut-off wall	16	16	15

Note: * Total seepage collected by the canal does not include the additional flows from re-routing of existing canals. Total seepage collect by the canal includes seepage from both sides of the canal.

Total seepage listed in the above table refers to total through and under seepage. Seepage into canal refers to the total of seepage from the reservoir side plus seepage from the adjacent lands to the seepage canal. Seepage collected by the blanket refers to seepage that is collected by the drainage blanket within the dam section. All quantities are in cubic feet per day per foot of dam.

With a typical critical gradient for the embankment material and the foundation soils being around 1.0, the minimum allowable safety factor against piping recommended ranges from 3 to 5. The estimated exit gradient ranged from about 0.05 to 0.1 which indicates that the development of soil piping is not anticipated. The output file from SEEP/W is shown on ***Figure A-5*** below.

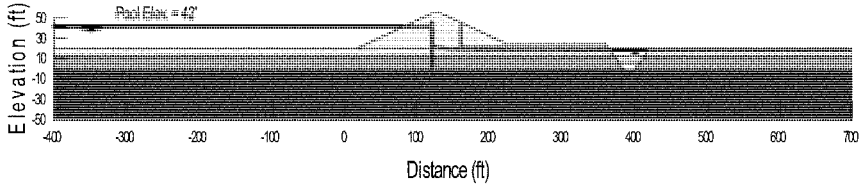


FIGURE A-5: SEEPAGE ANALYSIS OUTPUT

A.3.3 Slope Stability Analyses

A.3.3.1 General Description and Background

The embankment slopes were analyzed using Spencer's method of slices and the circular search routine of the SLOPE/W computer program. The SLOPE/W program was also developed by Geo-Slope International Ltd. All cases were analyzed using the consolidated-drained (S) shear strengths. This was done because of the predominance of granular materials that will be used for embankment construction.

A.3.3.2 Case Analyzed

The case described under the seepage analysis was also analyzed for slope stability, similar to the A8 design. The subsurface conditions used in the stability analyses were the same as those used for the seepage analysis discussed above. The phreatic surface estimated from the seepage analysis was used in the stability analyses. The shear strengths parameters used in the analysis are summarized below in ***Table A-3.***

TABLE A-3: SHEAR STRENGTH PARAMETERS

Material	Saturated Unit Weight (pcf)	Cohesion (psf)	Friction Angle (deg.)
Upper Sand	120	0	32
Upper Sand/Silt/Clay Deposit	125	800*	0
Limestone	140	2000*	45
Lower Sand/Silt/Clay Deposit	125	800*	0

Sandy Clay/Clay	125	1000*	0
Embankment Fill	120	0	32
Core Zone	125	800*	28*

Note: * Values were assumed based on typical values of the materials encountered. Data will be re-evaluated during the design phase of the project.

The cases considered for slope stability analysis were the upstream and downstream stability of the embankment using the Full-Pool condition and the side slopes stability of the seepage collection canal. The phreatic surface obtained from the full pool steady state seepage conditions was used in the analysis.

A.3.3.3 Design Requirements

The required factor of safety for the different design conditions described above are given in EM 1110-2-1902, "Engineering and Design Stability of Earth and Rock-Fill Dams", 1 April 1970, Table I, "Minimum Factors of Safety" and are shown in the table below:

Case	Shear Strength	Required Factor of Safety
Long Term with Full Pool	S	1.5
Long Term with No Pool	S	1.5
Steady State Seepage from Full Pool	S	1.5

A.3.3.4 Slope Stability Analysis Results

The Spencer's method of slices and the circular search routine was used in the analysis. Results of the slope stability analyses are presented below.

Case	Factor of Safety
Embankment, Full Pool, Upstream	2.3
Embankment, Full Pool, Downstream	2.0
Embankment, No Pool, Upstream	2.2
Canal's Side Slopes	1.7
Rapid Drawdown	1.6

All of these factors are above the minimum required factor of safety of 1.5 discussed above. Results of the stability analysis using the full pool downstream case is shown below in ***Figure A-6***.

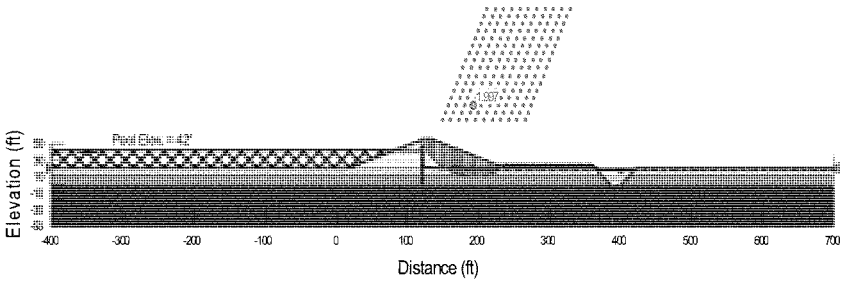


FIGURE A-6: SLOPE STABILITY OUTPUT

For the rapid drawdown analysis, it was determined that the embankment fill material (consisting mostly of fine sand materials) would have the ability to drain as quickly as the pool water level being drawn down. For that reason the RDD case was determined to be not critical with a safety factor of 1.6.

A.3.4 Settlement Analyses

Settlement analyses were performed for the reservoir dam using available consolidation data collected. Initial and consolidation settlements were evaluated at different locations of the reservoir embankment. Due to the variability in soil conditions, the total settlement estimated for the embankment ranges from about 6 to 38 inches. It is noted that most of the settlement ranges from 8 to 20 inches with isolated areas with settlements approaching 33 to 38 inches. It is that the majority of the settlement of the clayey soils beneath the embankment will take a period ranging from 1 to 3 years after construction.

A.3.5 Dewatering for Structures

It is anticipated that dewatering for structure excavations will be needed. For shallow foundations, dewatering could be potentially done by a well point system and/or perimeter ditches and sumps with dewatering pumps. However for deep foundations, it is anticipated that sheet pile cofferdams will be used with concrete tremie seal. These cofferdams then will be dewatered for structure construction. The cofferdams will be designed, by others, during the design phase of the project.

A.3.6 Other Foundation and General Construction Considerations for Structures

Though site-specific core borings will need to be drilled for each structure, it is anticipated that it will be possible to found the structures in this project on either shallow or deep foundations. During the design phase of the project, the foundations of the proposed structures will be evaluated in details to include type, bearing depth, settlement, bearing capacity determination, and construction procedures.

A.4 HYDROLOGIC MODELING

The model set used in the Caloosahatchee River (C-43) West Basin Storage Reservoir PIR is made up of three major components; 1) The South Florida Water Management Model (SFWMM), simulating the hydrology of the C&SF flood control project and the CERP, 2) The Freshwater Caloosahatchee River Basin model (FCRB), simulating the hydrology and hydraulics of the Caloosahatchee Basin from S-77 to S-79, and 3) CH3D, simulating salinity in the tidally influenced Caloosahatchee Estuary. See ***Figure A-7***.

The FCRB is the heart of the model set. Boundary conditions from the appropriate SFWMM simulation are provided to the FCRB, which simulates basin hydrology/hydraulics for the various planning conditions and alternatives. The resulting flow at S-79 provides the prime freshwater inflow boundary to CH3D. The CH3D simulates the salinity response by outputting spatially explicit time-varying salinity grids. For the alternatives evaluation modeling, a faster-running regression model was used as a surrogate for CH3D to produce the needed salinity grids. These salinity grids provide the major input to the Habitat Suitability Indicator models.

Each of these models is briefly discussed below.

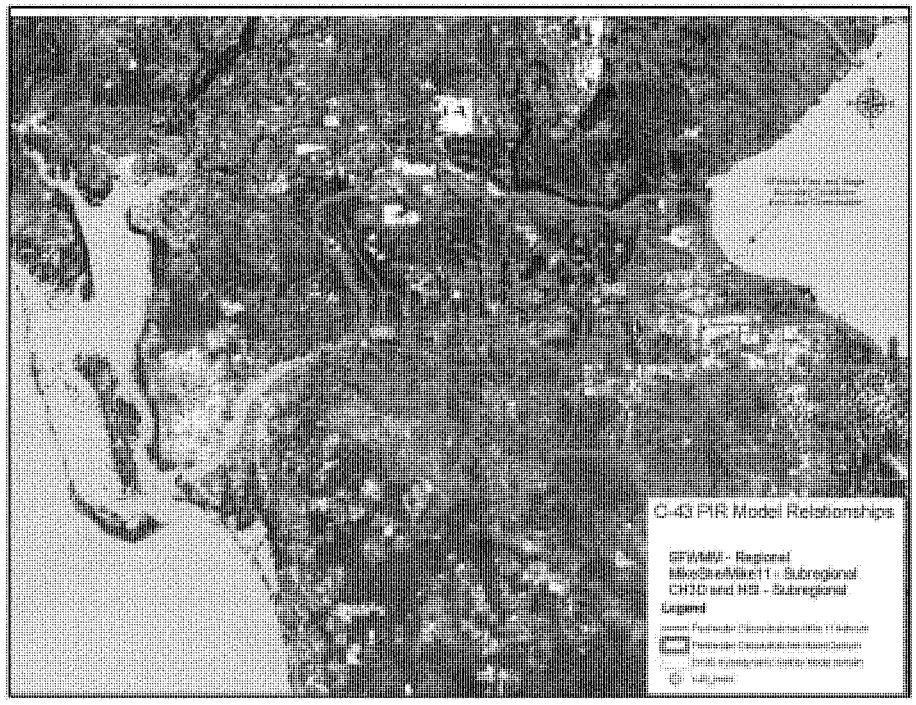


FIGURE A-7: CALOOSAHATCHEE (C-43) WEST BASIN STORAGE RESERVOIR PIR MODEL RELATIONSHIPS

1616

A.4.1 Regional Modeling

The SFWMM is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7,600 square miles using a mesh of 2 mile x 2 mile cells (2x2). In addition, the model includes inflows from Kissimmee River, and runoff and demands in the Caloosahatchee River and St. Lucie canal basins. The model simulates the major components of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and groundwater pumping. It incorporates current or proposed water management control structures and current or proposed operational rules. The ability to simulate water shortage policies affecting urban, agricultural, and environmental water uses in south Florida is a major strength of this model. The SFWMM simulates hydrology on a daily basis using climatic data for the 1965-2000 period which includes many droughts and wet periods. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. Technical staffs of many federal, state, and local agencies, as well as public and private interest groups have accepted the SFWMM as the best available tool for analyzing regional-scale structural and/or operational changes to the complex water management system in south Florida. Detailed SFWMM documentation is available at:
http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html.

A.4.1.1 SFWMM Boundary Condition Simulations

Utilization of the most currently accepted Lake Okeechobee base flow data to the Caloosahatchee Basin is critical to ensure consistency between the PIR and Acceler8 modeling. The 95BSR and D13R modeling runs for the Restudy were the previous basis for regional simulation with SFWMM of the "current" and "future with project" conditions, respectively. However, with the development of the 2000B2 and CERP0/1 runs as part of the Initial CERP Update (ICU), the basis for Lake Okeechobee discharges has been revised. In addition, 2000 and 2050 demand estimates (provided by Timothy Liebermann SFWMD on 11/19/04) and other information that is improved from those in 2000B2, 2050B2 and CERP1 are now available. New runs called 2000RD, 2050RD and CERP1RD , have been prepared for the PIR and Acceler8 efforts. These new runs incorporate the latest information, including the latest 2000 and 2050 demands.

The 2000RD run is derived from the 2000B2 simulation for ICU as documented at http://modeling.cerpzone.org/pmviewer/ModelRunInfo.do?modelrunID=52. Specific differences between the run assumptions are shown in the table below.

TABLE A-4: DIFFERENCES BETWEEN THE 2000B2 AND 2000RD MODEL RUNS

	2000B2 (for ICU)	2000RD (for C43 PIR and Acceler8)
SFWMM Version	V5.4	V5.4.2
Caloosahatchee Acreage	582,839 acres	578,013 acres
Caloosahatchee Irrigated Acreage	172,189 acres	172,337 acres
S4 Acreage	50,270 acres	42,581 acres
S4 Irrigated Acreage	39,861 acres	33,178 acres
Caloosahatchee Demand (Average Annual)	118 kac-ft	121 kac-ft
Caloosahatchee Runoff (Average Annual)	652 kac-ft	641 kac-ft
S4 Demand (Average Annual)	45 kac-ft	38 kac-ft
S4 Runoff (Average Annual)	52 kac-ft	42 kac-ft
Other Differences	Everglades Construction Project as of 3/31/04	Everglades Construction Project as of 11/16/04

The 2050RD run is derived from the 2050B2 simulation for ICU as documented at http://modeling.cerpzone.org/pmviewer/ModelRunInfo.do?modelrunID=53. Specific differences between the run assumptions are shown in the table below.

TABLE A-5: DIFFERENCES BETWEEN THE 2050B2 AND 2050RD MODEL RUNS

	2050B2 (for ICU)	2050RD (for C43 PIR and Acceler8)
SFWMM Version	V5.4	V5.4.2
Caloosahatchee Acreage	588,360 acres	578,013 acres
Caloosahatchee Irrigated Acreage	230,242 acres	205,556 acres
S4 Acreage	50,270 acres	42,581 acres
S4 Irrigated Acreage	40,626 acres	30,237 acres
Caloosahatchee Demand (Average Annual)	173 kac-ft	144 kac-ft
Caloosahatchee Runoff (Average Annual)	622 kac-ft	607 kac-ft
S4 Demand (Average Annual)	46 kac-ft	34 kac-ft
S4 Runoff (Average Annual)	51 kac-ft	43 kac-ft
Other Differences	Everglades Construction Project as of 3/31/04	Everglades Construction Project as of 11/16/04

The CERP1RD run is derived from the CERP1 simulation for ICU as documented at http://modeling.cerpzone.org/pmviewer/ModelRunInfo.do?modelrunID=56. Specific differences between the run assumptions are shown in the table below.

TABLE A-6: DIFFERENCES BETWEEN THE CERP1 AND CERP1RD MODEL RUNS

	CERP1 (for ICU)	CERP1RD (for C43 PIR and Acceler8)
SFWMM Version	V5.4	V5.4.2
Caloosahatchee Acreage	588,360 acres	578,013 acres
Caloosahatchee Irrigated Acreage	230,242 acres	205,556 acres
S4 Acreage	50,270 acres	42,581 acres
S4 Irrigated Acreage	40,626 acres	30,237 acres
Caloosahatchee Demand (Average Annual)	173 kac-ft	144 kac-ft
Caloosahatchee Runoff (Average Annual)	622 kac-ft	607 kac-ft
Lake Okeechobee Water Supply Deliveries to C43 Agriculture (Average Annual)	36 kac-ft	34 kac-ft
Caloosahatchee Estuary Target (Average Annual)	EST02 496 kac-ft	EST05 525 kac-ft
S4 Demand	46 kac-ft	34 kac-ft
S4 Runoff	51 kac-ft	43 kac-ft
Indian River Lagoon (IRL) Assumptions	RESTUDY	IRL South Authorized
Other Differences	Everglades Construction Project as of 3/31/04	Everglades Construction Project as of 11/16/04

A.4.2 Sub-Regional Modeling–MIKESHE

MIKESHE, a water resources modeling system, developed by DHI Water and Environment, Inc, was selected for sub-regional modeling of the Freshwater Caloosahatchee River Basin (FCRB). Close interaction between groundwater and surface water within the study area necessitates the use of a model which can concurrently simulate groundwater and surface water within the same model run. MIKESHE is an integrated groundwater and surface water modeling package, capable of simulating all major processes in the land phase of the hydrologic cycle such as rainfall, evapotranspiration, overland flow, unsaturated zone flow with multiple soil layers and types (one-dimensional finite difference), saturated zone flow with multiple geological layers (three-

dimensional finite difference flow), irrigation, drainage, pumping wells, and can support various types of land use and vegetation.

The surface water river/canal network is simulated within MIKESHE using the MIKE11 Hydrodynamic module. This module simulates the river hydraulics through the fully dynamic solution of the complete nonlinear St. Venant equations for open-channel flow. The application of the MIKE11 module is also ideal for this study due to the large number of complex hydraulic control structures within the basin. MIKE11 is capable of simulating many types of structures including weirs, pumps, overflow and underflow gates, culverts, and bridges. MIKE11 structures can contain extremely complex and nested logical operating schemes based upon a wide array of variables within the model. The FCRB model contains 129 water control structures and 515 miles of rivers and canals within the surface water network.

The model simulates irrigation within the basin through the use of conceptual "irrigation command areas". An irrigation command area spatially represents an irrigated area (farm, group of farms, or urban area) and describes the sources of irrigation water, including location of source, withdrawal rates, and cutoff thresholds. Each irrigation command area may have multiple sources including surface water (MIKE11 river branch), single wells, distributed shallow wells, or external sources which supply water from outside the model domain. The FCRB model contains 151 distinct irrigation command areas.

The FCRB receives boundary conditions from the SFWMM (2x2) along the Lake Okeechobee boundary (MIKESHE) as well as at several structures in the surface water network (MIKE11). The rainfall and evapotranspiration inputs are the same 2-mile x 2-mile gridded time series used in the SFWMM.

Topography was developed by the SFWMD and was imported into the model through the use of GIS. The FCRB model contains 13,608 grid cells, with 1,500 feet by 1,500 feet grid cell size. Of these 13,608 cells, there are 611 boundary cells and 12,997 internal cells. This gives a total model domain of 702,900 acres or 1,098 square miles. The model simulates three distinct, spatially-explicit groundwater units—the Holocene-Pliocene, the Lower Tamiami, and the Sandstone aquifers, separated by the Bonita Springs Marl and Upper Peace River Confining units. The model also contains the Berry Farm Clay layer which rests underneath the Berry Reservoir site. The model simulates 21 different land use types and six different soil types.

The FCRB model was calibrated for the time period September 1990 through September 1999 using actual meteorological data, stream flows and stages, and groundwater monitoring wells.

A.4.3 Estuary Salinity Modeling

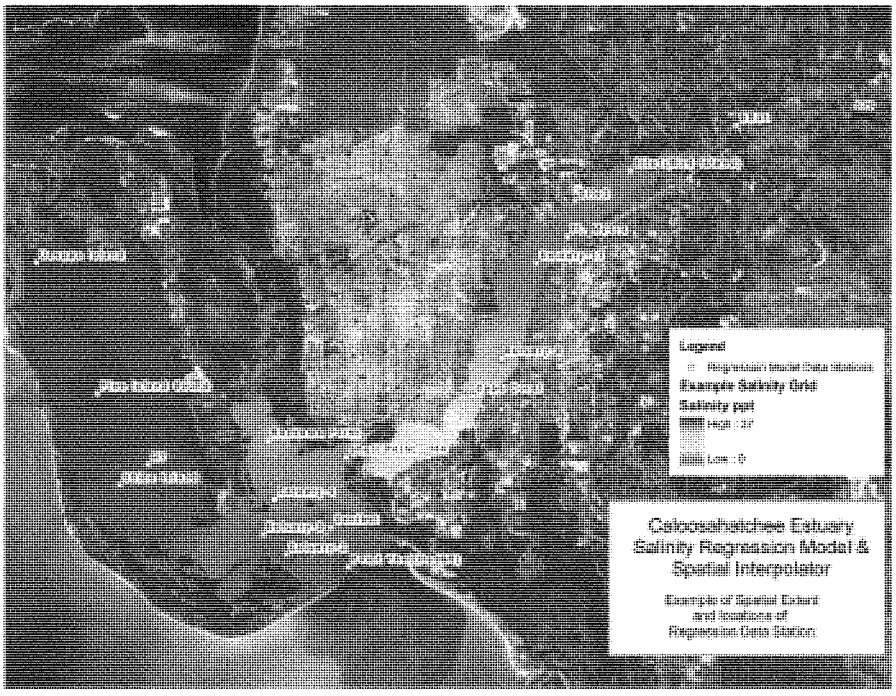
A.4.3.1 CH3D

The CH3D model is three-dimensional and employs curvilinear grids. The model simulates time-dependent circulation in estuaries, lakes, and coastal waters. It solves the three-dimensional equations of motion in a non-orthogonal boundary-fitted coordinate system with given computational domain, initial conditions, and boundary conditions. For the present application to the Caloosahatchee estuarine system, the model solves the conservation equations for the following hydrodynamic variables: surface elevation, 3-D velocities, salinity, and density. Multi-year simulation of salinity in the estuary is needed to evaluate alternatives. While the CH3D model could be used for these simulations, project deadlines preclude this option. Based on the CH3D hydrodynamic model results and observed data, a salinity regression model was developed to meet the requirement for multi-year analysis.

A.4.3.2 Salinity Regression Model and Spatial Interpolator

The salinity regression model was designed to use the freshwater discharges at S-79 to estimate the salinity values at 20 downstream stations. It was constructed in two phases: (1) finding the relationships between the constant discharges at S-79 and their corresponding equilibrium salinities at the 20 downstream stations (Q~S curves); (2) using a FORTRAN program and certain coefficients to adjust the salinity variation curves to match the monitoring salinity data and salinity data for specific stations taken from the calibrated CH3D salinity model. Since the FORTRAN code runs in seconds, the processing of the S-79 flow results from the MIKESHE alternative simulations is quite manageable. In order to produce the HSI model input, the next step is to produce spatially explicit salinity data (grids) from the daily salinity time-series at each of the 20 regression points. A set of Arc Info scripts was developed to automate an interpolation process to produce ASCII grid data representing average monthly salinity values. Interpolation schemes were tested and the results coordinated with the Ecological Subteam. The Inverse Distance Weighting scheme, with barriers to represent the landforms, was chosen. The spatial extent of the interpolator and the location of the Regression model data stations are shown in ***Figure A-8***.

FIGURE A-8: CALOOSAHATCHEE ESTUARY SALINITY REGRESSION MODEL AND SPATIAL INTERPOLATOR



A.4.3.3 Simulation Period

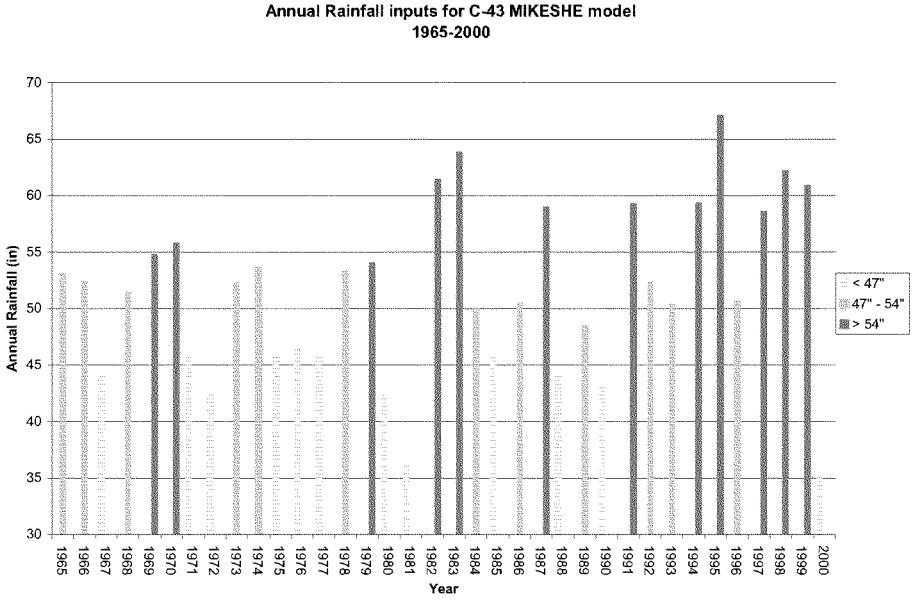
CERP General Guidance Memorandum # 1 provides guidance regarding modeling simulation periods as follows:

> *The time series of data (beginning with the date of the first data point through the date of the last data point) that comprises the full range of known conditions constitutes the period-of-record for undertaking this analysis. If a shorter period is used, the full range of hydrologic conditions must be represented including inter- and intra- annual variations due to droughts, periods of high and low water levels and natural fluctuations. An appropriate period-of-record will include natural fluctuations in rainfall and water levels, including droughts and periods of high water levels. Uncertainty about the adequacy of the data for compiling an appropriate period-of-record should be reflected in project documents. All simulations considered should use the same period of climatic record.*

The SFWMM Period of Record (POR) is 36 years from 1/1/1965 through 12/31/2000. This long POR simulation is possible due to the relatively low computational requirements of the SFWMM. The Subregional MIKESHE/MIKE11 computational requirements are significantly greater. One year of MIKESHE simulation on a 3.0 gigahertz CPU requires about 3.5 hours of computational time, thus a 36-year POR run would take approximately 126 hours (about a week). While a 36-year MIKESHE run has been tested, the modeling turnaround is not manageable given current resources and schedule. Furthermore, the CH3D model requires even greater computation resources. Accordingly, a POR shorter than 36 years is necessary to evaluate alternatives.

Figure A-9 shows the simulated annual rainfall depths over the entire FCRB model domain for the 36-year POR. The three categories; Dry <47", 47"<Average<54", and Wet>57" were established by ranking the 36 years from the least, 35" in 2000, to the greatest, 67" in 1995. The 36 ordered rainfall years were then divided into thirds (12 years each), and each year was assigned the relative designation of Dry (1st third), Average (2nd third), Wet (last third). The selected alternatives evaluation period is January 1, 1978 through December 31, 1986. This 9-year period contains three Dry, three Average, and three Wet years each, as well as the second-most wet and dry years observed. Also note the back to back dry years in 1980 and 1981 and the following wet years in 1982 and 1983. Therefore, the selection of this POR is in compliance with the intent of CERP Guidance Memoranda # 1.

FIGURE A-9: ANNUAL RAINFALL INPUTS FOR C-43 MIKESHE MODEL



A.4.4 Model Certification, Description of Models, and Modeling Assumptions

A.4.4.1 Model Certification Process

Efforts to develop the Caloosahatchee River (C-43) West Basin Storage Reservoir Project Implementation Report have relied heavily on numerous planning and engineering models. The models are necessary for estimation of benefits, costs, operational requirements, and/or ecological outputs. These estimates are essential to determine the best alternative. Because of the importance of these models, it is necessary to evaluate their acceptability. In an effort to determine the acceptability of planning models, the U.S. Army Corps of Engineers published Engineer Circular No. 1105-2-407. This circular was published 31 May 2005 and establishes the process and requirements for certification of planning models.

Planning models, as defined by the circular, are:

> "...any models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternatives to address the problems and take advantage of the opportunities, to evaluate potential effects of alternatives and to support decision making. It includes all models used for planning, regardless of their scope or source..."

The circular, however, does not cover engineering models. Engineering models will undergo a certification process that will be defined by the Science & Engineering Technology Initiative.

The criteria for planning model certification are defined in Section 7 of the circular. Models are certified on the basis of technical soundness. Technical soundness is the ability of the model to represent or simulate the processes and/or functions it is intended to represent. In addition, a certified model should utilize accepted theory, integrate Corps policies and requirements, properly incorporate the theory into the software code of the model, clearly define the assumptions of the model, employ proper functions and mathematics, and estimate/forecast the actual parameters it is intended to simulate. Lastly, the models should be efficient, effective, usable, and capable of presenting results clearly.

The process for certification of existing planning models, as outlined in Section 8 of the circular, starts with a proponent identifying the model to be used. The proponent is responsible for submitting the model and documentation to the appropriate Planning Center of Expertise (PCX). The PCX then determines the appropriate level of review and establishes a review team. The team provides comments and recommendations to the PCX..The PCX can conclude with a certification of the model.

The Jacksonville District Corps of Engineers has submitted (acted as the proponent) to the appropriate entity the models listed below (planning models were submitted to the appropriate PCX). The Jacksonville District also corresponded with Headquarters to determine the acceptability of engineering models:

PLANNING MODELS	ENGINEERING MODELS
HSI	Freshwater Caloosahatchee River Basin Model
IWR-PLAN	MIKE11
	MIKESHE
	SEEP/W
	SFWMM
	SLOPE/W
	Watershed Assessment Model

In addition to the models listed above, additional models may be used in the future to determine some of the outputs of the project. There may be a need to use BATHTUB (a reservoir water quality model), CH3D (a hydrodynamic, salinity, and temperature model), DMSTA (Dynamic Model for Stormwater Treatment Areas), and PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation.) If, in the future, these models are used for

this project, they will be put through the appropriate certification process required at that time.

A.4.4.2 Models Used, Model Criteria, Status of Certification

The model certification process outlined in Engineering Circular 1105-2-407 and the SET Initiative's process to certify engineering models are currently undergoing refinement and the PCXs and Headquarters are not yet certifying models. However, the PCXs are operating under guidance from IWR that allows them to approve models for use. Headquarters has provided the SFWMD with guidance that suggests the use of "due diligence" when evaluating engineering models until the certification process is finalized.

A.4.4.2.1 Model Name: HSI (Habitat Suitability Index)

Model Description and Use: HSI was developed by the U.S. Fish and Wildlife Service (USFWS). HIS models are used to determine the impact each alternative will have on the project area.. HSI methods were used for quantifying habitat value for oysters, *Vallisneria*, and seagrasses.

HSI methods are used to evaluate attributes that represent independent aspects of the ecosystem and provide a complete picture of the performance of different alternatives. Evaluation criteria are developed and weighted for each attribute. Hydrologic and hydraulic data are applied to the evaluation criteria and attributes to predict the ecological changes likely to occur under the with and without project conditions.

Peer Review: HSI methods and models are used throughout the environmental community. The HSI concept was developed by the USFWS in the early 1980's and is still used today. The HSI process is typically conducted by a team of environmental professionals.

Documentation/Support: HSI documentation can be found in USFWS habitat evaluation procedures, Fish and Wildlife Service Manual, 870 FW 1, http://www.fws.gov/policy/870fw1.html.

HSI models can be developed using spreadsheets or through the use of software provided by the Department of the Interior, http://www.fort.usgs.gov/products/software/hsin/hsin.asp.

Point of Contact(s): United States Fish & Wildlife Service, Division of Habitat and Resource Conservation (habitat@fws.gov)

Certification Status: The United States Army Corps of Engineers Planning Center of Expertise for Ecosystem Restoration has approved HSI modeling.

A.4.4.2.2 Model Name: IWR-Plan

Model Description and Use: IWR-PLAN was developed by the Institute for Water Resources. IWR-Plan Decision Support Software is designed to assist with formulation and comparison of alternative plans. IWR-PLAN can assist with plan formulation by combining solutions to planning problems and calculating the additive effects of each combination, or "plan." IWR-PLAN can assist with plan comparison by conducting cost effectiveness and incremental cost analyses, identifying the plans which are the best financial investments and displaying the effects of each on a range of decision variables.

IWR-PLAN takes user-defined solutions to planning problems and externally-generated estimates of each solution's effects and can formulate all possible combinations of those solutions, considering user-defined relationships between solutions. IWR-PLAN will then identify which combinations are the best financial investments through cost effectiveness and incremental cost analyses. Each combination of solutions is an alternative plan. If alternative plans have already been formulated outside IWR-PLAN, the user can bypass the routine for building combinations and still use IWR-PLAN to assist in identifying which plans are the best investments.

Peer Review: IWR-Plan has a team of analysts dedicated to testing and review. The model has been in use by Corps and non-Corps parties for many years. The model was developed in accordance with procedures authored by Corps HQ.

Documentation/Support: IWR-Plan was developed in accordance with the procedures manual Cost Effectiveness and Incremental Cost Analyses published by IWR in 1995 (IWR Report 95-R-1),
http://www.water-resources.us/inside/products/pub/iwrreports/95r01.pdf

IWR-Plan is supported by the Institute for Water Resources through Planning & Management Consultants, Ltd., http://www.pmcl.com/iwrplan/

Point of Contact(s): Leigh Skaggs, IWR,
lawrence.l.skaggs@iwr01.usace.army.mil

Certification Status: This model was sent to the PCX for certification; however, the PCX determined that IWR-Plan is not an ecosystem restoration model and therefore could not approve the model. The PCX transferred the model to Headquarters for approval. Approval from Headquarters is pending.

A.4.4.2.3 Model Name: Freshwater Caloosahatchee River Basin Model

Model Description and Use: The Freshwater Caloosahatchee River Basin Model was developed using MIKE11 and MIKESHE to simulate hydrologic conditions in the lower West Caloosahatchee basin and in turn to evaluate the different alternatives and their effects on the flows to the estuary. This model is based off of MIKE11 and MIKESHE.

Model Name: MIKE11

Model Description and Use: MIKE11 is the product of the Danish Hydraulic Institute. The model is an industry standard for simulating flow and water level, water quality and sediment transport in rivers, irrigation canals, reservoirs and other inland water bodies. It is a comprehensive engineering tool with a wealth of capabilities provided in a modular framework.

MIKE11 can be used for flood risk analysis and alleviation design, real-time flood forecasting, dam break analysis, optimization of reservoir and canal gate/structure operations, ecological and water quality assessments in rivers, reservoirs and wetlands, real-time water quality forecasting and pollutant tracking, sediment transport and river morphology, salinity intrusion in rivers and estuaries, integrated surface water, and groundwater and water analysis.

Peer Review: The Interagency Modeling Center reviewed the application of the model. US Federal Emergency Management Agency (FEMA) has approved MIKE11 and has added it to its exclusive list of hydraulic simulation tools accepted for use in the National Flood Insurance Program (NFIP).

Documentation/Support: MIKE11 is supported by the Danish Hydraulic Institute, VKI-Institute for the Water Environment and Danish Toxicology Centre http://www.dhigroup.com/. Numerous professional papers can be obtained from the DHI Library, http://www.dhigroup.com/Software/WaterResources/MIKE11/References/Papers.aspx.

Point of Contact(s): DHI North American Offices, http://www.dhigroup.com/Contact/DHIOffices/USA.aspx.

Certification Status: Headquarters (HQ) has advised the SFWMD to use "due diligence," thorough review, and documentation when using engineering models in Corps studies. The above information provides detailed information about the model and the SFWMD believes it satisfies HQ's current requirements.

A.4.4.2.4 Model Name: MIKESHE

Model Description and Use: MIKESHE was developed by the Danish Hydraulic Institute. It is a modeling tool that can simulate the entire land phase of the hydrologic cycle. It is an integrated modeling environment that allows components to be used independently and customized to local needs.

MIKESHE can be used for the analysis, planning and management of a wide range of water resources and environmental problems related to surface water and groundwater, such as; surface water impact from groundwater withdrawal, conjunctive use of groundwater and surface water, wetland management and restoration, river basin management, planning environmental impact assessments, aquifer vulnerability mapping with dynamic recharge and surface water boundaries, groundwater management, floodplain studies, impact studies for changes in land use and climate, impact studies of agricultural practices including irrigation, drainage, and nutrient and pesticide management.

Peer Review: IMC has reviewed the application of the model. DHI maintains support services for MIKESHE to allow professional users to provide feedback about the software. MIKESHE has also been the subject of many external reviews,
http://www.dhigroup.com/Software/WaterResources/MIKESHE/References/References.aspx

Documentation/Support: MIKESHE is supported by the Danish Hydraulic Institute, VKI-Institute for the Water Environment and Danish Toxicology Centre. Documentation is available at their website
http://www.dhigroup.com/.

Point of Contact(s): DHI North American Offices,
http://www.dhigroup.com/Contact/DHIOffices/USA.aspx.

Certification Status: HQ has advised the SFWMD to use "due diligence," thorough review, and documentation when using engineering models in Corps studies. The above information provides detailed information about the model and the SFWMD believes it satisfies HQ's current requirements.

A.4.4.2.5 Model Name: SEEP/W

Model Description and Use: SEEP/W is a product of Geo-Slope International. It's a finite element software product for analyzing groundwater seepage and excess pore-water pressure dissipation problems within porous materials such as soil and rock.

SEEP/W is used to model both saturated and unsaturated flow. The saturated/unsaturated formulation of SEEP/W makes it possible to analyze seepage as a function of time and to consider such processes as the infiltration of precipitation. The transient feature allows you to analyze such problems as the migration of a wetting front and the dissipation of excess pore-water pressure.

Peer Review: SEEP/W is offered through a private company, Geo-Slope International. Through their website, http://www.geo-slope.com/support/kb/advsearch.aspx, they offer users the ability to provide feedback. The software appears to be used in both the professional and academic community.

Documentation/Support: Limited documentation about SEEP/W is available without purchase of the software, http://www.geo-slope.com/products/seepw2004.aspx. Geo-Slope International provides online support.

Point of Contact(s): General inquires: info@geo-slope.com
Technical support: support@geo-slope.com

Certification Status: HQ has advised the SFWMD to use "due diligence," thorough review, and documentation when using engineering models in Corps studies. The above information provides detailed information about the model and the SFWMD believes it satisfies HQ's current requirements.

A.4.4.2.6 Model Name: SFWMM, (South Florida Water Management Model [2x2]))

Model Description and Use: SFWMM is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. The model domain covers an area of 7,600 square miles using a mesh of 2 mile x 2 mile cells.

The model simulates the major components of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and groundwater pumping. It incorporates current or proposed water management control structures and current or proposed operational rules.

Peer Review: This model was peer reviewed in 1989 and 2005. Both peer reviews were conducted in similar manners. The most recent peer review consisted of a panel of four engineering professors and one contractor with experience in model development. The reviewers were: Rafael L. Bras, Chair (Professor of Engineering, MIT), Anthony Donigian (President, Aqua Terra Consultants), Wendy Graham (Professor of Engineering, University of Florida), Vijay Singh (Professor of Engineering, Louisiana State University), and Jery

Stedinger (Professor of Engineering, Cornell University). The panel reviewed the adequacy of the methodology. Overall, they found the model to be appropriate; they cited areas of the model that excelled as well as areas that could use improvement. The results of their review are documented in *The South Florida Water Management Model, Version 5.5: Review of the SFWMM Adequacy as a Tool for Addressing Water Resources Issues*, http://webboard.sfwmd.gov:8080/~sfwmm/guests.

Documentation/Support: SFWMM is supported by SFWMD, http://www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html, and documentation of the model can be found at http://www.sfwmd.gov/org/pld/sfwmm_doc/menu.htm.

Point of Contact(s): Jayantha Obeysekera, Ph.D., P.E., Director. jobey@sfwmd.gov
Ken Tarboton, Ph.D., P.E., Sr. Supervising Engineer.
ktarbot@sfwmd.gov

Certification Status: HQ has advised the SFWMD to use "due diligence," thorough review, and documentation when using engineering models in Corps studies. The above information provides detailed information about the model and the SFWMD believes it satisfies HQ's current requirements.

A.4.4.2.7 Model Name: SLOPE/W

Model Description and Use: SLOPE/W is a product of Geo-Slope International. SLOPE/W is the leading slope stability software product for computing the factor of safety of earth and rock slopes.

Using limit equilibrium, SLOPE/W can model heterogeneous soil types, complex stratigraphic and slip surface geometry, and variable pore-water pressure conditions using a large selection of soil models. Slope stability analyses can be performed using deterministic or probabilistic input parameters. Stresses computed by a finite element stress analysis may be used in addition to the limit equilibrium computations, for the most complete slope stability analysis available.

Peer Review: SLOPE/W is offered through a private company, Geo-Slope International. Through their website, http://www.geo-slope.com/support/kb/advsearch.aspx, they offer users the ability to provide feedback. The software appears to be used in both the professional and academic community.

Documentation/Support: Limited documentation about SLOPE/W is available without purchase of the software, http://www.geo-

slope.com/products/slopew2004.aspx. Geo-Slope International provides online support.

Point of Contact(s): General inquires: info@geo-slope.com
Technical support: support@geo-slope.com

Certification Status: HQ has advised the SFWMD to use "due diligence," thorough review, and documentation when using engineering models in Corps studies. The above information provides detailed information about the model and the SFWMD believes it satisfies HQ's current requirements.

A.4.4.2.8 Model Name: WAM, a.k.a. WAMView (Watershed Assessment Model)

Model Description and Use: WAM was developed and is supported by the Ecosystems Research Division of the United States Environmental Protection Agency (USEPA). It was developed to allow engineers and planners to assess the water quality of both surface water and groundwater based on land use, soils, climate, and other factors. The model simulates the primary physical processes important for watershed hydrologic and pollutant transport. The WAM GIS-based coverages including: land use, soils, topography, hydrography, basin and sub-basin boundaries, point sources and service area coverages, climate data, and land use and soils description files.

The model can be used to assess P load strategies including the use of stormwater treatment areas (STAs) and reservoir-assisted stormwater treatment areas (RASTAs). WAM also has the ability to aid in the assessment of the impact of growth changes in the watershed.

Peer Review: IMC has reviewed this model for the Lake Okeechobee Projects. In addition, USEPA is committed to maintaining an open dialogue with users of the software. They accept feedback from users and most likely incorporate that feedback into future versions of its model.

Documentation/Support: WAMView is supported by the Ecosystems Research Division of the USEPA. Fact Sheets, user documentation, and links to technical support can be found at, http://www.epa.gov/ATHENS/wwqtsc/html/wamview.html.

Point of Contact(s): Tim Wool, EPA, wool.tim@epa.gov
Bob Ambrose, EPA, ambrose.robert@epa.gov

Certification Status: HQ has advised the SFWMD to use "due diligence," thorough review, and documentation when using engineering models in Corps studies. The above information provides detailed information about the model and the SFWMD believes it satisfies HQ's current requirements.

A.4.4.3 Hydrologic Modeling Application for Modeling of Alternatives

Daily outputs of flow for the S-79 structure were used to evaluate the project's final array of alternative plans by comparing the hydrologic performance of each alternative to the CERP system-wide performance measure "NE-3" (Caloosahatchee salinity envelope [EST05]). Performance measure NE-3 quantifies the amount of time that the flows coming through S-79 are within the range to maintain the desirable salinity envelope. The EST05 time series represents the best-case ecological scenario under the same climatological record to determine which alternative came closest to achieving the hydrologic performance targets set for the project. Because of the integral connection between groundwater and surface water in the Caloosahatchee River Basin, the MIKESHE model was used to simulate the surface and ground water hydrologic cycle. The MIKESHE modeling platform was developed as a subregional model to simulate the hydraulics and hydrology of the Caloosahatchee River Basin since the project is located outside the spatial resolution and domain of the SFWMM. Because the MIKESHE model and the SFWMM are two different modeling platforms, they operate separately. This separation requires the MIKESHE model to use boundary conditions obtained from SFWMM model to simulate Lake Okeechobee release to the Caloosahatchee River Basin. The MIKESHE model then receives a set time series of water volumes from the SFWMM boundary condition based on the planning assumptions applied in the 2050RD condition. The model runs described below are needed to identify the recommended plan (also see ***Table A-7***).

Pre Selected Alternative Plan (SAP) Model Runs:

- Pre-CERP baseline (2000 Base Conditions).

- Existing Conditions (EC): This model run includes existing land use and operations as of the initiation of the PIR. It is typically used as part of the NEPA analysis and also for state assurances related to flood protection. (It is assumed that the 2000 base run and the existing conditions are the same since it is assumed that there have been no major changes in the basin).

- 2050 Future Without Project (FWO): No project features in place (CERP). Typically the Corps uses a 50-year planning horizon so the model should be parameterized with appropriate land use, water demands, structure operations, etc. For CERP projects, the current guidance is to use 2050 as the future year.

- Alternatives Run: Run alternatives using the CERPRD boundary conditions with each alternative. Three alternative plans with different configurations will be run under this condition.

TABLE A-7: MODEL RUNS FOR USE IN SAP SELECTION

Description	Land Use	Water Del.	Boundary Conditions/ Flows	Sea Level Rise
Pre-CERP Baseline	2000	2000	2000RD (2x2)	N
Alt 1: Future Without Condition.	2050	2050	2050RD (2x2)	Y
Alt. 2 100000 ac-ft rev.	2050	2050	CERP1RD (2x2)	Y
Alt. 3A,B,C- 170000 ac-ft rev	2050	2050	CERP1RD (2x2)	Y
Alt. 4A,B- 220000 ac-ft rev	2050	2050	CERP1RD (2x2)	Y

In order to ensure consistency between the PIR and Acceler8 modeling, it is critical that the most currently accepted Lake Okeechobee base flow data to the Caloosahatchee River Basin be used in the analysis of the project. The 95BSR and D13R modeling runs for the Restudy were the previous basis for regional simulation with SFWMM of the "current" and "future with project" conditions, respectively. However, with the development of the 2000B2 and CERP0/1 runs as part of the Initial CERP Update (ICU), the basis for Lake Okeechobee discharges has been revised. Additionally, 2000 and 2050 demand estimates have been improved upon those used in 2000B2, 2050B2 and CERP1 conditions and are now available. The new runs which use the updated conditions are called 2000RD, 2050RD and CERP1RD. These conditions incorporate the latest information, including the latest 2000 and 2050 demands, and have been prepared for the PIR and Acceler8 efforts.

The 2000RD run is derived from the 2000B2 simulation for the ICU. Specific differences between the run assumptions are shown in ***Table A-8***.

TABLE A-8: DIFFERENCES BETWEEN EXISTING CONDITION RUNS (2000B2 SIMULATION AND 2000RD SIMULATION)

	2000B2 (for ICU)	2000RD (for C43 PIR and Acceler8)
SFWMM Version	V5.4	V5.4.2
Caloosahatchee Acreage	582,839 acres	578,013 acres
Caloosahatchee Irrigated Acreage	172,189 acres	172,337 acres
S4 Acreage	50,270 acres	42,581 acres
S4 Irrigated Acreage	39,861 acres	33,178 acres
Caloosahatchee Demand (Average Annual)	118 kac-ft	121 kac-ft
Caloosahatchee Runoff (Average Annual)	652 kac-ft	641 kac-ft
S4 Demand (Average Annual)	45 kac-ft	38 kac-ft
S4 Runoff (Average Annual)	52 kac-ft	42 kac-ft
Other Differences	Everglades Construction Project as of 3/31/04	Everglades Construction Project as of 11/16/04

The 2050RD run is derived from the 2050B2 simulation for the ICU. Specific differences between the run assumptions are shown in ***Table A-9***.

TABLE A-9: DIFFERENCES BETWEEN FUTURE WITHOUT PROJECT CONDITION RUNS (2050B2 SIMULATION AND 2050RD SIMULATION

	2050B2 (for ICU)	2050RD (for C43 PIR and Acceler8)
SFWMM Version	V5.4	V5.4.2
Caloosahatchee Acreage	588,360 acres	578,013 acres
Caloosahatchee Irrigated Acreage	230,242 acres	205,556 acres
S4 Acreage	50,270 acres	42,581 acres
S4 Irrigated Acreage	40,626 acres	30,237 acres
Caloosahatchee Demand (Average Annual)	173 kac-ft	144 kac-ft
Caloosahatchee Runoff (Average Annual)	622 kac-ft	607 kac-ft
S4 Demand (Average Annual)	46 kac-ft	34 kac-ft
S4 Runoff (Average Annual)	51 kac-ft	43 kac-ft
Other Differences	Everglades Construction Project as of 3/31/04	Everglades Construction Project as of 11/16/04

The CERP1RD run is derived from the CERP1 simulation for ICU. Specific differences between the run assumptions are shown in *Table A-10.*

TABLE A-10: DIFFERENCES BETWEEN FUTURE WITH CERP CONDITION RUNS (CERP1 SIMULATION AND CERP1RD SIMULATION)

	CERP1 (for ICU)	CERP1RD (for C43 PIR and Acceler8)
SFWMM Version	V5.4	V5.4.2
Caloosahatchee Acreage	588,360 acres	578,013 acres
Caloosahatchee Irrigated Acreage	230,242 acres	205,556 acres
S4 Acreage	50,270 acres	42,581 acres
S4 Irrigated Acreage	40,626 acres	30,237 acres
Caloosahatchee Demand (Average Annual)	173 kac-ft	144 kac-ft
Caloosahatchee Runoff (Average Annual)	622 kac-ft	607 kac-ft
Lake Okeechobee Water Supply Deliveries to C43 Agriculture (Average Annual)	36 kac-ft	34 kac-ft
Caloosahatchee Estuary Target (Average Annual)	EST02 496 kac-ft	EST05 525 kac-ft
S4 Demand	46 kac-ft	34 kac-ft
S4 Runoff	51 kac-ft	43 kac-ft
Indian River Lagoon (IRL) Assumptions	RESTUDY	IRL South Authorized
Other Differences	Everglades Construction Project as of 3/31/04	Everglades Construction Project as of 11/16/04

In addition, the hydrologic output of each alternative will also be used as output variables to develop and conduct the cost effectiveness and incremental cost analyses (CE/ICA) procedures which are instrumental in the selection of the National Ecosystem Restoration (NER) plan. The final alternatives will also be evaluated using ecological evaluation criteria developed for the project. The SAP will be based on the performance of one of these final alternatives in terms of attaining hydrological and ecological targets. These will be expressed in habitat units for various estuarine species (also explained in the section on Habitat Units) to help demonstrate which plan provides the greatest system-wide benefits to support project justification.

A.4.5 Hydrology and Hydraulics (H&H) Considerations for Embankments and Canals

A.4.5.1 General

The Caloosahatchee River (C-43) West Basin Storage Reservoir project area would consist of approximately 10,700 acres, of which approximately 10,480

acres are required in fee, approximately 20 acres in perpetual easements and approximately 200 acres in temporary easements for staging areas.. The area would incorporate a perimeter embankment with an adjacent perimeter canal and an interior embankment to divide the area into two cells (see plan view on Plate 1).

A.4.5.2 Embankment

The embankment would be designed and constructed to satisfy the hydraulic requirements of the impoundment pool with regard to pool elevation and anticipated wave run-up and the geotechnical requirements with regard to slope stability and seepage through the embankment.

Freeboard for the perimeter and internal dams measured above the normal full storage level (Elevation of 42 feet) as follows (***Table A-11***):

TABLE A-11: REQUIRED FREEBOARD HEIGHTS

Feature	Total Required Freeboard (ft)	Top of Dam Elevation (ft)
Cell 1	15	57
Cell 2	15	57
Internal Dam	9.4	51.4

The freeboard (wind setup plus wave run up) was calculated based on the Design Criteria Memorandum (DCM)-2 design criteria using the Shore Protection Manual, Volumes I and II, published by the Waterways Experiment Station of the USACE and STWAVE/ACES. The results of these analyses were presented in the Final Technical Memorandum–C-43 West Storage Reservoir Freeboard Analysis and Recommendation (included in this appendix). This technical memorandum represents the latest refinements incorporated into the Acceler8 60% Design. Changes to input parameters in the PMP event and wind/wave modeling have resulted in an average increase in embankment height of approximately 2.5 feet between the Draft PIR and this Final PIR. Further refinements are ongoing and will be incorporated into the design as they become available.

The 2-cell Reservoir was developed in the MIKESHE/MIKE11 model through the use of multiple input files. In the MIKE11 River Network model, the primary input files include the "network" file (*.nwk11) and the "cross-section" file (*.xns11).

The network file defines the linear path of each river or branch in the model. To add the Reservoir into the model, branches were defined to represent the Perimeter (Seepage) Canal and Cells 1 and 2 of the reservoir. Dummy branches were also defined at the location of various inflow and outflow structures.

Dummy branches were defined for the inflow pump, the outflow gates, and the service spillways.

The branches defined as Cell 1 and Cell 2 maintained the same position in space as the LPDD Header canals that currently exist at the project site. Proposed cross-sections were defined for each of the cells and the Perimeter (seepage) Canal.

The cross-section assumes a 3:1 side slope and bottom gradients generally conform to the existing topography of the site. A "slot" exists in each cross section at the approximate location of the former LPDD Header canal. This slot was included in the model to increase numerical stability during those periods of time when the Reservoir is dry.

It should also be noted that the total area of the slot is less than 10 square feet. The volume of water held in the slot is insignificant relative to the total volume of the Reservoir and reflects water that would be trapped in the micro-topography of the project site.

A.4.5.3 Slope Protection

It is anticipated that a stair step style soil cement design would be constructed pool side from the top of the embankment to the normal pool elevation. Each step would be 12 inches deep by 3 feet wide. A 16-inch flat plate style soil cement design would be constructed from the normal pool elevation to the toe of the embankment. The 16-inch flat plate design would also be constructed over the entire surface of the interior embankment. Grassing would be provided over the exterior portion of the perimeter embankment including a portion of the perimeter canal bank.

A.4.5.4 Perimeter Canal

A perimeter canal would be constructed adjacent to the outside slope of the perimeter embankment. The bottom width would be 10 feet at elevation 0.0 feet and the side slopes would be 1 Vertical on 2 Horizontal (1V:2.5H).

A.4.5.5 Construction Materials

Sufficient quantities of suitable construction material for the embankments and the impervious core within the embankments should be available from within the impoundment area. See Geotechnical analysis of in-situ materials.

A.4.5.6 Construction Access

Access to the site would be from SR 80 along the existing access road to the Berry Groves Field Office. Other access roads would be added as required for both construction and operation and maintenance activities.

A.4.5.7 Perimeter Road and Ramps

A perimeter road would be constructed around the impoundment area and ramps to the top of the embankment would be provided at reasonable intervals.

A.4.5.8 Pump Station C43-PS-1

A.4.5.8.1 General Description (See Mechanical Section for detailed discussion)

Pump Station C43PS-1 will consist of a 1,500 cfs pump station 252 feet long by 84 feet wide with intake located on the Townsend Canal and an over-the embankment arrangement for discharge to the Reservoir. The facility will house four main pumps. Two pumps will be 500 cfs capacity each, and two will be 250 cfs capacity each. The pump station building will consist of an operating floor at elevation 25.0 feet NAVD for the placement of most pump station machinery and a two-story steel structure above elevation 25.0 feet NAVD housing the control room, break room and workshop. A 60-ton overhead bridge crane with a hook height approximately 25 feet above the operating floor will be provided to facilitate the maintenance of pump station equipment. The selection of a 60-ton capacity crane is based on the anticipated weight of one 500 cfs pump.

A.4.5.9 Pump Station C43PS-4

A.4.5.9.1 General Description (See Mechanical Section for detailed discussion)

The pump station shall be designed to pump water from the Townsend Canal into the Perimeter Canal at a maximum 195 cfs rated capacity. The purpose of the station is for water supply to the neighboring landowners and maintenance of stage in the Perimeter Canal for seepage control. The station site would be at the southwest corner of the Reservoir at the southern limit of the SFWMD's property. The station discharge would be conveyed a distance of 1,500 feet to 2,000 feet to the Perimeter Canal via a conveyance canal paralleling the toe of slope of the Reservoir embankment.

The Townsend Canal provides flood conveyance for the citrus operations south of the Reservoir and irrigation water during the dry season. The normal canal stage upstream of the existing pump station is maintained for the farm operations at 23.5 feet NAVD. The Townsend Canal stage varies with the Caloosahatchee River.

A.4.5.9.2 Design Stages

The following stages shall be assumed for the design of the C43PS-4 Pump Station:

- Normal Dry Season Stage: 0.0 feet NAVD
- Design Low Water Stage: -3.0 feet NAVD
- Design High Water Stage:+3.3 feet NAVD
- Design Upper Pool Stage: +23.5 feet NAVD

A.4.5.9.3 Discharge Head

The use of a weir in lieu of flap gates to prevent backflow establishes the pool to pool static head for the pumping system. The weir crest was set at 26.0 feet NAVD with a 1.38 feet calculated head over the 10 feet wide broad crested weir at the rated flow condition of 50 cfs. The current Reservoir concept design is for the toe of the Reservoir's embankment to be near the SFWMD's southwest property line requiring the station's discharge canal to parallel this proposed earthwork to the east. The head established at the discharge weir would provide more than adequate gradient for the gravity flow through this reach of canal to its discharge point.

A.4.5.10 Water Control Structures

A.4.5.10.1 Culverts

A.4.5.10.1.1 Introduction

Several canals within the proximity of the Reservoir are tributary to the Perimeter Canal or flow is diverted from the Perimeter Canal into one of these adjacent canals. These canals include the Roberts Canal, LPDD Header Canal, Banana Branch Canal and the Fort Simmons Branch Canal. Box culverts were evaluated and utilized to convey flow into and out of the Perimeter Canal from the tributary canals.

A.4.5.10.1.2 Design Criteria and Standards

Contributing canal structures were sized such that future flows for the Townsend Canal, Ft. Simmons Branch, Banana Branch, and the LPDD Header Canal do not exceed existing condition flows for the 25-year and 100-year storm events. The 25-year and 100-year storm events were applied to the calibrated Freshwater Caloosahatchee River ("without project") MIKESHE Model and flow data was extracted from the model results for each canal of interest.

Subsequent model runs were completed for the "with project" condition. Results of these simulations were compared to the "without project" flows in each canal

of interest and used to size structures and to determine the initial operational procedures for each structure.

All elevations referenced are based on the NAVD1988.

A.4.5.10.1.2.1 C43S-7

Structure C43S-7 is located at the intersection of the upstream end of the Banana Branch Canal and the Perimeter Canal. It consists of a double 10 foot wide (W) x 10 foot tall (H) box culvert with one (1) sluice gate and one (1) weir gate. Headwater elevation for Normal Water Level (NWL) is 19.50 feet and 20.5 feet for High Water Level (HWL). Tail water elevation for NWL is 15.1 feet and 18.5 feet for HWL. With an invert elevation of 10 feet, the HWL conditions are contained within the box culvert height. Flow parameters examined are as follows: base flow of 15 cfs, Q_{25} of 374 cfs and Q_{100} of 492 cfs.

The above operational criteria resulted in a variation of Froude numbers ranging from 2.3 to 4 resulting in a transition flow stage since a true hydraulic jump does not fully develop. Based on the above Froude numbers a Type IV stilling basin with baffle blocks and an end sill is proposed to help assist with energy dissipation. Rip-rap is proposed at the downstream end of the stilling basin along the channel bottom and side slopes as some of the wave action from the transition flow stage will not be fully controlled by the proposed stilling basin. Stilling basin exit velocities for the peak event are roughly 7.0 ft/s reducing to approximately 0.5ft/s 60 feet downstream.

A.4.5.10.1.2.2 C43S-9

Structure C43S-9 is a double 6 foot W x 6 foot H box culvert that conveys flow from the Perimeter Canal through to the Fort Simmons Branch Canal which discharges into the Caloosahatchee River. The operational intent of the S-9 structure is to mimic, as closely as possible, the natural flows of the Fort Simmons Branch under existing conditions. Inlet control used for the Fort Simmons Culvert is a 6 foot x 6 foot sluice gate and a 6 foot x 6 foot weir gate. Discharges examined were 1 cfs for base flow, 66 cfs for 25 year event and 68 cfs for 100 year event as obtained from the latest MIKESHE model runs provided by DHI. The weir gate has the ability to address all flows examined. The sluice gate is anticipated to pass larger design flows that are greater than the base flow. Analysis of C43S-9 resulted in a Froude number of 6.01. This indicates that a true hydraulic jump will occur resulting in a Type III stilling basin. A stilling basin with baffle blocks and end sill have been designed to assist in dissipating energy on the downstream end of C43S-9. Structure C43S-9 has the ability to convey the Q100 event either via the sluice gate or weir gate. This provides a built-in redundancy should one gate be removed from service.

Structure C43S-9 does have the ability to convey additional flow should that be decided in the future.

A.4.5.10.1.2.3 C43S-14

Structure C43S-14 is a 10 foot W x 6 foot H box culvert that connects the Header Canal to the Perimeter Canal. This structure will convey water from the Perimeter Canal, into the Header Canal up to 153 cfs. A remotely actuated sluice gate is utilized at this location to convey flood flow into the Perimeter Canal. Structure S-14 will not be used as a means for daily flow control either to or from the Perimeter Canal. If the Perimeter Canal is at capacity, no additional flow will be introduced into the Perimeter Canal from the LPDD Header Canal.

A head water surface elevation of 23 feet was used for operations to match existing conditions. The tail water elevation, for structure C43S-14, is the water surface elevation in the Perimeter Canal which is 19.5 feet for NWL and 20.5 feet for HWL. The design flows utilized for S-14 were 143 cfs for Q25 and 153 cfs for Q100. HWL flows from the Header Canal will be contained within the box culvert. The flow regime for discharge from C43S-14 is Submerged Controlled Flow as the tail water ranges from 2.5 to 3.5 feet above the gate sill which affects the upper pool by the submergence of the tail-water and the gate opening.

A.4.5.10.2 Perimeter Canal Structures

A.4.5.10.2.1 Introduction

The Perimeter Canal is a man-made canal that collects seepage from Cells 1 and 2 of the C-43 WBSR, re-routes and conveys flow from the Roberts Canal to the Banana Branch Canal, and conveys irrigation flows, cell discharge flows, and flood flows. The Perimeter Canal is vital in assisting with the regulation and stabilization of stormwater runoff, regulatory releases from Lake Okeechobee and improving the salinity balance for the Caloosahatchee estuary. The Perimeter Canal also provides flow releases to the downstream portions of the Roberts Canal (Banana Branch), Fort Simmons Branch and the Townsend Canal. The Perimeter Canal has three discharge structures that help facilitate with the flow control measures described above identified as C43S-3, C43S-10, and C43S-11.

Perimeter Canal structures were sized such that future flows for the Townsend Canal, Ft. Simmons Branch, and Banana Branch do not exceed existing condition flows for the 25-year and 100-year storm events. The 25-year and 100-year storm events were re-evaluated during the 60% design phase by DHI and similarly were applied to the calibrated Freshwater Caloosahatchee River ("without project") MIKESHE Model and flow data was extracted from the model results for each canal of interest. Subsequent model runs were completed for the *"with project"* condition. Results of these simulations were compared to the

"without project" flows in each canal of interest and used to size structures and to determine the initial operational procedures for each structure.
Development of the C-43 WBSR Perimeter Canal design consisted of creating a hydraulic model utilizing HEC-RAS River Analysis System modeling software. The Perimeter Canal model analyzed various steady state model runs that originate at Pump Station 4 (C43PS-4) and continue around the perimeter of the Reservoir to a future point of convergence with the Townsend Canal for a total distance of approximately 78,500 feet (14.8 miles). Flows were conveyed through the Perimeter Canal through the following three (3) Perimeter Canal structures: C43S-3, C43S-10 and C43S-11 with contributing flows from the Roberts Canal, via structure C43S-15 and with discharges from C43S-14. Diverging flows evaluated for the Perimeter Canal included those for the Banana Branch Canal and the Fort Simmons Canal. Model runs, for specific event scenarios described below, were conducted after numerous cross-sections were created detailing canal configuration, channel elevation and losses. Model runs evaluated various conveyances through the Perimeter Canal while maintaining flow within channel banks and ideally one (1) or more feet of freeboard. Evaluation of the aforementioned scenarios provided a foundation for structure analysis associated with the Perimeter Canal. HEC-RAS modeling results for the Perimeter Canal can be found in the *Hydrology and Hydraulics Data and Calculations* in the IDR Volume II.

Various operation scenarios, specific to each structure, were evaluated for sizing of the structures. This includes the following: 100-year return storm event, C43PS-4 pumping with base flow, C43PS-4 pumping with 25 year return storm event, drawdown with 25-year return storm event, and *PEAK* operations with 100-year return storm event.

Design Criteria Memorandum DCM-3 states that drawdown for the discharge facilities should be capable of reducing the normal pool level to 10 percent of the *Normal Full Storage (elevation) Level* (NFSL) within a given period of 4 months. An average discharge of 500 cfs, per cell, would be required to meet the Reservoir drawdown criteria.

Schematics for the Perimeter Canal are provided in ***Figure A-1.***

All elevations referenced are based on the NAVD 1988.

A.4.5.10.2.2 Design Criteria and Standards

Initial design considerations for the Perimeter Canal Structures consisted of utilizing large main sluice gates in conjunction with stop log bays. The main gates were evaluated for passing flow events greater than Q_{25} while the stop log bays addressed flow events less than Q_{25}. The intent of the stop log bay was to passively maintain a constant water surface elevation with minimal manpower.

This design was modified as a result of the Critical Criteria Meeting held in April 2006. The SFWMD indicated that they wanted to refrain from the use of stop log bays. Their experience with stop log bays has proven that they require continual oversight requiring manpower to place and remove stop logs. In an effort to limit the need for manpower and improve operation of the canal system, double leaf gates and weir gates were evaluated.

Double Leaf Gates were evaluated as an option for flow control however concerns regarding continual maintenance to remove trash and debris that collects on the riser stem discouraged their use. Devices preventing trash from becoming entangled around the riser stem could be designed and fabricated but there is a concern with reliability to withstand severe weather conditions. Therefore, the double leaf gates were not recommended for design.

Weir gates function similar to that of a stop log bay, yet provide the owner/operator the flexibility of adjusting crest elevation should discharge parameters change in the future. Weir gates have the ability to be both manually operated and remote controlled. Upon evaluation it was determined that weir gates would be an effective method of controlling flow similar to that of a stop log bay with less manpower. All weir gates will have a concrete sill that will be formed behind the lower gate opening with a gasketed seal to prevent any underflow/leakage. Only the weir portion will be used to control discharge. With automation the weir provides flexibility unlike the stop log bays.

Unlike the double leaf gate, the upper portion of the weir gate can be fabricated such that the riser stem is above the design water surface elevation. This design consideration eliminates the concern of trash becoming entangled on the riser stem and the need for an independent device to divert debris. If desired these gates are capable of controlling the discharge flows for events less than Q_{25} for all three structures. They can be used in combination with the main gates for events greater than Q_{25} and they may be a form of redundancy should a main gate(s) be removed from service.

A.4.5.10.2.2.1 C43S-3

Pump Station 4 (C43PS-4) can be found at the furthest upstream portion of the Perimeter Canal. Should there be a demand for irrigation by the Paul Grove, C43PS-4 will pump 195 cfs into the Perimeter Canal. This flow will ultimately be conveyed through the Perimeter Canal to C43S-3 at which time it will be released into the LPDD Canal and used for irrigation for the Paul Grove. Other than seepage and irrigation demand by the Paul Grove, no additional flow will be introduced into the Perimeter Canal upstream of C43PS-4 under design conditions.

The Perimeter Canal bottom elevation, upstream of C43S-3 is proposed at elevation five feet with 1V:2H side slopes. The design normal water elevation is 23.5 feet with a high water elevation at 25 feet. Normal water levels desired upstream and downstream of C43S-3 within the canal are 23 feet and 19 feet respectively, and were used in the various operating scenarios evaluated.

C43S-3 consists of a Single Barrel 10 foot x 10 foot Box Culvert. The barrel will have a 10 foot x 10 foot weir gate with allowance for a five foot high weir opening.

Events evaluated and included in the Operation Summaries include the following flows: base flow (seepage) of 10 cfs, Q25 of 28 cfs, Q100 of 44 cfs, QPumping of 195 cfs which includes the operation of C43PS-4.

The intention of the weir gate is to passively maintain a constant water surface elevation upstream of C43S-3. The weir gate is capable of passing the peak design flow of 233 cfs, which consists of flow pumped via C43PS-4 of 195 cfs and the 25-year storm event. This is also true should the weir gate be removed from service. Maintenance of the gate would require special consideration and must be performed during flow periods below or equal to the base flow conditions.

Given the design criteria above, structure C43S-3 has a well defined hydraulic jump. The installation of baffle blocks allow for the stilling basin length to be reduced. With the need to possibly dewater the structure for maintenance, it is recommended that additional clearance be provided downstream to allow for equipment and room to perform maintenance. Thus, an additional 10 foot length from the downstream invert of the double barrel box culvert would be provided prior to placing the baffle blocks. A second row of baffles is not required for maintaining the jump within the stilling basin, but is recommended to reduce the assault on downstream channel protection. The distance from the gate and the upstream face of the baffle blocks is fixed at 30 feet. The stilling basin from the upstream face of the first row of baffle blocks to the downstream face of the end sill is lengthened in an effort to force a jump in this location. An end sill was incorporated into the design to elevate the high velocity flow from the channel floor. This end sill, with the aid of the tail-water, helps stabilize the jump and prevent channel erosion downstream.

A.4.5.10.2.2.2 C43S-10

Structure C43S-10 consists of a reinforced concrete spillway with one (1) 14 foot W x 8 foot H vertical roller gate and two (2) 10 foot W x 8 foot H weir gates to control flow through the Perimeter Canal. Design flow received by the Perimeter Canal from the Roberts Canal would be conveyed and discharged into the Banana Branch Canal prior to C43S-10.

The Perimeter Canal, between C43S-3 and C43S-10 has a channel bottom elevation zero feet and a NWL of 19 feet and a HWL of 20 feet. Tail-water elevations during normal and high water conditions are 15 and 16.5 feet respectively. The bank elevation between these two structures decreases from 26 feet, just downstream of C43S-3, to approximately 21 feet just upstream of structure C43S-10. Fill will be placed as necessary so that during high water conditions, two (2) feet of freeboard will be maintained.

Structure C43S-10 consists of one 14 foot x 8 foot Vertical Roller Gate and two (2) 10 foot x 8 foot weir gates. Flows analyzed for the operation of C43S-10 consisted of the following event scenarios: 100-year event, PS-4 Pumping with Base Flow, PS-4 Pumping with 25-year event, Drawdown with 25-year event and a PEAK event combined with a 100-year event. Drawdown Operations consist of a discharge of 500 cfs from both C43S-8 and C43S-1 as required to meet drawdown criteria provided in DCM-3

The vertical roller gate alone, or in combination with the weir gates, is capable of handling the flows required to achieve drawdown, as required by DCM-3. The vertical roller gate alone can fully manage the required drawdown discharge with a gate opening of 2.6 feet during NWL conditions. In the event of high water conditions the gate opening would be approximately 3.6 feet since the gate is operating under *Submerged Controlled Flow* conditions. This type of flow regime is controlled by both the submergence effect of the tail water and the gate opening. An operational summary for C43S-10 has been provided summarizing these scenarios.

A conservative approach was utilized for C43S-10 in analyzing the computation results. The resulting Froude number for C43S-10 was 4.0 which is borderline for the use of baffle blocks. A double row of baffle blocks and an end sill were employed to help ensure the occurrence of a hydraulic jump within the stilling basin. These methods assist in the dissipation of energy and the potential for channel erosion downstream of the basin.

With a future need to dewater the structure for maintenance it is necessary to maintain additional clearance downstream to allow for equipment to conduct maintenance. A 22 foot, 1.25 inch distance was provided prior to placing the baffle blocks. A second row of baffles was provided to assist in reducing the assault on downstream channel protection. The stilling basin from the upstream face of the first row of baffle blocks to the downstream face of the end sill is lengthened in an effort to contain a jump in this location. The tail-water would also assist with energy dissipation by drowning-out the effects of the hydraulic jump. Baffle placement will be examined further in the 60 percent design phase.

Examination of channel velocities upstream of C43S-10 for NWL and HWL, were computed utilizing *'FlowMaster'* hydraulic computer program. NWL and HWL Velocities are 0.68 and 0.66 ft/s respectively. Channel velocities are much less than the *Suggested Maximum Permissible Mean Channel Velocities* of 2.0 ft/s for fine sand as recommended in EM 1110-2-1601. Velocities immediately at the downstream side of the C43S-10 structure are designed to be dissipated via baffle blocks and end sill.

A.4.5.10.2.2.3 C43S-11

C43S-11 is the largest of the Perimeter Canal structures which consists of a reinforced concrete spillway with two (2) 14 foot W x 8 foot H Vertical Roller Gates and two (2) 10 foot W x 8 foot H weir gates to control and convey flow through the Perimeter Canal. Should a vertical roller gate be removed from service, the weir gates can provide limited discharge capacity, thus maintenance of a gate would require special consideration and be performed preferably during flow periods below or equal to the base flow conditions.

Flow criteria utilized for design and analysis of C43S-11 consisted of five (5) separate scenarios as described above for C43S-10. Associated flows are as follows: 100-year event 478 cfs, C43PS-4 pumping with base flow 91 cfs, C43PS-4 pumping with 25-year event 142 cfs, drawdown with 25-year event 1213 cfs and PEAK event with 100-year scenario 1783 cfs. Drawdown requires a discharge of 500 cfs from C43S-8 and C43S-1 which is necessary to achieve reduction of the storage in the Reservoir to 10 percent of the NFSL within a period of 4 months. The PEAK event scenario has the greatest discharge capacity required for C43S-11 as it includes a operational discharge of 720 cfs and 780 cfs for C43S-8 and C43S-1. The flow control combinations can be modified or varied to accommodate changing conditions or operational parameters.

The two weir gates proposed, in addition to the vertical roller gates, are capable of discharging up to the PEAK event discharge flow of 1,783 cfs. Should a vertical roller gate be removed from service the weir gates with the remaining vertical roller gate can accommodate flows up to and including the Q_{100} event. Economically, the benefit of additional weir gates necessary to replace the vertical roller gates during drawdown discharge events may not justify the additional cost. The frequency of the drawdown events may be such that the additional weir gates are not used for several years and may fall into disrepair because of environmental factors. These additional gates may become a maintenance issue as it will be necessary to inspect and exercise them periodically. Additional gates, as a form of redundancy for drawdown discharge flows, are not recommended.

The weir gates are intended to be a passive control to maintain a water surface elevation of 15 feet upstream of C43S-11. Of course, this will vary depending on

current water elevations and necessary discharge requirements. C43S-11 is a *Free Controlled Flow regime* with a vertical gate ogee sill elevation of 8.3 feet and tail-water elevation of 4.5 feet. Therefore, the discharge is not affected by the tail-water but is based only on the gate opening.

Structure operational criteria evaluated resulted in a Froude number indicative of a transitional flow stage where a true hydraulic jump does not fully develop. The potential for wave propagation has been evaluated and a 48 foot stilling basin is proposed to help dissipate energy associated with the transitional flow stage. Baffle blocks have not been included as they will provide little assistance for suppressing wave action. Widening the downstream basin and providing a large end sill will dampen the oscillating flow. Computations provided result in a 3.0 foot end sill. It was necessary to verify that a secondary jump was not being created by the addition of the end sill. A secondary jump did not result.

Channel protection will be provided downstream of the end sill to help assist in reducing channel erosion from the hydraulic jump associated with discharges through C43S-11.

A.4.5.10.3 Main Outlet Structures

A.4.5.10.3.1 Introduction

Each cell of the Reservoir has a gated outlet structure to provide operational flows to meet the needs of the project at S-79 in the Caloosahatchee River (up to 500 cfs). The outlets also manage the Reservoir level as necessary. These outlets are located in the northwest corner of each cell and discharge to the Perimeter Canal.

A.4.5.10.3.2 Hydraulic Design Criteria

A.4.5.10.3.2.1 General

- Use Corps of Engineers Engineering Manuals as appropriate;
- Provide Reservoir draw down capability within 120 days (USACE ER1110-2-50);
- Maintain water quality (release water at selected levels within Reservoir, use Cell 2 whenever possible);
- Size gates to enable each cell to provide necessary downstream flows;

- Use identical gates and similar structural design for each cell to provide design, construction, and maintenance advantages; and
- Provide redundant gates in each cell (maintain normal operation even with one gate not functioning).

A.4.5.10.3.2.2 Inlet Structure

- Provide capability of drawing water from various levels within the Reservoir to maintain water quality;
- Minimize head losses;
- Minimize possibility of vortex formation; and
- Provide trash rakes.

A.4.5.10.3.2.3 Gates

- Designate one service gate for normal operation;
- Second gate for dewatering needs and firm capacity; and
- Provide emergency gate to allow maintenance of service gates.

A.4.5.10.3.2.4 Conduits

- Design for uniform flow– separate conduits for each gate; and
- Design to convey high velocity flow through the dam without hydraulic jump–channel sloped to maintain unpressurized (open-channel) flow.

A.4.5.10.3.2.5 Energy Dissipation

- Use hydraulic jump stilling basin (EM 1110-2-1603, Plate 7-11 or USBR standard).
- Provide transition channel with erosion protection to Perimeter Canal (5 fps > velocity > 1 fps).
- Discharge to Perimeter Canal with velocity <1 fps during 100-year event.

A.4.5.10.3.3 Description

Each outlet consists of an intake structure, gated conduits through the dam section, and stilling basins and channel leading to the perimeter canal. The design of each outlet is essentially identical with the exception of a 3-foot difference in the invert elevation. C43S-1 is set at 18 and C43S-8 is set at 21 NAVD88, approximately 1-foot above existing grades at each location.

The sizing of the main outlets considers both providing project flows to S-79 of up to 500 cfs, the flows required to manage Reservoir levels, and the flows required to draw the Reservoir down to minimum levels within 120 days (USACE ER1110-2-50). The Reservoir meets the requirements of USACE ER1110-2-50. The maximum outflow per cell is 500 cfs.

The intake structure is designed to provide the capability of drawing water from various levels within the Reservoir to maintain water quality. Elevation views show how water may be drawn from three levels within the Reservoir, the lower (for emptying the cell), the middle, and upper thirds. The design assumes that the gates at either the upper or middle levels will provide 500 cfs with flow velocities of 4 fps at the openings. The gates are to be fully opened or fully closed. Trash struts are provided at the entrances to the intake structure. The intake structure is sized and configured with converging walls toward conduits to minimize the possibility of vortices.

The intake structure discharges to two gated-conduits through the dam, one for normal operation (operational conduit) and the other for standby (secondary conduit). Flow exits the intake structure into an approximately 60-foot long, 10-foot wide by 6-foot high, conduit leading to a gatewell. The intake structure can be dewatered to allow for inspection of the structure and downstream conduit.

Each gatewell has two gates, one service gate for normal operation and one gate for emergency and maintenance purposes. The emergency gate will operate either fully closed or fully opened. The service gate can be set at various openings. A gate size of 5 feet W x 6 feet H allows for operation at typical release flows (up to 500 cfs) and conveys the necessary flows to manage the Reservoir level.

The service gate is a sluice gate with downstream seals. The emergency gate will have seals on the upstream side. Both gates will be operated by a screw hoist.

An air vent is located downstream of each gatewell to meet the air demand of the flowing water. The conduit downstream of the gatewell expands to 10 feet W x 7 feet H. The conduit width has been increased in order to reduce the stilling basin depth by decreasing the flow per unit width. A bottom slope of two percent is provided to maintain supercritical flow.

The flow exits from the conduit into an open channel chute leading to a stilling basin. The stilling basin is sized based on standard requirements. The maximum flow velocity exiting the stilling basin is about 5 fps at a discharge of 500 cfs at the normal Reservoir level. For maximum flow rates under the Reservoir levels of 42 and 46 NAVD88, the exit velocity is about 7 fps.

The transition channel between the stilling basin and the Perimeter Canal is sized to reduce flow velocities to less than 1 fps. The transition channel and a portion of the Perimeter Canal are lined to prevent erosion as the flow slows down and waves are reduced.

A.4.5.10.4 Cell Balancing Structure

A.4.5.10.4.1 Introduction

The Cell Balancing Structure, C43S-12, is located between Cells 1 and 2 of the Reservoir. The primary function of the structure is to convey water between the cells and allow the cells to operate independently if needed. If one of the cells needs to be dewatered for maintenance, C43S-12 may be closed to isolate the cells.

A.4.5.10.4.2 Hydraulic Design Criteria

- Provide multi-barreled conduit for redundancy;
- Size the conduit to convey half of the C43PS-1 pump capacity of 1500 cfs with approximately 1-foot of head across the center dam. This criterion was chosen so that the cells would operate at nearly the same level with the conduit open.
- Design conduit to operate in either direction;
- Gates will normally be fully opened or closed; and
- Use gate and conduit sizes similar to other project structures if possible to provide design, construction, and maintenance advantages.

A.4.5.10.4.3 Description

Three 6 foot x 10 foot barrels were selected for the design. The three-barreled conduit conveys 750 cfs between Cells 1 and 2 with approximate 1-foot of elevation difference (0.8 feet depending on the head loss coefficients selected). If one barrel of the structure is out of service the other two barrels will convey 750 cfs between the cells with approximately 1.8 feet of elevation difference.

The gate and conduit dimensions are the same as those designed for the main outlets (C43S-1 and C43S-8). The gates are 5-foot W x 6-foot H. Each barrel will have two gates to allow operation in either direction and provide redundancy.

Bell-mouth inlets to each barrel are designed to minimize intake losses. Trash rakes are provided to prevent large debris from entering the conduits.

Stilling basins are also provided at both ends of the barrels to dissipate energy. Each basin will be surrounded by riprap or revetment to prevent erosion. The critical period during the filling process is when one cell is empty, the other full, and energy to be dissipated is at its maximum. The most cost effective way to provide energy dissipation is to open the gates slowly until a nominal level is achieved in the cell (approximately 3-foot depth). At this level flow velocities at the sill of the stilling basin will be reduced to non-erosive rates.

The ends of the structure match the existing ground elevations in Cells 1 and 2, 21 and 22 NAVD 88, respectively. The resulting slight slope across the structure does not have a significant effect on the hydraulics. Predicted settlement of the dam does not significantly affect the hydraulics.

A.4.5.10.5 Crest Spillway Structures

A.4.5.10.5.1 Introduction

Each cell of the Reservoir has an uncontrolled crest spillway structure to manage flood flows. C43CS-1 is located on the west side of Cell 1 and discharges to the Townsend Canal. C43CS-2 is located just east of S-8 in the northwest corner of Cell 2 and discharges to the Perimeter Canal. The design objective of the crest spillway structures is to minimize the surcharge storage of the Reservoir without exceeding the Allowable Discharge in the receiving channel.

A.4.5.10.5.2 Hydraulic Design Criteria

- Use Corps of Engineer Engineering Manuals as appropriate;
- Design Criteria Memorandum (DCM) 2 and 3;
- Size spillways to convey Allowable Discharge (100-year, 72-hour storm and Inflow Design Flood [IDF] storm events) without exceeding pre-project flow downstream (DCM-2, DCM-3 and Federal Emergency Management Agency (FEMA) floodplain management requirements);
- Set crest elevation at normal Reservoir level (El. 42.0 feet);
- Allow for wind setup and wave run-up;
- Use hydraulic jump stilling basin, transition to Perimeter Canal similar to main outlets; and
- Use identical configuration for each cell to provide design, construction, and maintenance advantages.

A.4.5.10.5.3 Description

The spillway consists of a weir structure discharging to a conduit through the dam. Once through the dam the flow is conveyed to a stilling basin in an open channel chute, and then on to a transition channel to the Perimeter Canal. The crest portions of the spillways are identical. The downstream ends differ due to elevations of the receiving channels. C43CS-1 discharges to the Townsend Canal with a normal water elevation of 21 feet. C43CS-2 discharges to the north Perimeter Canal with a normal water elevation of 19 feet. For additional analysis please reference the technical memo titled "Technical Memorandum for Spillway Design."

A.4.5.10.5.4 Alternative Spillway Designs

Several configurations of spillways were investigated before the above design was selected. Three specific cases were prepared and modeled in detail as defined below (***Table A-12***). The service spillway is considered the spillway to pass flood events up to the 100-year event (Allowable Discharge). The auxiliary spillway passes floods in excess of the 100-year.

TABLE A-12: SPILLWAY INFORMATION

Case	Service Spillway	Auxiliary Spillway
I	Sized to pass 100-year	Large to pass IDF
II	Sized to pass antecedent PMP storm	Smaller than Case I
II	Minimized	Gated structure at sill 30 NAVD 88 (assuming backup power on site)

A.4.5.10.5.5 Summary of Findings

The findings of the modeling results of the above spillway configurations may be summarized as follows:

- The low-flow design of the spillways is controlled by the Allowable Discharge. The Allowable Discharge from the Reservoir for the 100-year, 72-hour storm is estimated to be 400 cfs (Cells 1 and 2 combined) based on the hydrologic modeling completed for the project;
- The critical storm for high flow spillway design is the 30 percent Probable Maximum Precipitation (PMP) event. The PMP storm events for the project include three, 3-day rainfalls events separated by several days with no rainfall (DCM-2, guidelines and criteria). The difference between the 30 percent PMP storm and the 40 percent PMP storm is the overall volume (~88 inches and ~99 inches) and the separation between the first two rains (3 days for the 30 percent and 5 days for the 40 percent). There is less time to draw down the Reservoir after the first rainfall during the 30 percent PMP, making it the critical design storm for high flows. The maximum discharge from the project for either PMP event is estimated to be 2600 cfs (Cells 1 and 2 combined) based on the hydrologic modeling completed for the project;
- Due to the large inflow from high intensity rainfall, it is not cost effective to use a large auxiliary spillway. The service and auxiliary spillways should be combined;
- Use small crest length. Large crest length does not cost effectively reduce surcharge storage or freeboard due to large inflow (high intensity rainfall); and

- Computations show that the Reservoir surcharge storage between 42 and 46 NAVD 88 is adequate for design.

Additional configurations using one spillway (combined service and auxiliary) were investigated to achieve the design objective. The simplest configuration being a number of conduits set at the normal pool level of 42 NAVD 88. It was found that ten 10 foot W x 4 foot H culverts would be needed to keep the maximum Cell 1 level at 46 without discharge from the main gated outlet of the cell. The peak discharge of approximately 3,500 cfs, however, exceeds the allowable of 2,000 cfs (one cell). Culverts and weirs were not found to be effective in minimizing surcharge storage due to the limited head range and allowable discharge. Weirs can pass significant flows at low heads, but exceed the Allowable Discharge.

Operation of gates during non-rain periods of the 30 percent PMP is more effective in minimizing the surcharge storage. C43S-1 and C43S-8 each have two gates. Each gate has a discharge capacity in excess of 600 cfs for reservoir levels above 42 feet NAVD (total capacity in excess of 2400 cfs). Opening these gates to discharge 2,000 cfs during the non-rain 3-day period after the first rainfall of the 30 percent PMP draws the Reservoir down to 42 before the main rainfall begins without considering spillway flow. Gate operation alone, however, cannot be relied on during extreme events.

C43CS-1 and C43CS-2 are designed to convey the Allowable Discharge as defined above. It is proposed that the main outlet gates (C43S-1 and C43S-8) be used to minimize surcharge storage. A gate operation policy is needed to manage overall project discharges and in order to keep releases less than pre-project levels. The documentation of pre-project discharges from the site for the 100-year and PMP events is important.

A.4.5.10.5.5.1 Options for a Combined Spillway

Two options for a combined spillway were investigated in further detail, the weir and conduit option and the multi-barrel conduit option.

A.4.5.10.5.5.2 Recommended Option

The recommended combined spillway option for C43CS-1 and C43CS-2 is the weir and conduit option. It is approximately half the cost of the multi-barrel conduit option and more efficiently conveys water through the dam and on to the Perimeter Canal. The weir controls flows up to the 100-year event and the conduit controls higher flows when the weir drowns out. The weir is effective in passing the maximum allowable flow during the 100-year event with limited fluctuation of the Reservoir level. The conduit works well in limiting high flows during the PMP storm event, keeping the flow less than pre-project conditions.

When used in conjunction with C43S-1 and C43S-8 (open during non-rain periods) the Reservoir surcharge storage is minimized.

The design of the downstream portion of the spillway as the flow exits from the conduit through the dam is very similar to the main outlet. An open channel chute leads to a stilling basin and transition channel then on to the Perimeter Canal. The stilling basins for C43CS-1 and C43CS-2 are sized differently due to the different tail-water levels in their respective locations.

A.5 EMBANKMENTS AND CANALS

A.5.1 General

This appendix presents a discussion of preliminary project design considerations and construction methods utilized to address the overall project requirements and to support development of the project cost estimate. Much of this discussion refers to the 30 percent project design prepared by Stanley Consultants, inc. for the SFWMD under the ACCELER8 Program.

A.5.2 Proposed Plan

The SAP (Alternative 3B) would require the construction of a two-cell 170,000 acre-foot above ground storage reservoir, a 1,500 cfs pumping station, and a selection of water control structures. The reservoir project site would consist of approximately 10,500 acres, not including lands required for temporary staging areas. See Plate A-1.

The project is bounded by property lines along the east, south and west sides and by the Southern Florida Power easement line along the north side. The existing Townsend Canal, located along the west perimeter of the Reservoir, would serve as the west Perimeter Canal. The existing spoil piles along the east side of the Townsend Canal would be removed as part of the project. Drainage improvements are proposed outside of the project boundary and would include new or replacement culverts in the header canal east of the project. Improvements to or the relocation of the existing weir structure located at the mouth of the Townsend canal are included. Work to that structure would be done within an existing drainage easement.

The Perimeter Canal would serve as a seepage canal and as a means of conveying both surface storm water runoff and off site flows entering the project. The Perimeter Canal design includes littoral shelves along the exterior slope that are intended to promote wetland vegetation, fisheries and recreation activities.

Refer to the Hydrology and Hydraulics Appendix of this report for a detailed discussion of the projects features and related hydraulic requirements.

A.5.3 Civil Site Work

A.5.3.1 Site Preparation

The entire reservoir project site including the proposed embankment alignments and/or canal excavations would be cleared and grubbed to a depth of approximately 8 inches or to a depth sufficient to remove roots and other organic material.

A.5.3.2 Site Access/Entrance Road

Access to the project area would be provided by the existing paved entrance road from SR 80. This access road would be maintained during construction but a new entrance road would be constructed after completion of the project to provide permanent access to the project area. Plan and profile drawings of the proposed alignment are shown on Plates A-5 through A-7. A typical section of the entrance road is provided on Plate A-8.

A.5.3.3 Townsend Canal Channel Improvements

The hydraulic design of the West Basin Storage Reservoir project has shown that for the maximum pumping and discharge flows the channel at the SR 80 Bridges will need to be improved. Plate A-9 shows the proposed channel improvements. These include widening the channel bottom elevation, as well as the addition of scour protection across the entire channel width to prevent scour that would be caused by the high frequency of these flows.

PILE BENT ANALYSIS

The bridge pile bents were analyzed to determine if they have sufficient capacity and stability with the lower channel bottom elevation. The piles were analyzed for lateral loadings at both Strength and Service limit states to determine their performance.

The analysis shows that lateral deflection at the Service limit state will control. The actual loads in the piles at Strength limit state are low, and are not close to the pile capacities.

The allowable lateral deflection was taken to be 1.5 inches from AASHTO Standard Specifications for Highway Bridges, 17th addition, Section 4.5.12. The computed lateral deflections are as follows:

- As-Designed Case, assuming 100-Year Scour-Lateral Deflection=0.55 inches.
- Proposed Case – Lateral Deflection = 1.32 inches.

CONCLUSIONS

The following are the conclusions that we draw from the design and analysis performed thus far for the Caloosahatchee River (C-43) West Basin Storage Reservoir project:

- The bridges carrying SR 80 over Townsend Canal do not have sufficient hydraulic capacity for the existing condition flows in the canal. The canal will need to be widened if the normal criteria are to be met.
- Proposed pumping requirements of the Caloosahatchee River (C-43) West Basin Storage Reservoir project would require minor improvements to the existing Townsend Canal channel.
- The impacts to the existing bridges of the proposed channel improvements are within acceptable limits.
- All canal improvements can be accommodated within existing right-of-way.

A.5.3.4 Disposal/Borrow

Disposal and material stockpile areas would be located within the project area.

A.5.4 Embankments

As generally reported in the C-43 WSR Preliminary Design Report, the perimeter embankment would have an external geometry that includes a 12-foot wide crest (14 foot Crest Width including the soil cement protection) and 3H:1V side slopes. Crest elevations have been established at +57 feet NAVD for Cell 1 and Cell 2, respectively. The embankment would be constructed largely of random fill, but would also include a low permeability soil-bentonite (SB) wall, an internal drain, and upstream slope protection. The SB wall would extend from an elevation 5 feet above the normal pool elevation to 5 feet below the top of a clay layer which underlies the project site at depths generally in the range of 10 feet to 25 feet below existing surface grades.

A few structures pass through the perimeter embankment. At these locations, the above ground portion of the SB wall would be replaced with select fill. In addition, a roughly 100-foot wide bench with a 24-foot access road would be constructed above the existing ground surface immediately downstream of the perimeter embankment. A Perimeter Canal would be located on the outside of the bench.

The Interior Dam between Cells 1 and 2 would be a homogenous embankment with a crest elevation of +51.4 feet NAVD. It would not include any SB wall or internal drain. The side slopes of the separator dam would be covered on both

sides with soil-cement. Typical Sections of the proposed embankments are provided on Plates C-2 through C-4.

The components of the embankments are described in more detail in the following paragraphs as they were presented in the "C-43 WBSR Preliminary Design Report" prepared by Stanley Consultants.

A.5.4.1 Random Fill

Random fill is to consist of reasonably well graded sands (ASTM D 2487) having a maximum size of 4 inches, placed in 12 inch thick (loose measure) horizontal lifts. Each lift is to be compacted to not less than 95 percent of the maximum dry density determined in accordance with Standard Proctor (ASTM D 698). The random fill materials are to be obtained from relatively shallow excavations on the interior side of the Reservoir. No borrow features are to be made within 200 feet of the upstream toe of the perimeter embankment. In areas where no structures exist, the perimeter embankment is to be filled to elevation +47 feet NAVD, at which time the SB wall will be constructed. Following the soil-bentonite (SB) wall construction, the remaining portions of the random fill will be placed and compacted.

A.5.4.2 Select Fill

Select fill is to be placed around structures that pass through the perimeter embankment. It is to consist of a sand-clay mixture with a maximum size of 2 inches and not less than 25 percent passing the US Standard No. 200 Sieve. Select fill shall have a Liquid Limit not less than 25, a Plasticity Index not less than 10, and a placement moisture content that is within 3 percent of the optimum moisture content for compaction. Select fill will likely be obtained by excavation from borrow areas and/or from the required seepage collection canal excavation. The excavated materials are to be mixed until the select fill material achieves a reasonably uniform moisture content and gradation. It is to be placed in 8 inch thick horizontal lifts and each lift is to be compacted to at least 95 percent of the maximum dry density determined in accordance with ASTM D 698.

Special care is required to assure that the select fill placed adjacent to the structures is compacted to high density. The select fill is to be placed within a horizontal distance of 100 feet on both sides of the structure walls. The above-ground portion of the SB wall will overlap at least 50 feet into the previously placed select fill materials.

A.5.4.3 Soil–Bentonite Wall

A soil-bentonite (SB) wall is to be constructed in order to provide a seepage barrier through the perimeter embankment. The bottom of the SB wall should extend to a depth that is at least 5 feet into the underlying clay layer. The SB wall is to be located approximately 10 feet upstream of the centerline of the perimeter embankment, and is to be 3 feet wide. Excavations for the soil-bentonite wall should be stabilized using bentonite slurry having a minimum density of 64 pounds per cubic foot.

Backfill for the slurry filled trench should consist of a mixture of bentonite slurry, soil and dry bentonite. The backfill should be thoroughly mixed into a homogeneous mass prior to placement. The backfill should meet the following criteria:

- Slump ranging from 4 to 6 inches
- Amount passing the U.S. Standard No. 200 Sieve ranging from 30 to 40 percent
- Density ranging from 85 to 110 pcf
- Permeability of not more than 1 x 10-7 cm/sec when measured in laboratory tests

The subsurface profiles indicate the presence of moderately well cemented limestone within the vertical interval of the SB wall. Equipment selected for excavation of the bentonite wall must be capable of excavation of such materials from an elevation that is 25 to 30 feet above the existing ground surface. A heavy hydraulic backhoe having a minimum breakout force of 44,000 pounds will be capable of excavating the rock formation. Blasting will not be permitted.

A.5.4.4 Drainage Blanket

The drainage blanket should consist of filter sand meeting the physical requirements of C-33 Concrete Sand. It is to be placed on the prepared foundation surface in the approximate downstream one-third of the perimeter embankment footprint. The perimeter embankment design includes a chimney drain that is composed of on-site clean sand and which is connected to the drainage blanket. Such on-site sands can be obtained from shallow excavations provided the materials contain not more than 3 percent passing the US Standard No. 200 Sieve. The C-33 Sand will need to be imported from an offsite source. The drainage blanket should also include a continuous perforated pipe (toe drain) located near the downstream toe of the embankment. The seepage flows to the toe drain will be routed to manholes with eventual outfall to the Perimeter Canal.

A.5.4.5 Soil Cement

The crest width and upstream portion of the perimeter embankment is to be covered with soil cement. This will consist of both flat plate (below the normal pool elevation) and stair-step (above the normal pool). Flat plate portions of the soil cement are to be 16 inches thick. The stair-steps will be 12 inches high and have a 3-foot wide tread. The design cement content is 11 percent by weight and the required minimum density of the soil cement mixture is 95 percent of the maximum density determined in accordance with ASTM D 558. The soil cement is to have a minimum unconfined compressive strength of 700 psi at 7 days.

Flat plate soil cement will cover the crest and slopes of the interior dam between Cells 1 and 2.

A.5.4.6 Bench

Filling of the bench area should consist of random fill placement, similar to that described earlier in this section, but may include materials up to a maximum size of 12 inches. Lift thickness for the bench material placement should be not more than 2 feet. The bench fill should be compacted to at least 90 percent of maximum density (ASTM D 698).

A.5.4.7 Seeding and Sodding

Seeding and sodding would be provided throughout the project area as required to adequately protect side slopes and other unstabilized areas from erosion. Other bank protection methods are currently being evaluated as a more economical alternative to sodding.

A.5.5 Relocations

The project sponsor would be required to assume the costs for all relocations and alterations. The alternative plan presented in this report would require relocation of utilities to provide electrical and water service to the proposed pump stations. The estimated costs for this relocation are included in the project cost estimate. Refer to the Electrical Section of this appendix for individual site requirements.

A.5.6 Operations and Maintenance

A.5.6.1 General

The project sponsor would be responsible for operation and maintenance of the improvements and features proposed in this report upon completion of the construction project. The Contractor would be responsible for all maintenance during the construction contract.

A.5.6.2 Inspection

Joint field inspections with personnel from the U.S. Army Corps of Engineers and the local sponsor would be conducted on a regular basis to evaluate the performance and condition of the various project features. Additional field inspections would be conducted following a significant storm event.

A.5.6.3 Estimated Annual Costs

The estimated annual operation and maintenance cost for the project would be approximately $3,100,000. This is based on projected estimate of costs for operation and general maintenance of the pump stations including periodic replacement of operating equipment. This cost also includes maintenance of the embankments, entrance road, perimeter ditches and other project features.

A.5.6.4 O&M Manual

Operation and maintenance of the project facilities would be performed in accordance with instructions prepared and incorporated in the "Operation and Maintenance Manual" which would be furnished to the project sponsor. The O&M Manual would be prepared in accordance with ER 1110-2-401.

A.5.7 Quantities and Cost Estimates

A 30 percent Preliminary Design Level Cost Estimate was developed for the project by Stanley Consultants for the South Florida Water Management District's Acceler8 program. This cost estimate was reviewed by Jacksonville District and used as the basis for the direct costs in the preparation of the plan formulation cost estimates and of the MCACES cost estimate used in the Draft PIR. For this reason the MCACES cost estimate for the Draft PIR show User Created Cost items in lieu of the traditional Labor, Materials and Equipment breakdown. The Labor, Materials and Equipment breakdown is found in Stanley Consultants cost estimate. The 30 percent cost estimate was prepared by Stanley Consultants using MCACES Gold 5.31 software. It is dated 31 May 2006. R.S. Means' 2006 database adjusted by the Engineering News Record index was used as the basis for Stanley Consultants' crew based estimate. Vendors and equipment manufacturers were contacted by Stanley Consultants to confirm costs for specific items. Certain mechanical equipment was estimated using the Richardson (2004) guides as the database. Labor rates used in the 30 percent design cost estimate are the Davis Bacon Union Shop Labor Rates for Fort Myers, Florida

First, the cost estimates in the Draft PIR were prepared by transcribing the direct costs from the Acceler8 contractor's estimate to the MII software. Markups and contractor/subcontractor structure consistent with Jacksonville

District practices/conventions/history were added. A printout was made of the total project costs including unit pricing. Then, the unit pricing was used to prepare the plan formulation cost estimates. Finally, the Total Project Cost Summary for the selected plan in the Final PIR was prepared using the estimate from the Draft PIR as its basis. See Appendix B for presentation of project costs.

A.6 MECHANICAL AND ELECTRICAL DESIGN

A.6.1 Mechanical Design

A.6.1.1 Pump Station General Information and Size Criteria

The two pump stations for the Caloosahatchee River (C-43) West Basin Storage Reservoir project are significantly different in size and complexity. For the purposes of this report, the stations shall be differentiated as small-sized and large-sized. The small-sized pump station (PS-4) has a total pumping capacity of less than 250 cfs and includes no pumps that have a capacity of more than 75 cfs each. The large-sized pump station (PS-1) is defined as having at least one pump with a capacity greater than 450 cfs. The large horsepower requirements for the engines also indicate that this is a large pump station. The two pump stations shall be designed in accordance with Hydraulic Institute Standards, EM 1110-2-3102 (General Principles of Pumping Station Design and Layout), and EM 1110-2-3105 (Mechanical and Electrical Design of Pumping Stations). The small pump station will also follow the guidance of ETL 1110-2-313 (Hydraulic Design Guidance for Rectangular Sumps of Small Pumping Stations with Vertical Pumps and Ponded Approaches). The use of formed suction intakes and siphon discharges for the pumps at PS-1 shall be evaluated during preparation of the plans and specifications for the pumping station, and shall be based upon the channel intake design, the required pumping heads, and life cycle cost analysis.

Vertical, mixed flow pumps will be used for PS-1. Either vertical, mixed flow pumps in separate rectangular pump bays or can (also known as barrel) pumps with the vertical pumps mounted in an enclosed container will be used for PS-4. All of the pumps for both stations will be water-lubricated. The smaller pump station will be designed with conventional-discharge pumps. The larger pump station will be designed with the pumps configured with a siphon-type discharge. Pump station information is located on ***Table A-13,*** C-43 Pump Station Information. Plates M-1 and M-2 show plan and section views of a typical large-sized pump station that includes an FSI and a siphon discharge. (Note: In accordance with Florida Statute 119.07(6)(ee), only limited [conceptual drawings have been provided for this report. See Section A. 7 *Caloosahatchee River (C-43) West Basin Storage Reservoir Structures* below for more information.

TABLE A-13: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PUMP STATION INFORMATION

Pump Station	Total Flow Capacity (Cfs)	No. Of Pumps	Type Of Pumps	Flow Rate (Cfs)	Intake, Ngvd Min. Drawdown Pumping Level	Discharge, Ngvd Max. Discharge Pumping Level	Total Head	Pump Selection (In.)	Min. Efficiency %	Drive H.P.	Discharge Type	Station Size
PS-1	1500	2	Diesel	500	-3.0	42.0	48.1	84	80	3600	Siphon	Large
		2	Diesel	250	-3.0	42.0	47.7	60	80	1800		
PS-4	195	3	Electric	65	-3.0	27.4	36.9	36	80	375	Conventional	Small

A.6.1.2 Pump Station PS-1

The PS-1 pump station will be configured similar to that shown on Plates M-1 and M-2. This large-sized pump station will have the following features:

A.6.1.2.1 Pumps: Pumping Capacity, Pump Sizes, and General Information

The large-sized pumping station will have four pumping systems. The pumps in each of the stations will be mixed-flow-type vertical-shaft pumps. Power to the pumps will be provided by diesel engines through right angle reduction gear drives. ***Table A-13*** lists the number of pumps, the capacities of the pumps, the drives, etc., for this (and the smaller) pump station.

Plates M-1 and M-2 represent a four-bay pumping station, similar to the four-bay PS-1. The pumps at this pump station are expected to run at less than 400 rpm with a minimum efficiency of 80%. Because of the large pumping heads, the diesel engine pump drives will be very large. The diesel engine pump drives for the 500-cfs pumps should be about 3600 horsepower each, while the engines for the 250-cfs pumps should be about 1800 horsepower each.

The large-sized pumping station will include various support items including the following:

1. Diesel fuel system, including vaulted double-wall aboveground fuel storage tanks ASTs capable of holding enough fuel to operate all of the engine driven pumps and the emergency generator continuously for 7 days. About 95,000 gallons of storage capacity will need to be available at the site. This will comprise between five and eight ASTs, depending on the type of tank that is specified. Day tanks shall be provided and sized to supply adequately the diesel engine pump drives and generator within the limitations of NFPA 37. The Florida Administrative Code (FAC) shall be followed in designing the fuel system for the pumping station.

2. An overhead bridge- type electric crane/hoist will be used. The crane/hoist shall be capable of lifting and moving loads up to the heaviest loads in the pumping station. The crane/hoist will handle pumping station equipment such as the diesel engine pump drives, reduction gears, and the pumps during initial installation as well as for general service thereafter.

3. Toilet facility with a water closet, lavatory, and a shower. An electric-powered domestic water heater will also be provided. All plumbing systems will be designed in accordance with the International Plumbing Code.

4. Kitchen-type sink.

5. Potable water system and a septic system for the plumbing fixtures. The water source will likely be an on-site well. The system will consist of a well pump, water softener, reverse osmosis treatment system, storage tank, distribution pump, pressure tank, and ultraviolet disinfection system. The water well will be designed in accordance with EPA 570/9-75/001, the Manual of Water Well Construction Practices, and the septic system shall be in accordance with Florida Department of Health (FDOH) FAC Chapter 64E-6 (2006) Standards of Onsite Sewage Treatment and Disposal Systems.

6. Ventilation system to provide fresh air in the pump bays, generator area, and toilet room. The ventilation systems will achieve an operating floor design temperature inside the station of 100°F based upon an outdoor temperature of 93°F dry bulb (1% for Ft. Myers). The ventilation air will need to dissipate the heat from the pumping equipment, lights, generator, etc. located in the pump station, along with providing air for combustion for the diesel engines and generator.

7. Air-conditioning system for the office. The office will be mechanically cooled to a design temperature of 75 degrees F. The room will be served by a dedicated, DX split system. ASHRAE Guide and Data Books will be used in the design of the office air-conditioning system

8. Stilling wells containing float switches to be used for pump operations and water level monitoring.

9. Controls systems for the engine/motor pump drives. These systems shall be as described in the Electrical Design section.

10. During the detailed design, the designer shall coordinate with local and State authorities to ensure that the various permits (air, fuel, etc.) are all adequately addressed.

The pumps for this pump station may be designed with Formed Suction Intakes (FSI) and may include siphon discharges. A representative section of a pump station with an FSI and a siphon discharge is shown on Plate M-2. FSIs have been shown to be more efficient than typical suction bell intakes, but the design decision on whether to use them will be based on comparing increased construction costs with potential efficiency savings over the life of the project.

In order to reduce the engine size, horsepower, and fuel required to overcome the head on the pumps, siphoning discharge systems may be used. If a siphon discharge system is used, priming would be accomplished by means of a station vacuum system. The vacuum system provides vacuum to prime the siphon in the discharge pipes. Four vacuum pumps are provided: two duty, and two standby. Under normal operation, two vacuum pumps are required to establish the siphon for one discharge pipe. The siphons must be established one at a time. The system includes vacuum pumps, a barometric separator, valves, and piping. Again, the design decision on whether to use siphon discharges for the pumps in the pumping stations will be based on comparing potential savings on the cost of the diesel engine pump drives and the lower fuel requirements with the increased construction costs over the life-cycle of the pumping station. Note that if the siphon discharge is used, each pump discharge tube will be provided with twin vertical-lift type backflow gates, as shown on Plate M-2, with relief flaps located at the siphon terminus. The gates are needed to prevent the possibility of reverse siphoning and backflow due to incomplete breaking of the prime during pump shut down. Each gate will be raised and lowered by a single screw stem with a Limitorque type electric motor operator controlled from within the station.

For discharge pipes that will be below high water levels, a second means of preventing backflow will also be incorporated. The discharge pipes will have their upper invert elevation (summit) above the high water level on the discharge side. The siphon would then self-break. During design development the discharge arrangement will be selected based on a life cycle cost analysis of the operational and construction costs.

A custom engineered trash rake will be provided for the removal of trash accumulated on the trash rack and its conveyance to a disposal area. There are a wide variety of systems available, unique in their design and operation. For this size facility, either a front cleaning scraper bar type trash rake will be used, or a monorail traveling gripper rake will be used. The rakes will collect and remove coarse solids from the trash rack. The rake shall be a single piece of

equipment capable of automatic or manual raking of each bar screen and transporting debris to a designated dump site. The equipment may be supplied independently or in combination with the rack. The unit shall be capable of operating effectively in high wind. The rake equipment shall be designed to withstand sustained wind speeds up to 155 mph without structural damage.

A.6.1.3 Pump Station PS-4

Pump Station PS-4 will have three pumping systems. The pumps will be mixed-flow-type vertical-shaft pumps that will be located in separate rectangular pump bays or can (also known as barrel) pumps with the vertical pumps mounted in an enclosed container. Power to the pumps will be provided by direct-drive electric motors. ***Table A-13*** lists the number of pumps, the capacities of the pumps, the drives, etc., for PS-4.

This small-sized pump station will include pumps that are expected to run at no less than 600 rpm with an efficiency of about 80%. The pump drives should be about 375 horsepower each.

This small-sized pump station will include various support items including the following:

1. Hoisting system for maintenance or repair of the pumping equipment. At a minimum, the hoisting system will be designed to lift the heaviest piece of equipment in the pump station.

2. Ventilation system to provide fresh air in the pump bays and generator area. The ventilation systems will achieve an operating floor design temperature inside the station of 100°F based upon an outdoor temperature of 93°F dry bulb (1% for Ft. Myers). The ventilation air will need to dissipate the heat from the pumping equipment, lights, generator, etc. located in the pump station, along with providing air for combustion for the generator.

3. Stilling wells containing float switches to be used for pump operations and water level monitoring.

4. Trash rake/rack system will be an automatic, continuously rolling, flex rake and trash rack system such as that manufactured by Duperon.

5. An LP-gas emergency generator to supply power for backup emergency power for the general building service only during commercial power outages. This will include providing power for the lights and ventilation fans. Since the pumps in PS-4 are for water supply, the reliability requirements for flood control pump stations do not apply. Therefore, the

pumps will not need to be operated when commercial power is unavailable.

6. The LP-gas shall be stored in an underground storage tank 20 feet from the exterior wall of the building.

7. Controls systems for the motor pump drives. These systems shall be as described in the Electrical Design section.

8. During the detailed design, the designer shall coordinate with local and state authorities to ensure that the various permits (air, fuel, etc.) are all adequately addressed.

A.6.1.4 Gates

A.6.1.4.1 Sluice Gates

Sluice gates are cast iron gates, used in critical locations at structures S-1, S-8, and S-12. The gates are operated by a rising stem with electric motor actuators. The thrust required to open and close the gates are borne by the actuator and operating deck. The gate stems are laterally supported by guides along the length of the stem. The gates are flange mounted to the concrete structures.

A.6.1.4.2 Roller Gates

Roller gates are fabricated stainless steel gates located at structures S-10 and S-11. The gates are bottom opening and typical of the kind in use at many SFWMD gate structures. Rollers (wheels) are used to reduce the thrust required to open the gates. The rollers are run along a rail recessed in the concrete walls of the structure. The gates are raised and lowered with a cable and hoist system. Plate M-3 shows a representative spillway vertical lift gate arrangement.

A.6.1.4.3 Slide Gates

Slide gates are fabricated stainless steel gates located at structures S-1, S-3, S-7, S-8, S-9, S-14, and S-15. The gates are bottom opening with a rising stem and are operated with electric motor actuators. The thrust required to open and close the gates are borne by the actuator and operating deck. Long stems are laterally supported by guides attached to the concrete wall along the length of the stem. The gates are flange mounted to the concrete structures.

A.6.1.4.4 Weir Gates

Weir gates are fabricated stainless steel gates located at structures S-3, S-7, S-9, S-10, S-11, and S-15. The gates are downward opening and are operated by a rising stem with electric motor actuators. The thrust required to open and close the gates are borne by the actuator and operating deck. The gates are flange mounted to the concrete structures. Water flows over the top of the gate through an open panel. The open panel provides open flow area without placing the stem in the stream of water.

A.6.2 Electrical Design

A.6.2.1 Pumping Stations

A.6.2.1.1 General

A.6.2.1.1.1 Design Standards

Pump Stations and other structures shall be in accordance with NEC, NFPA, IESNA, TIA/IEA, IEEE, SFWMD standards, and recommended practice.

A.6.2.1.1.2 Power Service

A 480 Volt, three phase, electrical service shall be provided by the local utility company. 480 Volt, three phase engine-generator units shall be provided to supply necessary electrical power for pumping station operations. Transient Voltage Surge Suppression (TVSS) shall be provided at the service entrance.

A.6.2.1.1.3 Grounding

Pump station main grounding will include a grounding grid consisting of ground rods and #4/0 ground wire which will be bonded to the embedded metallic masses, sheet pile, and structural steel. Frames or enclosures of electrical equipment will be bonded to the grounding system. Ground conductor will be bare, soft annealed copper cables and ground rods would be of copper clad type, 3/4 inch in diameter by 8 feet long.

A.6.2.1.1.4 Lighting

High intensity discharge, industrial high bay luminaries will be used for the main pump station area with industrial fluorescent fixtures with electronic ballasts for office and general type areas. Exterior lighting for security purposes would be automatically controlled by photo-electric cells and contactors.

A.6.2.1.1.5 Wiring

Insulated copper conductors will generally be installed in either PVC coated rigid galvanized steel conduit or schedule 40 rigid plastic conduit. Conductors will be rated for 600 volt insulated types RHW, THW, THWN, or XHHW. All wiring will conform to UFGS Guide Specifications. Conductors will all be copper. Aluminum conductors will not be used.

A.6.2.1.1.6 Lightning Protection

A roof mounted lightning protection system shall be installed. The system shall consist of interconnected air terminals with ground conductors to connect to the station grounding grid. Conductors shall be stranded.

A.6.2.1.1.7 Backup Generators and Automatic Transfer Switches

Backup generators and automatic transfer switches shall be sized sufficiently to power diesel engine auxiliaries, trash rakes, exhaust fans, lights and SCADA equipment.

A.6.2.1.1.8 Stilling Wells and Water Level Sensors

The latest SFWMD standards for stilling wells and water level sensors shall be used. The water level sensors are sole source items.

A.6.2.1.2 Large Pump Station C43PS-1

A.6.2.1.2.1 Service

A single line diagram is shown on Plate E-01. A Station Motor Control Center single line diagram is shown on Plate E-02. The Engine Control Center Single Line Diagram is shown on Plate E-03. The Engine Control Center and Schedule are shown on Plate E-04. The Engine Pump Control Diagram is shown on Plate E-05. The SCADA System Diagram is shown on Plate E-06.

A.6.2.1.2.2 Equipment

Switchgear rated for 480 volt, three phase with a main breaker will be connected to the incoming service and would feed engine control centers and station equipment. Each engine control center will house starters and controls for auxiliary equipment for respective engine unit. Main switchboard would also feed a small transformer to supply 120/208 volts for small loads.

A.6.2.1.2.3 Controls

Each large pumping station shall have a centralized monitoring and control room. Each diesel engine for pumps will have a separate motor control center to supply power and house controls for engine auxiliaries, such as jacket water pump, engine lube pump, fuel filter pump, etc. as shown on Plate E-09. Diesel engines will also be equipped with a separate instrument panel and will house engine start/stop controls, pressure and temperature indicators to indicate engine performance. The diesel engine manufacturer will be required to submit a one-line diagram and control schematics for engines driving the pumps.

A.6.2.1.3 Small Pumping Station C43PS-4

A.6.2.1.3.1 Service

A single line diagram is shown on Plate E-07. The electric motor controls are shown on Plate E-08. The SCADA System Diagram is shown on Plate E-09.

A.6.2.1.3.2 Equipment

A motor control center (MCC) rated for 480 volt, three phase with a main breaker would be connected to the incoming service and would feed electric motors and station equipment. The MCC would also feed a small transformer to supply 120/208 volts for small loads. An ATS would provide backup power for the station.

A.6.2.1.3.3 Controls

Electric motor driven pumps shall be controlled from the MCC. Diesel engines will be equipped with a separate instrument panel, which will house engine start/stop controls, and pressure and temperature indicators to indicate engine performance. The diesel engine manufacturer will be required to submit a one-line diagram and control schematics for engines driving the pumps.

A.6.2.2 Other Structures

A.6.2.2.1 Spillways and Gated Culvert

A.6.2.2.1.1 General

A single line diagram is shown on Plate E-10.

A.6.2.2.1.2 Power Service

A 120/240 volt single phase or 208Y/120 volt, three phase, electrical service shall be provided by the local utility company. A 120/240 volt single phase or

208Y/120 volt, three phase engine-generator unit shall be provided to supply necessary electrical power for gate operations. Transient Voltage Surge Suppression (TVSS) shall be provided at the service entrance.

A.6.2.2.1.3 Grounding

Structure main grounding will include a grounding loop consisting of ground rods and #4/0 ground wire which will be bonded to the embedded metallic masses, sheet pile, and structural steel. Frames or enclosures of electrical equipment will be bonded to the grounding system. Ground conductor will be bare, soft annealed copper cables and ground rods would be of copper clad type, 3/4 inch in diameter by 8 feet long.

A.6.2.2.1.4 Lighting

Industrial fluorescent fixtures with electronic ballasts will provide interior lighting. Exterior lighting for security purposes would be automatically controlled by photo-electric cells and contactors.

A.6.2.2.1.5 Wiring

Insulated copper conductors will generally be installed in either PVC coated rigid galvanized steel conduit or schedule 40 rigid plastic conduit. Conductors will be rated for 600 volt insulated types RHW, THW, THWN, or XHHW. All wiring will conform to UFGS Guide Specifications. Conductors will all be copper. Aluminum conductors will not be used.

A.6.2.2.1.6 Backup Generators and Automatic Transfer Switches

Backup generators and automatic transfer switches shall be sized sufficiently to carry the load required.

A.6.2.2.1.7 Stilling Wells and Water Level Sensors

The latest SFWMD standards for stilling wells and water level sensors shall be used. The water level sensors are sole source items.

A.6.2.2.1.8 Power Distribution

A control center will be connected to the load side of the automatic transfer switch and will house a main breaker, combination starter for the gate motor, lighting panel, relay compartment, and a circuit for exterior lighting.

A.6.2.2.1.9 Gate and Motor Controls

Duplicate open-close push button stations in the control house and at the spillway structure would be provided for manual gate control. Necessary open, close, automatic control relays, and limit switches would be incorporated in the gate control circuit. A time delay relay will provide a 5-second energization delay to a dumping solenoid valve to permit unloaded start of the hydraulic power unit motor. Power and control circuits for water level recorders and gate position recorders will be provided.

A.6.2.3 Instrumentation Design

A.6.2.3.1 General

The remote automation components installed at the pump station and other structures are the remote terminal unit (RTU) and communication channel to the SFWMD control center. The automation components of all pump stations and structures that will eventually be operated and maintained by SFWMD must conform to SFWMD standards in order to (1) achieve cost efficiency in design, construction, operation and maintenance (2) meet safety, reliability, and performance requirements during routine and emergency operations. The automation components are broadly defined to include hardware, software, communications and user interface elements.

A.6.2.3.2 Reservoir Levels

Water levels in the reservoir cells will be monitored. Solar panels with battery powered storage capabilities will be used in locations that are not near a structure.

A.6.2.3.3 Large Pump Stations

Programmable logic controllers (PLCs) will be used to monitor and control the engines and station auxiliaries. An Ethernet network will connect the PLCs and station computer. Ethernet based IP cameras will also connect to the Ethernet network. The station computer will allow for operation of the station via Telvent HMI SCADA software. The station could also be remotely operated from a central command and control center using the Telvent software.

A.6.2.3.4 Small Pump Stations

A Motorola ACE3600 RTU will provide SCADA capabilities by allowing the station to be remotely operated. Local operation will be accomplished via a Graphical User Interface and local controls.

A.6.2.3.5 Water Control Structures

The RTU at each site requiring remote automation shall be the SFWMD standard Motorola ACE3600 system. RTU software shall be in accordance with the SFWMD standard load set.

A.6.2.3.6 Network Requirements

There are several possible options for network communications: VHF, UHF, or spread spectrum. It may also be desirable to provide a high bandwidth redundant microwave Ethernet bridge to connect the SFWMD backbone to the C43PS-1 station. Decisions about final network configuration and interface with the existing SFWMD control system will be made in conjunction with SFWMD at a later stage in the project.

A.6.2.3.7 Implementation and Construction

The construction plans will contain plans for the hardware components of the telemetry system. SFWMD has a basic interface program that will be loaded as the structures are completed. The contractor would then edit the basic program for the specific structure.

A.6.2.3.8 Operation and Maintenance

SFWMD will operate and maintain the telemetry network.

A.7 CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR STRUCTURES

A.7.1 C43PS-1 - 1500 cfs Pump Station

A.7.1.1 General Description

Florida Statute 119.07(6)(ee) states "Building Plans, blueprints, schematic drawings, and diagrams, including draft, preliminary and final formats, which depict the internal layout and structural elements of a building, ...or structure owned or operated by an agency are exempt from public record". Because this Final PIR report will be distributed for public record, limited (conceptual) structural drawings for only the large pump station and embankments are provided in this report. Any agency or reviewing authority, as permitted under the FL Statute, can request additional structural details as necessary to perform their respective review requirements. All structures proposed for this project are described in written detail as follows.

Pump Station C43PS-1 will consist of a 1,500 cfs pump station 252 feet long and 84 feet wide with intake located on the Townsend Canal and an over-the

embankment arrangement for discharge to the Reservoir. The facility will house four main pumps. Two pumps will be 500 cfs capacity each, and two will be 250 cfs capacity each. The pump station building will consist of an operating floor at elevation 25.0 feet NAVD for the placement of most pump station machinery and a two-story steel structure above elevation 25.0 feet NAVD housing the control room, break room and workshop. A 60-ton overhead bridge crane with a hook height approximately 25 feet above the operating floor will be provided to facilitate the maintenance of pump station equipment. The selection of a 60-ton capacity crane is based on the anticipated weight of one 500 cfs pump.

A 3 foot thick pipe gallery floor at elevation 10.0 feet NAVD will be provided below the operating floor and will be used to route piping and conduits across the pump station. This level will also be used to house the auxiliary pump systems, water treatment systems and collection tanks for waste fuel and waste oil. Access for the installation and removal of equipment at the pipe gallery level will be provided by means of a 10 foot x 10 foot opening through the operating floor. Personnel access to the pipe gallery level from the operating floor will be provided by means of stairs located adjacent to the opening to the pipe gallery. Ladders, stairs and access ways on the operating floor will be provided at other locations across the station.

A.7.1.2 Substructure

The in-situ soils in the area of the pump station consist mainly of clean sands, clayey sands and/or silty sands over approximately 20 feet of clay on top of clayey sands.

The substructure of the pump station will consist of cast-in-place reinforced concrete walls supported on mat foundations. The substructure will be constructed with a formed suction intake (FSI) for each main pump bay. The main pumps will be supported on the pipe gallery floor on supports to be provided per pump manufacturer's recommendations.

A.7.1.3 Superstructure

The superstructure consists of a steel frame building with wide flange steel columns and steel roof trusses supported on the operating floor of the pumping station. The roof will be made up of cast-in-place concrete slab on metal deck supported by steel roof purlins. Purlins will be supported on 82 foot span, 7 foot deep steel trusses on 18 foot spacing. Trusses are supported on wide flange steel columns spaced at 18 foot centers. The roofing system will consist of fully-adhered EPDM roofing applied to the concrete roof deck. Eight inch thick precast concrete wall panels form the exterior wall cladding system. Steel girts spanning horizontally between the steel columns provide the support for the wall panels. The bridge crane runways will be supported on steel haunches welded to

the flange of steel columns. The 25 foot hook height will be adequate to operate the crane hook for lifting, lowering or moving the machinery.

A.7.1.4 Siphon Break and Saxophone Discharge Structures

To facilitate the over-the-embankment arrangement, four siphon break structures and four saxophone discharge structures will be constructed. One set of structures will be constructed for each discharge pipe. Each cast-in-place concrete siphon break structure measuring 18 feet x 96 feet will be provided where the discharge pipes cross the top of the dam embankment, and will be designed per AASHTO and FDOT Standards to permit the passage of vehicular traffic over the discharge pipes. The structures will consist of base slabs, wing walls and vaults with access manholes. The structures will be designed to be water tight.

The saxophone discharge structures, each 28 feet x 76 feet, will consist of sheet pile cofferdams with tremie concrete seals to allow for dewatering the excavations required for the installation of the steel saxophone discharge pipes. Concrete thrust blocks will be poured around each discharge pipe prior to backfilling the remaining excavation. A cast-in-place concrete cap will be constructed on top of the sheet pile on three sides to create a sharp crested weir. The fourth side will be enclosed by the dam embankment. The purpose of the sharp crested weir structure is to ensure that the discharge pipes are submerged to the minimum elevation required by the hydraulic design of the pump station.

A.7.1.5 Service Bridge

An 18.0 foot wide cast-in-place concrete Service Bridge will be provided at the suction basin of the pump station on the north side. The bridge will be used to provide vehicular access from one side of the pump station to the other, and for positioning truck cranes during the installation and removal of stop logs. The bridge will be designed as a one-lane multiple span deck, supported on suction basin walls. The deck will be fixed at an interior wall, and will be free to expand at other walls.

A.7.1.6 Trash Screen Bridge

Trash screens and rakes for the pump station will be located on a pile-supported bridge structure located on the north side of the pump station.

A.7.1.7 Fuel Oil Containment

Fuel oil supply and waste fuel and oil storage tanks will be located within a cast-in-place concrete containment structure at one end of the pump station. The

containment will be designed to accommodate the volume of the largest fuel storage tank.

A.7.1.8 Stoplogs

One set of stoplogs will be stored at the station to allow for dewatering one bay of the pump station for maintenance. The stoplogs will be designed as steel panels extending vertically from the bottom of the suction bay to the top of the suction bay walls. The stoplogs will slide down recesses cast into the suction basin walls and training piers. The panels will consist of steel plate with channel stiffeners, lifting eyes and a perimeter neoprene gasket. All steel panels will be hot-dipped galvanized.

A.7.1.9 Design Load Criteria

A.7.1.9.1 Live Loads

The following live loads will be the basis for design (***Table A-14***):

TABLE A-14: ALLOWABLE LIVE LOADS

Occupancy or Use	Live Load
Roof	50 psf
Floors	250 psf
Operating Floor (non equipment areas)	250 psf*
Operating Floor (equipment placement areas)	100
Control Room	100
Restrooms	100
Equipment Storage Rooms	200
Maintenance Work Area	300
Stairways	100
Elevator Lift	200
Deck Grating	250
Service Bridge	HS-20**
Guardrails	50 lb/ft and 220 lb concentrated load

* Equipment placement areas will be designed to support the weight of the heaviest piece of machinery anticipated.
** Service bridge design will also consider current SFWMD truck crane equipment loadings.

A.7.1.9.2 Wind Loads

The design wind loading for the structure will be in accordance with the Florida Building Code, and ASCE 7:

Wind Speed: 120 mph (3 second gust)
Exposure C
Iw = 1.3

A mean recurrence interval (MRI) of 200 years will be used in place of the standard 50 year MRI. A factor of 1.14 will be applied to the code wind pressure values to upgrade to the 200 year MRI values.

A.7.1.9.3 Crane Loads

Bridge crane wheel loading will be treated as live load for the crane runway design. The design of the runway will consider impact loads equal to 18% of the crane load, longitudinal loads equal to 10% of the crane load, and lateral loads equal to 20% of the sum of the rated capacity of the crane and the weight of the hoist and trolley.

A.7.1.9.4 Hydrostatic Uplift Loads

Hydrostatic uplift forces will be determined in accordance with procedures described in U.S. Army Corps of Engineers, Engineering Manual (EM) 1110-2-3104, "Structural and Architectural Design of Pumping Stations." Hydrostatic uplift forces will be considered when evaluating the stability of the structure from overturning, sliding, uplift and foundation bearing. The following recommendations were given for preliminary design (all elevations refer to NAVD 88) (***Table A-15***):

Reservoir Level–Elevation 42.0 feet
Toe of Dam–Elevation 20.0 feet (bench at dam toe was modeled, with a transition to Elevation 16.0 feet away from toe)

TABLE A-15: RECOMMENDED HYDRAULIC GRADE LINE

Lagoon Level – EL 0.0	
Location	Hydraulic Grade Line Elevation
Dam Side of PS-1	+8.3
Lagoon Side of PS-1	+8.0
Lagoon Level – EL 8.0	
Location	Hydraulic Grade Line Elevation
Dam Side of PS-1	+13.9
Lagoon Side of PS-1	+13.7

Groundwater levels near PS-1:
Groundwater Level @ Toe of Dam–Elevation 12.9 feet
Groundwater Level @ Intake–Elevation 12.6 feet
Groundwater Level of 13.0 was assumed for preliminary design purposes.

A.7.1.9.5 Soil Lateral Loading Criteria

All substructures and retaining walls will be designed to resist lateral soil loadings. ***Table A-16*** summarizes the design criteria presented in the Preliminary Geotechnical Memo for the design of sheet pile retaining walls at this pump station.

TABLE A-16: SOIL LATERAL LOADING CRITERIA

Depth (feet)	Unit Weight (pcf)		ϕ Degrees	δ Degrees	C (psf)	Coefficient of Lateral Earth Pressure			k (pci)
	Moist	Buoyant				Ka	Ko	Kp	
0-20	110	60	30	18	0	0.33	0.50	3.00	25
20-40	100	43	0	0	1000	1.00	1.00	1.00	500
40-100	120	65	34	20	0	0.28	0.44	3.54	125

Notes: ϕ - angle of internal friction (degrees)
δ - angle of wall friction (degrees)
C - cohesion
Ka - coefficient of active lateral earth pressure
Ko - coefficient of at-rest lateral earth pressure
Kp - coefficient of passive lateral earth pressure
k - modulus of horizontal subgrade reaction
Depth refers to existing land surface grade

A.7.1.10 Materials

Structural Steel:
W shapes: ASTM A992/A992M, Grade 50.
C, MC and S shapes: ASTM A36/A36M.
L shapes: ASTM A36/A36M.
Plates: ASTM A36/A36M.
Structural square and rectangular tubing: ASTM A500, Grade B.
Structural pipes: ASTM A53/A53M, Grade B.
Round HSS: ASTM A500, Grade B.
High-strength bolts: ASTM A325/A325M, Types 1 or 3.
Standard bolts: ASTM A307.
Anchor bolts: ASTM F1554, Grade 36.
Sheet Pile: ASTM A572, Grade 50.
Fill Concrete: f'c = 2,500 psi at 28 days. (Tremie Concrete)
Structural Concrete: f'c = 4,000 psi at 28 days.
Precast Concrete: f'c = 5,000 psi, minimum at 28 days.
Reinforcing Steel: ASTM A615/A615M, Grade 60.

A.7.1.11 Design Standards

Concrete:
ACI 318: Building Code Requirements for Reinforced Concrete, by the American Concrete Institute.
EM 1110-2-2104: Strength Design for Reinforced Concrete Hydraulic Structures.

Hydraulic factors will be applied to the overall load factor equations for structures or portions thereof that are classified as hydraulic in accordance with EM 1110-2-2104.

Structural Steel:
Manual of Steel Construction (Ninth Edition) by the American Institute of Steel Construction Inc,

Masonry:
Building Code Requirements for Masonry Structures, ACI 530.

Sheet Pile Retaining Walls:
EM 1110-2-2504, Design of Sheet Pile Walls

A.7.2 C43PS-4 - 195 cfs Pump Station

A.7.2.1 General Description

C43PS-4 will consist of a 195 cfs Pump Station 46 feet wide and 58 feet long with three pumps of 65 cfs capacity each. The main building will be supported on concrete footing. The pumps will be located at elevation 19.0 feet on a 3 feet thick floor slab. The wall units will be of fully grouted concrete masonry units (CMU). The roof framing will consist of cast-in-place concrete beams with precast concrete hollow core roof slabs. Three aluminum hatches provided along the center line of pumps will facilitate pump removal and replacement. The pump station will be un-manned and will be operated remotely or automatically operated.

A.7.2.2 Codes and Standards

The following design codes, requirements, and standards shall apply:

- SFWMD Guidelines Type 2 Water Supply Pump Station
- Florida Building Code;
- ACI 318-05 - Building Code Requirements for Reinforced Concrete ;
- ACI 350R - Concrete for Environmental Structures;
- ANSI/ASCE 7-02 Standard - Minimum Design Loads for Buildings and Other Structures;
- National Fire Protection Association - NFPA 101 - Life Safety Code;
- PCI MNL-120 - Design Handbook;
- Steel Construction Manual - AISC, Ninth Edition;
- Structural Welding Code – AWS D1.1;
- National Concrete Masonry Association Design Tables;
- Standard Specifications for Highway Bridges, American Association of State Highway Officials; and

- FDOT Standard Specifications for Road and Bridge Construction, 2000.

A.7.2.3 Loads and Design Criteria

The following loads and design assumptions shall be used in the structural analysis and calculations:

- Roof L.L. = 50 psf
- Floor L.L. = 250 psf
- Reinforced concrete unit weight = 150 pcf;
- 10 inches thick hollow core slab unit weight = 86 psf; and
- Roof covering with insulation unit weight = 9 psf

Wind loads shall be determined in accordance with the Florida Building Code and FWMD guidelines for a Type 2, water supply station and shall utilize the following criteria:

- Wind Velocity: ~120 mph per wind map FBC;
- 200 yr mean recurrence interval;
- 50 yr from 200 yr recurrence adjustment factor = 1.14;
- Roof: 0 degrees;
- Mean Roof Height: 24 feet ;
- Importance Factor = 1.15, for water supply pump station;
- Exposure category C, adjustment factor ~ 1.35; and
- Building Dimensions: 46 feet x 58 feet ~ rectangular enclosed building, no windows, low rise building.

The following load factors were utilized by Stanley Consultants in accordance with ASCE-07 Standard "Minimum Design Loads for Buildings and Other Structures and ACI-318:

U = 1.4(D + F)
U = 1.2(D + F + T) + 1.6(L + H) + 0.5(Lr or S or R)
U = 1.2D + 1.6(Lr or S or R) + (1.0L or 0.8W)
U = 1.2D + 1.6W + 1.0L + 0.5(Lr or S or R)
U = 1.2D + 1.0E + 1.0L + 1.6S
U = 0.9D + 1.6W + 1.6H
U = 0.9D + 1.0E + 1.6H

Hydraulic structures are required by SFWMD to satisfy both strength and serviceability requirements. ACI-350R requires an additional load factor of 1.3 be applied to the results of the above listed load equations. In addition, the factor for soil lateral loads is required to be increased to 1.7 as per ACI-350R.

As per SFWMD guidelines for Type 2 pump stations, the C43PS-4 substructure shall be designed to resist the saturated soil pressure to grade with an added 500 psf for traffic surcharge. Service bridges and operating floors shall be designed to support AASHTO HS25 loading.

A.7.2.4 Stability

A stability analysis shall be made of the station's retaining walls and intake structure. Unfactored loads shall be used in the stability analysis as indicated in EM 1110-2-2104. The walls shall be analyzed for failure due to sliding, rotation about the toe, and by failure of the foundation material. In accordance with EM1110-2-6058, a minimum safety factor of 2.0 and 1.5 shall be provided for overturning and sliding respectively.

A.7.2.5 Reinforced Concrete Design

The 28 day compressive strength for cast-in-place concrete elements shall be specified as 4000 psi. For precast elements, the strength shall be specified as 5000 psi. The minimum concrete cover shall be not less than 1.5 x the maximum aggregate size or 2.5 x the bar diameter. The following concrete cover shall be assumed in the analysis:

- Cast against earth: 4 inches
- Elements with surfaces exposed to abrasion, channel side faces: 3 inches
- Slabs, walls, and beams typical: 1.5 inches

The reinforcement tensile strength shall be taken as 60 ksi. The minimum temperature steel for the abutments, piers, and walls shall be specified as #5 bars at 12 inches on centers. The wall thicknesses shall be sufficient to allow the proper placement and consolidation of concrete and shall be designed in multiples of 2 inches to simplify formwork. For typical design and detailing of the reinforcement, multiples of 6 inches shall be used in the spacing of the primary and secondary steel. Bar spacing shall be taken as 1.5 x bar diameter or 1.5 x the maximum aggregate size. The minimum spacing between layers shall be 6 inches.

Construction joints shall be located to facilitate construction, limit the horizontal depth of the placement and shall not impair the strength and water tightness of the structure. Horizontal joints shall be located at the base of walls and typically at the maximum spacing of 10.0 feet.

Reinforcement shall be continuous through construction joints. Waterstops shall be used in construction joints where there is a head differential and the possibility of water flow through the joints.

A.7.3 Water Control Structures

A.7.3.1 Culverts

Cast-in-place concrete box culverts C43S-7 and C43S-9 are located north of the storage reservoir. Culverts C43S-14 and C43S-15 are located in the Header Canal east of Cell 2 of the Reservoir. All culverts have dewatering features.

Calculations for the structures include structural stability checks for flotation and preliminary design for a typical culvert section. The box culvert design program LRFD Box Culvert V2.21 as published by the Florida Department of Transportation will be used for the design. This program analyzes cast-in-place concrete box culverts for conformance to AASHTO LRFD bridge design specifications.

Anticipated settlement of the culvert structures will be minimal. Underseepage will be controlled by installing a 5 foot concrete cutoff wall.

A.7.3.1.1 Design references

- EM 1110-2-2902 Conduits, Culverts and Pipes, USACE 31 October, 1997
- ETL 11102-307 Engineering and Design Flotation Stability Criteria for Concrete Hydraulic Structures, USACE 20 August 1987;
- Standard Specification for Highway Bridges, AASHTO; and
- Geotechnical Report by DE&T, dated 01/06/06.
- ACI 318-05 – Building Code Requirements for Reinforced Concrete

A.7.3.2 C43S-7- Gated Double Barrel Box Culvert

Structure C43S-7 is a double barrel 10 foot W x 10 foot H box culvert with one sluice gate and one weir gate located at the intersection of Banana Branch Canal and Perimeter Canal. Flow parameters examined are as follows: Base flow of 80 cfs, Q25 of 816 cfs and Q100 of 840 cfs. Weir gate will be operational for base flows and when this flow is exceeded, sluice gate will be used to handle the excess flow. Energy dissipation and erosion control measures will need to be examined.

A.7.3.3 C43S-9 - Gated Double Barrel Box Culvert

Structure C43S-9 is a double barrel 6 foot W x 6 foot H box culvert with a 6 foot x 6 foot sluice gate and a 6 foot x 6 foot weir gate. It is intended to convey flow from Perimeter Canal to the Fort Simmons Canal. The weir gate will be used to allow base flow to pass. For flows greater than the base flow, the sluice gate will be used. Maintenance of the sluice gate will require special consideration and

must be done during low flow periods. Therefore, both gates must be operational to convey flows greater than the base flow.

A.7.3.4 C43S-14 - Gated Single Barrel Box Culvert

Structure C43S-14 connects the Header Canal to the Perimeter Canal. The structure is a single barrel 10 foot W x 6 foot H box culvert with a sluice gate to convey flood flow into the Perimeter Canal. The main purpose of this structure is to relieve flooding from SR 29 via the Header Canal and will not be used as a means for daily flow control either to or from Perimeter Canal. No additional flow will be introduced into the Perimeter Canal should the Perimeter Canal or the Townsend Canal reach full capacity.

A.7.3.5 C43S-15- Gated Double Barrel Box Culvert

Structure C43S-15 conveys flow from Roberts Canal to the Perimeter Canal. The structure is a double barrel 10 foot W x 8 foot H box culvert with an independently operated sluice gate and weir gate. The culvert is designed for flow parameters of 80 cfs of base flow, Q25 of 598 cfs and Q100 of 691 cfs. The 10 foot W x 8 foot H weir gate is intended to pass only the base flow. Flows above the base flow will be controlled by the sluice gate. Both gates should be operational to convey flows greater than the base flow. Maintenance of a gate should only be performed when the flows are at or below the base flow conditions.

A.7.4 Perimeter Canal Structures

A.7.4.1 C43S-3- Double Barrel Gated Culvert

C43S-3 is a double barrel reinforced concrete box culvert 10 foot W x 10 foot H which will be used to regulate water flow around the Perimeter Canal. Each barrel will have its own intake structure consisting of an upward opening stainless steel slide gate and a downward opening stainless steel weir gate. Calculations for this structure are based on structural stability check against flotation (uplift); hydraulic design data based upon the 100-year flood event and Allowable Stability Factors recommended by the USACE. Also, per geotechnical recommendations, a five foot tremie seal within a sheetpile cofferdam is assumed for construction and sheetpile cutoff walls embedded five feet into the clay layer are assumed at the upstream and downstream ends of the structure to reduce seepage flow underneath the structure. No longitudinal sheetpile cutoff wall is used since the perimeter dam includes a full depth soil-bentonite cutoff wall.

A.7.4.1.1 Design References

- EC 1110-2-6058 Stability Requirements, USACE 30 November, 2003;
- ETL 11102-307 Engineering and Design Flotation Stability Criteria for Concrete Hydraulic Structures, USACE 20 August 1987;
- Design of Small Dams, published by United State Department of Interior, Bureau of Reclamation, A Water Resources Technical Publication; and
- Geotechnical Report by DE&T, dated 01/06/06.

A.7.4.2 C43S-10 - Three Bay Reinforced Concrete Spillway

C43S-10 is a three (3) bay concrete spillway which will be used to regulate water flow around the Perimeter Canal. The structure has one bay 14 foot x 10 foot with a roller gate on an ogee weir and two bays of 10 foot x 10 foot with downward opening weir gates. Calculations for this structure are based on structural stability checks including sliding, flotation (uplift) and bearing. Hydraulic design data based upon the 100-year flood event and Allowable Stability Factors recommended by the USACE are used for the stability checks. Also, per geotechnical recommendations, a five foot tremie seal within a sheetpile cofferdam is assumed for construction and a sheetpile cutoff wall embedded five feet into the clay layer is assumed at the upstream end of the structure to reduce seepage flow underneath the structure. No longitudinal sheetpile cutoff wall is used since the perimeter dam includes a full depth soil-bentonite cutoff wall.

A.7.4.2.1 Design References

- EC 1110-2-6058 Stability Requirements, USACE 30 November, 2003;
- ETL 11102-307 Engineering and Design Flotation Stability Criteria for Concrete Hydraulic Structures, USACE 20 August 1987;
- Design of Small Dams, published by United State Department of Interior, Bureau of Reclamation, A Water Resources Technical Publication; and
- Geotechnical Report by DE&T, dated 01/06/06.

A.7.4.3 C43S-11 - Four Bay Reinforced Concrete Spillway

C43S-11 is the largest of the Perimeter Canal structures and is a four (4) bay reinforced concrete spillway which will be used to regulate water flow around the Perimeter Canal. The structure consists of two (2) 14 foot x 8 foot roller gate bays with vertical opening roller gates on ogee weirs and two (2) 10 foot x 8 foot weir gate bays with downward opening weir gates on fixed weirs. The two weir gates in addition to the vertical roller gates, are capable of discharging a normal discharge flow of 500 cfs should one of the roller gates be removed from service.

Calculations for this structure include structural stability checks which include sliding, flotation (uplift) and bearing. Hydraulic design data based upon the 100-year flood event and Allowable Stability Factors recommended by USACE are also used in the stability checks. Also, per geotechnical recommendations, a five foot tremie seal within a sheetpile cofferdam is assumed for construction and a sheetpile cutoff wall embedded five feet into the clay layer is assumed at the upstream end of the structure to reduce seepage flow underneath the structure. No longitudinal sheetpile cutoff wall is used since the perimeter dam includes a full depth soil-bentonite cutoff wall.

Manatee Structure

A pile founded concrete manatee structure/barrier will be installed at the mouth of the Townsend Canal to prevent manatee access to the Townsend Canal. The USFWS has determined that if manatees were allowed in the Townsend Canal, a potential threat exists by intermittingly altering the temperatures through discharges from the reservoir. This could provide an intermittent and potentially harmful warm water refugia.

A.7.4.3.1 Design References

- EC 1110-2-6058 Stability Requirements, USACE 30 November, 2003
- ETL 11102-307 Engineering and Design Flotation Stability Criteria for Concrete Hydraulic Structures, USACE 20 August 1987;
- Design of Small Dams, published by United State Department of Interior, Bureau of Reclamation, A Water Resources Technical Publication; and
- Geotechnical Report by DE&T, dated 01/06/06.

A.7.5 Main Outlet Structure

A.7.5.1 General

Each cell of the Reservoir has a gated outlet structure to provide operational flows to meet the needs of the project at S-79 in the Caloosahatchee River. The outlets also maintain necessary Reservoir levels. These outlet structures are located in the northwest corner of each cell and discharge to the Perimeter Canal.

A.7.5.2 C43S-1 and C43S-8 - Gated Outlet Structures

C43S-1 and C43S-8 are the main outlets for Cell 1 and Cell 2 respectively. The designs are very similar with the major difference being that C43S-8 has a two foot higher sill elevation and 1-foot shorter dam crest. Both outlets discharge into the north Perimeter Canal with C43S-1 discharging four feet lower than

C43S-8. Each outlet consists of the following outlet components, listed from upstream to downstream:

1. Gated intake structure that allows inflows at upper or mid-level Reservoir depths for control of water quality and water temperature, the gates can be remotely or manually operated
2. Double barrel cast-in-place conduit though the base of the dam;
3. Double gatewell to house service and emergency gates;
4. Double-bay stilling basin for energy dissipation; and
5. Transition channel to Perimeter Canal

A.7.5.2.1 Structural Design Criteria

Corps of Engineers Engineering Manuals referenced:

- EC 1110-2-6058 Stability Analysis of Concrete Structures
- ETL 1110-2-307 Flotation Stability Criteria for Concrete Hydraulic Structures
- EM1110-2-2400 Structural Design & Evaluation of Outlet Works
- EM1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures
- EM1110-2-2902 Conduits Culverts and Pipe
- EM1110-2-2502 Retaining & Flood Walls

A.7.5.2.2 General Criteria

a) Use identical gates and similar structural layout and design for each cell to provide design, construction, and maintenance advantages
b) Provide redundant gates in each outlet to allow normal operation with one gate out of service or to allow reservoir drawdown within 120 days;
c) Provide expansion and construction joints that accommodate the expected differential settlement (12 to 16 inches at the centerline of the dam);
d) Provide sufficient concrete cover over reinforcement in areas of major hydraulic activity;
e) Provide proper access for maintenance, operation, and monitoring of components;
f) Provide water tight connections at intersections with the dam's seepage controlling features;
g) Provide means for capturing and handling large debris before it enters conduits; and
h) Provide means for dewatering structural components for inspection and maintenance.

A.7.5.2.3 Stability Criteria

Each outlet component and element was evaluated by Stanley Consultants and sized to provide a suitable margin of safety between the overall forces and combinations of loads that can cause unsatisfactory resistance to flotation, sliding or bearing failure. The required factors of safety for stability were designated for "critical" structures that are new and thus well defined in EC 1110-2-6058. A flotation safety factor of 1.30 was used for scheduled maintenance of all outlet components.

A.7.5.2.4 Strength Criteria

Preliminary structural analysis, design and detailing were performed by Stanley Consultants for multiple structural elements for a typical outlet location. C43S-1 being a taller structure typically controlled the design requirements. Sections were analyzed for both shear and flexural strength based on Load Factor Design. The compressive strength of concrete was taken as 3,500 psi due to the lower stresses typical of hydraulic structures, and the steel reinforcement yield stress was chosen as 60,000 psi. This preliminary analysis only considered the load combination(s) that were regarded as critical to select the preliminary thickness and reinforcement for each element. Load combinations included self weight, dry and saturated soil weight, internal and external water pressures, uplift, and construction vehicle loading. Structural analysis was done using Staad.Pro (a finite element structural analysis software package) to determine factored moments and shears required in the design and sizing of members.

A.7.5.2.5 Serviceability Criteria

All of the outlet components were considered Hydraulic Structures and as such, factored loads were multiplied by an additional hydraulic factor (Hf) of 1.30 in lieu of performing additional serviceability analyses. Shrinkage and temperature reinforcement is taken as 0.2% of the gross section of the element. With regard to concrete cover protection over the steel reinforcement, hydraulic structures are required to have the following protection:

a) Unformed surfaces in contact with foundation - 4 inches
b) Formed surfaces subject to abrasion - stilling basin slabs and baffles - 6 inches;
c) Formed surfaces stilling basin walls, conduit slabs/walls 24 inches or >, - 4 inches;
d) Surfaces stilling basin walls, conduit slabs/walls 12 inches to 23 inches, - Formed 3 inches; and
e) Elements 12 inches or less in accordance with ACI code.

A.7.5.2.6 Intake Structure

The cast-in-place intake structure 47 feet x 39.25 feet is box shaped with an open top. Perimeter walls are two feet in thickness. A 3 foot thick base slab support the box structure. A center training wall is included to guide the water into double barrel box shape conduit which exits opposite to the headwall.

Access to the top of the intake structure can be accomplished from the crest of the dam. The top of the intake consists of heavy duty steel grating supported by eighteen concrete beams and two girders. The grating panels at the gates are removable so that gates can be accessed, raised and serviced on site or removed off site. Ladder rungs are provided for access to the interior of the intake. An outside ladder is also provided for access from a boat or barge when the reservoir is partially filled. An access road provides vehicular access to the bottom of the intake when the cell is empty.

Intake gates control the quality of the water being released through the outlet. Four upper slide gates are located on the side walls and four mid-level slide gates are located on the side wall and headwall. These gates can be remotely or manually operated to control water quality and temperature. Two lower-level slide gates are located in the headwall at the intake sill. These gates are manually operated during the rare event of a full reservoir drawdown. All the slide gates are located on the inside of the walls and operate either in the fully open or fully closed position and are subject to unseated head conditions. On the exterior face of the wall opening, trash rakes are provided at two feet on centers in both directions to prevent large debris from entering the intake. A rounded entrance at each opening minimizes turbulence.

Sluice gates located at the entrance to the conduits allow for dewatering of the conduits upstream of the gatewell without having to drawdown the entire reservoir. The sluice gates are manually operated, and also provide a second level of emergency protection for the gatewells. Sluice gates provide a better seal to minimize leakage. The gates work in either fully open or fully closed position and are subject to seated head conditions. The concrete surfaces at the entrances are bell-mouth shaped to minimize intake head losses. The gates are 8' wide to allow for a wider middle wall section to house the gate side frames.

Flotation stability was found to preclude the ability to dewater the large and relatively light intake structure with a full reservoir pool. In order to safely dewater the intake structure, the surrounding reservoir will have to be lowered to elevation 24.0 feet or lower. It is anticipated that the reservoir cells may be completely dry every 5 to 10 years at which time an intake inspection should be scheduled. The gates can all be removed from the top. The walls of the intake were designed as cantilevers to resist a nominal exterior (or interior) water load of 12 feet.

Overturning and sliding stability involves the calculation of dynamic load action due to reservoir waves during a hurricane event.

A.7.5.2.7 Double Barrel Conduit

The cast-in-place double-barrel conduit is rectangular in shape with each barrel 10 feet W x 6 feet H. The conduit is designed to resist hydrostatic loads due to a full pool during a dewatered condition. The conduits are also designed for a fully pressurized condition with moist soil conditions near the gatewell for a condition where the embankment upstream slope is faced with a fairly impervious layer.

Expansion joints are provided at the intersections of major elements in the outlet. Additional expansion joints have been introduced along the conduits to allow the structure to settle with the embankment. Camber is provided at the gatewell such that the conduits will have a final positive downward slope ranging from 2% to 3% after settlement has taken place.

Flotation stability was computed by Stanley Consultants for the upstream section of the conduits. The conduits need to be overlaid by at least one foot of soil in order to be safely dewatered. The access ramp to the intake provides more than adequate soil support.

A.7.5.2.8 Gatewell Structure

The gatewell structure is a cast-in-place double-bay rectangular chamber that provides access to the service and emergency gates. The exterior walls were designed to resist surrounding water pressures from a full pool reservoir condition while dewatered inside.

The conduits are narrowed at the gatewell to allow for smaller gates to be used. Cast iron gates are proposed for the service and emergency gates due to the high head and requirement for full operating range (as opposed to fully open or closed). The service gates are operated remotely while the emergency gates are operated manually. The service gates operate under a seated head condition while the emergency gates operate under an unseated head condition.

The massive gatewells are not subject to major overturning or flotation instabilities. Bearing pressures were computed at the base of the gatewell for the critical condition when the concrete work is complete but the structure has not yet been backfilled. The allowable bearing pressure of 4,000 psf is well above the actual pressures exerted at the base.

Each bay of the gatewell has a ladder fitted with a safety cage and a retractable safety post at the top. The grating panels at the top are removable so that gates can be accessed, raised and serviced on site or removed off site.

A.7.5.2.9 Stilling Basin

The stilling basin is a cast-in-place double-bay rectangular conveyance channel that dissipates most of the discharged water's energy before it reaches the receiving channel, the Perimeter Canal. The U-shaped channel walls were designed to resist at-rest lateral saturated soil loads and uplift pressures when dewatered.

At the downstream side, a slab connects the top of the walls to bridge over the structure and allow not only through traffic but also a location from which to install dewatering needles. A sheet pile cut-off wall is provided to prevent scouring beneath the slab in the event of failure of the riprap system.

Flotation stability of the stilling basin was computed by Stanley Consultants and found to require the Perimeter Canal water surface be set no higher than the normal water level (NWL) in order to safely dewater the stilling basin. The dewatered basin can be accessed from the gatewell and a dewatered conduit. A portable ladder can be lowered into the basin slab if there is a need to access the inside. Each conduit is independent from the other. Therefore inspection of a full conduit train is possible while the adjacent train is in operation.

Sliding stability of the basin was checked for water loading on the baffle blocks. A hydrostatic lateral pressure corresponding to the fluid energy grade line was used to compute the driving lateral force in lieu of a more detailed method of analysis. The basin was found to be safe against sliding instabilities.

A.7.5.3 C43S-12 Triple Conduit Cell Balancing Structure

A.7.5.3.1 General

Preliminary structural analysis, design and detailing were performed by Stanley Consultants. The Cell Balancing Structure, C43S-12, is located on the interior dam between Cells 1 and 2 of the reservoir. The primary function of the structure is to convey water between the cells and allow the cells to operate independently if needed. If one of the cells needs to be dewatered for maintenance C43S-12 may be closed to isolate the cells.

The general configuration of this structure is similar to the design of the main outlets C43S-1 and C43S-8 with the following major differences: C43S-12 is a triple conduit structure and water flows in the conduits in both directions depending on which cell is empty or filled. The dam crest elevation of the

interior dam at the balancing structure matches that of Cell 1. The east and west stilling basins are identical in configuration except that the east basin is set one foot higher in grade to allow water to drain by gravity from Cell 2 to Cell 1 during a drawdown event. The top of the conduits at the ends are shaped upward to minimize head losses when water flows in the opposite direction. The balancing structure consists of the following components listed from west to east:

1. Triple bay uncontrolled inlet/stilling basin structure
2. Triple barrel cast-in-place conduit along the base of the dam;
3. Triple gatewell to house service and emergency gates; and
4. Triple bay uncontrolled and un-gated inlet/stilling basin structure.

A.7.5.3.2 Structural Design Criteria

Corps of Engineer Engineering Manuals referenced:

- EC 1110-2-6058 Stability Analysis of Concrete Structures
- ETL 1110-2-307 Flotation Stability Criteria for Concrete Hydraulic Structures
- EM1110-2-2400 Structural Design & Evaluation of Outlet Works
- EM1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures
- EM1110-2-2902 Conduits Culverts and Pipes
- EM1110-2-2502 Retaining & Floodwall

A.7.5.3.3 General Criteria

a) Use identical gates and similar structural layout and design for each conduit to provide design, construction, and maintenance advantages;
b) Provide one redundant conduit train to allow normal operation with one conduit out of service;
c) Provide expansion and construction joints that accommodate the expected differential settlement (12 to 16 inches at the centerline of the dam);
d) Provide sufficient concrete cover over reinforcement in areas of major hydraulic activity;
e) Provide proper access for maintenance, operation, and monitoring of components; and
f) Provide means for capturing and handling large debris before it enters the conduit.

A.7.5.3.4 Stability Criteria

Each outlet component and element was evaluated and sized to provide a suitable margin of safety between the overall forces and combinations of loads that can cause unsatisfactory resistance to flotation, sliding or bearing failure. The required factors of safety for stability were designated for "critical"

structures that are new and thus well defined (EC 1110-2-6058). A flotation safety factor of 1.30 was used for scheduled maintenance of all structure components.

A.7.5.3.5 Strength Criteria

Refer to Main Outlet Structures C43S-1 and C43S-8.

A.7.5.3.6 Serviceability Criteria

Refer to Main Outlet Structures C43S-1 and C43S-8.

A.7.5.3.7 Inlet/Stilling Basin Structure

The cast-in-place inlet/stilling basin structure is formed by an excavated plunge pool that dissipates the energy from water releases at the start of filling a reservoir cell. The top of the inlet wall of the east basin is set 1.0 foot higher than the surrounding grade to minimize sediment loads from entering Cell 1.

The structure is un-gated and uncontrolled, however trash rakes are provided at the entrances to prevent large debris from entering the conduit. A rounded entrance at each opening minimizes turbulence.

Flotation stability of the basin was found to preclude the ability to dewater the structure with a groundwater level to the top of the basin (same as the existing grade). Weep holes and a drain system will be designed to allow basin dewatering. The basin walls were designed for a nominal exterior water load of 10' resisted as a cantilever wall. Sliding was not considered because the excavated basin has adequate passive soil resistance behind the back wall. An access road provides vehicular access to the bottom of the intake when the particular Reservoir cell is empty.

A.7.5.3.8 Triple Barrel Conduit

Refer to Main Outlet Structures C43S-1 and C43S-8. Flotation stability was not computed for the conduits because they can not be dewatered under a full pool reservoir condition.

A.7.5.3.9 Gatewell Structure

The gatewell structure is a cast-in-place triple-bay rectangular chamber that provides access to the service and emergency gates. The exterior walls were designed to resist surrounding water pressures from a full pool reservoir condition while dewatered inside.

Normal operation of the structure is to balance the water levels at the two cells with all the gates fully open at all times. When one cell is to be dewatered, the gatewell gates operate in the same fashion as the service gates of the main outlets C43S-1 and C43S-8.

Both service and emergency gates have a dual and opposite role for reversed reservoir operation. All 6 gates are thus furnished with controls to be operated remotely. The service gates operate under a seated head condition while the emergency gates operate under an unseated head condition. Cast iron gates are proposed for the service and emergency gates due to the high head and requirement for full operating range (as opposed to fully open or closed).

The massive gatewells are not subject to major overturning or flotation instabilities. Bearing pressures were computed at the base of the gatewell for the critical condition when the concrete work is complete but the structure has not yet been backfilled. The allowable bearing pressure of 4,000 psf is well above the actual pressures exerted at the base.

Each bay of the gatewell has a ladder fitted with a safety cage and a retractable safety post at the top. The grating panels at the top are removable so that gates can be accessed, raised and serviced on site or removed off site.

A.7.5.4 C43CS-1 and C43CS-2 Crest Spillway Structures

A.7.5.4.1 General

Each cell of the reservoir has an uncontrolled crest spillway structure to manage flood flows. C43CS-1 is located on the west side of Cell 1 and discharges to the Townsend Canal. C43CS-2 is located just east of C43S-8 in the northwest corner of Cell 2 and discharges to the Perimeter Canal. The design objective of the crest spillway structures is to minimize the surcharge storage of the reservoir without exceeding the allowable discharge.

The design of the two crest spillways is very similar with the major difference being that C43CS-1 uses a deeper and different type of stilling basin design. The overflow weir and conduit for both spillways are set at the same elevation however the crest of the dam is set one foot higher at C43CS-1. Each spillway consists of the following components, listed from upstream to downstream:

- Uncontrolled/un-gated inlet weir allows overflows higher than the NFSL of 42.0
- Single barrel cast-in-place conduit through the dam at invert elevation 38.0 feet
- U-shaped spillway chute
- Single-bay stilling basin for energy dissipation
- Transition channel to Perimeter Canal

A.7.5.4.2 Structural Design Criteria

Corps of Engineer Engineering Manuals referenced:

- EC 1110-2-6058 Stability Analysis of Concrete Structures
- ETL 1110-2-307 Flotation Stability Criteria for Concrete Hydraulic Structures
- EM1110-2-2400 Structural Design & Evaluation of Outlet Works
- EM1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures
- EM1110-2-2902 Conduits Culverts and Pipes
- EM1110-2-2502 Retaining & Flood Walls

A.7.5.4.3 General Criteria

a) Use similar structural layout and design for each spillway to provide design, construction, and maintenance advantages
b) Provide expansion and construction joints that accommodate the expected differential settlement;
c) Provide sufficient concrete cover over reinforcement in areas of major hydraulic activity;
d) Provide proper access for maintenance, operation, and monitoring of components;
e) Provide water tight connections at intersections with the dam's seepage controlling features; and
f) Provide means for dewatering structural components for inspection and maintenance.

A.7.5.4.4 Stability Criteria

Each spillway component and element was evaluated by Stanley Consultants and sized to provide a suitable margin of safety between the overall forces and combinations of loads that can cause unsatisfactory resistance to flotation, sliding or bearing failure. The required factors of safety for stability were designated for "critical" structures that are new and thus well defined (EC 1110-2-6058). A flotation safety factor of 1.30 was used for scheduled maintenance of all spillway components.

A.7.5.4.5 Strength Criteria

Preliminary structural analysis, design and detailing were performed for multiple structural elements for a typical spillway location. C43CS-1 being a taller stilling basin structure typically controlled the design requirements. Sections were analyzed for both shear and flexural strength based on Load

Factor Design. The compressive strength of concrete was taken as 3,500 psi due to the lower stresses typical of hydraulic structures, and the steel reinforcement yield stress was chosen as 60,000 psi. This preliminary analysis only considered the load combination(s) that were regarded as critical to select the preliminary thickness and reinforcement for each element.

Load combinations included self weight, dry and saturated soil, internal and external water pressures, uplift, and construction vehicle loading. Structural frame analysis was done using Staad.Pro (a finite element structural analysis software package) to determine factored moments and shears required to deign and size members of the structure.

A.7.5.4.6 Serviceability Criteria

All of the spillway components were considered Hydraulic Structures and as such, factored loads were multiplied by an additional hydraulic factor (Hf) of 1.30 in lieu of performing additional serviceability analyses. Shrinkage and temperature reinforcement is taken as 0.2% of the gross section of the element. With regard to concrete cover protection over the steel reinforcement, hydraulic structures are required to have the following protection:

a) Unformed surfaces in contact with foundation - 4 inches
b) Formed surfaces subject to abrasion, stilling basin slabs and baffles-6 inches;
c) Formed surfaces, stilling basin walls, conduit slabs/walls 24 inches-4 inches;
d) Formed surfaces stilling basin walls, conduit slabs/walls 12 inches to 23 inches-3 inches; and elements 12 inches or less in accordance with ACI code.
e) The Geotechnical Report provided in the Civil section details the soil column information under each of the structures and makes recommendations with regard to soil parameters, suitable foundation materials, dewatering methods, and estimates of expected settlement.

A.7.5.4.7 Inlet Weir Structure

The cast-in-place inlet structure is basically a flat slab on grade supporting a concrete weir. The downstream end is joined by a vertical training wall to convey properly flows into the single conduit. The radius of the weir was selected based on USACE guidelines. At the entrance to the conduit a small breast wall is provided to limit allowable discharges and to help deflect potential wave run up action.

Flotation stability criteria for hydraulic structures according to ETL 1110-2-307 (1987) report is a factor of safety of 1.50 for normal operation, which is the case

for this weir structure. However, flotation stability criteria according to the 2003 EC 1110-2-6058 (Stability Analysis of Concrete Structures), recommends a factor of safety of 1.3 for usual load conditions. The computed factor of safety is 1.40 for the proposed geometry. This is considered adequate given the massive weir shape.

Overturning and sliding stability were not of significant relevant to this structure.

Access to the inlet weir structure can be accomplished from the crest of the dam. A perimeter concrete pad is provided to allow maintenance vehicles to approach the area. The reservoir can be lowered four feet temporarily to access this site.

A.7.5.4.8 Single Barrel Conduit

The cast-in-place single-barrel conduit is rectangular in shape and designed to resist soil loads to the crest of the dam. Construction vehicle loads were also analyzed.

Expansion joints are provided at the intersections of major elements in the spillway. After pre-loading, settlement will be very small and therefore the conduits can be constructed to a final positive downward slope of 2%. A small camber and an expansion joint in the center will be provided.

A.7.5.4.9 Spillway Chute

The spillway chute structure is a cast-in-place U-shaped single-bay rectangular chute that delivers flows to the stilling basin. The walls are outside the dam prism and avoid the need for fall protection.

The spillway chute is not subject to major overturning or flotation instabilities. However, sliding stability is of concern because of the relatively steep angle of the 3:1 slope. The calculated factor of safety is about 1.2 for sliding on random fill. The required factor of safety is 1.70. The downstream stilling basin, however is embedded deep and has ample capacity to resist and carry additional sliding forces from the chute.

A.7.5.4.10 Stilling Basin

The stilling basin is a cast-in-place single-bay rectangular conveyance channel that dissipates most of the discharged water's energy before it reaches the receiving channel. The U-shaped channel walls were designed to resist at-rest lateral saturated soil loads and uplift pressures when dewatered.

At the downstream side, a slab connects the top of the walls to bridge over the structure and allow not only through traffic but also a location from which to install dewatering needles. C43CS-1 is fairly deep and thus a similar slab was continued for a portion of the basin to reduce the moment and shear requirements at the base of the walls.

C43CS-2 is provided with a sheet pile cut-off wall to prevent scouring beneath the slab in the event of failure of the sloping riprap system. C43CS-1 is not provided with sheet pile protection because the downstream channel is flat. A concrete shear key is sufficient.

Flotation stability of the stilling basins was computed and found to require the receiving canal water surface be set no higher than the NWL in order to safely dewater the stilling basin. C43CS-1 is deeper and therefore has an increased ability to resist flotation with higher canal levels in the Townsend. The dewatered basins can be accessed from the perimeter toe road. A portable ladder can be lowered into the basin slab if there is a need to access the inside.

Sliding stability of the basin was checked for water loading on the baffle blocks in the case of C43CS-2. A hydrostatic lateral pressure corresponding to the fluid energy grade line was used to compute the driving lateral force in lieu of a more detailed method of analysis. The basin was found to have ample resistance against sliding instabilities. C43CS-1 does not have baffle blocks.

A manatee structure, S-484, will be installed near the mouth of the Townsend Canal to prevent manatee access to C-43PS-1. The concrete structure consists of a pile foundation with trash rake and screens of sufficient coverage to not allow harm to manatees.

A.7.5.4.11 Structure Nomenclature

The structures numbers as described in this PIR document will be revised to reflect standard CERP naming conventions. All future documents going forward will reference the new names/numbers shown in ***Table A-17***.

TABLE A-17: STRUCTURE NOMENCLATURE

OLD NAME	NEW NAME	TYPE	FUNCTION and/or DESCRIPTION	Discharge
	470-485			
Old	**Final**			
		Embankments		
	D-470	Dam Embankment	C-43 West Basin Reservoir Perimeter Embankment	
	D-470I	Dam Embankment	C-43 West Basin Reservoir Interior Embankment	
		Canals		
	C-470	Perimeter Canal	C-43 West Basin Reservoir Perimeter Canal	
		Structures		
C43PS-1	S-470	Pump Station	from Townsend Canal to Cell 1 of reservoir	1500
C43S-1	S-471	Discharge Structure	from Cell 1 of reservoir to Perimeter Canal	
C43CS-1	S-472	Emergency Spillway	from Cell 1 of reservoir to Townsend Canal	
C43S-8	S-473	Discharge Structure	from Cell 2 of reservoir to Perimeter Canal	
C43CS-2	S-474	Emergency Spillway	from Cell 2 of reservoir to Perimeter Canal	
C43S-12	S-475	Discharge Structure	cell balancing structure between Cell 1 and 2 of reservoir	
C43PS-4	S-476	Pump Station	Townsend Canal to Perimeter Canal	150+
C43S-3	S-477	Gated Culverts	flow regulation around Perimeter Canal (southeast corner of Cell 2)	
C43S-15	S-478	Gated Culverts	conveys flows from Roberts Canal to Perimeter Canal	
C43S-14	S-479	Gated Culvert	connects Header Canal with Perimeter Canal	
C43S-7	S-480	Gated Culverts	connects Banana Branch Canal with Perimeter Canal	
C43S-9	S-481	Gated Culverts	connects Fort Simmons Canal with Perimeter Canal	
C43S-10	S-482	Gated Spillway	flow regulation around Perimeter Canal (north and middle of Cell 1 northern perimeter)	
C43S-11	S-483	Gated Spillway	flow regulation around Perimeter Canal (northwestern corner of Cell 1)	
	S-484	**Available**	Manatee Structure	
	S-485	**Available**		

A.8 REFERENCES

Hunter, M.E., 1968, Molluscan guide fossils in Late Miocene sediments of southern Florida: Gulf Coast Association of Geological Societies Transactions, v. 18, p. 439-450.

Missimer, T.M., 1984, The geology of South Florida: A summary: in Gleason, P.J., (ed.), Environments of South Florida, present and past II: Miami Geological Society Memoir 2, p. 385-404.

Sproul, C.R., Boggess, D.H., and Woodard, H.J., 1972, Saline-water intrusion from deep artesian sources in the McGregor Isles area of Lee County, Florida: Florida Bureau of Geology Information Circular 75, 30 p.

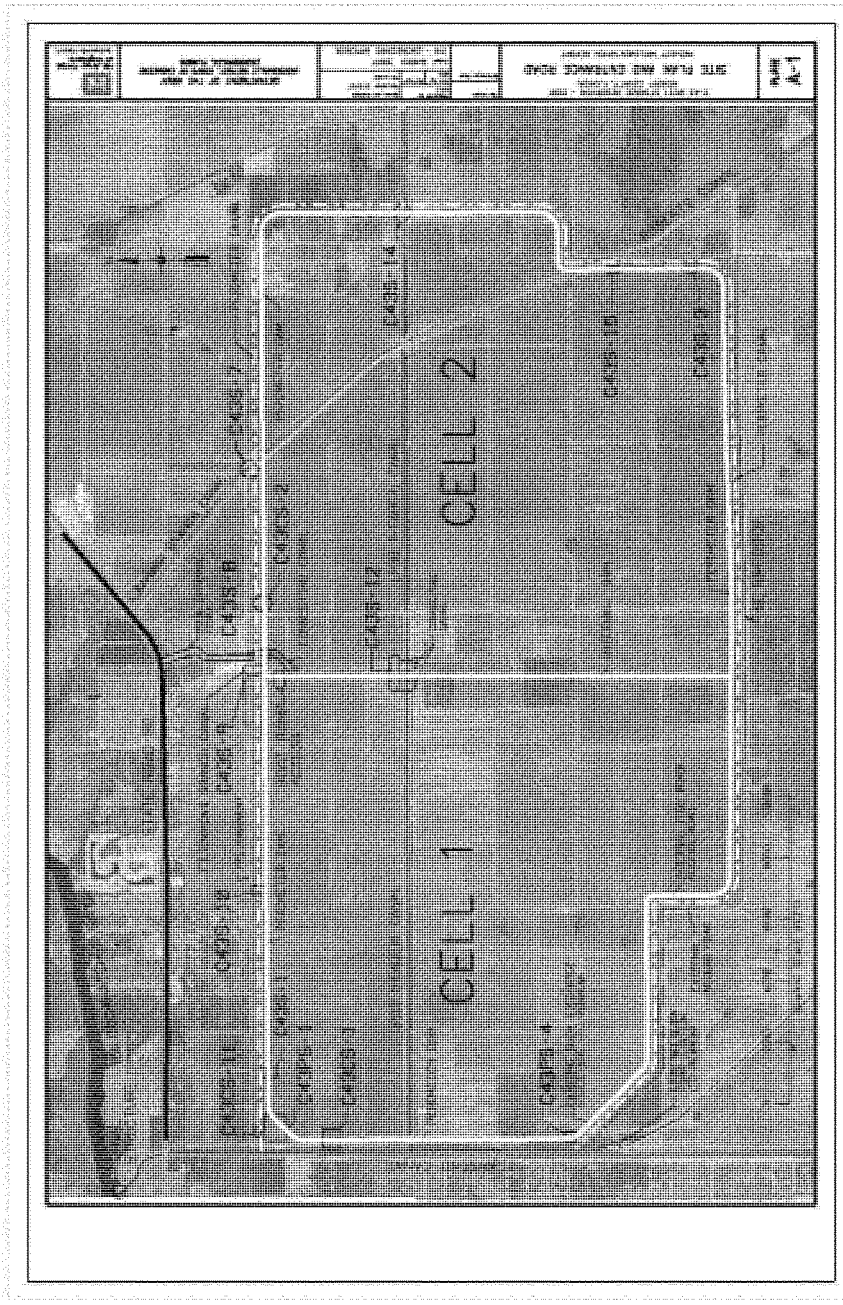
Engineering Manuals (EM), U.S. Army Corps of Engineers

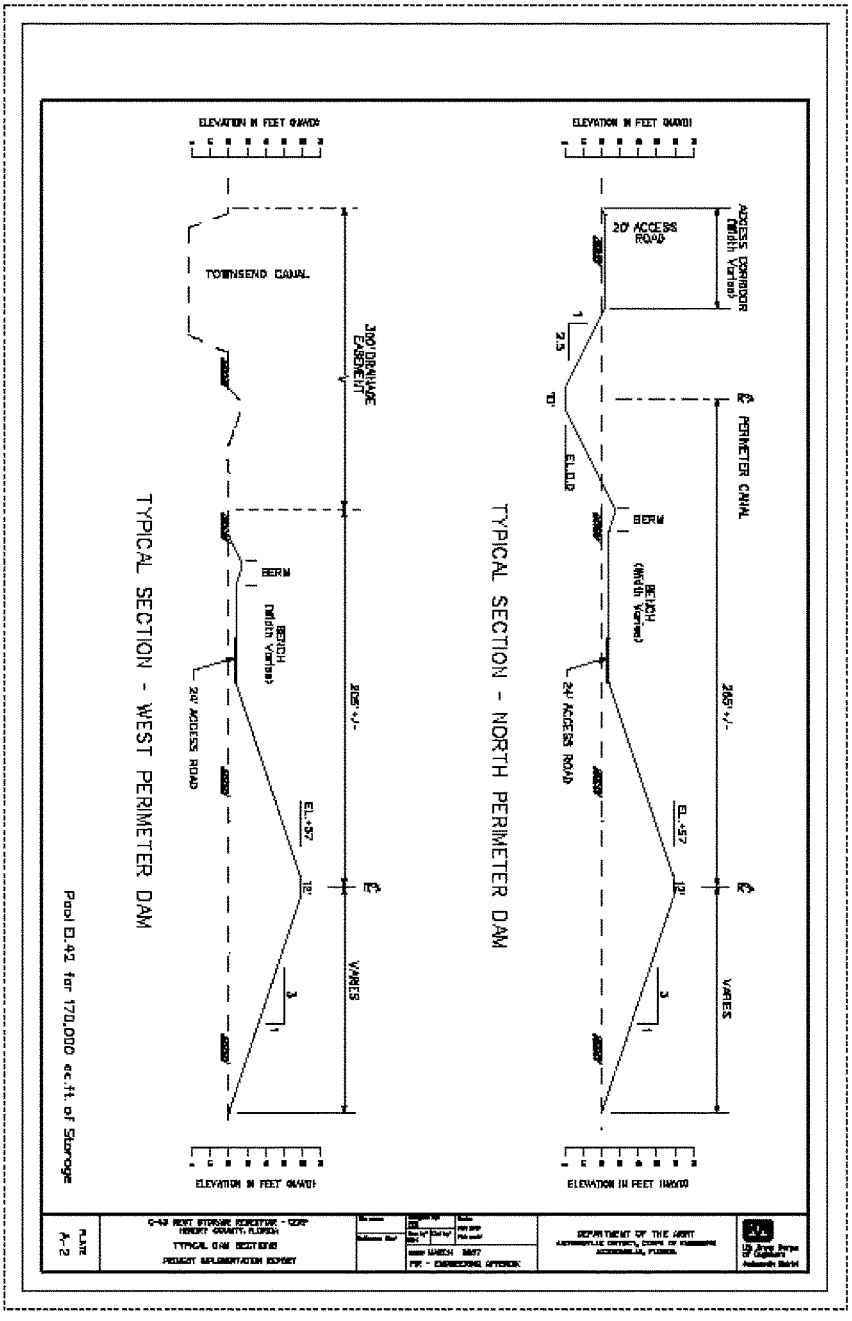
1. EM 1110-2-3102, General Principles of Pumping Station Design and Layout
2. EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations

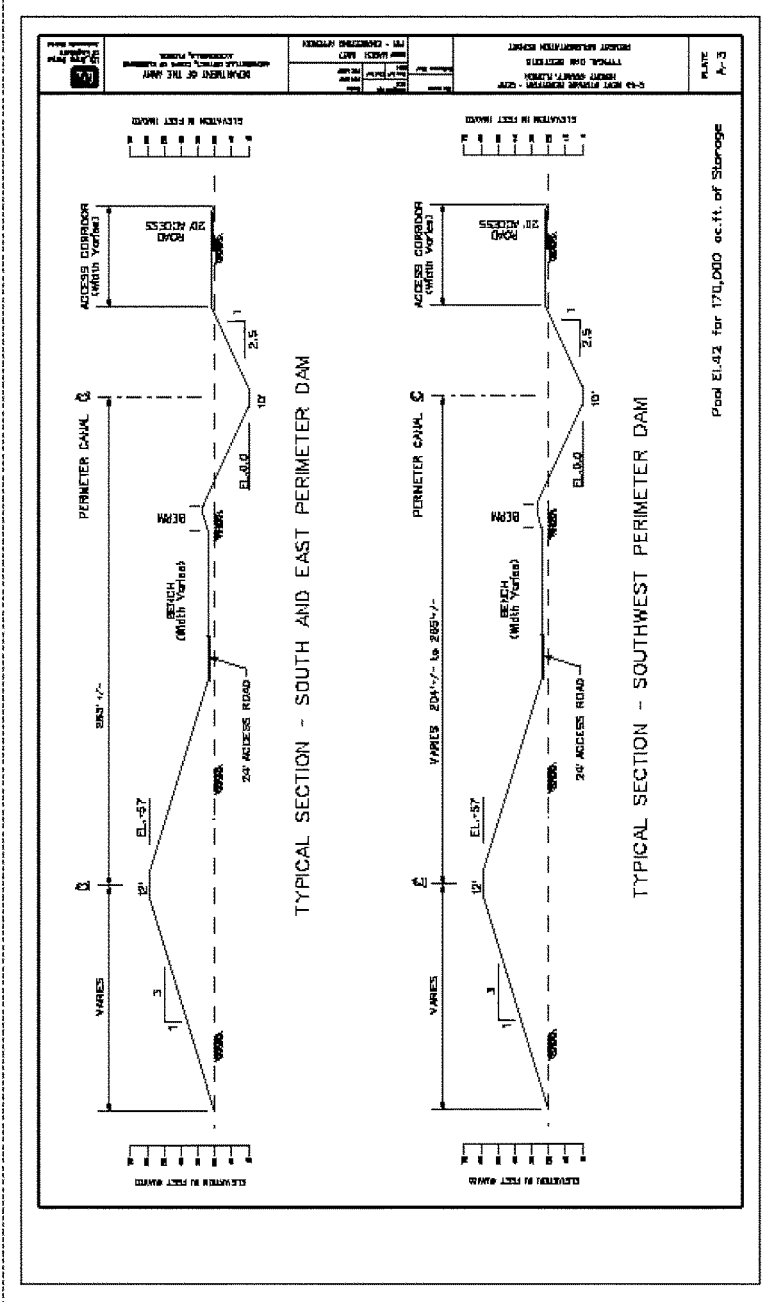
A.9 ENGINEERING PLATES

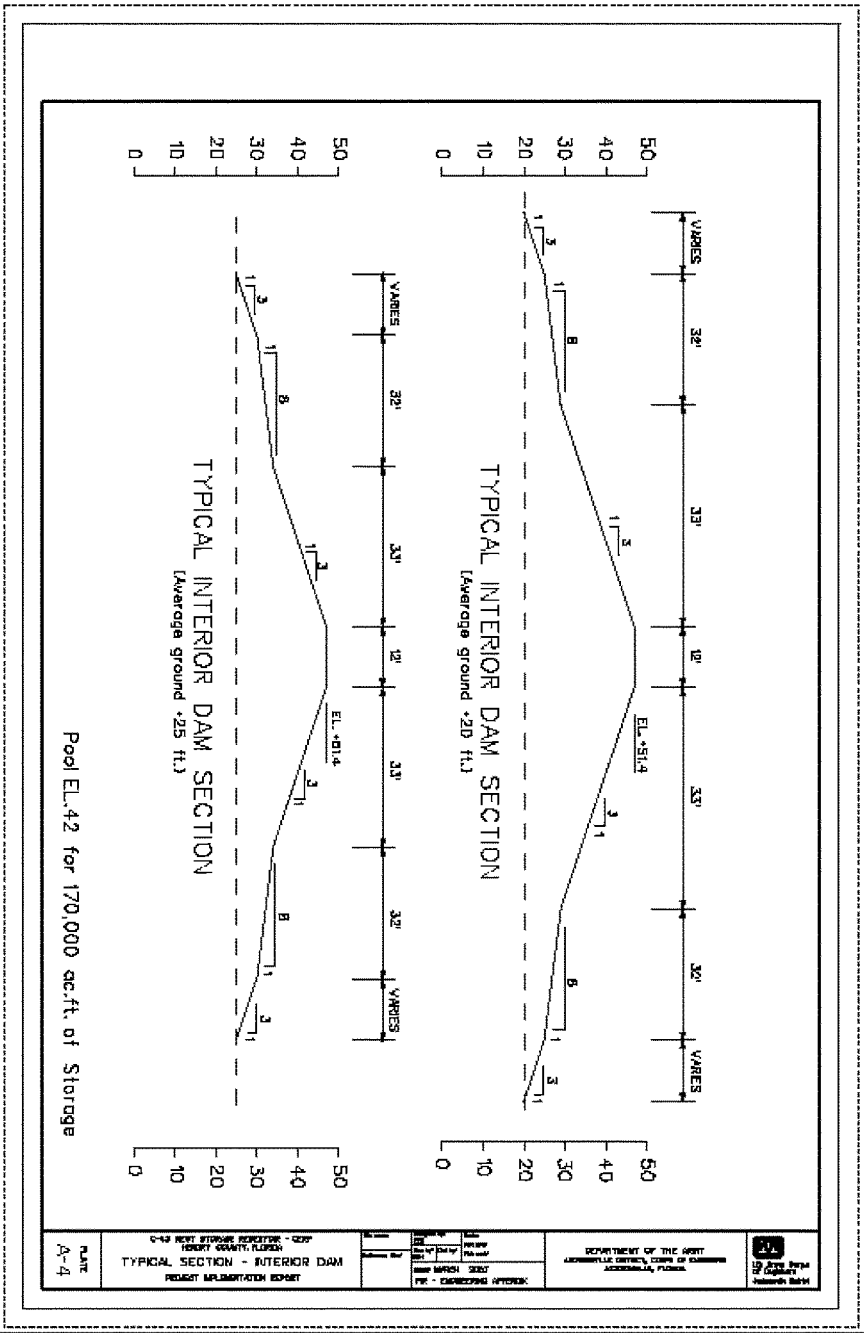
Index to Plates

Plate No.	Plate Title
General/Civil/Site Design	
A-1	Site Plan and Entrance Road
A-2	Typical Dam Sections (North and West Perimeter)
A-3	Typical Dam Sections (South/East/Southwest Perimeter)
A-4	Typical Section–Interior Dam
A-5	Entrance Road Plan and Profile
A-6	Entrance Road from SR80
A-7	Entrance Road from SR80 (continuation)
A-8	Entrance Road from SR80–Typical Section
A-9	Bridge Modification
Mechanical	
M-1	1500 cfs Pump Station Plan
M-2	Large Sized Pumping Station Section
M-3	Spillway Vertical Lift Gate – Overhead Type
Electrical	
E-01	Large Pump Station-Single Line Diagram
E-02	Large Pump Station Motor Control Center-Single Line Diagram
E-03	Large Pump Station Engine Control Center MCC Single Line
E-04	Large Pump Station Engine Control Center
E-05	Large Pump Station Engine Pump Control Diagram
E-06	Large Pump Station SCADA System Diagram
E-07	Small Pump Station–Single Line Diagram
E-08	Small Size Pump Station Electric Motor Controls
E-09	Small Pump Station SCADA Control Diagram
E-10	Gated Spillway/Culvert/Tunnel-Single Line Diagram


CELL 2
CELL 1


TYPICAL SECTION - WEST PERIMETER DAM
TYPICAL SECTION - NORTH PERIMETER DAM
TOWNSEND CANAL
100' DRAINAGE EASEMENT
BERM
BENCH (Width Varies)
20' ACCESS ROAD
EL.+57
12'
VARIES
265'+/-
PERIMETER CANAL
ACCESS CORRIDOR (Width Varies)
24' ACCESS ROAD
ELEVATION IN FEET (NAVD)
Pool El.42 for 170,000 ac.ft. of Storage
PLATE A-2
TYPICAL DAM SECTIONS
PROJECT IMPLEMENTATION REPORT
DEPARTMENT OF THE ARMY


TYPICAL SECTION - SOUTH AND EAST PERIMETER DAM
TYPICAL SECTION - SOUTHWEST PERIMETER DAM
PERIMETER CANAL
ACCESS CORRIDOR (Width Varies)
20' ACCESS ROAD
BERM
BENCH (Width Varies)
24' ACCESS ROAD
VARIES
EL.+57'
EL.0.0
Pool El.42 for 170,000 ac.ft. of Storage


TYPICAL INTERIOR DAM SECTION
(Average ground +20 ft.)
EL. +51.4
VARIES
32'
33'
12'
33'
32'
VARIES
TYPICAL INTERIOR DAM SECTION
(Average ground +25 ft.)
EL. +61.4
VARIES
32'
33'
12'
33'
32'
VARIES
Pool EL.42 for 170,000 ac.ft. of Storage
TYPICAL SECTION - INTERIOR DAM
PLATE
A-4

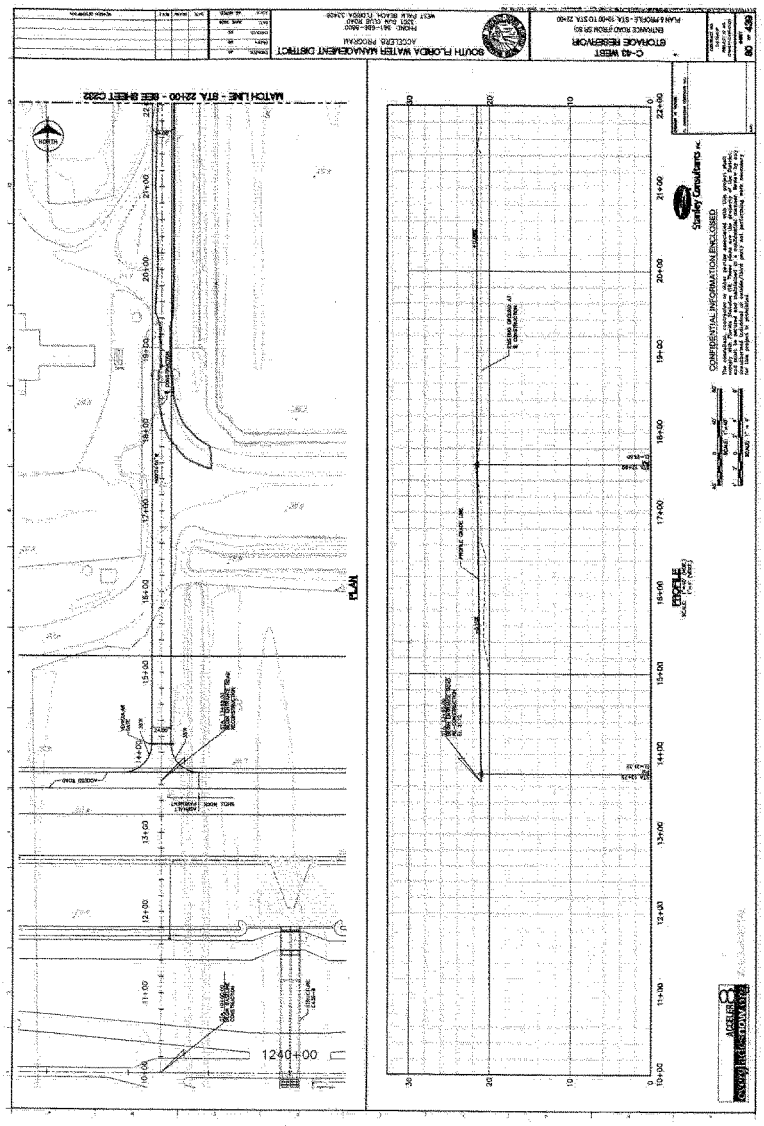


PLATE A-5

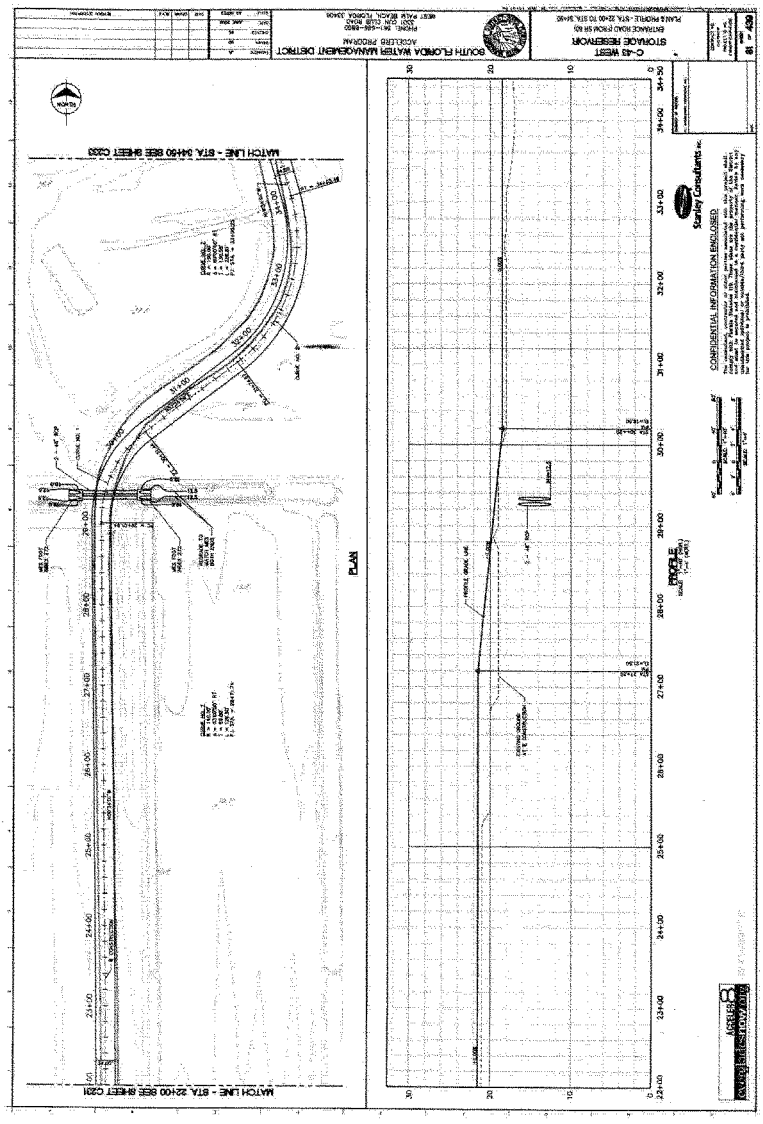


PLATE A-6

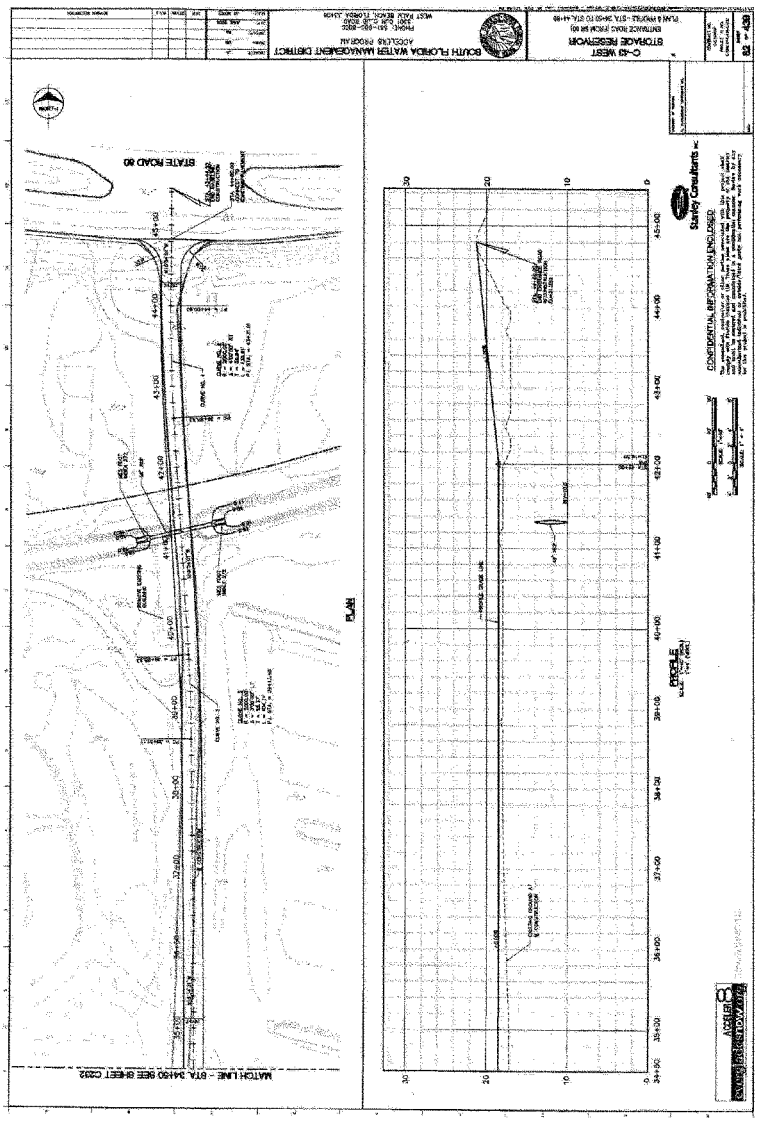

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
C-43 WEST
STORAGE RESERVOIR
ACCESS ROAD PLAN
PLAN & PROFILE - STA 34+50 TO STA 44+50
PLAN
PROFILE
STATE ROAD 80
MATCH LINE - STA 34+50 SEE SHEET C2202
Stanley Consultants
CONFIDENTIAL INFORMATION ENCLOSED

PLATE A-7

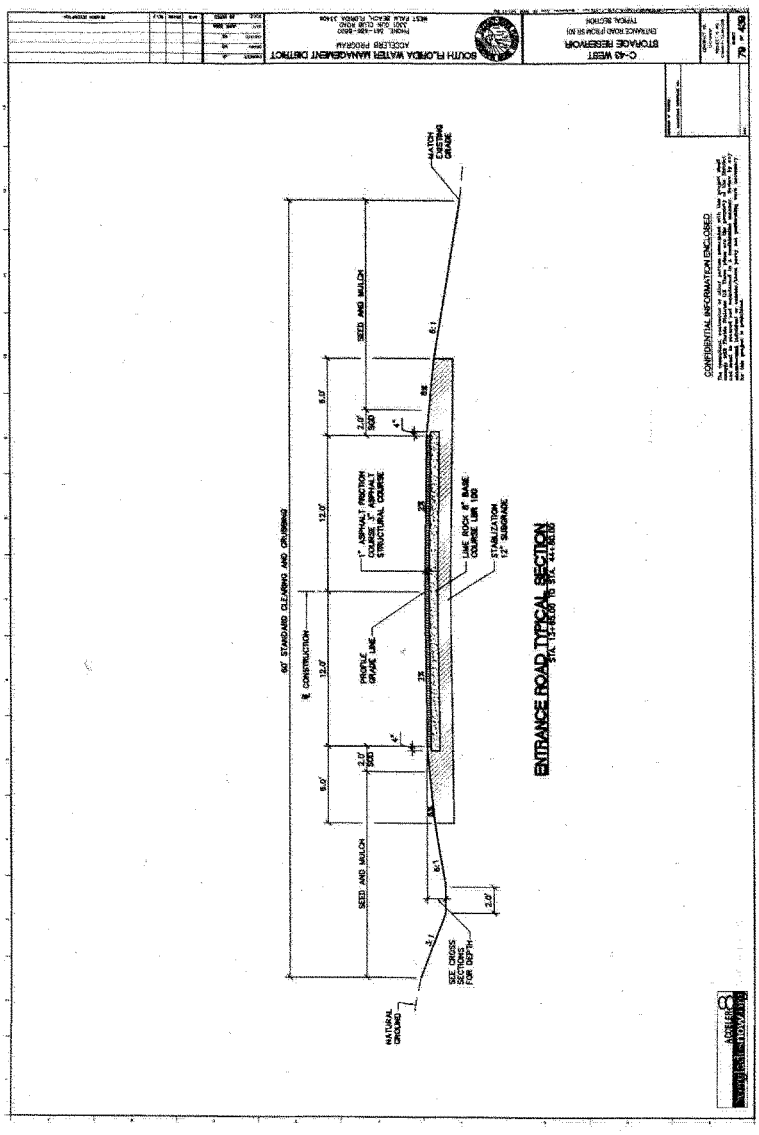
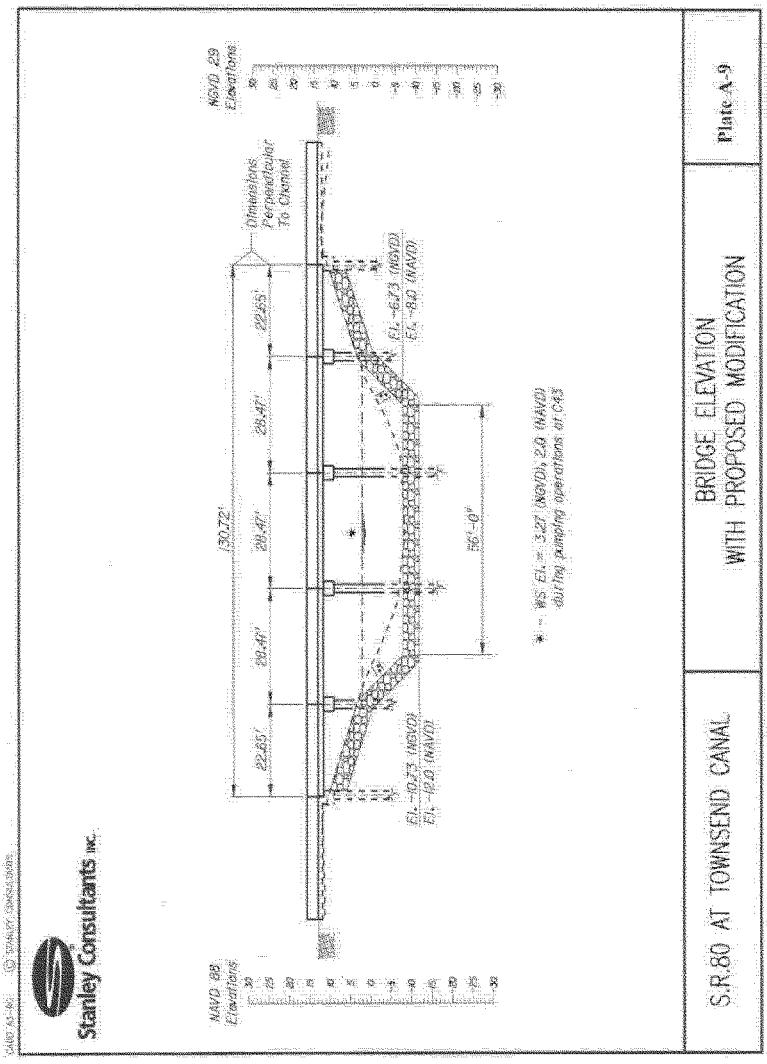
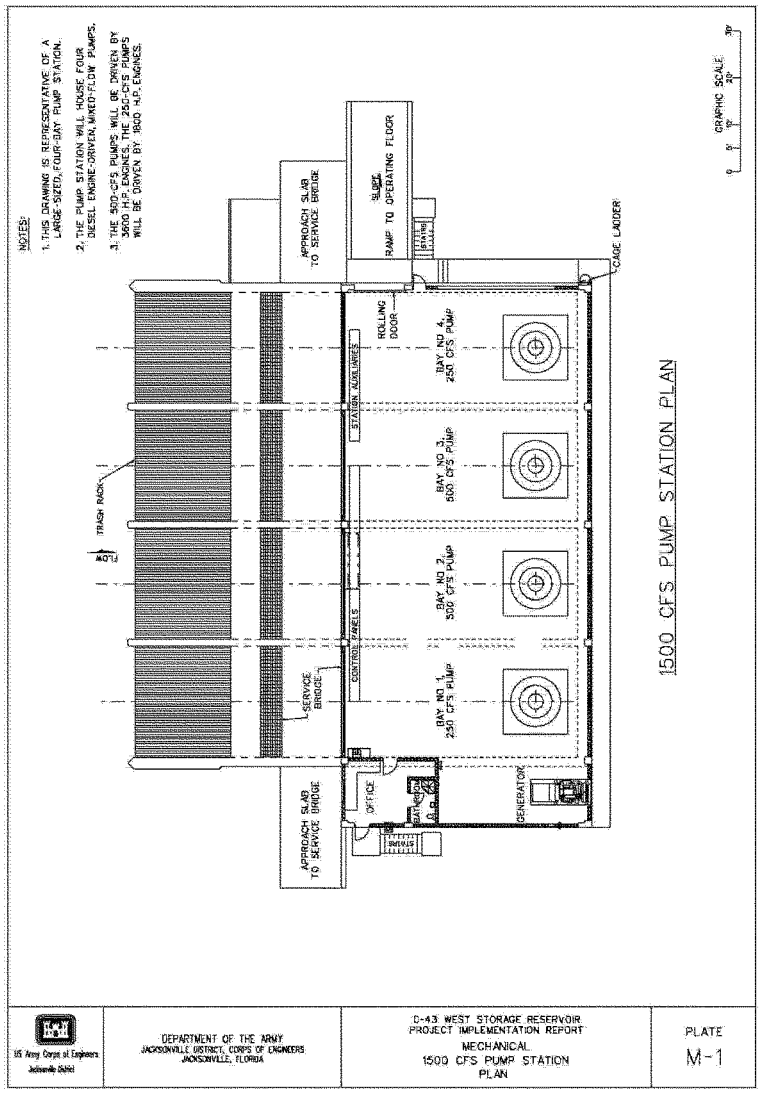
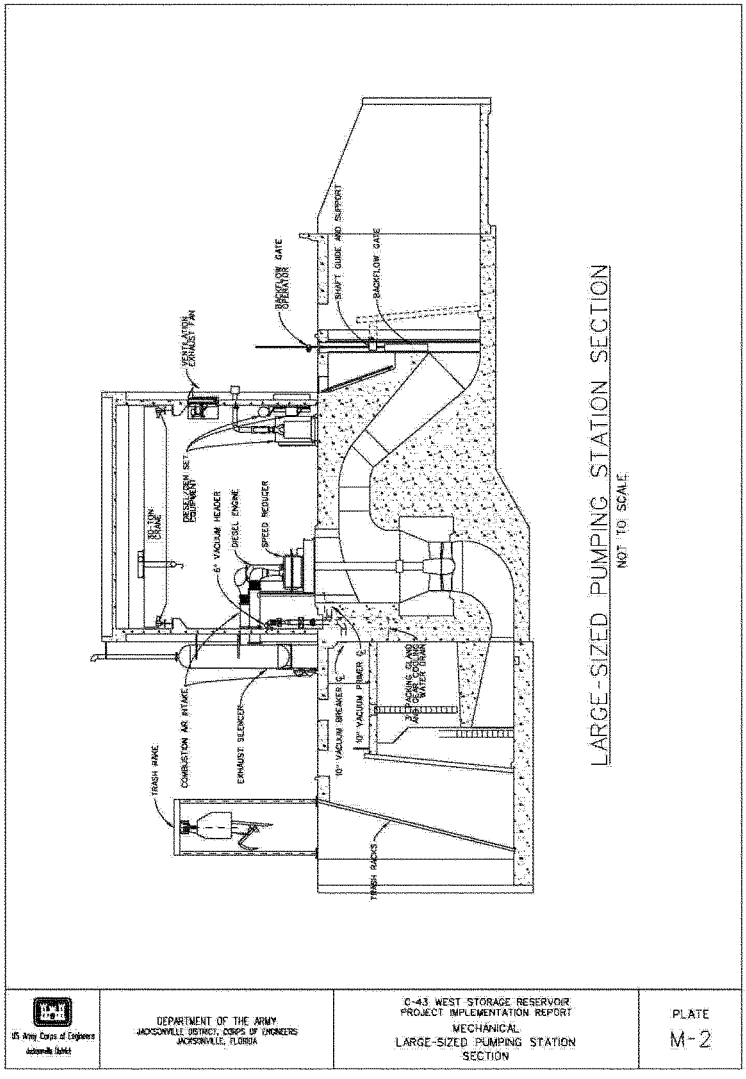
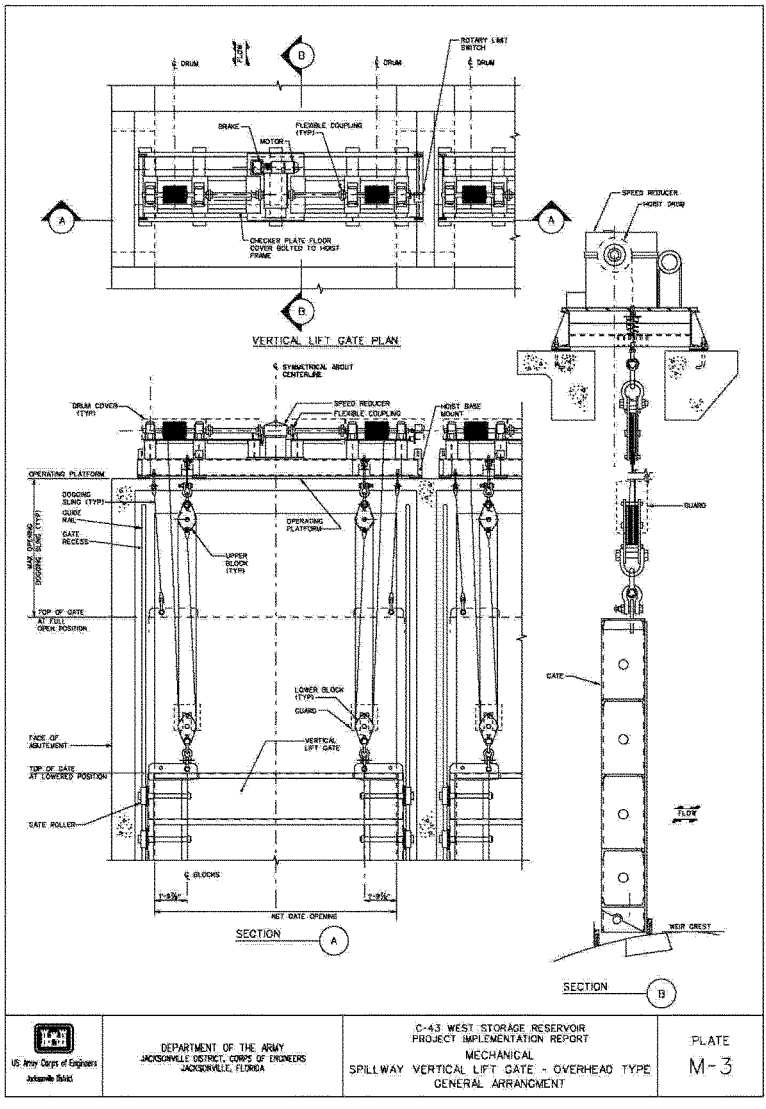

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
C-43 WEST
ENTRANCE ROAD TYPICAL SECTION
CONFIDENTIAL INFORMATION ENCLOSED
ENTRANCE ROAD TYPICAL SECTION
SEED AND MULCH
SOD
1" ASPHALT FRICTION COURSE 3" ASPHALT STRUCTURAL COURSE
LIME ROCK 6" BASE COURSE LBR 100
STABILIZATION 12" SUBGRADE
PROFILE GRADE LINE
60' STANDARD CLEARING AND GRUBBING
CONSTRUCTION
EXISTING GRADE
NATURAL GROUND
SEE CROSS SECTIONS FOR DEPTH

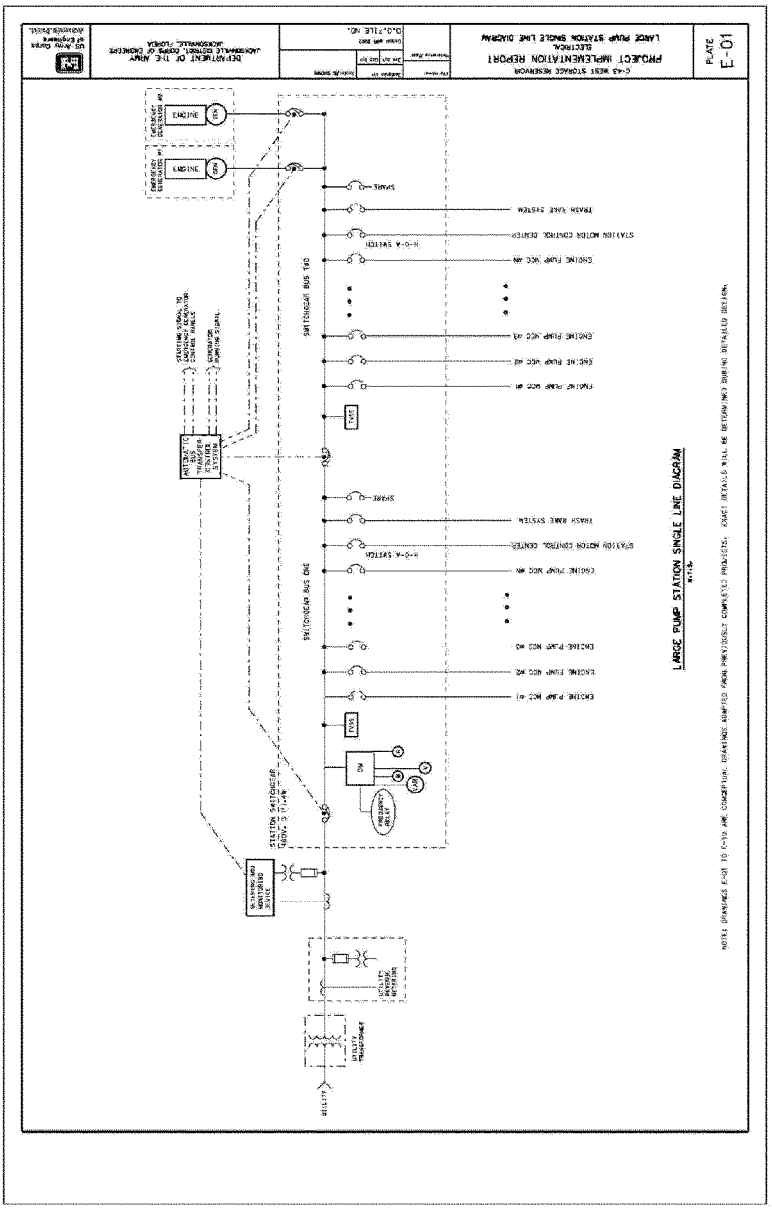
PLATE A-8

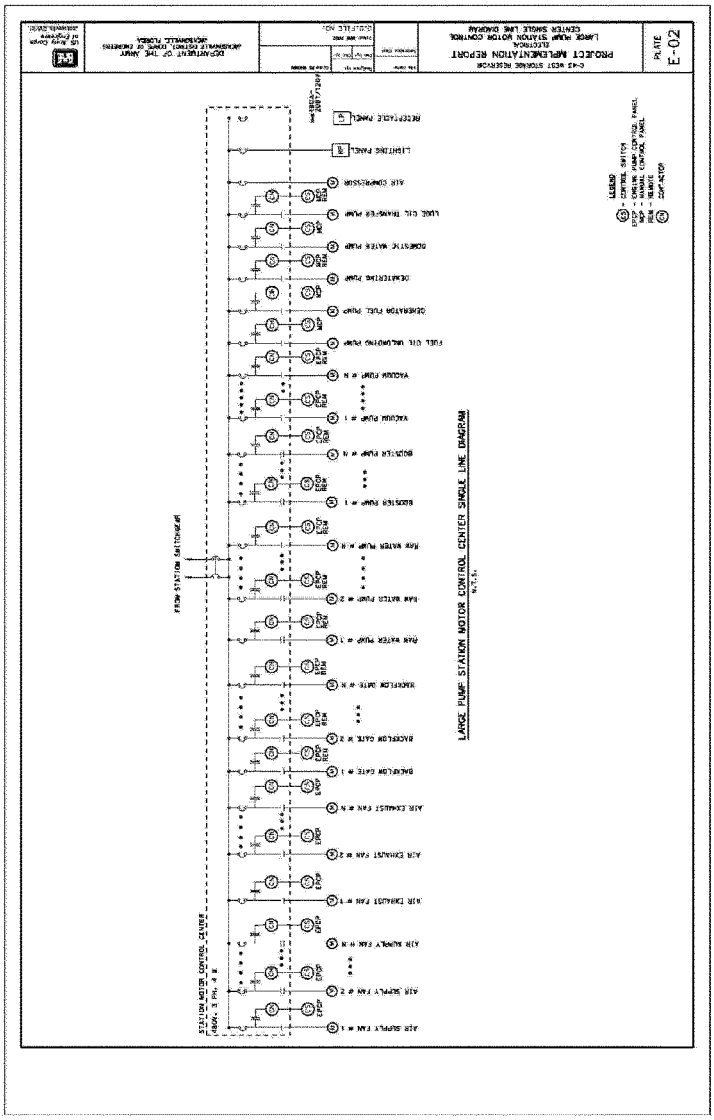

Stanley Consultants INC.
NAVD 88 Elevations
NGVD 29 Elevations
Dimensions Perpendicular To Channel
130.72'
22.65'
28.41'
28.41'
28.41'
22.65'
28.41'
156'-0"
EL. -10.73 (NGVD)
EL. -12.0 (NAVD)
EL. -6.73 (NGVD)
EL. -8.0 (NAVD)
* - WS EL. = 3.27 (NGVD) 2.0 (NAVD) during pumping operations at C-43
S.R.80 AT TOWNSEND CANAL
BRIDGE ELEVATION
WITH PROPOSED MODIFICATION
Plate A-9

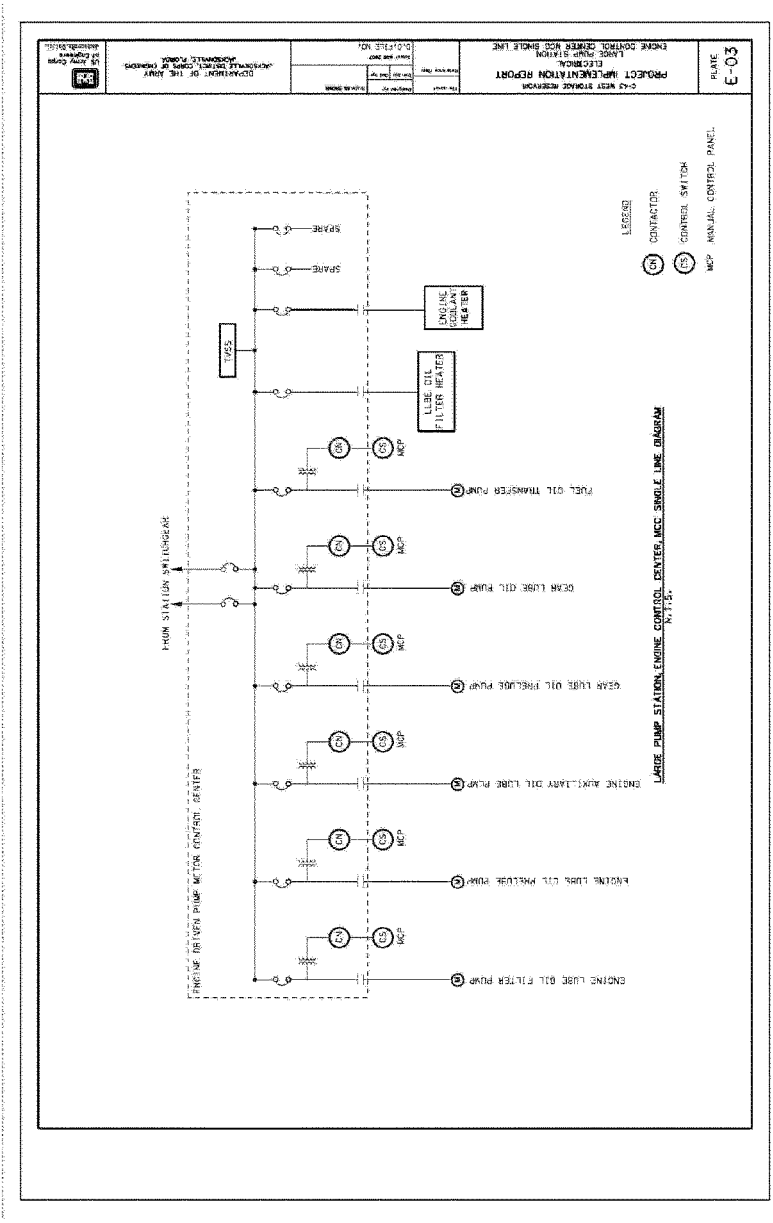

NOTES:
1. THIS DRAWING IS REPRESENTATIVE OF A LARGE-SIZED, FOUR-BAY PUMP STATION.
2. THE PUMP STATION WILL HOUSE FOUR DIESEL ENGINE-DRIVEN, MIXED-FLOW PUMPS.
3. THE 500-CFS PUMPS WILL BE DRIVEN BY 3600 H.P. ENGINES, THE 250-CFS PUMPS WILL BE DRIVEN BY 1800 H.P. ENGINES.
GRAPHIC SCALE
APPROACH SLAB TO SERVICE BRIDGE
SLOPE RAMP TO OPERATING FLOOR
CAGE LADDER
ROLLING DOOR
STATION AUXILIARIES
BAY NO 4, 250 CFS PUMP
BAY NO 3, 500 CFS PUMP
BAY NO 2, 500 CFS PUMP
BAY NO 1, 250 CFS PUMP
TRASH RACK
SERVICE BRIDGE
CONTROL PANELS
OFFICE
GENERATOR
APPROACH SLAB TO SERVICE BRIDGE
1500 CFS PUMP STATION PLAN
US Army Corps of Engineers
Jacksonville District
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
C-43 WEST STORAGE RESERVOIR
PROJECT IMPLEMENTATION REPORT
MECHANICAL
1500 CFS PUMP STATION
PLAN
PLATE
M-1

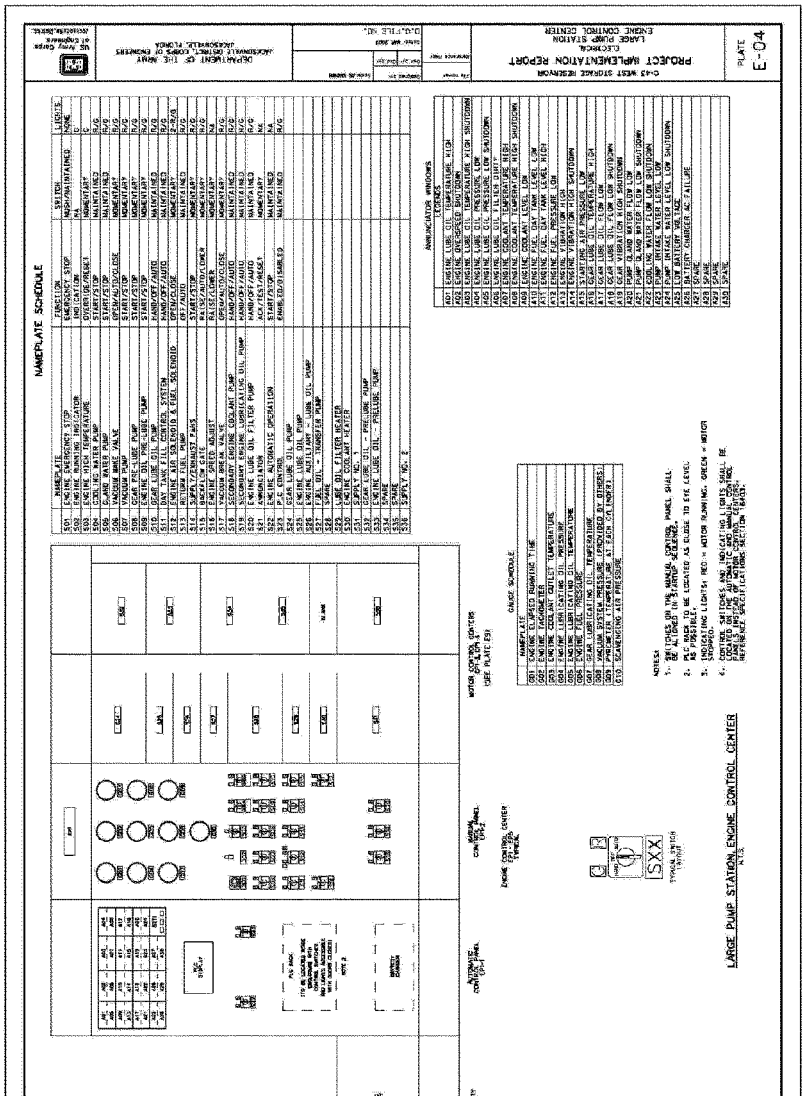

LARGE-SIZED PUMPING STATION SECTION
NOT TO SCALE
BACKFLOW GATE OPERATOR
SHAFT GUIDE AND SUPPORT
BACKFLOW GATE
VENTILATION EXHAUST FAN
DESELCHEN SET EQUIPMENT
30-TON CRANE
6" VACUUM HEADER
DIESEL ENGINE
SPEED REDUCER
COMBUSTION AIR INTAKE
EXHAUST SILENCER
TRASH RAKE
10" VACUUM BREAKER
10" VACUUM PRIMER
PACKING GLAND COOLING WATER SUPPLY
TRASH RACKS
US Army Corps of Engineers
Jacksonville District
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
C-43 WEST STORAGE RESERVOIR
PROJECT IMPLEMENTATION REPORT
MECHANICAL
LARGE-SIZED PUMPING STATION
SECTION
PLATE
M-2

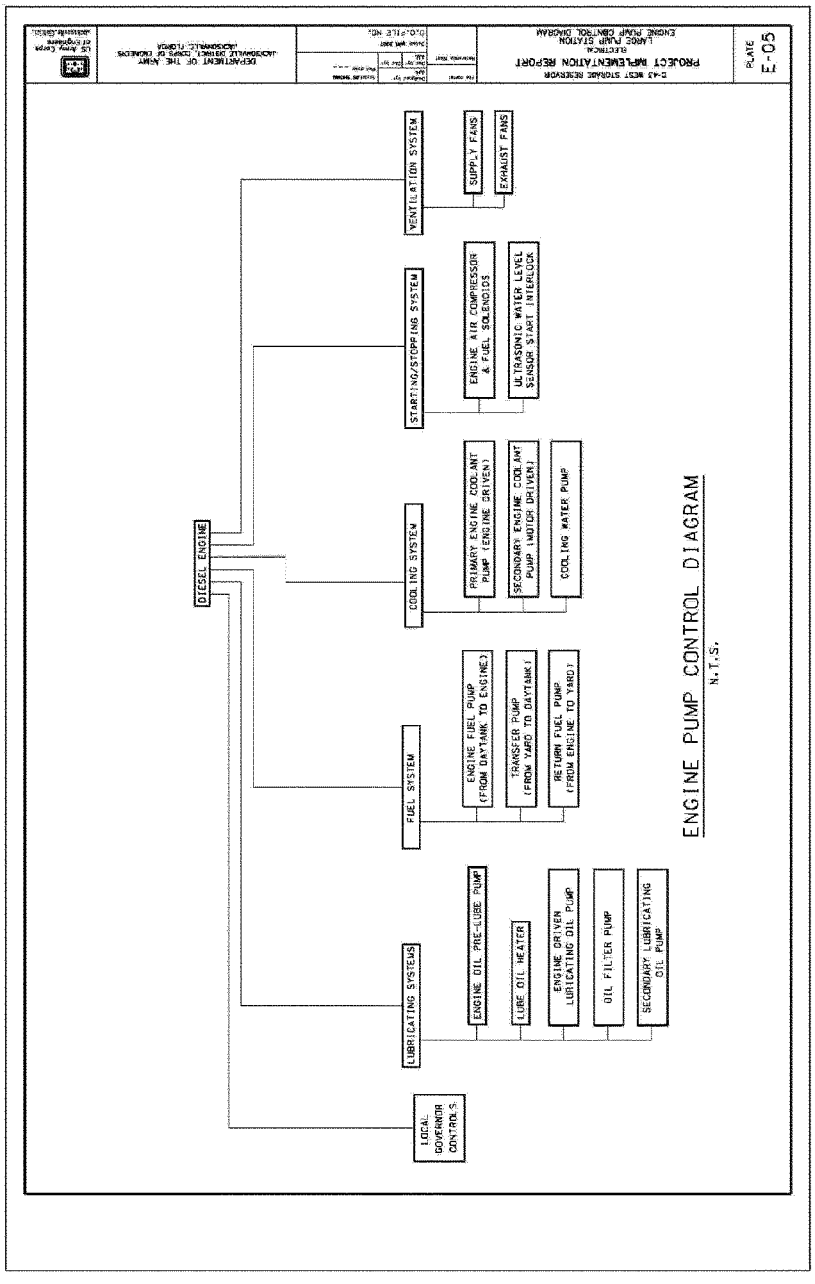

VERTICAL LIFT GATE PLAN
SECTION A
SECTION B
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
US Army Corps of Engineers
C-43 WEST STORAGE RESERVOIR
PROJECT IMPLEMENTATION REPORT
MECHANICAL
SPILLWAY VERTICAL LIFT GATE - OVERHEAD TYPE
GENERAL ARRANGMENT
PLATE
M-3

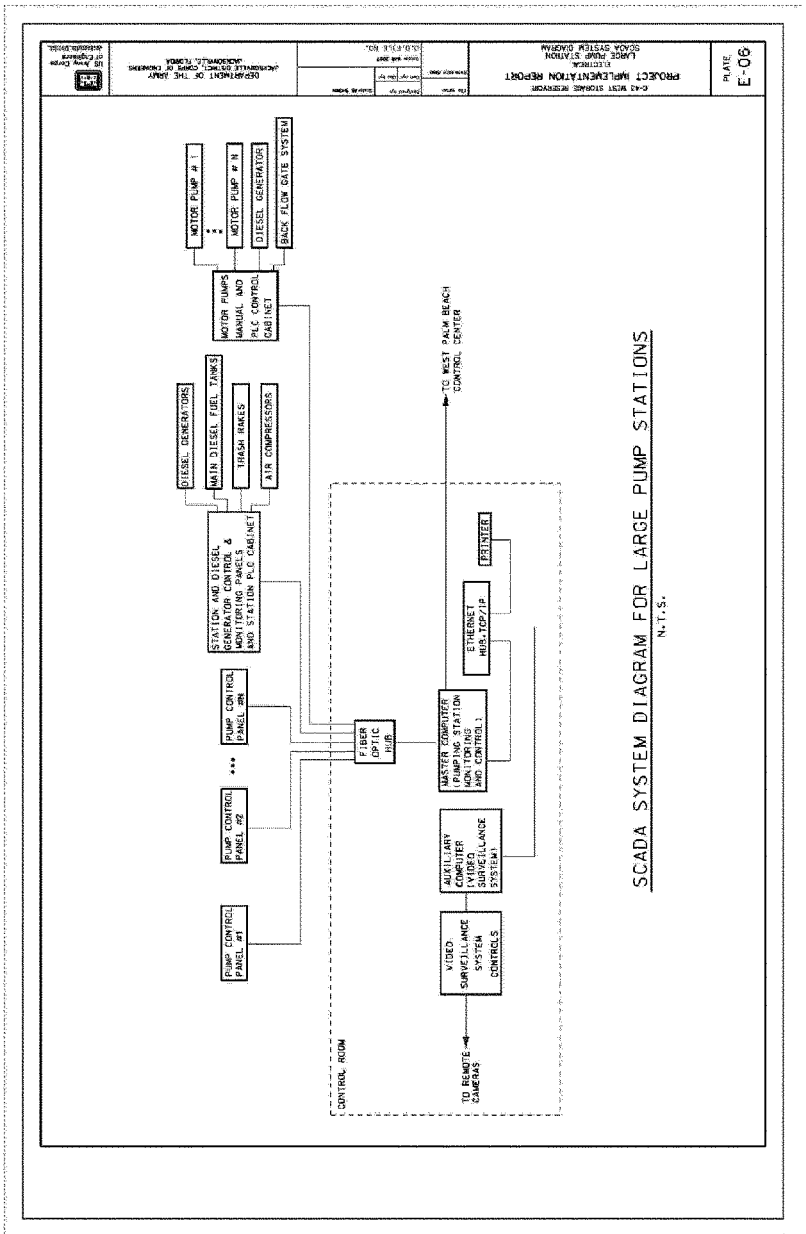

PLATE
E-01
LARGE PUMP STATION SINGLE LINE DIAGRAM

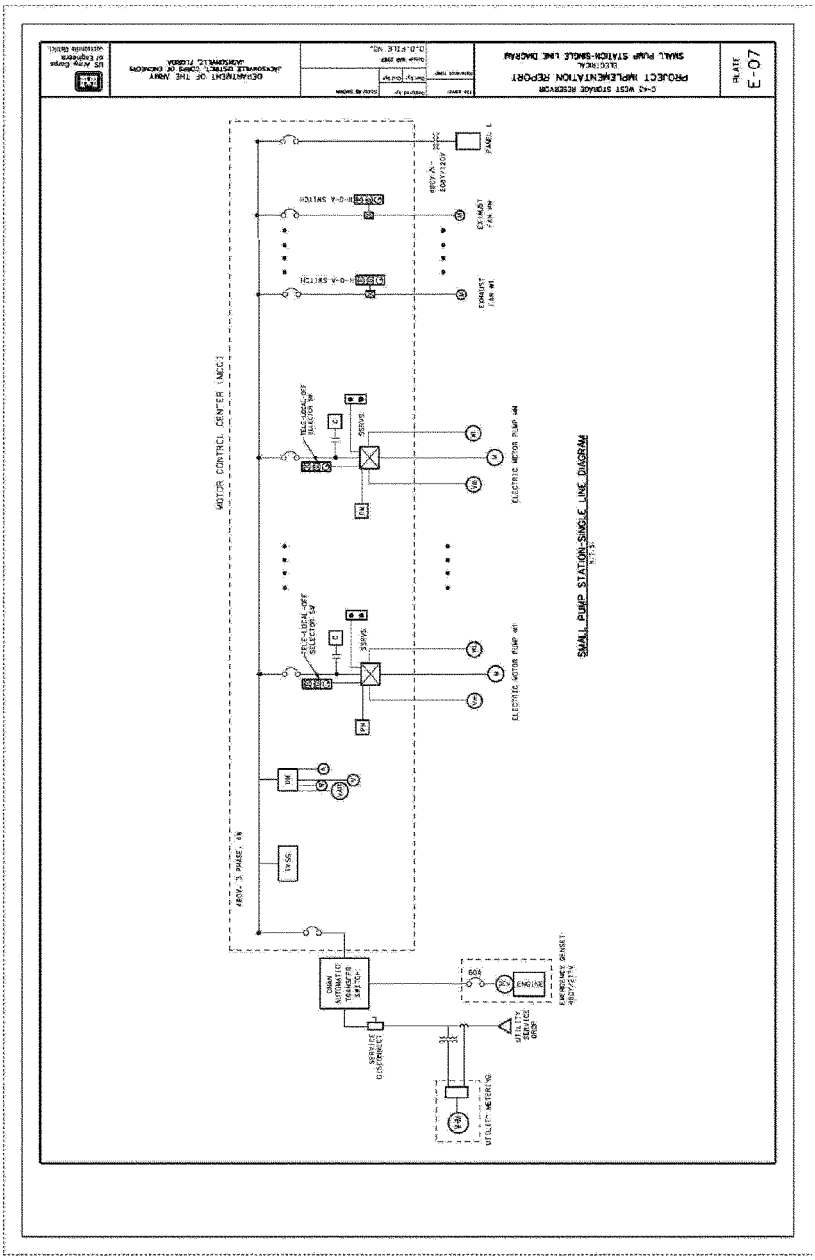

PLATE
E-02
PROJECT IMPLEMENTATION REPORT
LARGE PUMP STATION MOTOR CONTROL
CENTER SINGLE LINE DIAGRAM
LARGE PUMP STATION MOTOR CONTROL CENTER SINGLE LINE DIAGRAM
LEGEND
FROM STATION MOTOR CONTROL CENTER

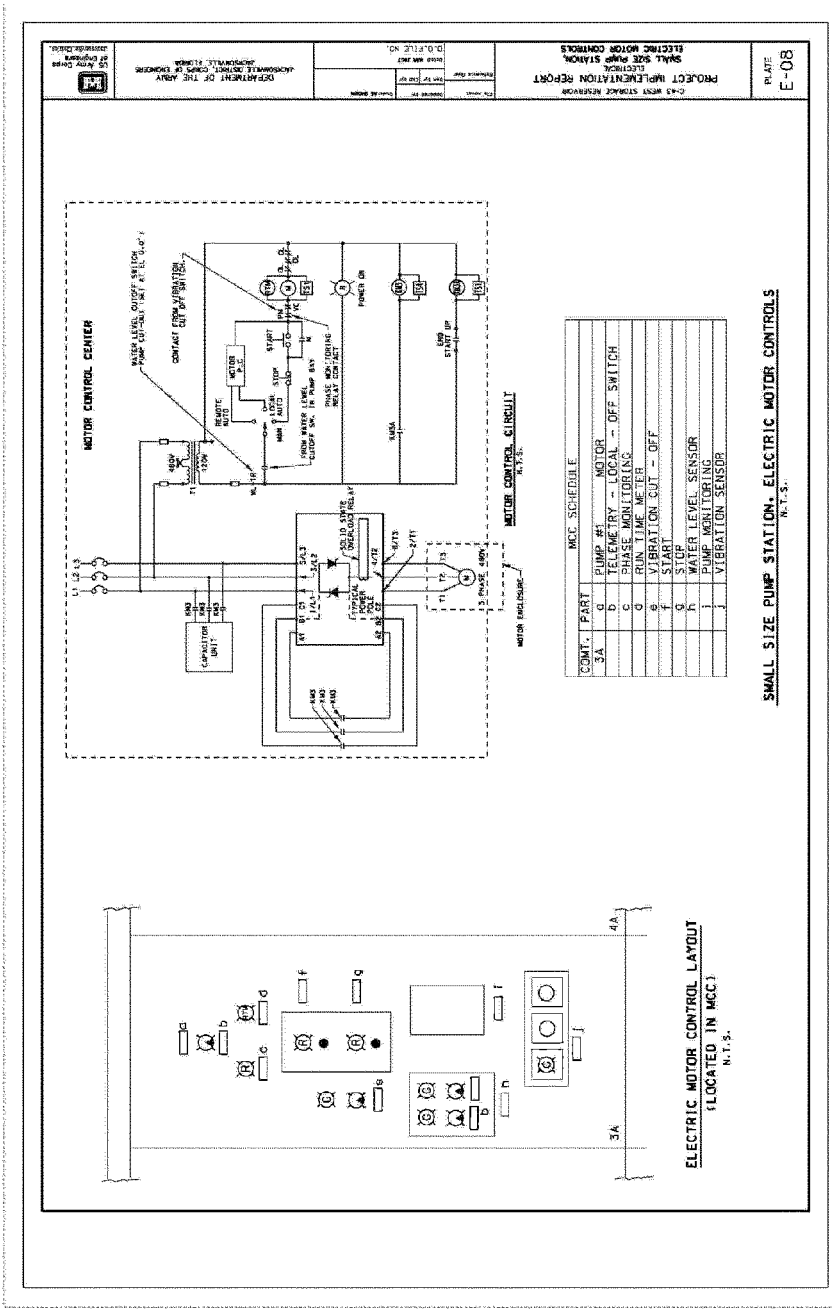

PLATE E-03
C-43 WEST STORAGE RESERVOIR
PROJECT IMPLEMENTATION REPORT
ELECTRICAL
LARGE PUMP STATION
ENGINE CONTROL CENTER MCC SINGLE LINE
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DRAWING NO.
LEGEND
CONTACTOR
CONTROL SWITCH
MCP MANUAL CONTROL PANEL
LARGE PUMP STATION, ENGINE CONTROL CENTER, MCC, SINGLE LINE DIAGRAM
N.T.S.
MAIN STATION SWITCHGEAR
ENGINE DRIVEN PUMP MOTOR CONTROL CENTER
SPARE
SPARE
ENGINE COOLANT HEATER
LUBE OIL FILTER HEATER
TYP.5
FUEL OIL TRANSFER PUMP
GEAR LUBE OIL PUMP
GEAR LUBE OIL PRELUBE PUMP
ENGINE AUXILIARY OIL LUBE PUMP
ENGINE LUBE OIL PRELUBE PUMP
ENGINE LUBE OIL FILTER PUMP

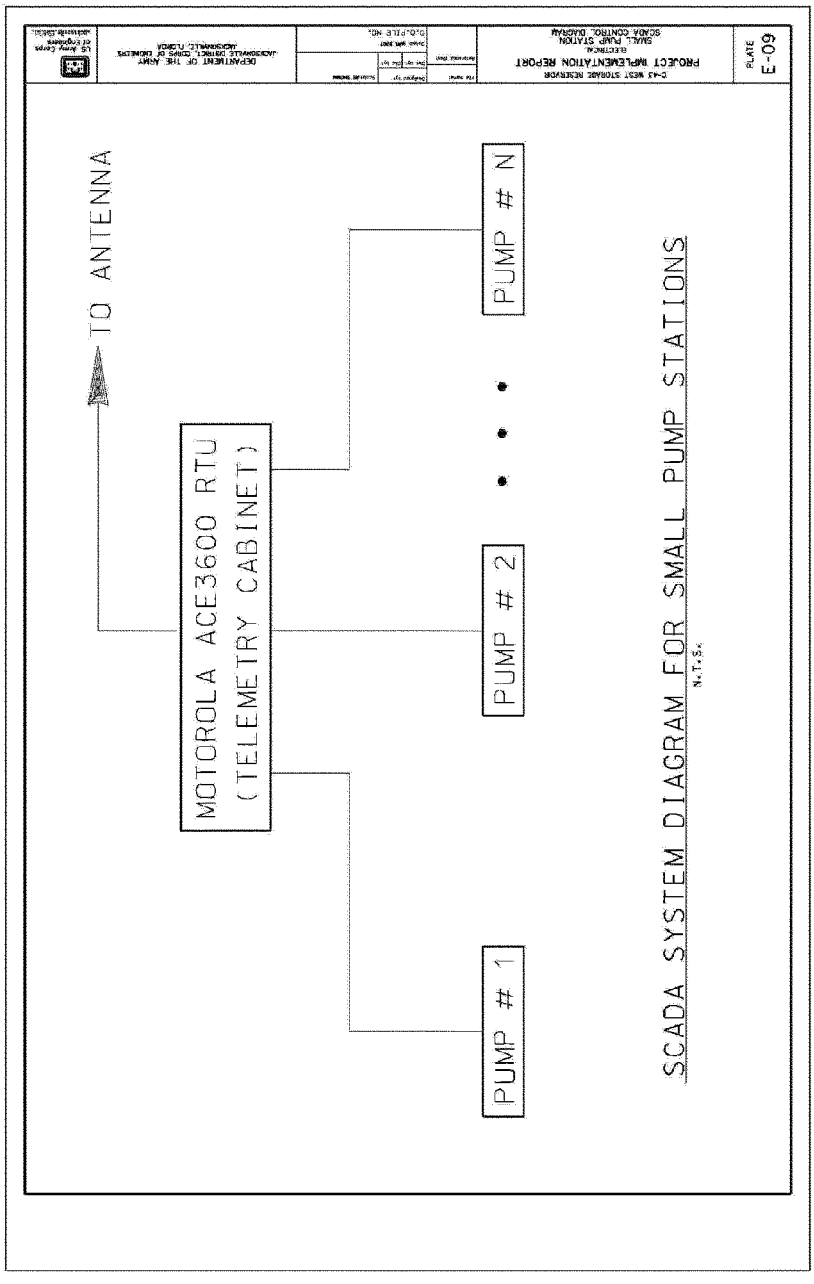


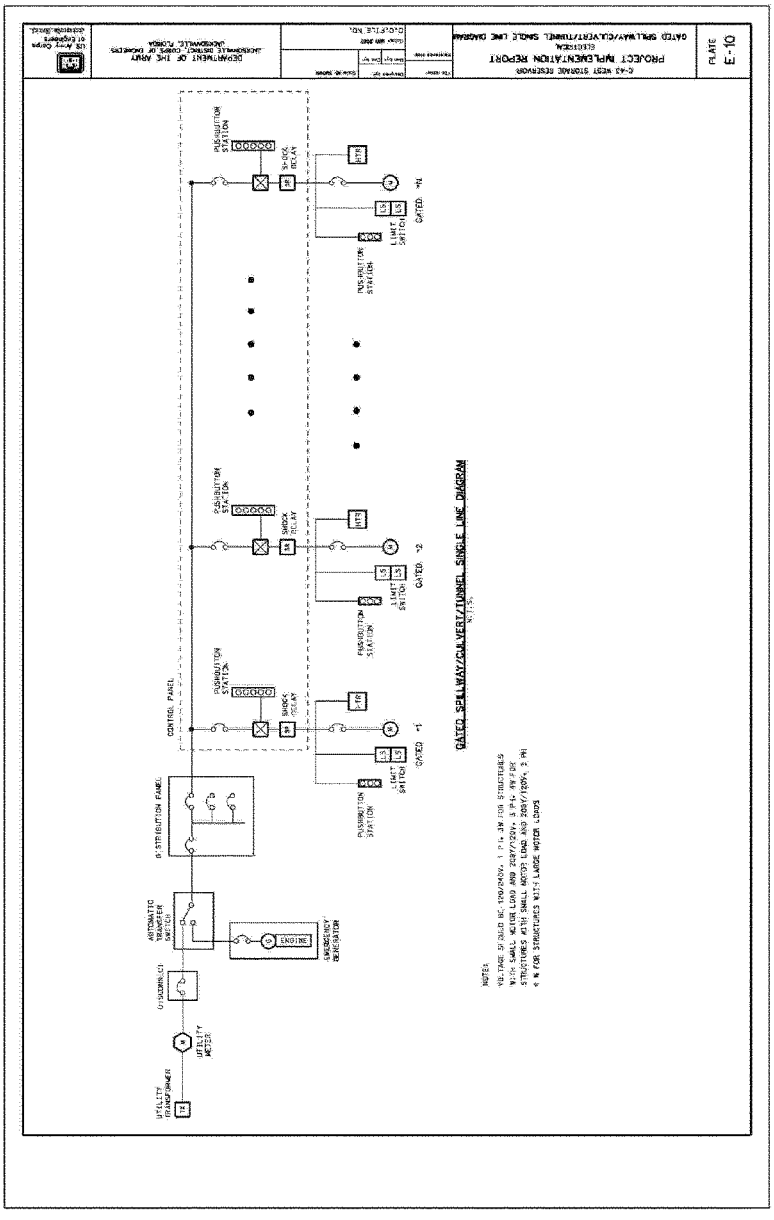

PROJECT IMPLEMENTATION REPORT
LARGE PUMP STATION
ELECTRICAL
ENGINE PUMP CONTROL DIAGRAM
PLATE
E1-05
ENGINE PUMP CONTROL DIAGRAM
N.T.S.
DIESEL ENGINE
VENTILATION SYSTEM
SUPPLY FANS
EXHAUST FANS
STARTING/STOPPING SYSTEM
ENGINE AIR COMPRESSOR & FUEL SOLENOIDS
ULTRASONIC WATER LEVEL SENSOR START INTERLOCK
COOLING SYSTEM
PRIMARY ENGINE COOLANT PUMP (ENGINE DRIVEN)
SECONDARY ENGINE COOLANT PUMP (MOTOR DRIVEN)
COOLING WATER PUMP
FUEL SYSTEM
ENGINE FUEL PUMP (FROM DAYTANK TO ENGINE)
TRANSFER PUMP (FROM YARD TO DAYTANK)
RETURN FUEL PUMP (FROM ENGINE TO YARD)
LUBRICATING SYSTEMS
ENGINE OIL PRE-LUBE PUMP
LUBE OIL HEATER
ENGINE DRIVEN LUBRICATING OIL PUMP
OIL FILTER PUMP
SECONDARY LUBRICATING OIL PUMP
LOCAL GOVERNOR CONTROLS


SCADA SYSTEM DIAGRAM FOR LARGE PUMP STATIONS
N.T.S.
TO WEST PALM BEACH CONTROL CENTER
TO REMOTE CAMERAS
CONTROL ROOM
MOTOR PUMP # 1
MOTOR PUMP # N
DIESEL GENERATOR
BACK FLOW GATE SYSTEM
MOTOR PUMPS MANUAL AND PLC CONTROL CABINET
DIESEL GENERATORS
MAIN DIESEL FUEL TANKS
TRASH RAKES
AIR COMPRESSORS
STATION AND DIESEL GENERATOR CONTROL & MONITORING PANELS AND STATION PLC CABINET
PUMP CONTROL PANEL #N
PUMP CONTROL PANEL #2
PUMP CONTROL PANEL #1
FIBER OPTIC HUB
MASTER COMPUTER (PUMPING STATION MONITORING AND CONTROL)
ETHERNET HUB, TCP/IP
PRINTER
AUXILIARY COMPUTER (VIDEO SURVEILLANCE SYSTEM)
VIDEO SURVEILLANCE SYSTEM CONTROLS
C-43 WEST STORAGE RESERVOIR
PROJECT IMPLEMENTATION REPORT
ELECTRICAL
LARGE PUMP STATION
SCADA SYSTEM DIAGRAM
PLATE
E-06


PLATE
E-07
C-43 WEST STORAGE RESERVOIR
PROJECT NAPLEMENTATION REPORT
SMALL PUMP STATION-SINGLE LINE DIAGRAM
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
MOTOR CONTROL CENTER (MCC)
SMALL PUMP STATION-SINGLE LINE DIAGRAM
ELECTRIC MOTOR PUMP #4
ELECTRIC MOTOR PUMP #3
ENGINE
SERVICE DISCONNECT
UTILITY METERING


PROJECT IMPLEMENTATION REPORT
SMALL SIZE PUMP STATION
ELECTRIC MOTOR CONTROLS
PLATE
E-08
MOTOR CONTROL CENTER
MOTOR CONTROL CIRCUIT
N.T.S.
MCC SCHEDULE
COMT. PART
3A a PUMP #1 MOTOR
b TELEMETRY - LOCAL - OFF SWITCH
c PHASE MONITORING
d RUN TIME METER
e VIBRATION CUT - OFF
f START
g STOP
h WATER LEVEL SENSOR
i PUMP MONITORING
j VIBRATION SENSOR
SMALL SIZE PUMP STATION, ELECTRIC MOTOR CONTROLS
N.T.S.
ELECTRIC MOTOR CONTROL LAYOUT
(LOCATED IN MCC)
N.T.S.


PLATE
E-09
PROJECT IMPLEMENTATION REPORT
C-43 WEST STORAGE RESERVOIR
SMALL PUMP STATION
ELECTRICAL
SCADA CONTROL DIAGRAM
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
TO ANTENNA
MOTOROLA ACE3600 RTU
(TELEMETRY CABINET)
PUMP # 1
PUMP # 2
PUMP # N
SCADA SYSTEM DIAGRAM FOR SMALL PUMP STATIONS
N.T.S.


PROJECT IMPLEMENTATION REPORT
GATED SPILLWAY/CULVERT/TUNNEL SINGLE LINE DIAGRAM
PLATE
E-10
GATED SPILLWAY/CULVERT/TUNNEL SINGLE LINE DIAGRAM
CONTROL PANEL
PUSHBUTTON STATION
SHOCK RELAY
LIMIT SWITCH
GATED
UTILITY TRANSFORMER
UTILITY METER
AUTOMATIC TRANSFER SWITCH
ENGINE
EMERGENCY GENERATION
DISTRIBUTION PANEL
NOTES:

A.10 TECHNICAL MEMORANDUM FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR SPREADSHEET MODEL AND WATER BUDGET ANALYSIS FOR PROJECT DELIVERY TEAM MARCH 6, 2007 MSR 262

and

TECHNICAL MEMORANDUM FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR APPLICATION OF SPREADSHEET TO EVALUATION OF C-43 STORAGE RESERVOIR PROJECT ALTERNATIVES FOR C-43 PROJECT DELIVERY TEAM MARCH 23, 2007 MSR 264

The following Technical Memorandums were provided by the SFWMD and were prepared by the Interagency Modeling Center (IMC). The memos describe the methodology used to create and utilize a spreadsheet analysis to simulate the 2000 and 2050 condition with and without project for the purposes of fulfilling requirements under GM 2,4 and 5 and describes the results and conclusions from the spreadsheet analysis.

INTERAGENCY MODELING CENTER

Technical Memorandum

To: Janet Starnes, Beth Marlowe

From: Interagency Modeling Center (IMC)

Project: C-43 Reservoir Phase I

Subject: Water Budget Spreadsheet Model

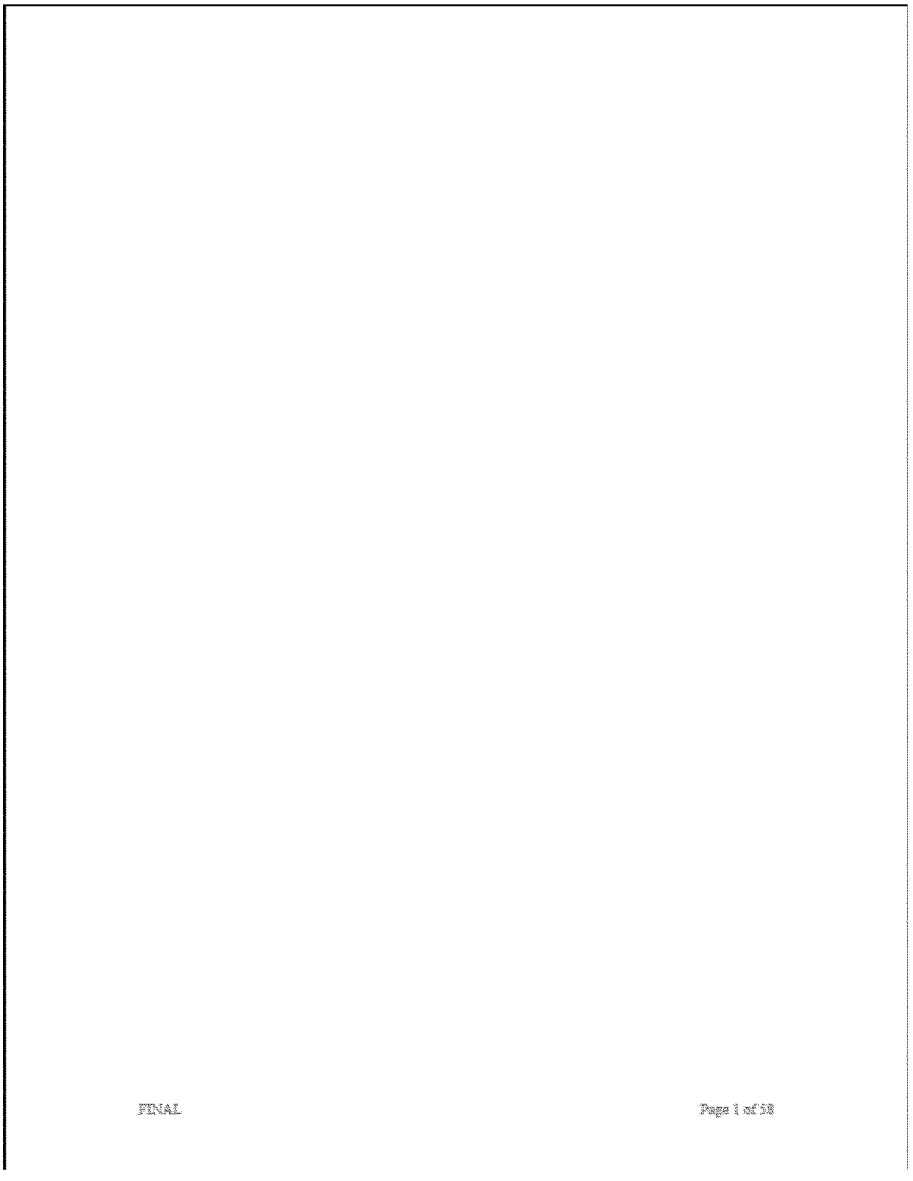
Spreadsheet Model and Water Budget Analysis

for

C-43 Project Delivery Team

March 6, 2007
MSR 262

FINAL Page 0 of 58


FINAL
Page 1 of 58

Contents

Contents ..... Page 2

Section 1 - Introduction ..... Page 4

Section 2 - Approach ..... Page 9

Section 3 - Model Application: Simulations of 2000 and 2050 ..... Page 14

Section 4 - Discussion of Results ..... Page 31

Section 5 - Conclusions and Recommendations ..... Page 32

Appendix I - Spreadsheet Model User Documentation ..... Page 34

Appendix II - Sensitivity Analysis ..... Page 42

Appendix III - Reservoir Preferred Operation Rules ..... Page 46

Section 1 – Introduction

1.1 Project Background

The C-43 Basin Storage Reservoir Phase I Project comprises the C-43 West Storage Reservoir (Figure 1) located on the Berry Grove property in the western portion of the Caloosahatchee Watershed in Hendry County, Florida.

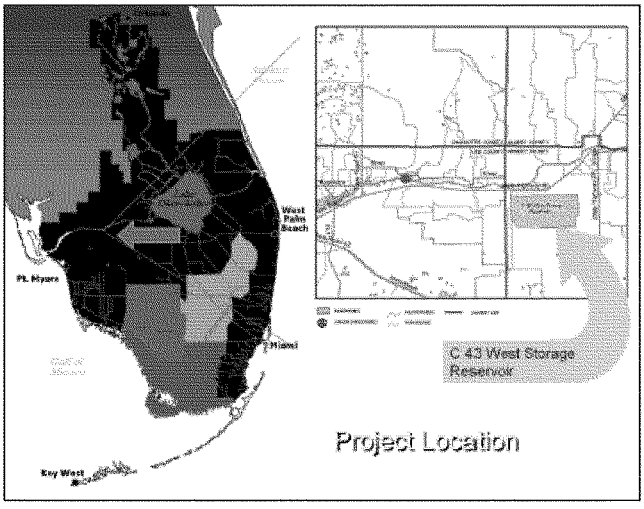


Figure 1. Location of the Proposed Site for the C-43 West Storage Reservoir.

The purpose of the C-43 Basin Storage Reservoir Phase I Project is to improve water deliveries to the estuary, provide for dry season flows, reduce magnitude of wet season high flows, restore downstream salinity levels and ensure the availability of water for the natural system needs of the Caloosahatchee Estuarine System. Subsequent phases of the C-43 Storage Reservoir Project will address these same issues in addition to providing additional water resource benefits through provision of supplemental water resources for agriculture and urban users thereby benefiting the regional system by reducing the dependence on Lake Okeechobee.

FINAL Page 4 of 58

The selected plan for Phase I of the Project is a two cell reservoir with storage capacity approximately 170,000 acre-feet, inflow pump capacity of 1500 cubic feet per second (cfs) and design outflow capacity ranging from 1,000 cfs to 1,500 cfs. The reservoir is an above ground reservoir with earthen dam and an embedded slurry wall extended to intercept a clay layer underlying the reservoir site. A seepage collection system consisting of a seepage canal and structures is included in the project to capture seepage from the reservoir. The reservoir sits on a project site of approximately 11,000 acres with the actual two cell reservoir footprint estimated at between 9,000 and 10,500 acres. The reservoir intake is on the Townsend Canal which is directly connected to the C-43 Canal (Caloosahatchee River) downstream of S-78 (Ortona Lock and Dams) but upstream of S-79 (W. P Franklin Lock and Dam) both gated structures for managing water level within the reach of the C-43 Canal.

The identified project strategy involves attenuation of high flows at S-79 (a shaving of the peaks during high flows) into storage and subsequent release from reservoir storage of the available volumes to meet dry season low flow requirements at S-79 with the intent of improving the salinity balance in the downstream estuary.

The Interagency Modeling Center (IMC) has been tasked through MSR 262 to develop a spreadsheet model of the C-43 Basin Storage Reservoir, Phase I selected project for subsequent analyses for meeting CERP planning requirements including assurances, quantification of water made available for restoration and so on as described in the scope. This report documents the objectives, scope of work approach, describes the modeling tool developed and the simulations conducted on behalf of the C-43 Project Delivery Team (PDT) per MSR 262.

1.2 Objectives and Scope of Work

The objectives of the study conducted by the IMC are as follows.

1) Develop a spreadsheet tool suitable for meeting the requirements identified in the customer requirements section (Section 1.3) and submitted as attachment to MSR 262 by the C-43 PDT.
2) Utilize the spreadsheet to simulate the 2000 and 2050 condition with and without project for the purposes of fulfilling
   a. GM #2-Next Added Increment Analysis requirement
   b. GM #4 requirements for Identifying Water Made Available by the Project-volumetric analysis from spreadsheet output, and
   c. GM #5-Serves at the basis for Draft Project Operating Manual-Spreadsheet operations of Existing Conditions with Project (same as Initial Operating Regime).
3) Deliver the spreadsheet with a user guide and model results the PDT for subsequent analyses.
4) Deliver the model results to assurances team for subsequent analyses and write-up
5) Document the spreadsheet and provide a project report describing the analyses, the key assumptions, limitations and application to the PDT.

1.3 Customer Requirements

The IMC was tasked by the PDT through MSR 262 to develop a simplified spreadsheet model of the C-43 West Reservoir based on capture of excess flow over S-79 as derived from SFWMM simulation of the base conditions. The detailed scope and customer requirements are as follows:

C-43 Basin Storage Reservoir - Part 1
Purpose and Key Assumptions for Spreadsheet Analysis
February 7, 2007

Purpose of Spreadsheet Analysis

- Fulfill GM #2 Next Added Increment Analysis requirement. This analysis will include an ecological assessment using the existing interface with industry grid for RSM analysis.
- Fulfill GM #4 requirements for Identifying Water Made Available by the Project: volumetric analysis from spreadsheet output.
- Fulfill GM #1-Serves as the basis for Draft Project Operating Manual. Spreadsheet operation of Existing Conditions with Project(same as Initial Operating Regime) will be used as the basis for draft operating manual.
- NOTE: The spreadsheet will not be used to fulfill of GM #3 requirements for Storage Change analysis or Elimination or Transfer of Existing Legal Sources and Flood Protection. To fulfill this requirement a combination of assumption documentation and information from AS design modeling will be used.

FINAL Page 6 of 58

System-wide

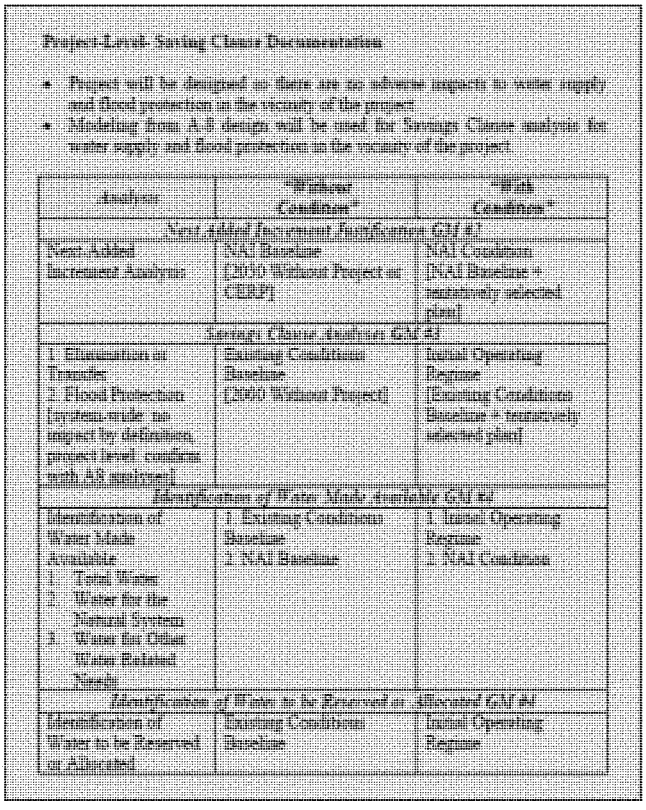
Base Spreadsheet Assumptions:

- Flow data for Existing Conditions Baseline (2000) and Future Without Project Condition (2050 with no CERP projects in place) is derived from South Florida Water Management Model runs 3000FD and 3050RD.
- Existing Conditions Baseline, Pre-CERP Baseline, and Initial Operating Regime without project are essentially all the same conditions related to demands and CERP Project operations affecting this project, therefore, the 2000 Existing Conditions Baseline will be used for analyses requiring these different conditions.
- ET from reservoir will be included. The mass balance terms for the reservoir are reservoir inflow, reservoir release, reservoir seepage will be assumed to be zero. ET losses (based on area volume relationship), and perhaps reservoir direct precipitation.
- System losses from the river to groundwater from the point of release of the reservoir to S-79 will be factored into the spreadsheet analysis.
- No agricultural or urban water supply deliveries are supplied by the reservoir these demands continue to be supplied from Lake Okeechobee or current groundwater sources.
- Eastern Caloosahatchee Basin (east of S-79) is not affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary west of S-79, there will be no impacts on the Western Caloosahatchee Basin.

Reservoir Operation Assumptions:

- Water will be pumped into the reservoir only when there are excess flows over S-79. Excess will be treated initially as high flows over some threshold that will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 03).
- Releases from the reservoir are made when flows over S-79 are below desirable levels (450 cfs). Releases will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 03).
- Including basic seasonal operational variability in the spreadsheet for filling and draining the reservoir is preferable.

FINAL Page 7 of 58



Project-Level Saving Clause Documentation

- Project will be designed so there are no adverse impacts to water supply and flood protection in the vicinity of the project.
- Modeling from A-3 design will be used for Savings Clause analysis for water supply and flood protection in the vicinity of the project.

Analysis	"Without Condition"	"With Condition"
Next Added Increment Justification (Q1 #1)		
Next Added Increment Analysis	NAI Baseline [2060 Without Project or CERP]	NAI Condition [NAI Baseline + tentatively selected plan]
Savings Clause Analysis (Q1 #2)		
1. Elimination or Transfer 2. Flood Protection [project-under no impact by definition, project level conform with AS analyses]	Existing Conditions Baseline [2060 Without Project]	Initial Operating Regime [Existing Conditions Baseline + tentatively selected plan]
Identification of Water Made Available (Q1 #3)		
Identification of Water Made Available 1. Total Water 2. Water for the Natural System 3. Water for Other Water Related Needs	1. Existing Conditions Baseline 2. NAI Baseline	1. Initial Operating Regime 2. NAI Condition
Identification of Water to be Reserved or Allocated (Q1 #4)		
Identification of Water to be Reserved or Allocated	Existing Conditions Baseline	Initial Operating Regime

FINAL Page 8 of 52

Section 2 – Approach

The approach and assumptions used by the IMC team for developing the C-43 West Reservoir spreadsheet model is discussed in the following section.

2.1 Assumptions and Considerations for the Analyses

2.1.1 Project Assumptions Provided by PDT

The following are project assumptions provided by the customer as requirements. These assumptions were implemented in the spreadsheet model except where additional information renders them inappropriate or unnecessary.

- Flow data at S-79 for the Existing Conditions Baseline (2000) and "Future Without" Project Condition (2050 with no-CERP projects in place) is derived from South Florida Water Management Model runs 2000RD and 2050RD.
- Existing Conditions Baseline, Pre-CERP Baseline, and Initial Operating Regime without project are essentially all the same conditions related to demands and C&SF Project operations affecting this project, therefore, the 2000 Existing Conditions Baseline will be used for analyses requiring these different conditions.
- ET from reservoir will be included. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, ET losses, and reservoir direct precipitation. Reservoir seepage will be assumed to be zero.
- System losses from the river to groundwater from the point of release of the reservoir to S-79 will be factored into the spreadsheet analysis.
- No agricultural or urban water supply deliveries are supplied by the reservoir. These demands continue to be supplied from Lake Okeechobee or current groundwater sources.
- Eastern Caloosahatchee Basin (east of S-78) is not affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary west of S-79, there will be no impacts on the Western Caloosahatchee Basin and no effort to depict these will be included in the spreadsheet.
- Water will be pumped into the reservoir only when there are excess flows over S-79. Excess will be treated initially as high flows over some threshold that will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Releases from the reservoir are made when flows over S-79 are below desirable levels (450 cfs). Releases will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Basic seasonal operational variability for filling and draining the reservoir is included in the spreadsheet model.

2.1.2 Additional Assumptions

In addition to the assumption provided by the PDT, the IMC has implemented the following additional assumptions for the reasons provided.

1) Minimal natural losses to reservoir releases between the project and S-79 can be expected. An efficiency of delivery factor of 1 or 100% is used in the spreadsheet to ensure that all releases from the reservoir arrive at S-79. This assumption is based on analyses of more rigorous hydrologic modeling that was conducted using the MIKESHE model that show that within the reach of the Townsend Canal and the portion of C-43 from the Townsend Canal – C-43 Canal intersection, the canal are gaining and have water level that is consistently lower than groundwater elevation. This assumption was further verified with topographic data completed as part of the data preparation for the Southwest Florida Feasibility Study which show that the C-43 and Townsend canals in this region are at notable lower elevation than the adjacent land (Figure 2).

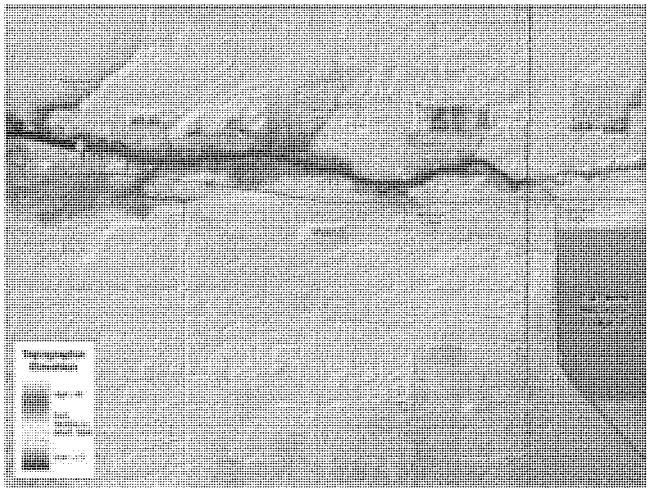


Figure 2. Topographic map of the C-43 and environ downstream of the Townsend Canal confluence.

2) Reservoir size of approximately 170,000 acre feet and pump station total capacity of 1500 cfs will be used in the spreadsheet analyses. Actual size for reservoir will be determined based on storage – depth – surface area relationship provided by the C-43 West Reservoir Acceler8 Team. This assumption was deemed appropriate in that it utilizes the most current available information on possible reservoir geometry consistent with the project site.
3) In basin flow routing and other internal details such as flow between multiple cells or multiple releases will not be included in the spreadsheet analysis as such detail are at

a more refined scale that the analysis. IMC considers this assumption appropriate since the focus of the spreadsheet analysis is the redistribution of excess flow over S-79 through use of the reservoir to improve timing and quantity of flow over S-79. The localized operations can be represented by simple reservoir filling or release operation within the spreadsheet analyses.

4) Progressively more complex operations that meet the customer requirement will be implemented, starting from simple breakpoint based flow decision to perfect knowledge (operation based on the identified estuary target EST05) to bound the solution. This assumption ensures successive suitable operations that provide increasing information on model and expected reservoir performance as the complexity increases to the recommended operations. The tool shall retain the flexibility to implement the simplified operations.
5) A preferred operation that represent best results (but not optimal) will be delivered and processed for subsequent analyses. IMC proposes this assumption or approach to ensure that a simple yet realistic set of operations that are intuitive and provide superior performance are generated and recommended to the PDT.
6) IMC will implement seasonality in reservoir operations to recognize that wet and dry season operations would differ, and same season operation would also differ based on the state (full or empty) of the reservoir. The generalized logic of the operation is provided below (Figure 3).

Fill	WET SEASON	DRY SEASON	
Early in Season	Fill slowly to retain capacity for later in the season	Fill aggressively in preparation for rest of dry season	Pump capacity (and channel capacity) are limiting. Intake threshold and volume may vary but based on a consistent logic. The Threshold will be determined by iteration.
Late in Season	Fill reservoir faster to get full by end of year (use available capacity as a factor)	Fill slowly to retain capacity for wet season	

Empty	WET SEASON	DRY SEASON	
Early in Season	Release aggressively to create capacity for filling reservoir later in the season	Release less aggressively to extend ability to release longer into the dry season	The constraint to the release strategy listed to the side are reservoir release capacity and the requirement that wet season flows should not greatly fall below EST05 and Dry season flow over S-79 should not greatly exceed EST05
Late in Season	Release more carefully to keep reservoir full going into the dry season	Release more aggressively to empty reservoir in preparation for the wet season	

Figure 3. Generalized operational logic to implement seasonality.

7) Reservoir filling and release actions will not occur on the same day.
8) Based on comment from technical review team, IMC will implement adjustment for runoff from the reservoir site using the initially specified ratio of land area of reservoir to land area of basin as well as one or more alternative approaches that consider precipitation to runoff relationship in watershed. These alternative approaches will allow simple or more complex representation of this adjustment to meet the user need. The precipitation based approach allows representation of the

delay between rainfall and runoff and was considered a desirable recommendation of the technical review team.

9) IMC will implement an operational feature that reduces fill action when the reservoir is full or close to full. The intent is to minimize the possibility of oscillations in reservoir operation and stage that could result from very sensitive pump criteria that pump every day to replenish daily losses to evapotranspiration. The justification of this assumption is the need to more closely match a realistic operation. The feature implemented can be disabled by the user at run time.
10) Reservoir base ranges from 18 feet NAVD to 20 feet NAVD with an average at 19.24 feet. This assumption is based on the most current design information available from the Acceler8 project documentation.
11) Reservoir elevation at full pool is 42 feet NAVD with a corresponding storage of 178,602 acre-foot. This assumption is based on the most current design information available from the Acceler8 project documentation plus data provided by Acceler8 project team.
12) Daily potential evapotranspiration data for the analyses will be extracted from the SFWMM modeling dataset for consistency. IMC believes that this represents the most reliable data for the purpose of the modeling exercise and that data is available for the period of record, 1965 to 2000.
13) Daily rainfall data will be extracted from the SFWMM modeling dataset for consistency. IMC believes that this represents the most reliable data for the purpose of the modeling exercise and that data is available for the period of record, 1965 to 2000.
14) Statistics and performance graphics will be generated based on a period of record simulation of 36 years, January 1965 to December 2000.

2.2 Spreadsheet Development

IMC implemented a phased dual channel approach that involved the development and initial refinement of two independent proof-of-concept spreadsheets. Each was initiated independent of the other but based on the same requirements from the PDT. Due to the aggressive schedule of the project, a simultaneous technical review was initiated to lag the development. Taking input from the review team, IMC combined the desirable features of the two approaches into a single spreadsheet model for final refinement and application.

The spreadsheet model is centered on a water budget equation for the reservoir. The equation is based on conservation of mass and relates the inflows to the reservoir, outflows from the reservoir to the change in storage in the reservoir over some fixed time scale. The equation is represented below in lay terms states that inflows to the reservoir minus outflows from the reservoir is equal to the change in storage in the reservoir.

$$\frac{dS}{dt} = Q_{in} - Q_{out}$$

Where $\frac{dS}{dt}$ is the rate of change in storage,

Q_{in} represents the rate of inflow to the reservoir, in this case direct precipitation on reservoir plus the pumped volumes.

Q_{out} represents the rate of outflow from the reservoir. It combines in this case, releases from the reservoir, spillway releases, and losses to evapotranspiration, (seepage set at zero by assumption).

The spreadsheet model implements the following actions.

Based on flows over S-79 on a daily basis

1) The spreadsheet determines if there is adequate flow to capture for storage in the reservoir. The threshold for capture depending on the operation scheme implemented could range from
   a. Checking if the flow exceeds a specified peak flow at which storage is initiated,
   b. Comparing the daily flow to daily target flows and capturing the excess subject to reservoir capacity and pump capacity, or
   c. Determined based on a specified operation strategy the seasonal threshold and volume to store subject to pump and reservoir storage capacity.
2) The spreadsheet determines what proportion of the available flow can be captured subject to the criteria below depending on the operation scheme implemented.
   a. The pump capacity (1500 cfs)
   b. The difference between total flow over S-79 and the target flow, subject to reservoir capacity and pump capacity, and
   c. Based on a specified seasonal release strategy or decision table specified by the user within the spreadsheet.

These inflows along with direct precipitation onto the reservoir represent total inflows into the reservoir used in the mass balance.

Based on flows over S-79 and available capacity in the reservoir, the spreadsheet does the following actions.

1) Determines evaporation losses by taking the product of the potential evapotranspiration rate and the surface area of the reservoir (which is varied depending on storage within the reservoir)
2) Determines if rainfall or other activity has resulted in reservoir stage in excess of the spillway elevation and releases subject to limit of the spillway (the final model has operational features that preclude or limits the likelihood of this occurrence).
3) Determines release from the reservoir for environmental purposes to augment S-79 flows depending on the operational scheme implemented. The release decision and volume of release could be
   a. Based on a fixed release to bring S-79 flows to a minimum specified threshold subject to reservoir release structure capacity,

FINAL Page 13 of 58

b. Based on meeting the deficit between S-79 flows and the target series, EST05, or
c. Based on a specified seasonal release strategy or decision specified by the user in the spreadsheet.

These outflows are accumulated to represent total outflows from the reservoir used in the mass balance equation for each daily time step.

The spreadsheet computed the daily change in storage and associated water surface elevation both of which are considered in determining fill and release operation in subsequent time steps. The model creates an updated flow over S-79 that reflects the changes to the original flow resulting from reservoir fill or release activities.

A more detailed description of the sequence of computation with a sample cycle through one time step is presented in the User Manual attached as Appendix I to this report.

Section 3 – Model Application: Simulations of 2000 and 2050

The focus of the spreadsheet model is the modification or adjustments of flow over S-79 with the intent of improving the salinity distribution in the downstream estuary. The model has no salinity or ecological component and relies on hydrologic surrogate to infer improved performance. The hydrologic surrogate used is the flow over S-79 and its closeness to a flow target time series EST05 which has been demonstrated by others to be a restoration series that would result in optimal habitat conditions for several indicator species in the estuary. The May, 2003 report titled "Existing Legal Sources for Caloosahatchee Estuary at the Franklin Lock and Dam (S-79) by the Coastal Ecosystem Division of the South Florida Water Management District describes the basis for EST05.

As a means to showing closeness to EST05 as a whole and quantifying other desirable matches to portions of the restoration flow series, a number of performance measure graphics were built in to the spreadsheet, five in total. Also, in order to confirm reasonable behavior of model features and results, several graphics and charts of these features were incorporated and used during model application to determine changes in operation necessary to yield superior performance.

3.1 Performance Measures

The performance measures are nested in the "PMs" Worksheet of the spreadsheet and include the following charts.

3.1.1 Distribution of Monthly Flows.

The first performance measure is a histogram of the distribution of monthly flows over S-79 for the target restoration flow series EST05, the existing "without project" or base condition, and the "with project" condition depicting percentage of time each flow

range occurs in the period of record simulation. A sample of the graphics is shown in below (Figure 4).

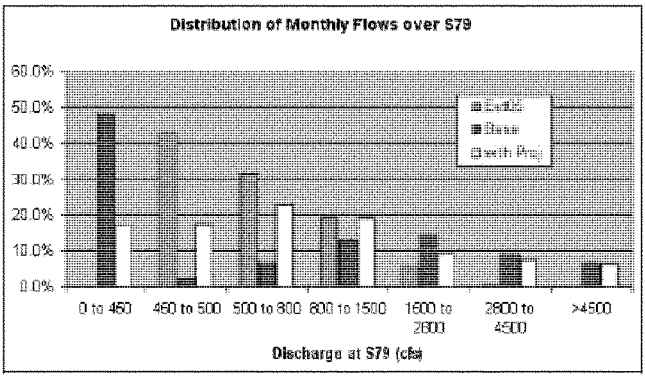


Figure 4. Histogram of monthly flows over S-79 in cfs.

An alternative that shows a closer match between the "with project" condition and the EST05 series is considered a better alternative when this measure is considered. The selection of the preferred operation is based on this and other measure evaluated in combination.

3.1.2 Caloosahatchee Estuary Salinity Envelope Criteria.

The second performance measure is the estuary salinity envelope criteria developed and used by CERP for the Caloosahatchee Estuary by the SFWMM model. This performance graphic has been duplicated in the spreadsheet and depicts the count of number of months with a low flow criteria (less than 450 cfs) not met in the "without project" (base condition) and the "with project" condition during the dry season. The measure also shows the count of exceedance of a high flow threshold (2800 cfs) with and without project. A sample graphic is shown below (Figure 5). In interpreting this measure, a series of operations that reduces the number of low flow occurrence and reduces the number of high flow exceedance represents a better set of operations. Note that EST05 has no occurrences of flows below 450 cfs and establishes a target count of zero for the low flow portion of this measure.

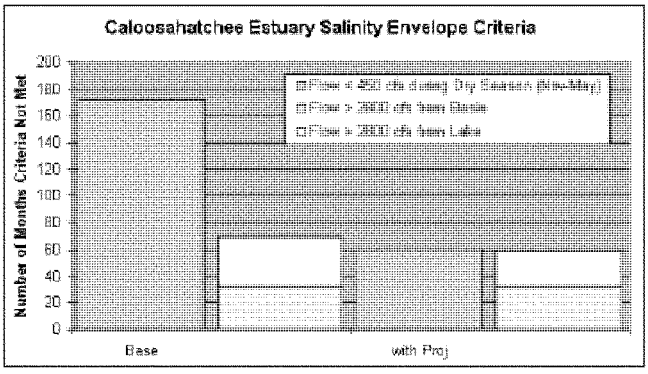


Figure 5. Caloosahatchee Estuary salinity envelope criteria.

3.1.3 Flow Duration Curve.

A flow duration curve generated by ranking and plotting the flow over S-79 and the percentage of time that the flow is equaled or exceeded is used as one of the measures. This plot is generated for the target restoration flow series EST05 as well as the "with project" and "without project" conditions. The "with project" condition that more closely matches EST05 represents the better performance. Below (Figure 5) is a sample plot extracted from the spreadsheet simulation. While it is desirable to consider the area under the curve as new water made available by the project, this does not represent the water made available as described in the guidance memoranda for assurances. Separate analyses for assurances will be delivered separately as part of this project. The curve does show the ability of the "with project" condition to extend availability of low flows from the "without project" condition towards the EST05 conditions with no occurrences of flows less than 450 cfs.

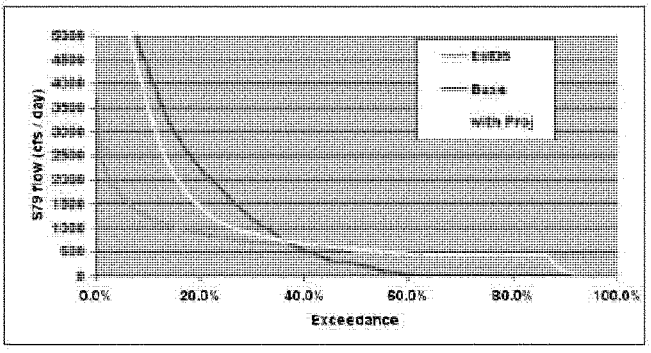


Figure 6. Flow Duration Curve.

3.1.4 Consecutive Days with No Flows to Estuary.

Based on technical input from coastal ecologists, an additional measure depicting the consecutive number of times in the simulation period of record that 10 or more days of no flows to the estuary occurred was developed. This measure counts a 30 day no flow event as one occurrence. A 30 day event with flows to the estuary introduced on the 15th day alone will result in a count of two occurrences. The measure also presents the maximum number of consecutive days with no flow under the "with project" and "without project" conditions. This measure using both parts of the chart show the frequency and extent of no flow (defined within the spreadsheet as the 5 cfs base flow rate) conditions observed in flows over S-79 over the 36 year period of record. An operational scheme that results in lower count of number of consecutive days of no flows and reduces the extent of the maximum number of consecutive no flow days represents a more desirable operational regime. A key caution in interpreting this graphic is that a small flow much less than the desirable 450 cfs will break the count of consecutive days so that releases from the reservoir of rainfall induced volumes that result in small flows in the order of tens of cfs count as breaks to the consecutive dry days count.

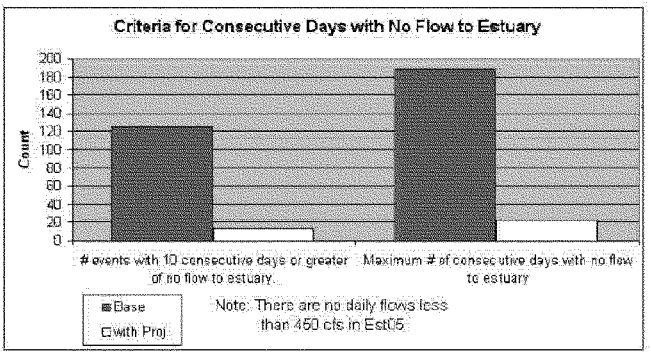


Figure 7. Criteria for consecutive days with no flow to estuary.

3.1.5 Hydrograph of flow over S-79.

The final performance measure used is a plot of flows in cfs over S-79 for the EST05 series, the "with project" and "without project" conditions. In addition, superimposed on the plot is the pump filling and reservoir release operations. This graphic allows actual comparison of improvements to S-79 discharges and closeness of those improvements to the EST05 restoration series.

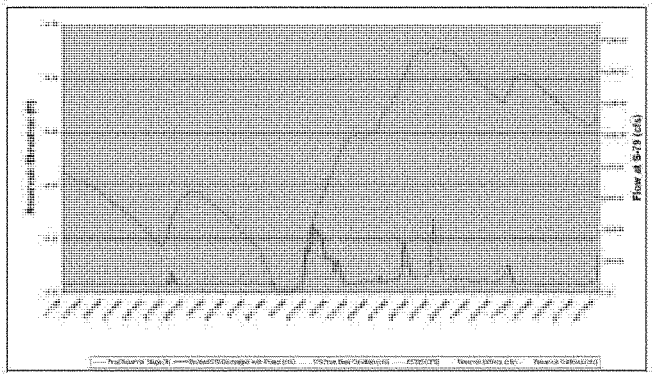


Figure 8. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modification to pre-project S-79 flows.

3.2. Spreadsheet Performance Checks

Six charts were used to perform checks on different aspects of the spreadsheet to ensure that assumptions were not violated and that the features in the spreadsheet were functioning as intended. The six charts are shown below (Figure 9) and include:

1) A plot of reservoir surface elevation: This chart shows the rate of use of the reservoir, how often it is full or empty.
2) A reservoir stage exceedance curve that shows what percentage of the time the reservoir surface elevation equals or exceeds a particular stage value.
3) An x-y plot of the adjustments to S-79 flows to accommodate the reduction in runoff resulting from converting the project from an agricultural land use to a reservoir. This plot shows minimal impact from the adjustment.
4) A scatter plot of inflows with reservoir stage to depict what operations are occurring as the reservoir fills.
5) A scatter plot of outflows with reservoir stage to show what release operations are occurring at different reservoir stage values, and
6) A scatter plot of inflows versus outflow to demonstrate that inflows and outflows are not occurring simultaneously.

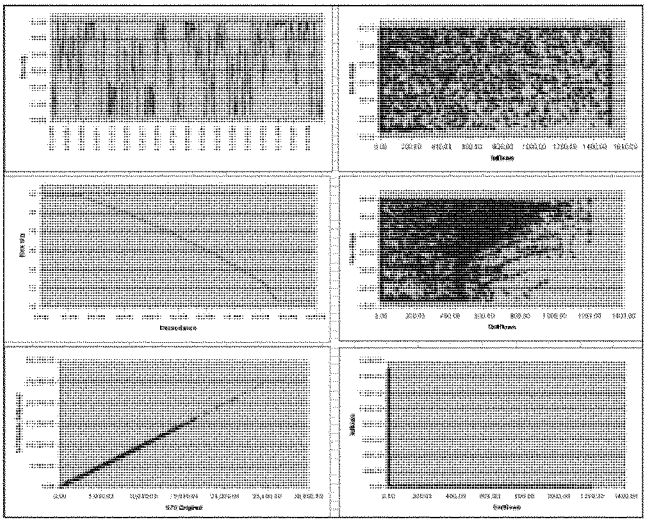


Figure 9. Plots used to check and confirm that spreadsheet model is performing as intended.

3.3. Simulation of 2000 Conditions

The spreadsheet was used to simulate the 2000 conditions.

3.3.1 Simplified Operation with Minimum and Maximum S-79 Threshold

Initial analyses used the simplified operations with a defined low flow threshold and defined high flow threshold. The high flow threshold was varied randomly between 2500 cfs and 4200 cfs and the low flow threshold was set at 450 cfs. Examination of the performance under this operational regime shows improvement over the "without project" condition but also resulted in a somewhat unnatural response with extended periods of fixed flow at 450 cfs in the low flow range. The performance measures for a high flow threshold of 2800 cfs and a low flow threshold of 450 cfs are presented below (Figure 10).

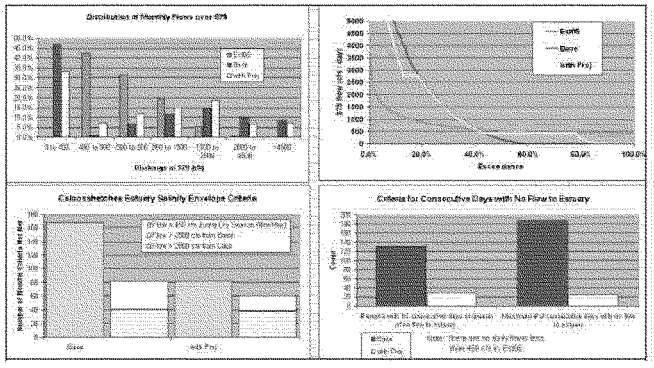


Figure 10. Performance measures for reservoir operations based on high flow (2800 cfs) and low flow (450 cfs) thresholds under year 2000 conditions.

- The histogram showed some improvement in the low flow range over the "without project" condition but flows lower than 450 cfs still occurred more than 30% of the time.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 167 to 82 from the without project to the "with project" condition.
- The flow duration curve for the "with project" conditions shows two steps corresponding to the selected high flow and low flow threshold, 2800 and 450 cfs respectively. The period of time when flows over S-79 equaled or exceeded 450 cfs was extended from about 45 % of the time under the "without project" condition to greater than 70% of the time under the "with project" conditions.

- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 131 under the "without project" condition to 29 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 188 days to 25 days with the reservoir in place.

3.3.2 Bounding Operation with Operations Tied to EST05

An operational scenario that ties fill and release decisions to S-79 flows in excess of, or in deficit of the EST05 flow series was then implemented. This operational strategy assumes perfect knowledge and under ideal condition will deliver the EST05 or restoration flows to the Estuary. This operation is similar to operation implemented in other previous analysis by the PIR team. Under the "perfect knowledge" scenario, reservoir fill decisions and reservoir empty decisions are forced to reproduce EST05 like flows at S-79 subject to availability of water within the reservoir and pump and release structure capacities. The performance measures observed under this scenario are presented below (Figure 11).

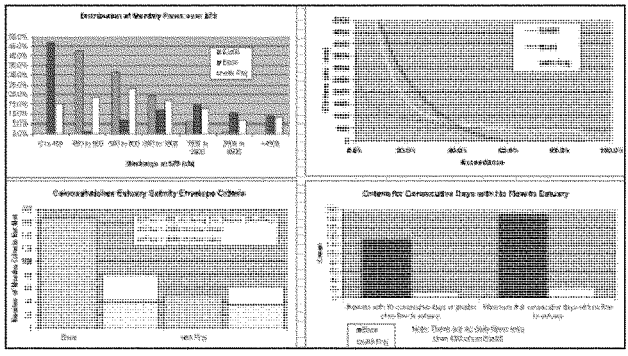


Figure 11. Performance measures for reservoir operations based on matching estuary target flow series EST05 under year 2000 conditions.

- The histogram showed some greater improvement in the low and mid flow range over both the simplified operations and the "without project" condition. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 15% of the time. This suggest that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs is not possible with the current reservoir specifications (size intake and outflow features).

- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 167 to 52 from the without project to the "with project" condition. An improvement of 30 occurrences over the simple operations.
- The flow duration curve for the "with project" conditions shows no steps but a gradual merge of the plot under the "with project" conditions to the EST05 plot until the reservoir becomes incapable of delivering 450 cfs. The reservoir is capable of delivering 450 cfs or greater 87% of the time over the 36 year simulation period, a significant improvement over the "without project" condition and a sizeable improvement over simplified operations.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 131 under the "without project" condition to 14 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 188 days to 23 days with the reservoir in place.

Below (Figure 12) shows a plot of flows over S-79 for a portion of the simulation and illustrates the operations under this release strategy. While reservoir is full and excess flows over S-79 do not exceed pump capacity, the plot of modified time series of flows over S-79 is co-incident with the EST05 time series. This is the case even when there are no S-79 flows under the "without project" conditions. However, when S-79 excess flows determined from the difference between the "without project" flows and the EST05 time series exceed 1500 cfs (pump capacity), the excess is allowed to flow over S-79 under the "with project" condition.

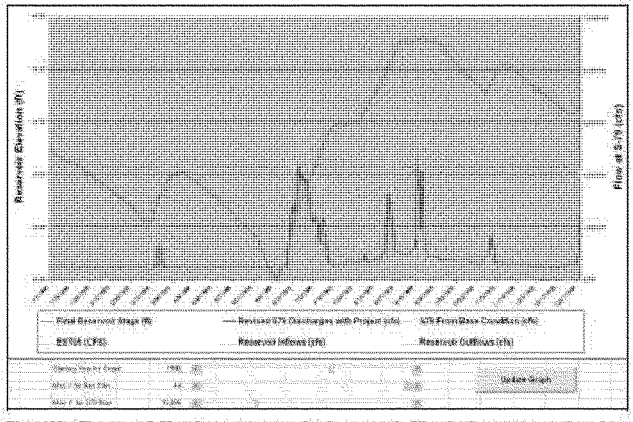


Figure 13. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modifications to pre-project S-79 flows under EST05 driven operations.

5.3.3 Preferred Operation – Based on Seasonality and Reservoir State.

The general logic presented in section 2.1.1 was implemented by providing a series of flow rates based on flows over S-79 that would be used for filling or releasing stored water from the reservoir considering the season of the year and the storage currently within the reservoir. The initial number specified were modified in an iterative procedure until a series of operations that performed better than the "perfect knowledge" operations were identified and a pre-specified timeline for operational improvements were reached. The result though while not necessarily optimal indicates that with operations tuning possible after the project is designed and built, the operation of the reservoir using a logical sequence of rules or a decision table can approach or exceed those forced to mimic EST05. The resulting operations are shown in the appendix to this report.

5.3.3.1 Iterative Procedure.

An initial array of operations corresponding to reservoir stage was developed by examining and analyzing flow data over S-79 derived from SFWMM simulations, actual data, and EST05 flow series. By examining plots of histograms of these flows, and volumes of water necessary to create shifts in the distribution for key years, a pattern was identified. Using best professional judgment, the identified patterns and information contained in previous more rigorous hydrologic modeling conducted for the C-43 project recommended flow and release volumes corresponding to flow over S-79 was developed. These volumes were adjusted to account for state of the reservoir. The reservoir states decided upon was empty reservoir initially defined as the bottom five feet of storage, full reservoir which corresponded to the top 9 feet of storage and medium reservoir which was the condition in between.

The initially specified operations was modified to generate more conservative or less conservative release strategies in order to determine the sensitivity of the model to selected initial operating conditions. The exercise demonstrated that more stringent release rules resulted extended the ability of the reservoir to meet low flows for a longer period but reduced the improvement during high flows. The opposite was the observation for more liberal release policies. Figure 13 shows the high range and low range of several operation iterations. As can be observed from the plot, operations that reduce the high flow occurrences (move the curve towards the lower percentage exceedance) improve towards EST05 (a portion of which is visible at the lower left corner of the upper plot), result in earlier divergence from EST05 in the lower plot. Those operations which provided low flows for the longest period show less of an improvement to high flows (were more to the right on the high flow plot).

The final selected operation (depicted as the heavy line in Figure 13) performed reasonably well, equaling or marginally surpassing the "perfect knowledge" performance on the high side and performing significantly better on the low flows.

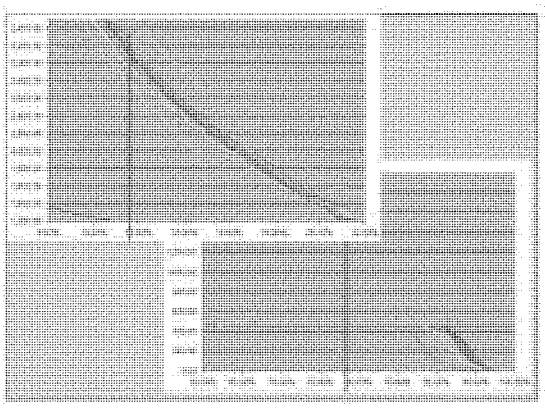


Figure 13. Extremes of the exceedance curves for several model iterations using perturbed operations for the purpose of selecting the preferred operation.

3.3.3.2 Performance Measures for the Preferred Operations

The performance measures observed under this scenario are presented below (Figure 14).

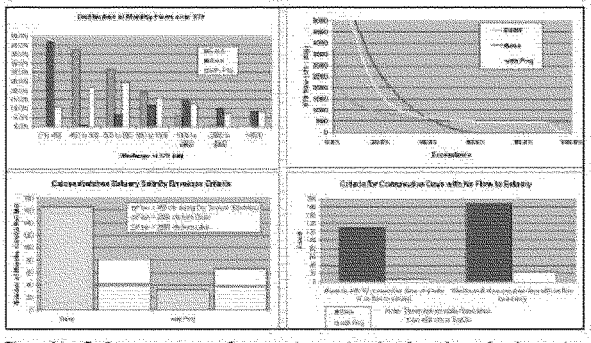


Figure 14. Performance measures for reservoir operations based on the preferred operation (considering seasonality and reservoir state) under year 2000 conditions.

- The histogram showed some greater improvement in the low and mid flow range over both the simplified operations and the "without project" condition and is similar but slightly better than the results under "perfect knowledge" operations. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 10% of the time. This suggest that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs is not possible with the current reservoir specifications (size intake and outflow features).
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 167 to 32 from the without project to the "with project" condition. An improvement of 50 occurrences over the simple operations, and 20 over the "perfect knowledge" operations.
- The flow duration curve for the "with project" conditions shows some raggedness corresponding to several small steps at specified operation breakpoints. It is an improvement over the simple operations in appearance and over other operational regimes explored in performance. The reservoir is capable of delivering 450 cfs or greater about 90% of the time over the 36 year simulation period, a significant improvement over the "without project" condition and a sizeable improvement over simplified operations.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 131 under the "without project" condition to 5 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 188 days to 23 days with the reservoir in place.

This operation strategy provided the best performance observed during the modeling exercise. While it is not the optimal solution, it is considered sufficiently close and adequate for planning level analyses. A more rigorous analysis can be conducted when the project enters the design phase.

3.4. Simulation of 2050 Conditions

The spreadsheet was used to simulate the 2050 conditions.

3.4.1 Simplified Operation with Minimum and Maximum S-79 Threshold

Initial analyses used the simplified operations previously described in section 3.3.1 was conducted using 2050 flows at S-79 derived from the SFWMM model. This future condition run does not assume other CERP components in place. The high flow threshold was varied randomly between 2500 cfs and 4200 cfs and the low flow threshold was set at 450 cfs. Examination of the performance under this operational regime shows improvement over the "without project" condition but as with the 2000 scenarios resulted in a somewhat unnatural response with extended periods of fixed flow at 450 cfs in the low flow range. The performance measures for a high flow threshold of 2800 cfs and a low flow threshold of 450 cfs are presented below (Figure 15) and are very similar to the performance observed for the 2000 scenario.

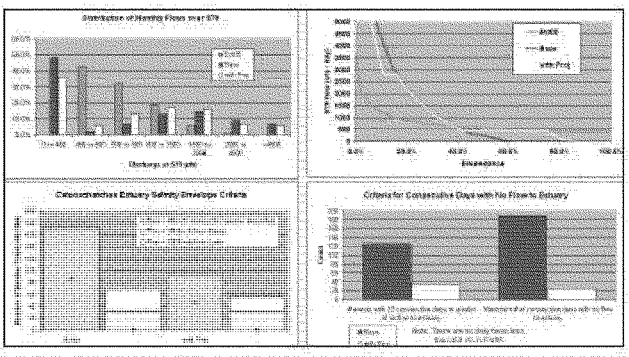


Figure 15. Performance measures for reservoir operations based on high flow (2800 cfs) and low flow (450 cfs) thresholds under year 2050 conditions.

- The histogram showed some improvement in the low flow range over the "without project" condition but flows lower than 450 cfs still occurred more than 35% of the time.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 94 from the without project to the "with project" condition. The reduction in the high flow criteria, flows greater than 2800 cfs, was modest.
- The flow duration curve for the "with project" conditions as with the 2000 condition run shows two steps corresponding to the selected high flow and low flow threshold, 2800 and 450 cfs respectively. The period of time when flows over S-79 equaled or exceeded 450 cfs was extended from about 42 % of the time under the "without project" condition to greater than 75% of the time under the "with project" conditions.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 35 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 189 days to 25 days with the reservoir in place.

3.4.2 Bounding Operation with Operations Tied to EST05

Simulating the 2050 conditions using the "perfect knowledge" operations previously described in section 3.3.2 yielded the performance depicted below (Figure 16).

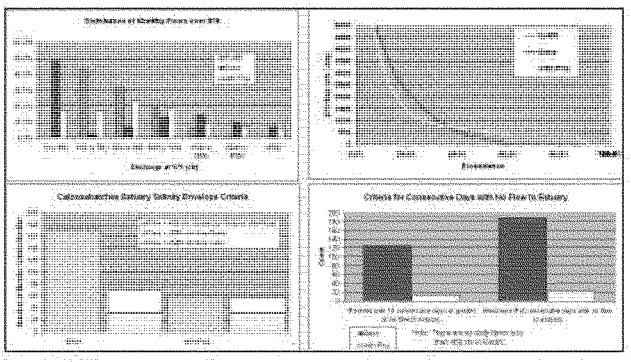


Figure 16. Performance measures for reservoir operations based on matching estuary target flow series EST05 under year 2050 conditions.

- The histogram again showed some improvement in the low and mid flow range over both the simplified operations and the "without project" condition. The occurrences of flows lower than 450 cfs were limited to approximately 17% of the time. This suggest that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs is not possible with the current reservoir specifications (size intake and outflow features) under projected 2050 conditions.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 60 from the without project to the "with project" condition. An improvement of 34 occurrences over the simple operations. The reduction in the high flows even with perfect knowledge was a modest 12 occurrences, reducing from 69 under the "without project" condition to 57 under the "with project" condition.
- The flow duration curve for the "with project" conditions again show a gradual merge of the plot under the "with project" conditions to the EST05 plot until the reservoir becomes incapable of delivering 450 cfs. The reservoir is capable of delivering 450 cfs or greater about 87% of the time over the 36 year simulation period, a significant improvement over the "without project" condition and some improvement over simplified operations.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 14 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 189 days to 23 days with the reservoir in place.

Below (Figure 17) shows a plot of flows over S-79 for a portion of the simulation and illustrates the operations under this release strategy. The selected period is a dry period when the reservoir volume ranges from empty to the just barely over half full for the

entire year. This plot explains the details of this operation scheme. Moving from left to right on the plot, when the flow over S-79 exceed EST05, the pump kick on and pumps at a rate equal to the difference between S-79 flows under the "without project" conditions and the target defined by EST05. When the pump capacity is reached, the pumping rate is capped and the excess continues to flow over S-79 resulting in flows greater than EST05. When flows under "without project" conditions drop such that they are greater than EST05 but less than pump capacity, the pumping rate reduces until the pump shuts off when the flows from both series become equal. When the flows under the "without project" conditions fall below EST05, reservoir releases commence at a rate adequate to bring the flow rates up to EST05. This persists until the reservoir volumes are inadequate to sustain such flows and the rate drops, limited by reservoir volume until there are no flows from the reservoir. As flows become available again for capture, the reservoir fills but at a rate limited to the excess over EST05 flows and limited by pump capacity. Releases commence, even with an almost empty reservoir once flows dip below EST05 flow rates.

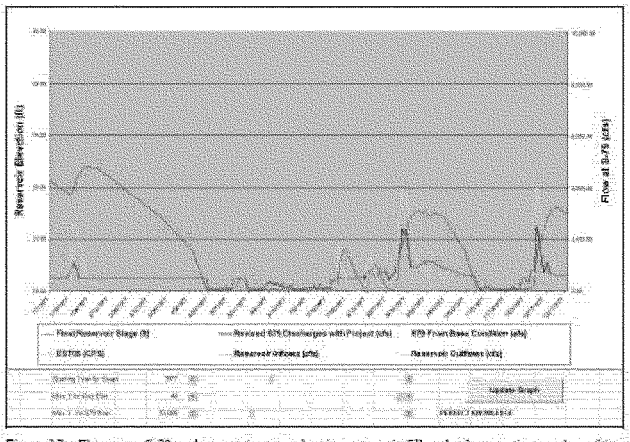


Figure 17. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modifications to pre-project S-79 flows under EST05 driven operations. Note extended periods of low to empty reservoir and periods of no flows over S-79 to estuary

3.4.3 Preferred Operation – Based on Seasonality and Reservoir State.

The final selected operations derived as described under 3.3.3 were implemented without change for the 2050 conditions. The iterative procedure was not duplicated. The resulting performance measures observed under this scenario are presented below (Figure 18).

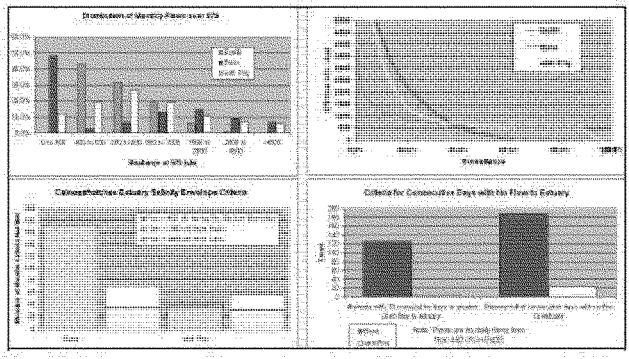


Figure 18. Performance measures for reservoir operations based on the preferred operation (considering seasonality and reservoir state) under year 2050 conditions.

- The histogram showed significantly greater improvement in the low and mid flow range over both the simplified operations and the "without project" condition and is better than the results under "perfect knowledge" operations. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 11% of the time. This suggest that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs is not possible with the current reservoir specifications (size intake and outflow features) under 2050 projected conditions.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 36 from the without project to the "with project" condition. An improvement of 58 occurrences over the simple operations, and 24 over the "perfect knowledge" operations.
- The flow duration curve for the "with project" conditions shows some raggedness corresponding to several small steps at specified operation breakpoints. It is an improvement over the simple operations in appearance and over other operational regimes explored in performance. The reservoir is capable of delivering 450 cfs or greater about 88% of the time over the 36 year simulation period, a significant improvement over the "without project" condition and a sizeable improvement over simplified operations.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 5 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 189 days to 23 days with the reservoir in place.

The operation strategy unrefined or optimized for 2050 flow conditions provided superior performance to the EST05 driven operation. As noted previously, while this operation strategy may not be the optimal operation strategy, it is considered sufficient for planning level analyses. A more rigorous analysis can and should be conducted when the project enters the design phase.

Below (Figure 19) shows a plot of flows over S-79 for the same portion of the simulation depicted in Figure 17. Figure 19 represents the results obtained from using the preferred operations and is compared with the results of the "perfect knowledge" operation to explain why the preferred operation yields better performance.

The selected period is a dry period when the reservoir volume ranges from empty to just barely over half full for the entire year. This plot explains the details of this preferred operation strategy and shows how it is able to meet the low flow criteria for longer period by releasing less than EST05 during a very dry event. Again, moving from left to right on the plot, when the flow over S-79 some threshold defined by the operation rules and depending on the season (January and February corresponding to the last month of early dry and the first month of late dry in this case), the pump kick on and pumps at a rate specified in the rules. When the pump capacity is reached, the pumping rate is capped and the excess continues to flow over S-79. When flows under "without project" conditions drop such that it crosses a decision threshold, the pumping rate reduces until the pump shuts at the specified S-79 flows for the current season at which the reservoir makes no releases. When the flows under the "without project" conditions fall below a release threshold, reservoir releases commence at a specified rate according to the operational rules. Releases persist until modified by either, flow thresholds, reservoir state, release capacity or reservoir volumes. When reservoir volumes become inadequate to meet the specified releases, the rate drops, limited by reservoir volume until there are no flows from the reservoir. As flows become available again for capture, the reservoir fills but at the specified rate limited only by pump capacity. If the reservoir is low and is within the state defined as empty, a stingy release strategy is applied and captured flow is dolled out at a low rate specified in the release rules corresponding to the reservoir state and season. Observe that this operation results in the availability of flows throughout the early dry season (right hand side of the plot) in the period depicted while the reservoir ran dry for the EST05 driven operations.

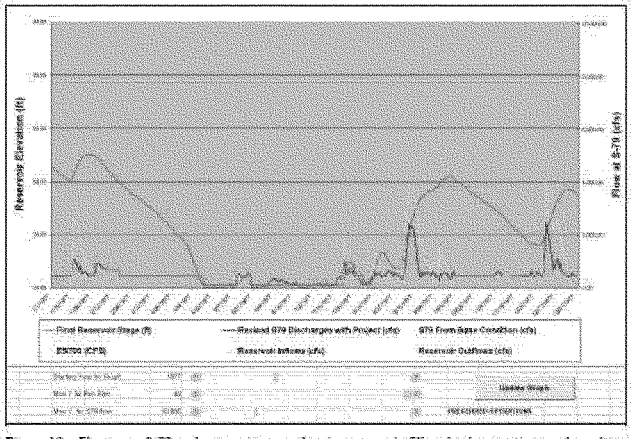


Figure 19. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modifications to pre-project S-79 flows under preferred operations. Note extended periods of low to empty reservoir but reduced periods of no flows over S-79 to estuary compared to Figure 17.

Section 4 - Discussion of Results

As stated in the introduction to this report, *"the purpose of the C- 43 Storage Reservoir Phase I Project is to improve water deliveries to the estuary, provide for dry season flows, reduce magnitude of wet season high flows, restore downstream salinity levels and ensure the availability of water for the natural system needs of the Caloosahatchee Estuarine System."*

The results of simulation using the spreadsheet model of both 2000 and 2050 conditions with project and comparison of those scenarios to the "without project" conditions suggest the following.

4.1 Water Deliveries to the Estuary

The "with project" runs using the preferred operations significantly extend the period of deliveries to the estuary over the "without project" conditions. The flow duration curves for both 2000 and 2050 scenarios show a shift in the percent of time flow to the estuary exceeds 450 cfs in the order of 45 percent with a slightly smaller shift for period of no flow to the estuary. If the simulated reduction is coupled with the realization that in

real life operations, actions that are different from the rule may be implemented to extend the available storage in the end of the very dry period, perhaps by implementing pulse releases, there is a possibility that zero flow to the estuary conditions may be further limited. The improvement in deliveries to the estuary is significant and should be reflected in the ecological modeling effort to establish habitat units. The current results still show period of no flow over S-79, this will have to be addressed in Phase II of this PIR.

4.2 Magnitude of West Season Flows

The results suggest more modest improvement in the area of high flows to the estuary, a reduction in percent exceedance in the order of 4 to 5 percent at 2800 cfs. The 12 to 14 point reduction in all flows over 2800 cfs, a 20 % improvement, leaves almost 50 occurrences more than the target, of flows greater than 2800 in the 36-year period of simulation. The pump capacity and reservoir volume are limiting in this respect. Without off line, long term storage (such as is projected to be capable through aquifer storage and recovery,) the reservoir fills quickly and high flow events pass by unhindered. To significantly affect the high flow conditions, other efforts such as CERP project components that result in a reduction in releases to the watershed from the regional system, along with the planned second phase of the C-43 Reservoir project will need to be implemented.

4.3 Retention of Water for Natural System

The results as described in section 4.1 show that the "with project" conditions meet the objective of storing water for the natural system. The quantification of the volume of water made available will be presented in a separate report.

Section 5 - Conclusions and Recommendations

The IMC has developed and implemented a spreadsheet model of the C-43 Basin Storage Reservoir, Phase I project. The spreadsheet model based on a water budget of the reservoir and flows over S-79 stores excess flow during high flow events for release during low flow event with the objective of achieving to the extent possible restoration flows to the Caloosahatchee Estuary.

The following are conclusions that can be reached from the results of the analyses completed using the model:

1) A reservoir project with the specifications provided by the C-43 PDT (170,000 acre ft storage, 1500 cfs inflow pump capacity, 1,200 to 1,500 outflow capacity) will provide significant benefit during low flow conditions by augmenting flows to the estuary.

2) The reservoir will significantly minimize zero flow conditions to the estuary and will reduce the frequency of occurrence of less that 450 cfs, minimum restoration flows, over the existing conditions and future condition without the project.
3) The reservoir will have modest improvement in reduction of high flow.
4) While less than the "without project" condition, without additional efforts beyond the C-43 West Phase I reservoir project, high flow event will still significantly exceed the target frequency.
5) The project stored and makes water available to the natural system when needed by the estuary

APPENDIX I

SPREADSHEET MODEL USER DOCUMENTATION

FINAL Page 35 of 58

An Overview and User Manual for the Spreadsheet Model "C43_PIR-model_Final.xls"

Walter Wilcox & Akintunde Owosina

Introduction

The proposed C43 basin reservoir is expected to provide additional storage which will allow for increased operational flexibility in controlling discharges to the downstream Caloosahatchee Estuary. In order to illustrate the potential performance associated with this project, the spreadsheet model "C43_PIR-model_Final.xls" has been developed. The spreadsheet's primarily goal is to compare the with-project discharge over S79 (the downstream point at which the basin discharges into the estuary) to both the pre-project discharge over S79 and to the EST05 time series representing restoration target flows over S79 for a 36 year, daily period of simulation. In addition, the spreadsheet also shows a water budget for the reservoir and tracks reservoir inflows, releases and storage. The factors influencing the scope of the spreadsheet development and analysis are encompassed in other project documents and therefore, the primary purpose of this document is to catalog the means and methods by which the spreadsheet functions.

Methodology

The spreadsheet is predicated on a mass balance approach assuming that flows observed in a base condition at S79 can be captured, stored offline in a defined reservoir control volume and then later released to discharge at S79 during a more desirable period. As such, the primary equations utilized in the spreadsheet involve the mechanism by which S79 flows are diverted and the criteria for such diversions (including operational intent and conveyance limitations). Climate conditions affecting the reservoir control volume are also considered. The governing equation for mass balance on the reservoir is:

$$Res_Sto_f = Res_Sto_i + Res_Inflows + Rainfall - Evaporation - Res_Releases - Seepage \quad \text{(Equation 1)}$$

where Res_Sto_f is the storage in the reservoir at the end of the time step, Res_Sto_i is the storage in the reservoir at the beginning of the time step, Res_Inflows is the inflow to the reservoir control volume during the time step and Res_Releases is the outflow from the reservoir control volume during the time step. The governing equation for modification to S79 flows as a result of reservoir operations is:

$$S79_{wproj} = S79_{pre\text{-}proj} - Runoff_Adjust - Res_Inflows + Res_Releases * Efficiency \quad \text{(Equation 2)}$$

where Runoff_Adjust accounts for a water budget correction involving the potential effect of the reservoir footprint on basin runoff and Efficiency accounts for potential losses between the reservoir discharge point and the estuary. S79 flow and other data for Existing Conditions Baseline (2000) and Future without Project Condition (2050 with no-

FINAL Page 36 of 58

CERP projects in place) are derived from South Florida Water Management Model (SFWMM) runs 2000RD and 2050RD. The following assumptions related to regional influences (excluding S79) are made in conducting the spreadsheet analysis:

- No agricultural or urban water supply deliveries are supplied by the reservoir; these demands continue to be supplied from Lake Okeechobee or current groundwater sources
- Eastern Caloosahatchee Basin (east of S-78) is not affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary west of S79, there will be no impacts on the Western Caloosahatchee Basin.
- The regional system, including Lake Okeechobee and non-C43 downstream basins will not be impacted by the project.

Example Daily Time Step

The following outlines how the model calculates an end of day reservoir storage and S79 flow value from the initial S79 flow term for a given day. Italics refer to worksheets in the "C43_PIR-model_Final.xls" workbook.

- In *Reservoir_Model*, S79 flow from the base condition (cfs) is taken from *Input TS* (originally derived from SFWMM simulations).
- S79 flow contributed by basin runoff is modified to account for the existence of the reservoir footprint. This helps to ensure that the analysis does not affect the basin water budget and artificially "generate" water from rainfall on the reservoir. The means by which runoff is adjusted is determined by which option is used to adjust runoff to S79 (described in more detail under the "User Options" section).
- Reservoir inflows are calculated based on a combination of factors including desired operational intent, inflow pump capacity and available volume in reservoir.
- Rainfall (if any) occurs on the entire reservoir footprint.
- An intermediate storage volume is calculated as the previous end-of-day storage plus inflows and rainfall. This volume (and associated stage/area) will be referenced in remaining decisions within the time step.
- Reservoir outflows are calculated based on a combination of factors including desired operational intent, outflow spillway capacity, overflow spillway capacity, expected efficiency in delivery from reservoir to S79 (assumed to be 100% for analysis, but can be user specified) and available volume in reservoir.
- Evaporation on the water surface area within the reservoir (after outflows) occurs. Total evaporation is limited to the available volume in the reservoir.
- Reservoir seepage losses occur (assumed to be zero for analysis, but can be user specified).
- End-of-day reservoir storage and associated stage is calculated using the governing mass balance in Equation 1.
- Revised, with-project S79 flows are calculated by subtracting reservoir inflows and adding reservoir outflows (including efficiency term) to the adjusted S79 flows calculated in Step 2 (application of Equation 2).

FINAL Page 37 of 58

Spreadsheet Structure

While the model produces 36 years of daily output, only the first several rows of data in each calculation column retain the equations required to perform a simulation. This is done in order to save on memory and disk storage requirements. The rows that retain active formulas are typically highlighted through use of red and/or blue text. Spreadsheet simulations are controlled by a high level macro that is accessed by clicking on the "Run Simulation" button in the *Reservoir_Model* worksheet (Figure 1). This macro propagates required equations throughout the workbook and updates all dependent series including pivot tables and sorted data prior to saving the majority of data as values. A related macro, accessed by clicking on the "Condense Spreadsheet and Save" button in the *Reservoir_Model* worksheet, deletes many data arrays in an effort to condense file size for quicker transfer through ftp, e-mail, etc.

Worksheet Descriptions

- *Reservoir_Model* – This worksheet is the primary simulation engine for the analysis. Rows 1-9 contain many of the user input options and columns E-S perform the daily simulation of the reservoir and accompanying changes to S79 flows. Data to the right of Column Z is associated with post-processing results to be displayed on subsequent worksheets.
- *PMs* – Graphs of various evaluation criteria (performance measures) associated with S79 discharges and reservoir operation. Included are the following: 1) S79 discharge histogram; 2) Caloosahatchee Estuary salinity envelope criteria (per RECOVER); 3) Daily S79 flow duration curve; 4) Criteria for consecutive days with no flow to the estuary at S79; and 5) Interactive graph showing detailed reservoir performance for a specified year.
- *Checks* – Graphs of various metrics associated with reservoir and basin performance are displayed in this worksheet. Included are the following: 1) Reservoir stage hydrograph; 2) Reservoir stage duration curve; 3) Scatter plot of original vs adjusted S79 flows for the base condition; 4) Reservoir stage vs inflows; 5) Reservoir stage vs outflows; 6) Reservoir inflows vs outflows
- *Pivot* – Houses pivot tables of monthly average S79 flow for the pre- and with-project conditions. This sheet is automatically updated when the "Run Simulation" macro is invoked.
- *Input TS* – Contains time-series data imported from the SFWMM including S79 flows, basin runoff, rainfall and potential evapotranspiration (PET).
- *Ops* – This worksheet is only utilized if option #2 (Seasonal/Res stage criteria) is used in the operational criteria drop box on the *Reservoir_Model* worksheet. The operations defined in this sheet will select a desired inflow / release volume to be used in the simulation of the reservoir operations. The decision is predicated on the definition of three terms – 1) base condition adjusted flow at S79; 2) current season (early dry, late dry, early wet or late wet); and 3) current reservoir state (empty, medium or full).
- *Res* – This sheet contains information provided by Stanley Consultants on the proposed reservoir storage to area to stage relationship. Although information is provided for individual cells (numbers 1 and 2), only the total, aggregated values are used by the workbook. This worksheet contains six defined arrays

(areasta, areasto, staarea, stasto, stoarea and stosta) which are used in the various lookup tables in other worksheets. Modifications to the proposed footprint / bathymetry of a reservoir alternative can be accommodated by changing the definition of these arrays.

- *Est05* – Contains the time-series and sorted daily restoration target flows desired over S79.

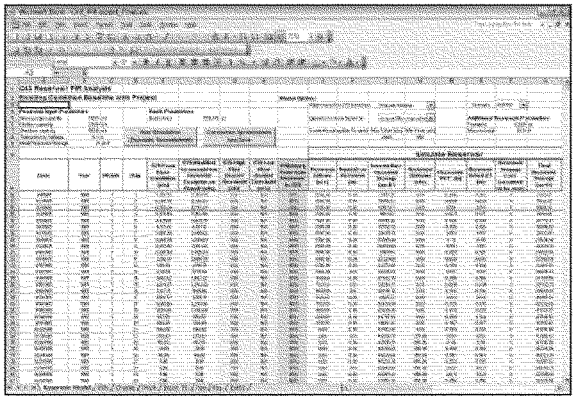


Figure 1. Screen Capture of "C43_PIR-model_Final.xls"

User Options

- Reservoir Input Parameters – In cells B-5 to B-9 of the *Reservoir_Model* worksheet, users can specify values for the following terms: 1) Reservoir inflow pump capacity; 2) Reservoir outflow capacity; 3) Reservoir overflow capacity; 4) Tolerance for Spillage; and 5) Initial Reservoir Storage. The additional parameters of reservoir footprint and maximum reservoir height are specified in cells P7 and P8. These values are referenced back the volume-stage-area relationship provided in the *Res* worksheet. Option # 4 (Tolerance for Spillage) is used in operating the reservoir to avoid overtopping. Inflows to the reservoir are stopped at the maximum reservoir height – tolerance and outflows are begun at the maximum reservoir height – tolerance + 0.1 ft.
- Adjust runoff to S79 drop box – This option has little effect on the overall analysis, but various methodologies were proposed by the technical team and incorporated into the model. The following options may be selected:
  - Landarea Ratio – S79 flow will be adjusted using the equation:
    $S79_{adj} = S79_{base} - Runoff_{Basin} * ResFootprint / Basin\ Area$
  - Daily RF/RO Ratio – S79 flow will be adjusted using the equation:

$S79_{adj} = S79_{base} - Runoff_{Basin} * Rainfall_{Res} / Rainfall_{Basin} * ResFootprint / Basin Area$

- Accumulated RF/RO Ratio – S79 flow will be adjusted using the equation:

$S79_{adj} = S79_{base} - Runoff_{Basin} * AccRF_{Res} / AccRF_{Basin} * ResFootprint / Basin Area$

where AccRF represents the 10-day moving accumulation of previous rainfall. It is recommended that Option 3 (accumulated RF/RO ratio) be selected for analysis.

- Operational criteria drop box – The following options may be selected:
  - Max/Min S79 thresholds – Reservoir operations will attempt to keep daily S79 flow between the thresholds specified in cells L8 and M8 (these can be modified by the user).
  - Seasonal/Res stage criteria – Operations will be dictated by the prescribed lookups found in the *Ops* worksheet as described above. The user can control the parameters of the lookup by modifying several fields in the *Ops* sheet including:
    - S79 flow categories in B8 to C16
    - Reservoir stage breakpoints for defining empty / medium / full in cells B20 and B21.
    - The season (early dry, late dry, early wet or late wet) associated with each calendar month in cells G8 to G19
    - The fill and release volumes by modifying the factors in columns U-X.
  - Use of EST05 – Reservoir operations will attempt to match daily flow as closely as possible to the EST05 daily value as taken from the *Est05* worksheet.
- Scenario drop box – Used to select which SFWMM run to reference for the Base Condition. The available options are the 2000RD (for existing condition) and 2050RD (for future condition) scenarios.
- Detailed reservoir performance graphic – In the *PMs* worksheet, there is an interactive graph illustrating reservoir stage as well as various simulated flows associated with the reservoir and S79. To control this graphics, the user may use the pull bars to specify the desired year (x-axis) and maximum y-axis scaling values for reservoir elevation and flows. Once appropriate values have been selected, the "Update Graph" button should be clicked to implement changes.
- Consecutive days of no-flow to S79 option - In the *PMs* worksheet, the number of consecutive days required to increment a count in the fourth graphic can be modified by updating cell AZ4 in the *Reservoir_Model* worksheet.
- Reservoir seepage loss – If desired, an equation for calculating reservoir seepage loss can be added to cells P12-P14 in the *Reservoir_Model* worksheet. As long as the equation occupies all three cells, it will be propagated during analysis.
- Efficiency term from reservoir to S79 - If desired, an equation or value for calculating efficiency in deliveries from the reservoir to S79 can be added to

cells I12-I14 in the *Reservoir_Model* worksheet. As long as the equation occupies all three cells, it will be propagated during analysis.

APPENDIX II

SENSITIVITY ANALYSIS

A sensitivity analyses of key model parameters is recommended but was not completed in a detailed manner under the current scope. An informal, ad-hoc sensitivity analyses was performed for the selection of the preferred operation scheme which showed that the model was sensitive to the operations parameters specified. These include the breakpoints depths for defining an empty, medium or full reservoir, the breakpoints for flow over S-79 at which different release of fill rates are implemented (especially at the 2000 cfs point.) The performance of the model is also sensitive to the definition of the seasons; however the sensitivity diminishes as the operations across seasons become more similar.

The IMC recommends a more robust sensitivity analyses if this tool is to used as part of future work on the C-43 phase II project.

APPENDIX III

RESERVOIR PREFERRED OPERATION RULES

The seasonal operation implemented in the spreadsheet is based loosely on the logic contained below (Figure III-1).

Fill	WET SEASON	DRY SEASON
Early in Season	Fill slowly to retain capacity for later in the season	Fill aggressively in preparation for rest of dry season
Late in Season	Fill reservoir faster to get full by end of year (use available capacity as a factor)	Fill slowly to retain capacity for wet season

Pump capacity (and channel capacity) are limiting. Intake threshold and volume may vary but based on a consistent logic. The Threshold will be determined by iteration.

Empty	WET SEASON	DRY SEASON
Early in Season	Release aggressively to create capacity for filling reservoir later in the season	Release less aggressively to extend ability to release longer into the dry season
Late in Season	Release more carefully to keep reservoir full going into the dry season	Release more aggressively to empty reservoir in preparation for the wet season

The constraint to the release strategy listed to the side are reservoir release capacity and the requirement that wet season flows should not greatly fall below EST05 and Dry season flow over S-79 should not greatly exceed EST05

Figure III-1. Generalized operational logic to implement seasonality.

In determining and assigning numerical values to the general logic above, the following definitions were adopted.

Seasons

Early wet season was defined as June to July
Late Wet season was defined as August to October
Early Dry season was defined as November to January
Late Dry season was defined as February to May
The definitions of these seasons are in the operations "Ops Worksheet" in the spreadsheet and can be changed within the spreadsheet. See below (Figure III-2).

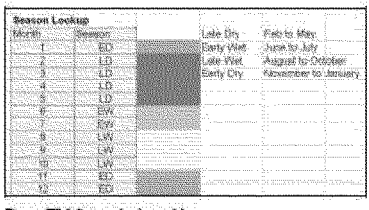


Figure III-2 Season lookup table

Reservoir State

The state of the reservoir, empty, medium or full is defined in the "Ops Worksheet" and can be changed within the spreadsheet. The initial definition is as shown below:

Empty reservoir:	Elevation 19 to 25 NAVD
Medium full reservoir:	Elevation 25 to 33 NAVD
Full reservoir:	Elevation 33 to 42 NAVD

Following changes made to this parameter to determine preferred operations, the reservoir state definition was simplified to use just two zones shown below (Figure III-3).

Reservoir Breakpoints

Stage	Storage
29	57534
42	178602

19.2	to	29.0	Empty
29.0	to	42.0	Mid
42.0	to	42.0	Full

Figure III-3. Reservoir break points for defining reservoir state.

Flow Decision Breakpoints

A series of ranges of flow were established at which fill decision or release decisions will be made. These ranges differ for fill or release but were limited to 9 categories in each case. Below (Figure III-4) shows the flow at which operational decision changes occurred within the mode.

Operations Parameters

S79 flow

Fill	Drain	Category
520.01	250.01	1
650.01	350.01	2
850.01	450.01	3
1000.01	550.01	4
1200.01	800.01	5
1500.01	1000.01	6
2000.01	1500.01	7
2800.01	2800.01	8
99999	99999	9

Figure III-4. Flow decision breakpoints

The Initial operation rules specified based on examination and analyses of available data is shown below (Table III-1 and Table III-2).

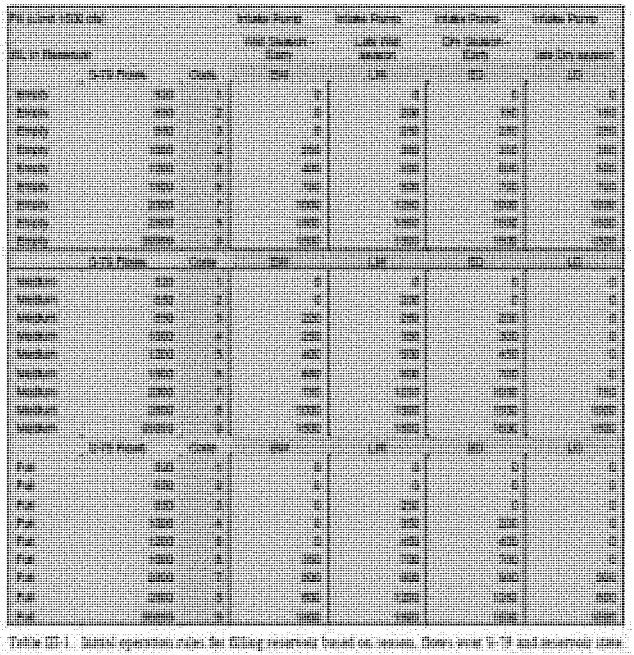


Table III-1 Initial operation rules for filling reservoir based on season, flows near S-79 and reservoir stage

As can be observed from the data contained in Table III-1 and Table III-2, the pumping and release rates (in cfs) meet the intent of the logic described in Figure III-1. These initial values were subject to small variations for the purpose of developing successively improved performance. The final set of operations described in this appendix and shown in Table III-3 and Table III-4 were the result of the iterative process and were used as the preferred operations for both the 2000 and 2050 scenarios.

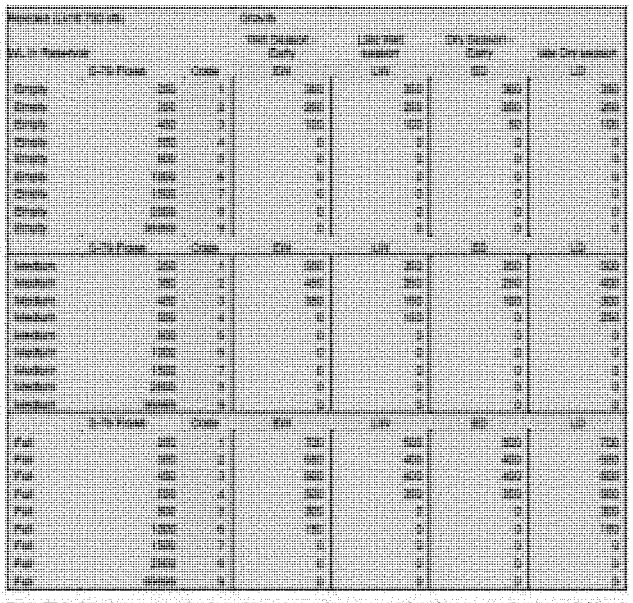


Table III-2. Initial operation rules for making releases from reservoir based on season, flows over S-79 and reservoir state.

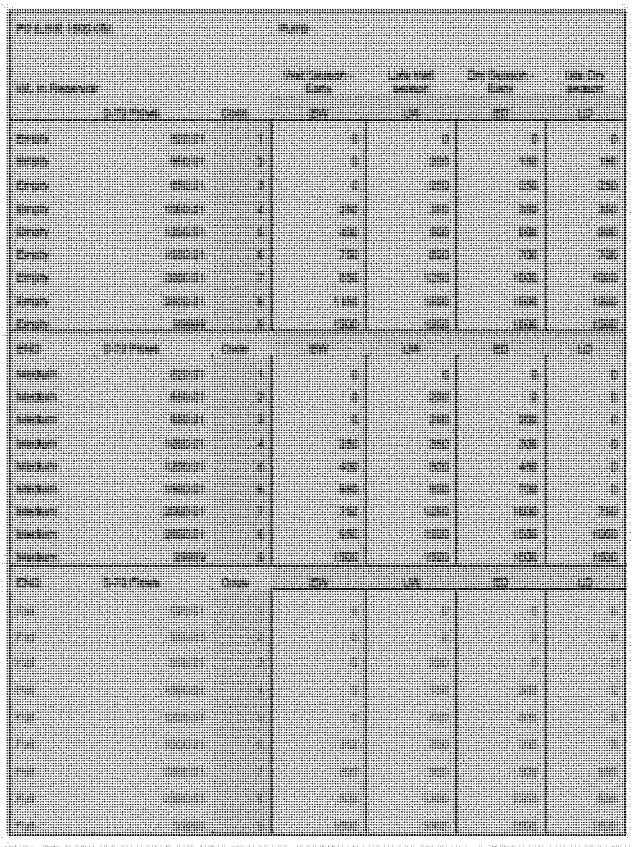


Table III-3 Initial operation rules for filling reservoir based on season, flows over S-79 and reservoir state (Note values in red while defined were not used due to reservoir state condition)

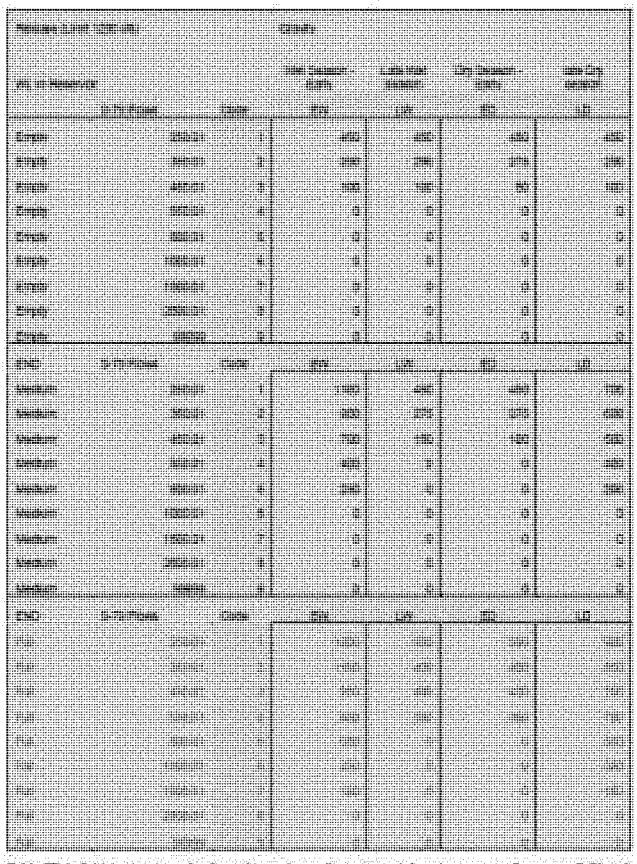
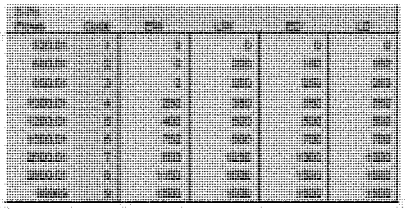


Table III-4. Initial operation rules for making releases from reservoir based on season, flows over S-79 and reservoir state (Note values in red while defined were not used due to reservoir state condition)

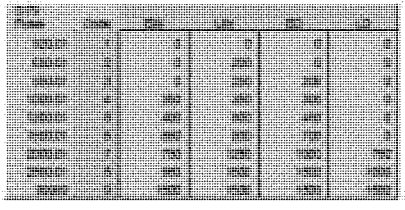
Preferred Operations

Reservoir Fill Decision

1) If the reservoir is empty, a state defines as having 10 feet or less of water or a water surface of elevation 29 feet or less, implement the following operations depending on the season (Early Wet – EW, Late Wet – LW, Early Dry – ED, Late Dry – LD) and flows over S-79 less than the value shown to the left of the table.

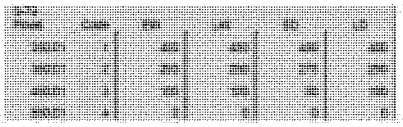


2) If the reservoir is medium or full, a state defines as having more than 10 feet of water, or a water surface of elevation of more than 29 feet NAVD, implement the following operations depending on the season (Early Wet – EW, Late Wet – LW, Early Dry – ED, Late Dry – LD) and flows over S-79 less than the value shown to the left of the table.

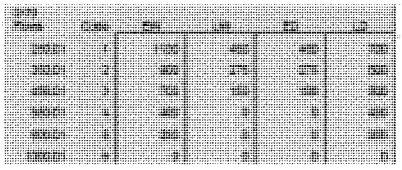


Reservoir Environmental Release Decision

1) If the reservoir is empty, a state defines as having 10 feet or less of water or a water surface of elevation 29 feet or less, implement the following operations depending on the season (Early Wet – EW, Late Wet – LW, Early Dry – ED, Late Dry – LD) and flows over S-79 less than the value shown to the left of the table.



2) If the reservoir is medium or full, a state defines as having more than 10 feet of water, or a water surface of elevation of more than 29 feet NAVD, implement the following operations depending on the season (Early Wet – EW, Late Wet – LW, Early Dry – ED, Late Dry – LD) and flows over S-79 less than the value shown to the left of the table.



Operation Exceptions

The following conditions void the rule based operation

1) Ignore reservoir filling rule if reservoir full to within a specified value of spillway (5000 acre feet used in spreadsheet) or within specified height in feet (specified within the model as tolerance for spillage = 0.3 feet used in spreadsheet) of spillway elevation.
2) Release at maximum rate (specified as 1200 cfs) despite release rule if reservoir full to within 0.2 feet of spillway elevation. (specified within the model as tolerance for spillage – 0.1)
3) Suspend release rule if reservoir is empty.

Operation pattern resulting from the rules and exceptions above are graphically depicted in the check plots shown below.

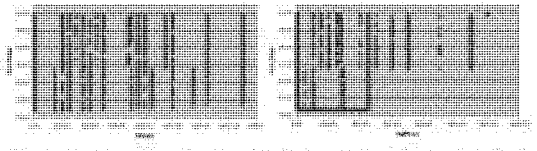


Figure III-5. Inflow and outflow operations plotted against reservoir stage for preferred operations.

Customer Requirements

The IMC has fulfilled the objectives of this project and has met the customer requirements.

The objectives of the study conducted by the IMC are as follows.

1) Develop a spreadsheet tool suitable for meeting the requirements identified in the customer requirements section (1.3) of this report and submitted as attachment to MSR 262 by the C-43 PDT.

The IMC has developed a spreadsheet suitable for meeting the requirements identified in the customer requirements section of this report. The IMC has demonstrated the application of the spreadsheet tool using the C-43 Basin Storage Reservoir, Phase 1 Project.

2) Utilize the spreadsheet to simulate the 2000 and 2050 condition with and without project for the purposes of fulfilling

a. GM #2-Next Added Increment Analysis requirement

b. GM #4 requirements for Identifying Water Made Available by the Project-volumetric analysis from spreadsheet output, and

c. GM #5-Serves at the basis for Draft Project Operating Manual-Spreadsheet operations of Existing Conditions with Project (same as Initial Operating Regime).

The IMC has used the spreadsheet model to simulate 2000 and 2050 conditions and has produced model results with and without project for subsequent analyses by others. In addition the IMC has implemented the methodology for satisfying GM # 2, GM #4 and GM #5.

3) Deliver the spreadsheet with a user guide and model results to PDT team for subsequent analyses.

The IMC has delivered the spreadsheet to the PDT and the results of the spreadsheet for subsequent analyses.

4) Deliver the model results to assurances team for subsequent analyses and write-up.

The IMC has delivered the model results to the assurances team for subsequent analyses.

5) Document the spreadsheet and provide a project report describing the analyses, the key assumptions, limitations and application to the PDT.

The IMC has documented the spreadsheet by preparing and delivering a user documentation report. The IMC has further documented it effort by developing and delivering a technical memo detailing the work completed under MSR 262.

Features Checklist

- Flow data for Existing Conditions Baseline (2000) and Future "without project" condition (2050 with no-CERP projects in place) is derived from South Florida Water Management Model runs 2000RD and 2050RD.
- ET from reservoir will be included. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, reservoir seepage will be assumed to be zero, ET losses (based on area volume relationship), and perhaps reservoir direct precipitation (not yet confirmed).
- System losses from the river to groundwater from the point of release of the reservoir to S-79 will be factored into the spreadsheet analysis. (Evaluation of relevant available data indicates that use of 100% efficiency is reasonable for this project)
- No agricultural or urban water supply deliveries are supplied by the reservoir these demands continue to be supplied from Lake Okeechobee or current groundwater sources
- Water will be pumped into the reservoir only when there are excess flows over S-79. Excess will be treated initially as high flows over some threshold that will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Releases from the reservoir are made when flows over S-79 are below desirable levels (450 cfs). Releases will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Including basic seasonal operational variability in the spreadsheet for filling and draining the reservoir is preferable.

FINAL Page 57 of 58

INTERAGENCY MODELING CENTER

Technical Memorandum

To: Janet Starnes, Beth Marlowe

From: Interagency Modeling Center (IMC)

Project: C-43 Reservoir Phase I

Subject: Alternative Evaluation Using C-43 Spreadsheet Model

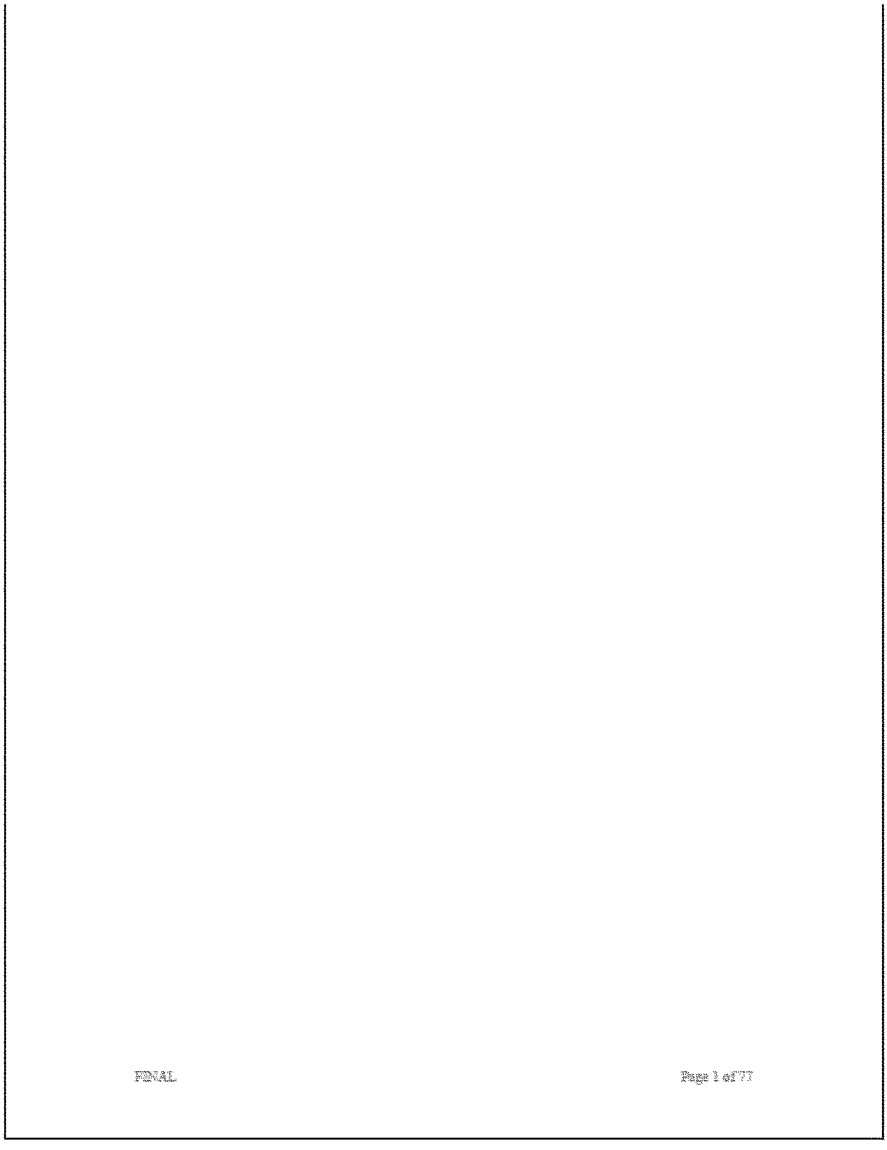
Application of Spreadsheet Model to Evaluation of
C-43 Storage Reservoir Project Alternatives

for

C-43 Project Delivery Team

March 23, 2007
MSR 264

FINAL Page 0 of 77


FINAL
Page 1 of 77

Contents

Contents ..... Page 2

Section 1 – Introduction ..... Page 4

Section 2 – Approach ..... Page 8

Section 3 – Initial Array of Alternatives/Options ..... Page 13

Section 4 – Model Application ..... Page 16

Section 5 – Discussion of Results ..... Page 42

Section 6 – Discussion of Results ..... Page 50

Section 7 – Conclusions and Recommendations ..... Page 51

Appendix I ..... Page 54
- Alternative 2 ..... Page 56
- Alternative 3b ..... Page 60
- Alternative 3c ..... Page 64
- Alternative 4 ..... Page 68

Appendix II ..... Page 72

Section 1 – Introduction

1.1 Project Background

The C-43 Basin Storage Reservoir Phase I Project comprises the C-43 West Storage Reservoir (Figure 1) located on the Berry Grove property in the western portion of the Caloosahatchee Watershed in Hendry County, Florida.

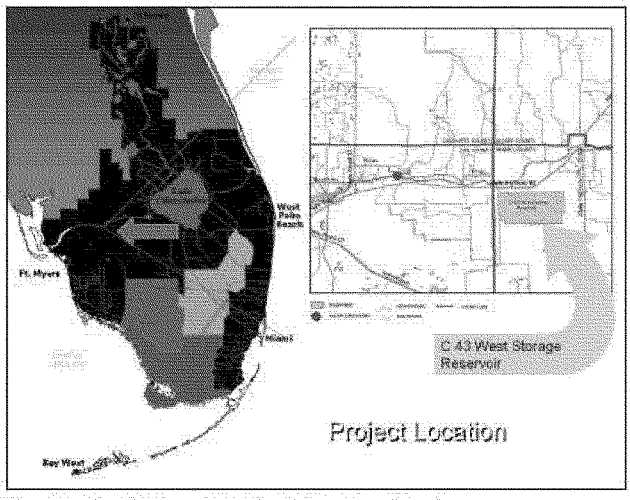


Figure 1. Location of the Proposed Site for the C-43 West Storage Reservoir.

The purpose of the C-43 Basin Storage Reservoir Phase I Project is to improve water deliveries to the estuary, provide for dry season flows, reduce magnitude of wet season high flows, restore downstream salinity levels and ensure the availability of water for the natural system needs of the Caloosahatchee Estuarine System. Subsequent phases of the C-43 Storage Reservoir Project will address these same issues in addition to providing additional water resource benefits through provision of supplemental water resources for agriculture and urban users thereby benefiting the regional system by reducing the dependence on Lake Okeechobee.

In selecting the components of the Phase I project, the Project Delivery Team (PDT) used a formal plan formulation process described in Section 5 of the Draft PIR report and considering the objectives and opportunities of the project as well as documented project siting criteria. The criteria included such factors as land use and land cover, proximity to primary canal, site elevation, potential restoration value, location within the watershed (proximity to the Estuary), soil suitability for the project and so on. The screened list of potential sites was further reduced by considering threatened and endangered species and geotechnical screening concerns. One site, the Berry Groves property in the Western Caloosahatchee Basin and several in the Easter Caloosahatchee Basin were developed as a final list of potential sites. Considering the focus of the first phase of the project, improving the flows to the estuary, the project location in the Western Caloosahatchee Basin was selected for development of alternatives.

The Interagency Modeling Center (IMC) has been tasked through MSR 264 to modify a spreadsheet model of the C-43 Basin Storage Reservoir previously developed for conducting Next Added Increment (NAI) and project assurances analyses and apply the spreadsheet to the evaluation of the alternatives for the basis of selecting a recommended plan. This report documents the objectives, scope of work approach, and describes the modeling tool modification and simulations conducted on behalf of the C-43 PDT per MSR 264.

1.2 Objectives and Scope of Work

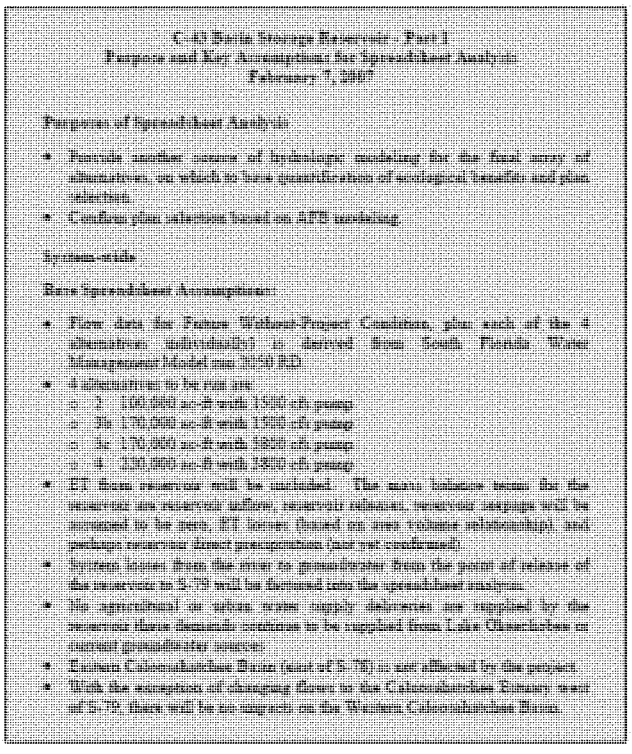
The objectives of the study conducted by the IMC are as follows.

1) Develop a spreadsheet tool suitable for meeting the requirements identified in the customer requirements section (Section 1.3) and submitted as attachment to MSR 264 by the C-43 PDT.
2) Utilize the spreadsheet to evaluate the project alternative scenario using the 2050 (NAI) condition for the purposes of plan selection.
3) Deliver the spreadsheet results to the PDT for further analyses and computation of habitat units.
4) Document the spreadsheet and provide a project report describing the analyses, the key assumptions, limitations and application to the PDT.

1.3 Customer Requirements

The IMC was tasked by the PDT through MSR 264 to modify and apply a simplified spreadsheet model of the C-43 West Reservoir based on capture of excess flow over S-79 as derived from SFWMM simulation of the 2050 future base conditions. The detailed scope and customer requirements are as follows:

FINAL Page 5 of 77



C-43 Basin Storage Reservoir - Part 1
Purpose and Key Assumptions for Spreadsheet Analysis
February 7, 2007

Purposes of Spreadsheet Analysis:

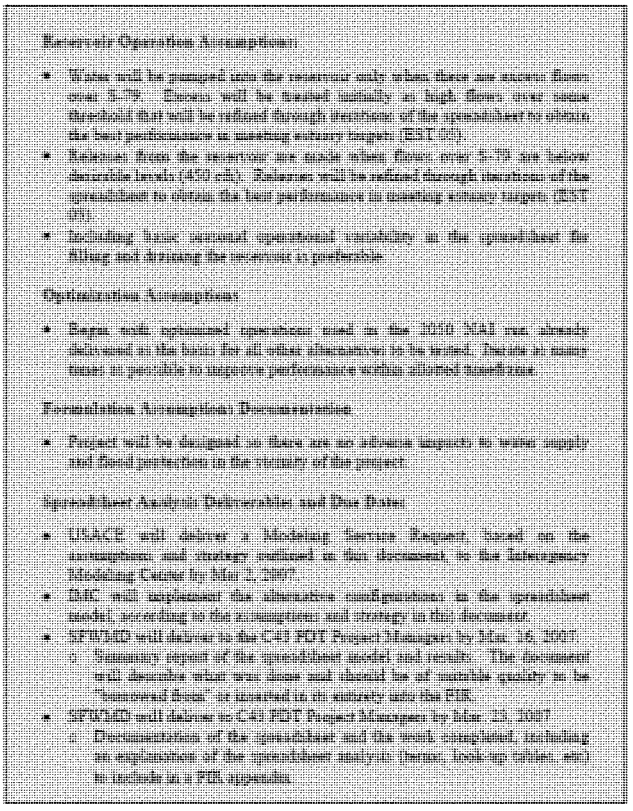
- Provide another source of hydrologic modeling for the final array of alternatives, on which to base quantification of ecological benefits and plan selection.
- Confirm plan selection based on ATM modeling.

System-wide

Base Spreadsheet Assumptions:

- Flow data for Future Without-Project Condition, plus each of the 4 alternatives, individually, is derived from South Florida Water Management Model run 3A09.RD
- 4 alternatives to be run are:
  - 1: 100,000 ac-ft with 1500 cfs pump
  - 2a: 170,000 ac-ft with 1500 cfs pump
  - 3a: 170,000 ac-ft with 1850 cfs pump
  - 4: 220,000 ac-ft with 1850 cfs pump
- ET from reservoir will be included. The mass balance terms for the reservoir are reservoir inflow, reservoir release, reservoir seepage will be assumed to be zero, ET (based on pan evaporation), and perhaps reservoir direct precipitation (but not confirmed)
- Seepage losses from the river to groundwater from the point of release of the reservoirs to S-79 will be factored into the spreadsheet analysis.
- No agricultural or urban water supply deliveries are supplied by the reservoir these demands continue to be supplied from Lake Okeechobee or current groundwater sources.
- Eastern Caloosahatchee Basin (east of S-79) is not affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary west of S-79, there will be no impacts on the Western Caloosahatchee Basin.

FINAL Page 6 of 17



Reservoir Operation Assumptions:

- Water will be pumped into the reservoir only when there are excess flows over S-79. Excess will be treated initially as high flows over some threshold that will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Releases from the reservoir are made when flows over S-79 are below desirable levels (450 cfs). Releases will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Including basic seasonal operational variability in the spreadsheet for filling and draining the reservoir is preferable.

Optimization Assumptions:

- Bages with optimized operations used in the 2010 NAI run already delivered as the basis for all other alternatives to be tested. Iterate as many times as possible to improve performance within allotted timeframe.

Formulation Assumptions Documentation:

- Project will be designed as there are no adverse impacts to water supply and flood protection in the vicinity of the project.

Spreadsheet Analysis Deliverables and Due Dates:

- USACE will deliver a Modeling Service Request based on the assumptions and strategy outlined in this document to the Interagency Modeling Center by May 2, 2007.
- IMC will implement the alternative configurations in the spreadsheet model, according to the assumptions and strategy in this document.
- SFWMD will deliver to the C-43 PDT Project Manager by May 16, 2007:
  - Summary report of the spreadsheet model and results. The document will describe what was done and should be of suitable quality to be "borrowed from" or inserted in its entirety into the PIR.
- SFWMD will deliver to C-43 PDT Project Manager by May 23, 2007:
  - Documentation of the spreadsheet and the work completed, including an explanation of the spreadsheet analysis (terms, look-up tables, etc) to include in a PIR appendix.

FINAL Page 7 of 77

Section 2 – Approach

The approach and assumptions used by the IMC team for modifying and applying the C-43 West Reservoir spreadsheet model is discussed in the following section.

2.1 Assumptions and Considerations for the Analyses

2.1.1 Project Assumptions Provided by PDT

The following are project assumptions provided by the customer as requirements. These assumptions were considered and implemented in the spreadsheet model for the evaluation of project alternatives.

- Flow data at S-79 for the "Future Without" Project Condition (plus each of the 4 alternatives individually) is derived from South Florida Water Management Model run 2050RD.
- 4 alternatives to be run are:
  - 2 100,000 ac-ft with 1500 cfs pump
  - 3b 170,000 ac-ft with 1500 cfs pump
  - 3c 170,000 ac-ft with 3800 cfs pump
  - 4 220,000 ac-ft with 3800 cfs pump
- ET from reservoir will be included. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, ET losses, and reservoir direct precipitation. Reservoir seepage will be assumed to be zero.
- System losses from the river to groundwater from the point of release of the reservoir to S-79 will be factored into the spreadsheet analysis.
- No agricultural or urban water supply deliveries are supplied by the reservoir. These demands continue to be supplied from Lake Okeechobee or current groundwater sources.
- Eastern Caloosahatchee Basin (east of S-78) is not affected by the project.
- With the exception of changing flows to the Caloosahatchee Estuary west of S-79, there will be no impacts on the Western Caloosahatchee Basin.
- Water will be pumped into the reservoir only when there are excess flows over S-79. Excess will be treated initially as high flows over some threshold that will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Releases from the reservoir are made when flows over S-79 are below desirable levels (450 cfs). Releases will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Basic seasonal operational variability for filling and draining the reservoir is included in the spreadsheet model.

2.1.2 Additional Assumptions

In addition to the assumption provided by the PDT, the IMC has implemented the following additional assumptions for the reasons provided.

1) Minimal natural losses to reservoir releases between the project and S-79 can be expected. An efficiency of delivery factor of 1 or 100% is used in the spreadsheet to ensure that all releases from the reservoir arrive at S-79. This assumption is based on analyses of more rigorous hydrologic modeling that was conducted using the MIKESHE model that show that within the reach of the Townsend Canal and the portion of C-43 from the Townsend Canal – C-43 Canal intersection, the canal are gaining and have water level that is consistently lower than groundwater elevation. This assumption was further verified with topographic data completed as part of the data preparation for the Southwest Florida Feasibility Study which show that the C-43 and Townsend canals in this region are at notable lower elevation than the adjacent land (Figure 2).

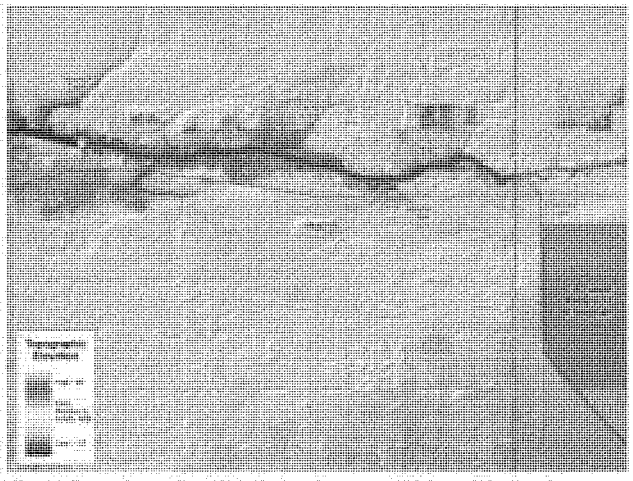


Figure 2. Topographic map of the C-43 and environ downstream of the Townsend Canal confluence.

2) Exact reservoir storage volume of 100,000, 170,000 and 220,000 acre feet and pump station total capacity of 1,500 and 3,800 cfs will be used in the spreadsheet analyses.
3) In basin flow routing and other internal details such as flow between multiple cells or multiple releases will not be included in the spreadsheet analysis as such

detail are at a more refined scale than the analysis. IMC considers this assumption appropriate since the focus of the spreadsheet analysis is the redistribution of excess flow over S-79 through use of the reservoir to improve timing and quantity of flow over S-79. The localized operations can be represented by simple reservoir filling or release operation within the spreadsheet analyses.

4) Progressively more complex operations that meet the customer requirement will be implemented; starting from simple operations based on a low and a high flow threshold to perfect knowledge (operation based on the identified estuary target EST05) to bound the solution. This assumption ensures successive suitable operations that provide increasing information on model and expected reservoir performance as the complexity increases to the recommended operations. The tool as modified retains the flexibility to implement the simplified operations.
5) A preferred operation that represent best results (but not optimal) will be delivered and processed for subsequent analyses. IMC proposes this assumption or approach to ensure that a simple yet realistic set of operations that are intuitive and provide superior performance are generated and recommended to the PDT.
6) IMC will implement seasonality in reservoir operations to recognize that wet and dry season operations would differ, and same season operation would also differ based on the state (full or empty) of the reservoir. The generalized logic of the operation is provided below (Figure 3).

Fill	WET SEASON	DRY SEASON	
Early in Season	Fill slowly to retain capacity for later in the season	Fill aggressively in preparation for rest of dry season	Pump capacity (and channel capacity) are limiting. Intake threshold and volume may vary but based on a consistent logic. The Threshold will be determined by iteration.
Late in Season	Fill reservoir faster to get full by end of year (use available capacity as a factor)	Fill slowly to retain capacity for wet season	

Empty	WET SEASON	DRY SEASON	
Early in Season	Release aggressively to create capacity for filling reservoir later in the season	Release less aggressively to extend ability to release longer into the dry season	The constraint to the release strategy listed to the side are reservoir release capacity and the requirement that wet season flows should not greatly fall below EST05 and Dry season flow over S-79 should not greatly exceed EST05
Late in Season	Release more carefully to keep reservoir full going into the dry season	Release more aggressively to empty reservoir in preparation for the wet season	

Figure 3. Generalized operational logic to implement seasonality.

7) Reservoir filling and release actions will not occur on the same day.
8) Adjustment for runoff from the reservoir site using a simple methodology based on a specified ratio of land area of reservoir to land area of basin will be implemented. A more rigorous approach that considers precipitation to runoff relationship in the watershed will also be implemented and is provided as option in the spreadsheet. These alternative approaches will allow simple or more complex representation of this adjustment to meet the user need.

9) IMC will implement an operational feature that reduces fill action when the reservoir is full or close to full. The intent is to minimize the possibility of oscillations in reservoir operation and stage that could result from very sensitive pump criteria that pump every day to replenish daily losses to evapotranspiration. The justification of this assumption is the need to more closely match a realistic operation. The feature implemented can be disabled by the user at run time.
10) Reservoir base ranges from 18 feet NAVD to 20 feet NAVD with an average at 19.24 feet. This assumption is based on the most current site information available from the Acceler8 project documentation. This reservoir base will be used for each reservoir size.
11) Reservoir elevation at full pool will be determined based on elevation necessary to result in storage capacity of 100,000, 170,000 and 220,000 acre feet. The profile will be from the current design information provided by the Acceler8 project team during the NAI and assurances analyses.
12) Daily potential evapotranspiration data for the analyses will be extracted from the SFWMM modeling dataset for consistency. IMC believes that this represents the most reliable data for the purpose of the modeling exercise and that data is available for the period of record, 1965 to 2000.
13) Daily rainfall data will be extracted from the SFWMM modeling dataset for consistency. IMC believes that this represents the most reliable data for the purpose of the modeling exercise and that data is available for the period of record, 1965 to 2000.
14) Statistics and performance graphics will be generated based on a period of record simulation of 36 years, January 1965 to December 2000.

2.2 Spreadsheet Modification

IMC made minor modifications to the previously developed spreadsheet model of the C-43 reservoir. The modifications included:

- Reviewing and modifying any spreadsheet equation hardwired to the pump and reservoir size to utilize a referenced cell that is assigned based on the alternative being simulated.
- Incorporate a drop down list of alternatives.
- Incorporate look-up and interpolation capability for computing pool elevation corresponding to reservoir capacity.
- Incorporate option for user specified reservoir storage.
- Implement operations features for alternate pump sizes.

The spreadsheet model is centered on a water budget equation for the reservoir. The equation is based on conservation of mass and relates the inflows to the reservoir, outflows from the reservoir to the change in storage in the reservoir over some fixed time scale. The equation is represented below in lay terms states that inflows to the reservoir minus outflows from the reservoir is equal to the change in storage in the reservoir.

$$\frac{dS}{dt} = Q_{in} - Q_{Out}$$

Where $\frac{dS}{dt}$ is the rate of change in storage,

Q_{in} represents the rate of inflow to the reservoir, in this case direct precipitation on reservoir plus the pumped volumes.

Q_{Out} represents the rate of outflow from the reservoir. It combines in this case, releases from the reservoir, spillway releases, and losses to evapotranspiration, (seepage set at zero by assumption).

The spreadsheet model implements the following actions.

Based on flows over S-79 on a daily basis

1) The spreadsheet determines if there is adequate flow to capture for storage in the reservoir. The threshold for capture depending on the operation scheme implemented could range from
   a. Checking if the flow exceeds a specified peak flow at which storage is initiated,
   b. Comparing the daily flow to daily target flows and capturing the excess subject to reservoir capacity and pump capacity, or
   c. Determined based on a specified operation strategy the seasonal threshold and volume to store subject to pump and reservoir storage capacity.
2) The spreadsheet determines what proportion of the available flow can be captured subject to the criteria below depending on the operation scheme implemented.
   a. The pump capacity (1500 or 3800 cfs)
   b. The difference between total flow over S-79 and the target flow, subject to reservoir capacity and pump capacity, and
   c. Based on a specified seasonal release strategy or decision table specified by the user within the spreadsheet.

These inflows along with direct precipitation onto the reservoir represent total inflows into the reservoir used in the mass balance.

Based on flows over S-79 and available capacity in the reservoir, the spreadsheet does the following actions.

1) Determines evaporation losses by taking the product of the potential evapotranspiration rate and the surface area of the reservoir (which is varied depending on storage within the reservoir)
2) Determines if rainfall or other activity has resulted in reservoir stage in excess of the spillway elevation and releases subject to limit of the spillway (the final model has operational features that preclude or limits the likelihood of this occurrence).
3) Determines release from the reservoir for environmental purposes to augment S-79 flows depending on the operational scheme implemented. The release decision and volume of release could be

a. Based on a fixed release to bring S-79 flows to a minimum specified threshold subject to reservoir release structure capacity,
b. Based on meeting the deficit between S-79 flows and the target series, EST05, or
c. Based on a specified seasonal release strategy or decision specified by the user in the spreadsheet.

These outflows are accumulated to represent total outflows from the reservoir used in the mass balance equation for each daily time step.

The spreadsheet computed the daily change in storage and associated water surface elevation both of which are considered in determining fill and release operation in subsequent time steps. The model creates an updated flow over S-79 that reflects the changes to the original flow resulting from reservoir fill or release activities.

A more detailed description of the sequence of computation with a sample cycle through one time step is presented in the User Manual attached as Appendix I to this report.

Section 3 – Initial Array of Alternatives/Options

The plan formulation and evaluation process involves identifying, organizing, and combining management measures to create the different alternative plans for the project. The alternatives proposed generally fall within the following broad definition:

- No Action – same as future without condition
- Alternative(s) with smaller storage volumes than the Restudy
- Alternative(s) with storage volumes similar to the Restudy
- Alternative(s) with larger storage volumes than the Restudy

Three alternative reservoir sizes that satisfy the general definition were identified and provided to the IMC for further analyses using the spreadsheet tool. For the middle reservoir size that was similar to the Restudy storage, two alternatives were selected for consideration based on the additional criteria of the inflow pump capacity for filling the reservoir. The resulting four alternatives were the same alternatives that were previously analyzed by the PDT using a more rigorous hydrologic model of the watershed. A detailed description of the alternatives as well as the basis for their selection can be found in the draft PIR report for the Part I-Phase I PIR. The alternatives identified by the PDT for further analyses were:

- 100,000 acre-feet storage with 1500 cfs pump – smaller storage volumes than the Restudy
- 170,000 acre-feet storage with 1500 cfs pump – storage volumes similar to the Restudy and storage and pump capacity consistent with Acceler8 design for the C-43 reservoir

FINAL Page 13 of 77

- 170,000 acre-feet storage with 3800 cfs pump – storage volumes similar to the Restudy and storage but not pump capacity consistent with Acceler8 design for the C-43 reservoir
- 220,000 acre-feet storage with 3800 cfs pump – larger storage volumes than the Restudy

These alternatives represent Alternative 2, Alternative 3b, Alternative 3c and Alternative 4 of the final array presented in Section 5.4 of the PIR. The features of each alternative are summarized and are described in more detail below (Table 1).

Feature	Alt 2	Alt 3B	Alt 3C	Alt 4
Storage Reservoir				
100,000 ac-ft Reservoir	☑			
170,000 ac-ft Reservoir		☑	☑	
220,000 ac-ft Reservoir				☑
Pump Capacity				
1500 cfs Capacity	☑	☑		
3800 cfs Capacity			☑	☑
Canals & Seepage				
Townsend Canal Imp	☑	☑	☑	☑
Seepage Management	☑	☑	☑	☑

Table 1. Features of the Four project Alternatives for Evaluation.

Alternative 2 – 100,000 ac-ft Reservoir with 1,500 cfs Pumping Capacity

Alternative 2 was developed as a smaller restoration alternative for the Lower Caloosahatchee Basin. This alternative is consistent with the CERP recommendation for a reservoir in this area, but it should be noted that this alternative's total storage volume of 100,000 acre-feet is significantly reduced from the 160,000 acre-feet of storage CERP estimated would be needed in this sub-region. Alternative 2 design summary is presented below (Table 2).

Design Parameters	Parameter Values
Storage Volume (acre-feet)	100,000
Storage Area / Reservoir Footprint (acres)	9,530 / 11,000
Project Footprint – Staging, O&M, etc. (acres)	13,300
Normal Pool Elevation / Pool Depth	35 ft NAVD88 / 10-15 ft
Dam Elevation / Dam Height	52 ft NAVD88 / 27-32 ft
Total Fill Rate – Pump Capacity (cfs)	1,500
Seepage management	Perimeter canal, 17 ft cutoff wall

Table 2. Alternative 2 Design Summary.

Alternative 3 B – 170,000 ac-ft Reservoir with 1,500 cfs Pumping Capacity

This alternative comes closest to approximating the Restudy C-43 recommended volume of approximately 160,000 ac-ft storage reservoir and is the size evaluated and recommended in the Acceler8 planning process. Alternative 3 is a two-cell reservoir with

a "normal pool" storage capacity of 170,000 acre-feet. The reservoir design includes a pump station with 1,500 cfs capacity to pump water from the Townsend Canal to fill the Reservoir. Alternative 3b design summary is presented below (Table 3).

Design Parameters	Parameter Values
Storage Volume (acre-feet)	170,000
Storage Area / Reservoir Footprint (acres)	9,530 / 11,000
Project Footprint – Staging, O&M, etc. (acres)	13,300
Normal Pool Elevation / Pool Depth	42 ft NAVD88 / 17-22 ft
Dam Elevation / Dam Height	59 ft (NAVD88) / 34-39 ft
Total Fill Rate – Pump Capacity (cfs)	1,500
Seepage management	Perimeter canal, 17 ft cutoff wall

Table 3. Alternative 3b Design Summary

Alternative 3C – 170,000 ac-ft Reservoir with 3,800 cfs Pumping Capacity

Alternative 3C is very similar to alternative 3B. The only difference is a larger pumping capacity and the associated modified reservoir operations to optimize storage performance with greater pumping flexibility. The reservoir design includes a pump station (3,800 cfs pumping capacity) to pump water from the Townsend Canal to fill the Reservoir. The water surface elevation is approximately 42 ft (NAVD88) at "normal pool". Other structural elements would be the same as described in the previous Alternative 3B. The expectation is that inclusion of the larger pump allows for greater operational flexibility. In particular, the reservoir can be filled much faster than under Alternatives 3B allowing the reservoir to capture more water during short duration high flow events. Alternative 3c design summary is presented below (Table 4).

Design Parameters	Parameter Values
Storage Volume (acre-feet)	170,000
Storage Area / Reservoir Footprint (acres)	9,530 / 11,000
Project Footprint – Staging, O&M, etc. (acres)	13,300
Normal Pool Elevation / Pool Depth	42 ft NAVD88 / 17-22 ft
Dam Elevation / Dam Height	59 ft (NAVD88) / 34-39 ft
Total Fill Rate – Pump Capacity (cfs)	3,800
Seepage management	Perimeter canal, 17 ft cutoff wall

Table 4. Alternative 3c Design Summary

Alternative 4 – 220,000 ac-ft Reservoir with 3,800 cfs Pump

Alternative 4 has the largest capacity of the reservoir sizes in the proposed alternatives with a storage capacity of 220,000 ac-ft. The inflow pump capacity is 3,800 cfs. The reservoir location and other associated features are the similar to Alternative 3C. The water surface elevation is approximately 47 ft (NAVD88) at "normal pool". Alternative 4 design summary is presented below (Table 5).

Design Parameters	Parameter Values
Storage Volume (acre-feet)	220,000
Storage Area / Reservoir Footprint (acres)	9,530 / 11,000
Project Footprint – Staging, O&M, etc. (acres)	13,300
Normal Pool Elevation / Pool Depth	47 ft NAVD88 / 22-27 ft
Dam Elevation / Dam Height	64 ft (NAVD88) / 39-44 ft
Total Fill Rate – Pump Capacity (cfs)	3,800
Seepage management	Perimeter canal, 17 ft cutoff wall

Table 5. Alternative 3c Design Summary.

Section 4 – Model Application

The focus of the spreadsheet model is the modification or adjustments of flow over S-79 with the intent of improving the salinity distribution in the downstream estuary. The model has no salinity or ecological component and relies on hydrologic surrogate to infer improved performance. The hydrologic surrogate used is the flow over S-79 and its closeness to a flow target time series EST05 which has been demonstrated by others to be a restoration series that would result in optimal habitat conditions for several indicator species in the estuary. The May, 2003 report titled "Existing Legal Sources for Caloosahatchee Estuary at the Franklin Lock and Dam (S-79) by the Coastal Ecosystem Division of the South Florida Water Management District describes the basis for EST05.

As a means to showing closeness to EST05 as a whole and quantifying other desirable matches to portions of the restoration flow series, a number of performance measure graphics were built in to the spreadsheet, five in total. Also, in order to confirm reasonable behavior of model features and results, several graphics and charts of these features were incorporated and used during model application to determine changes in operation necessary to yield superior performance. These performance measures will be used to rank the alternatives. It is expected that habitat unit created by each alternative will be developed from the spreadsheet model results will be used to rank the alternatives as well.

4.1 Performance Measures

The performance measures are nested in the "PMs" Worksheet of the spreadsheet and include the following charts.

4.1.1 Distribution of Monthly Flows

The first performance measure is a histogram of the distribution of monthly flows over S-79 for the target restoration flow series EST05, the existing "without project" or base condition, and the "with project" condition depicting percentage of time each flow

range occurs in the period of record simulation. A sample of the graphics is shown in below (Figure 4).

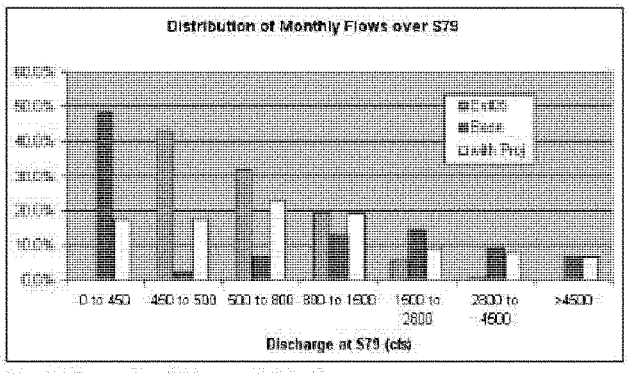


Figure 4. Histogram of monthly flows over S-79 in cfs.

An alternative that shows a closer match between the "with project" condition and the EST05 series is considered a better alternative when this measure is considered. The selection of the preferred operation for each alternative is based on this and other measure evaluated in combination.

4.1.2 Caloosahatchee Estuary Salinity Envelope Criteria

The second performance measure is the estuary salinity envelope criteria developed and used by CERP for the Caloosahatchee Estuary by the SFWMM model. This performance graphic has been duplicated in the spreadsheet and depicts the count of number of months with a low flow criteria (less than 450 cfs) not met in the "without project" (base condition) and the "with project" condition during the dry season. The measure also shows the count of exceedance of a high flow threshold (2800 cfs) with and without project. A sample graphic is shown below (Figure 5). In interpreting this measure, a series of operations that reduces the number of low flow occurrence and reduces the number of high flow exceedance represents a better set of operations. Accordingly, a project alternative that results in the lower count of low flow events and high flow events represent a better alternative based on this criterion. Note that EST05 has no occurrences of flows below 450 cfs and establishes a target count of zero for the low flow portion of this measure.

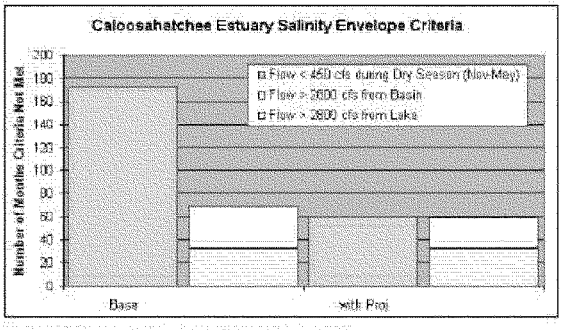


Figure 5. Caloosahatchee Estuary salinity envelope criteria

4.1.5 Flow Duration Curve

A flow duration curve generated by ranking and plotting the flow over S-79 and the percentage of time that the flow is equaled or exceeded is used as one of the measures. This plot is generated for the target restoration flow series EST05 as well as the "with project" and "without project" conditions. The project alternative that more closely matches EST05 represents the better performance. Below (Figure 5) is a sample plot extracted from the spreadsheet simulation. The plot shows, for each alternative, the ability of the "with project" condition to extend availability of low flows towards the EST05 conditions (with no occurrences of flows less than 450 cfs.)

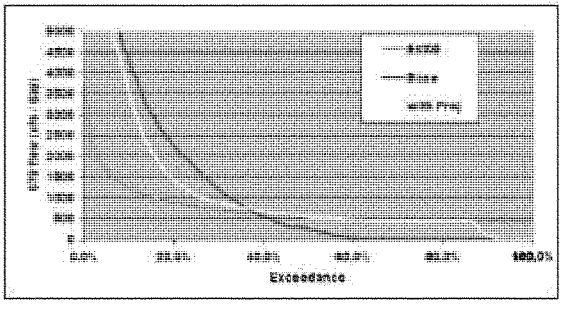


Figure 6. Flow Duration Curve

4.1.4 Consecutive Days with No Flows to Estuary

Based on technical input from coastal ecologists, an additional measure depicting the consecutive number of times in the simulation period of record that 10 or more days of no flows to the estuary occurred was developed. This measure counts a 30 day no flow event as one occurrence. A 30 day event with flows to the estuary introduced on the 15th day alone will result in a count of two occurrences. The measure also presents the maximum number of consecutive days with no flow under the "with project" and "without project" conditions. This measure using both parts of the chart show the frequency and extent of no flow (defined within the spreadsheet as the 5 cfs base flow rate) conditions observed in flows over S-79 over the 36 year period of record. A project alternative that results in lower count of number of consecutive days of no flows and reduces the extent of the maximum number of consecutive no flow days represents a more desirable alternative. A key caution in interpreting this graphic is that a small flow much less than the desirable 450 cfs will break the count of consecutive days so that releases from the reservoir of rainfall induced volumes that result in small flows in the order of tens of cfs count as breaks to the consecutive dry days count.

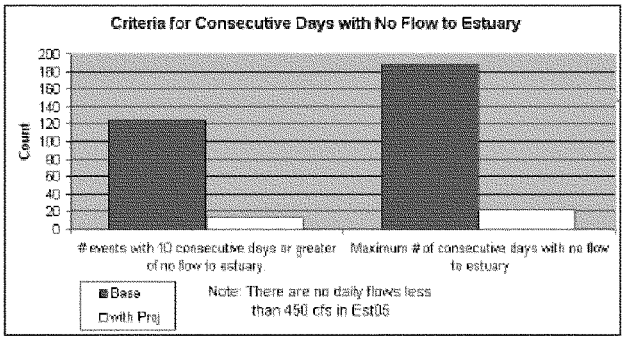


Figure 7. Criteria for consecutive days with no flow to estuary

4.1.5 Hydrograph of Flow over S-79

The final performance measure used is a plot of flows in cfs over S-79 for the EST05 series, the "with project" and "without project" conditions. In addition, superimposed on the plot is the pump filling and reservoir release operations. This graphic allows actual comparison of improvements to S-79 discharges and closeness of those improvements to the EST05 restoration series over a variable one year window for each alternative. This final measure is not quantitative but provides a qualitative assessment of the performance of each alternative. It is used significantly during simulation but has less utility for

comparing across alternatives. It can and is used to emphasize subtle performance differences that may not be apparent from the quantitative measures described above.

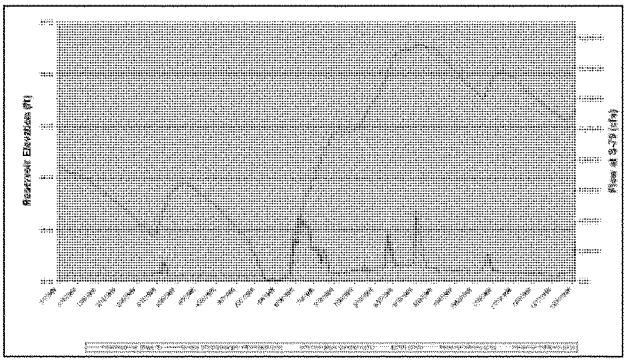


Figure 8. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modification to pre-project S-79 flows.

4.2 Spreadsheet Performance Checks

Six charts were used to perform checks on different aspects of the spreadsheet to ensure that assumptions were not violated and that the features in the spreadsheet were functioning as intended. The six charts are shown below (Figure 9) and include:

1) A plot of reservoir surface elevation: This chart shows the rate of use of the reservoir, how often it is full or empty. It also depicts reservoir fill elevations that correspond to the pool elevation for each alternative simulated.
2) A reservoir stage exceedance curve that shows what percentage of the time the reservoir surface elevation equals or exceeds a particular stage value.
3) An x-y plot of the adjustments to S-79 flows to accommodate the reduction in runoff resulting from converting the project from an agricultural land use to a reservoir. This plot shows minimal impact from the adjustment.
4) A scatter plot of inflows with reservoir stage to depict what operations are occurring as the reservoir fills.
5) A scatter plot of outflows with reservoir stage to show what release operations are occurring at different reservoir stage values, and
6) A scatter plot of inflows versus outflow to demonstrate that inflows and outflows are not occurring simultaneously.

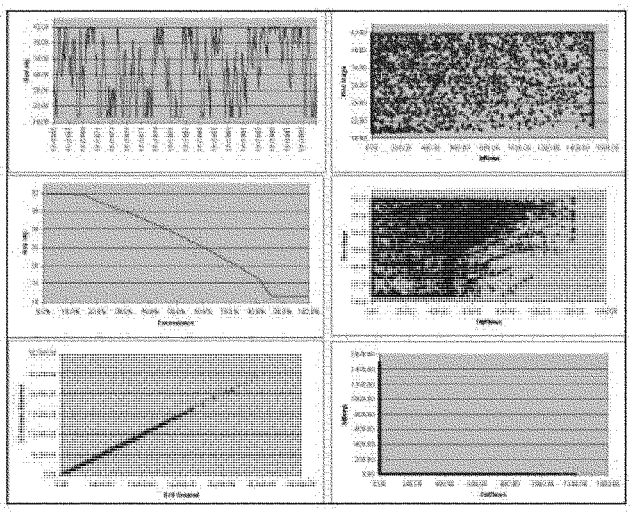


Figure 9. Plots used to check and confirm that spreadsheet model is performing as intended.

4.3 Simulation of Alternative 2

The spreadsheet was used to simulate the reservoir performance for Alternative 2. The model input parameters related to reservoir size and pump size were set at 100,000 acre-foot and 1,500 cfs respectively. The computational adjustments for maximum pool elevation were checked prior to simulations of operations. The approach used was to perform two sets of bounding simulations, the first based on a simplified operation where reservoir filling and release decisions are based on a specified flow threshold (at S-79) and the second based on the target flow distribution (also at S-79) as defined by the EST05 series. These bounding runs are then followed by several iterations of an operation scheme that is based on the general operation strategy presented in section 2.1.2. The iterative process is terminated when the resulting flow series based on the seasonal operations show performance improvements over the EST05 based simulation.

4.3.1 Simplified Operation with Minimum and Maximum S-79 Threshold

Initial analyses used the simplified operations with a defined low flow threshold and defined high flow threshold. The high flow threshold was set at 2800 cfs and the low flow threshold was set at 450 cfs. Examination of the performance under this operational

regime shows improvement over the "without project" condition. This performance represents the lower bound on performance expected from Alternative 2. The performance measures for a high flow threshold of 2800 cfs and a low flow threshold of 450 cfs are presented below (Figure 10).

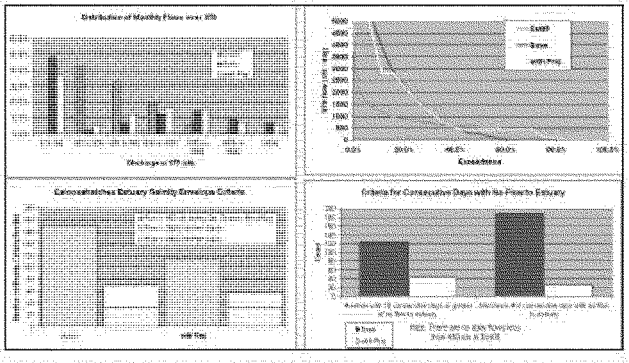


Figure 10. Alternative 2 performance measures for reservoir operations based on high flow (2800 cfs) and low flow (450 cfs) thresholds.

- The histogram showed some improvement in the low flow range over the "without project" condition but flows lower than 450 cfs still occurred more than 35% of the time.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 113 from the without project to the "with project" condition.
- The flow duration curve for the "with project" conditions shows two steps corresponding to the selected high flow and low flow threshold, 2800 and 450 cfs respectively. The period of time when flows over S-79 equaled or exceeded 450 cfs was extended from below 45 % of the time under the "without project" condition to greater than 70% of the time under the "with project" conditions.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 42 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 189 days to 25 days with the reservoir in place.

4.3.2 Operations Based on EST05

An operational scenario that ties fill and release decisions to S-79 flows in excess of, or in deficit of the EST05 flow series was then implemented to develop the theoretical upper bound. This operational strategy assumes perfect knowledge and under ideal

condition with adequate storage and pump capacity will deliver the EST05 flows or restoration flows to the Estuary. This operation is similar to operation implemented in other previous analysis by the PIR team. Under the "perfect knowledge" scenario, reservoir fill decisions and reservoir empty decisions are forced to reproduce EST05 like flows at S-79 subject to availability of water within the reservoir and pump and release structure capacities. The performance measures observed under this scenario are presented below (Figure 11).

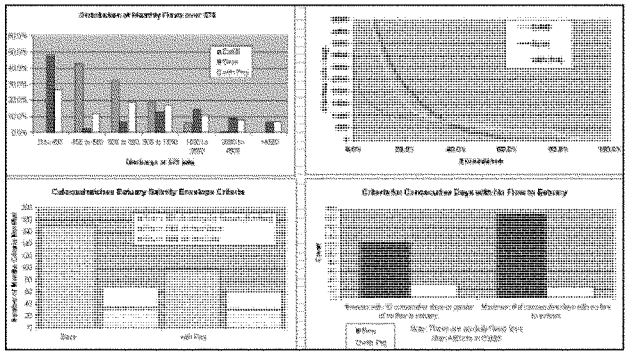


Figure 11. Alternative 2 performance measures for reservoir operations based on matching estuary target flow series EST05.

- The histogram showed some improvement in the low and mid flow range over both the simplified operations and the "without project" condition. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 25% of the time. This suggests that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs are not possible with the 100,000 acre foot reservoir and a 1500 cfs pump specified in Alternative 2.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 97 from the without project to the "with project" condition. A slight improvement over the results for simplified operations.
- The flow duration curve for the "with project" conditions shows no steps but a gradual merge of the plot under the "with project" conditions to the EST05 plot until the reservoir becomes incapable of delivering 450 cfs. The occurrences of flows of less than 450 cfs to the estuary reduces to 22% of the time over the 36 year simulation period for Alternative 2 with this operation scheme, a significant improvement over the "without project" condition and a slight improvement over simplified operations.

- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 32 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 189 days to 24 days with the reservoir in place.

Below (Figure 12) shows a plot of flows over S-79 for a portion of the simulation and illustrates the operations under this release strategy. While reservoir is full and excess flows over S-79 do not exceed pump capacity, the plot of modified time series of flows over S-79 is co-incident with the EST05 time series. This is the case even when there are no S-79 flows under the "without project" conditions. However, when S-79 excess flows determined from the difference between the "without project" flows and the EST05 time series exceed 1500 cfs (pump capacity), the excess is allowed to flow over S-79 under the "with project" condition.

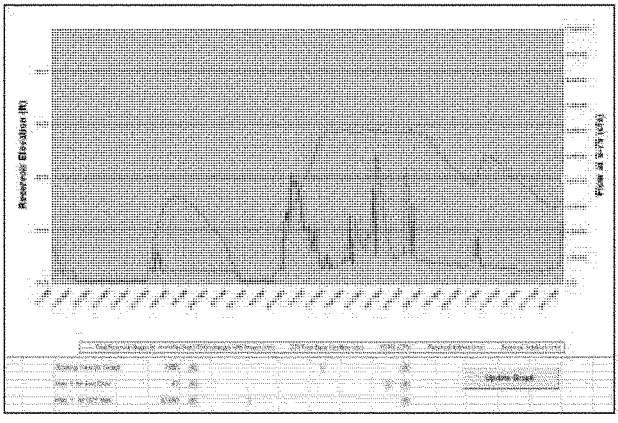


Figure 12. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modifications to pre-project S-79 flows under EST05 driven operations for Alternative 2.

4.3.3 Preferred Operation – Based on Seasonality and Reservoir State

The general logic presented in section 2.1.2 was implemented by providing a series of flow rates based on flows over S-79 that would be used for filling or releasing stored water from the reservoir considering the season of the year and the storage currently within the reservoir. An iterative procedure was used to generate operation ranges and magnitudes that resulted in reservoir performance that exceeded the performance from the "perfect knowledge" operations. The resulting operations while not necessarily

optimal, show that with operations tuning possible after the project is designed and built, the operation of the reservoir using a logical sequence of rules or a decision table can approach or exceed those forced to mimic EST05. The resulting preferred operations for Alternative 2 are shown in the appendix to this report.

4.3.3.1 Iterative Procedure

An initial array of operations corresponding to reservoir stage was developed by examining and analyzing flow data over S-79 derived from SFWMM simulations, actual data, and EST05 flow series. By examining plots of histograms of these flows, and volumes of water necessary to create shifts in the distribution for key years, a pattern was identified. Using best professional judgment, the identified patterns and information contained in previous more rigorous hydrologic modeling conducted for the C-43 project recommended flow and release volumes corresponding to flow over S-79 was developed. These volumes were adjusted to account for state of the reservoir. The reservoir states decided upon was empty reservoir initially defined as the bottom five feet of storage, full reservoir which corresponded to the top 9 feet of storage and medium reservoir which was the condition in between.

The initially specified operations was modified to generate more conservative or less conservative release strategies in order to determine the sensitivity of the model to selected initial operating conditions. The exercise demonstrated that more stringent release rules extended the ability of the reservoir to meet low flows for a longer period but reduced the improvement during high flows. The opposite was the observation for more liberal release policies. Figure 13 shows the high range and low range of several operation iterations. As can be observed from the plot, operations that reduce the high flow occurrences (move the curve towards the lower percentage exceedance) improve towards EST05 (a portion of which is visible at the lower left corner of the upper plot), result in earlier divergence from EST05 in the lower plot. Those operations which provided low flows for the longest period show less of an improvement to high flows (were more to the right on the high flow plot).

The final selected operation (depicted as the heavy line in Figure 13) performed reasonably well, equaling or marginally surpassing the "perfect knowledge" performance on the high side and performing significantly better on the low flows.

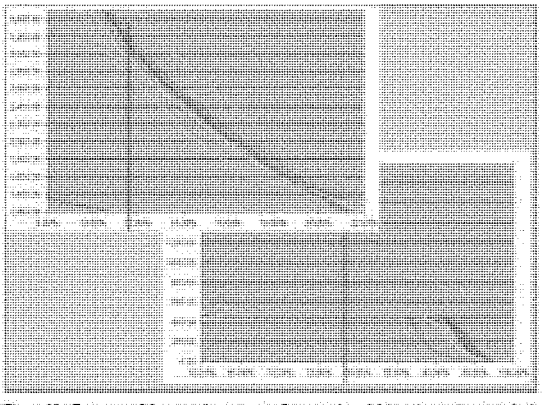


Figure 13. Extremes of the exceedance curves for several model iterations using perturbed operations for the purpose of selecting the preferred operation.

4.3.3.2 Performance Measures for the Preferred Operations

The performance measures observed using the preferred operations for Alternative 2 are presented below (Figure 14).

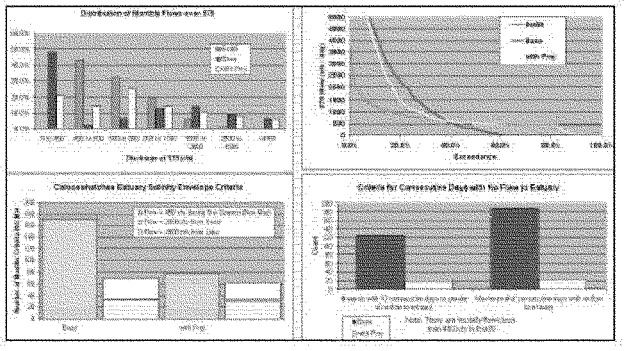


Figure 14. Alternative 2 performance measures for reservoir operations based on the preferred operation (considering seasonality and reservoir state).

- The histogram showed greater improvement in the low and mid flow range over both the simplified operations and the "without project" condition and is slightly better than the results under "perfect knowledge" operations. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 21% of the time. This suggests that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs are not possible with Alternative 2 reservoir specifications (100,000 acre-foot reservoir and 1500 cfs pump).
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 76 from the without project to the "with project" condition. An improvement of 37 occurrences over the simple operations, and 19 over the "perfect knowledge" operations.
- The flow duration curve for the "with project" conditions shows some raggedness corresponding to several small steps at specified operation breakpoints. It is an improvement over the simple operations in appearance and over other operational regimes explored in performance. The occurrences of flows of less than 450 cfs to the estuary reduces to approximately 18% of the time over the 36 year simulation period for Alternative 2 with the preferred operations, a significant improvement over the "without project" condition and an improvement over both bounding operation schemes.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 20 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 23 days with the reservoir in place.

This operation strategy provided the best performance observed during the modeling exercise for Alternative 2 and the results will be used in the comparison of Alternative 2 to the other project alternatives. While it is not the optimal solution, it is considered sufficiently close and adequate for planning level analyses. A more rigorous analysis can be conducted if this alternative is selected as the preferred alternative for the project and when the project enters the design phase.

4.4 Simulation of Alternative 3b

The spreadsheet was used to simulate the reservoir performance for Alternative 3b. The model input parameters related to reservoir size and pump size were set at 170,000 acre-foot and 1,500 cfs respectively. The computational adjustments for maximum pool elevation were checked prior to simulations of operations. The approach previously described in Section 4.3 was applied to Alternative 3b.

4.4.1 Simplified Operation with Minimum and Maximum S-79 Threshold

Initial analyses used the simplified operations with a defined low flow threshold and defined high flow threshold. The high flow threshold was set at 2800 cfs and the low flow threshold was set at 450 cfs. Examination of the performance under this operational regime shows improvement over the "without project" condition. This performance represents the lower bound on performance expected from Alternative 3b. The performance measures for a high flow threshold of 2800 cfs and a low flow threshold of 450 cfs are presented below (Figure 15).

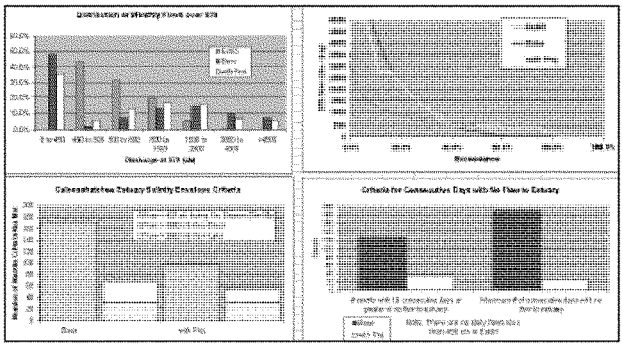


Figure 15. Alternative 3b performance measures for reservoir operations based on high flow (2800 cfs) and low flow (450 cfs) thresholds.

- The histogram showed some improvement in the low flow range over the "without project" condition but flows lower than 450 cfs still occurred more than 35% of the time.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 96 from the without project to the "with project" condition.
- The flow duration curve for the "with project" conditions shows two steps corresponding to the selected high flow and low flow threshold, 2800 and 450 cfs respectively. The period of time when flows over S-79 equaled or exceeded 450 cfs was extended from below 45 % of the time under the "without project" condition to approximately 75% of the time under the "with project" conditions.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 36 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 25 days with the reservoir in place.

4.4.2 Operations Based on EST05

An operational scenario that ties fill and release decisions to S-79 flows in excess of, or in deficit of the EST05 flow series was then implemented to develop the theoretical upper bound. This operational strategy assumes perfect knowledge and under ideal condition with adequate storage and pump capacity will deliver the EST05 flows or restoration flows to the Estuary. This operation is similar to operation implemented in other previous analysis by the PIR team. Under the "perfect knowledge" scenario, reservoir fill decisions and reservoir empty decisions are forced to reproduce EST05 like flows at S-79 subject to availability of water within the reservoir and pump and release structure capacities. The performance measures observed under this scenario are presented below (Figure 16).

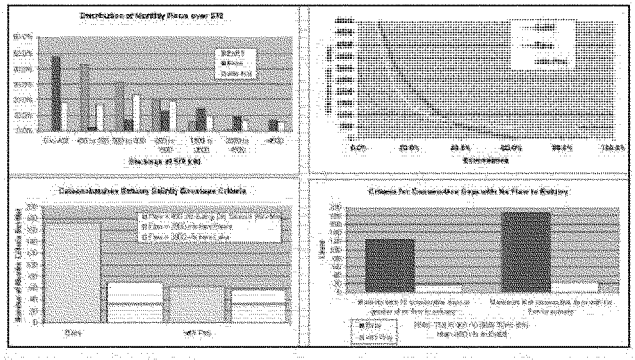


Figure 16. Alternative 3b performance measures for reservoir operations based on matching estuary target flow series EST05.

- The histogram showed some improvement in the low and mid flow range over both the simplified operations and the "without project" condition. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 18% of the time. This suggests that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs are not possible with the 170,000 acre foot reservoir and a 1500 cfs pump specified in Alternative 3b.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 63 from the without project to the "with project" condition. A significant improvement over the results for simplified operations.
- The flow duration curve for the "with project" conditions shows no steps but a gradual merge of the plot under the "with project" conditions to the EST05 plot until the reservoir becomes incapable of delivering 450 cfs. The occurrences of flows of less than 450 cfs to the estuary reduces to approximately 14% of the time over the 36 year simulation period for Alternative 3b with EST05 based

operations, a significant improvement over the "without project" condition and a slight improvement over simplified operations.

- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 16 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply. From 189 days to 23 days with the reservoir in place.

Below (Figure 17) shows a plot of flows over S-79 for a portion of the simulation and illustrates the operations under this release strategy. This figure represents the same one year period depicted in Figure 12. A comparison of Figures 12 and 17 shows a reduction in the period of time with flows less than 450 cfs with a larger reservoir. This is expected since once filled, the larger reservoir has 70,000 acre foot more of storage to use towards meeting estuary target flows.

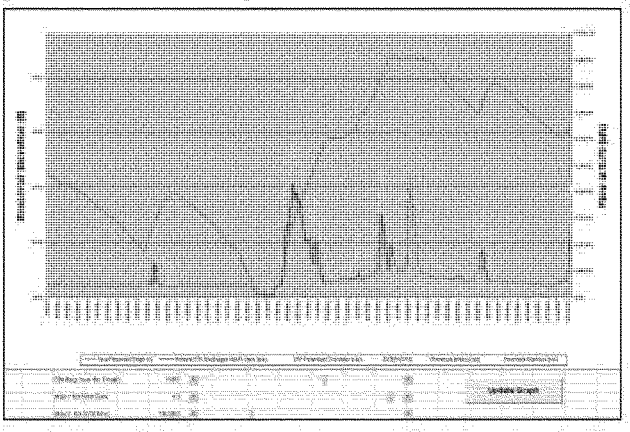


Figure 17. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modifications to pre-project S-79 flows under EST05 driven operations for Alternative 3b.

4.4.3 Preferred Operation – Based on Seasonality and Reservoir State

The procedure for implementing seasonal operations described in Section 4.3.3 was implemented for Alternative 3b. The iterative procedure involved specification and perturbation of fill and release operations as well as state parameters that describe the state (full, medium or empty) of the reservoir. For each of the iterations, the resulting flow series over S-79 was compared to previous iterations and results from EST05 driven operations. The parameters resulting in the better performance was recorded and further

perturbed until performance from the seasonal operations surpassed the "perfect knowledge" EST05 based operations. The best performing set of operations and parameters is the preferred operations. The initial set of operations for this alternative was the best performing set from the NAI modeling exercise.

The performance measures observed using the preferred operations for Alternative 3b are presented below (Figure 18).

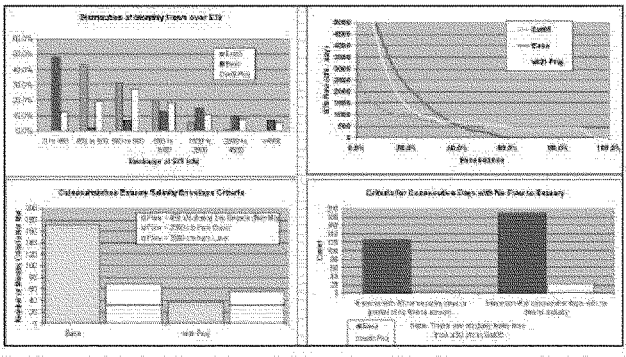


Figure 18. Alternative 3b performance measures for reservoir operations based on the preferred operation (considering seasonality and reservoir state).

- The histogram showed greater improvement in the low and mid flow range over both the simplified operations and the "without project" condition and is slightly better than the results under "perfect knowledge" operations. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 12% of the time. This suggests that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs are not possible with Alternative 3b reservoir specifications (170,000 acre-foot reservoir and 1500 cfs pump).
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 37 from the without project to the "with project" condition. An improvement of 59 occurrences over the simple operations, and 26 over the "perfect knowledge" operations.
- The flow duration curve for the "with project" conditions shows some raggedness corresponding to several small steps at specified operation breakpoints. It is an improvement over the simple operations in appearance and over other operation schemes explored in performance. The occurrences of flows of less than 450 cfs to the estuary reduces to approximately 12% of the time over the 36 year simulation period for Alternative 3b with the preferred operations, a significant

improvement over the "without project" condition and an improvement over both bounding operation schemes.

- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 5 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 23 days with the reservoir in place.

This operation strategy provided the best performance observed during the modeling exercise for Alternative 3b and the results will be used in the comparison of Alternative 3b to the other project alternatives. While it is not the optimal solution, it is considered sufficiently close and adequate for planning level analyses. A more rigorous analysis can be conducted if this alternative is selected as the preferred alternative for the project and when the project enters the design phase.

4.5 Simulation of Alternative 3c

The spreadsheet was used to simulate the reservoir performance for Alternative 3c. Alternative 3c is identical to 3b with the exception of the inflow pump capacity. The model input parameters related to reservoir size and pump size for Alternative 3c were set at 170,000 acre-foot and 3,800 cfs respectively. The computational adjustments for maximum pool elevation were checked prior to simulations of operations. The approach previously described in Section 4.4 was applied to Alternative 3c.

4.5.1 Simplified Operation with Minimum and Maximum S-79 Threshold

Initial analyses used the simplified operations with a defined low flow threshold and defined high flow threshold. The high flow threshold was set at 2800 cfs and the low flow threshold was set at 450 cfs. Examination of the performance under this operational regime shows improvement over the "without project" condition. This performance represents the lower bound on performance expected from Alternative 3c. The performance measures for a high flow threshold of 2800 cfs and a low flow threshold of 450 cfs are presented below (Figure 19).

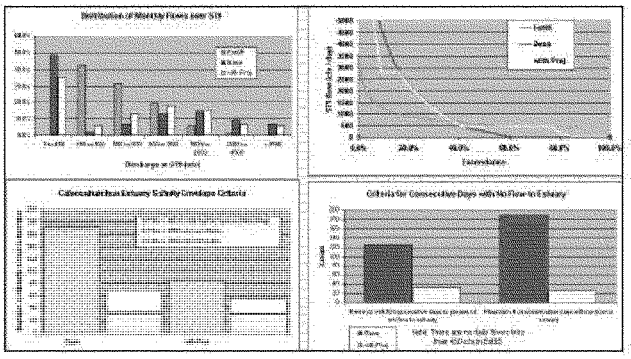


Figure 19. Alternative 3c performance measures for reservoir operations based on high flow (2800 cfs) and low flow (450 cfs) thresholds.

- The histogram showed some improvement in the low flow range over the "without project" condition but flows lower than 450 cfs still occurred more than 35% of the time.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 86 from the without project to the "with project" condition.
- The flow duration curve for the "with project" conditions shows two steps corresponding to the selected high flow and low flow threshold, 2800 and 450 cfs respectively. The period of time when flows over S-79 equaled or exceeded 450 cfs was extended from below 45 % of the time under the "without project" condition to approximately 77% of the time under the "with project" conditions.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 31 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 25 days with the reservoir in place.

4.5.2 Operations Based on EST05

The performance measures for Alternative 3c using the EST05 based "perfect knowledge" operations are shown below (Figure 20). As described previously (Section 4.3.2) this operational strategy assumes perfect knowledge and delivers the restoration target flows to the Estuary subject to availability of water within the reservoir and pump and release structure capacities. As the reservoir size and pump capacity increases, this operation scheme approaches delivery of EST05 flows over S-79.

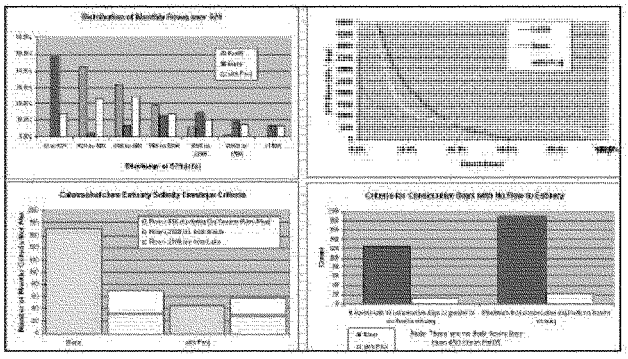


Figure 20. Alternative 3c performance measures for reservoir operations based on matching estuary target flow series EST05.

- The histogram showed some improvement in the low and mid flow range over both the simplified operations and the "without project" condition. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 14% of the time. This suggests that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs are not possible with the 170,000 acre foot reservoir and a 3800 cfs pump specified in Alternative 3c.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 45 from the without project to the "with project" condition. A significant improvement (41 less occurrences) over the results for simplified operations.
- The flow duration curve for the "with project" conditions shows no steps but a gradual merge of the plot under the "with project" conditions to the EST05 plot until the reservoir becomes incapable of delivering 450 cfs. The occurrences of flows of less than 450 cfs to the estuary reduces to approximately 11% of the time over the 36 year simulation period for Alternative 3c with EST05 based operations, a significant improvement over the "without project" condition and a slight improvement over simplified operations.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 12 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 23 days with the reservoir in place.

FINAL Page 34 of 77

Below (Figure 21) shows a plot of flows over S-79 for a portion of the simulation and illustrates the operations under this release strategy. This figure represents the same period depicted in Figures 12 and 17. A comparison of Figures 17 and 21 show a reduction in the period of time with flows over S-79 less than 450 cfs with the same reservoir capacity. The larger inflow pump specified for Alternative 3c allows a more aggressive capture of flow during a dry season event (left portion of the plot) sufficient to allow releases through the dry season. While flows still fell below 450 cfs in the period shown, there was no period of no-flow to the estuary with this alternative under 1986 like conditions.

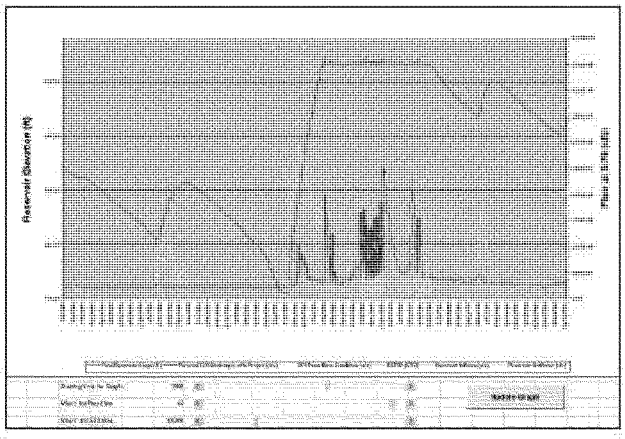


Figure 21. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modifications to pre-project S-79 flows under EST05 driven operations for Alternative 3c.

4.5.3 Preferred Operation – Based on Seasonality and Reservoir State.

The procedure for implementing seasonal operations described in Section 4.3.3 was implemented for Alternative 3c. The iterative procedure involved specification and perturbation of the seasonal fill and release operations as well as state parameters that describe the state (full, medium or empty) of the reservoir. For each of the iterations, the resulting flow series over S-79 was compared to previous iterations and results form EST05 driven operations. The parameters resulting in the better performance was recorded and further perturbed until performance from the seasonal operations surpassed the "perfect knowledge" EST05 based operations. The best performing set of operations and parameters is the preferred operations.

The performance measures observed using the preferred operations for Alternative 3c are presented below (Figure 22).

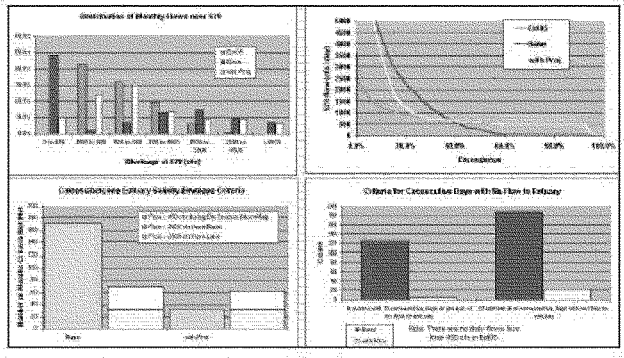


Figure 22. Alternative 3c performance measures for reservoir operations based on the preferred operation (considering seasonality and reservoir state).

- The histogram showed greater improvement in the low and mid flow range over both the simplified operations and the "without project" condition and is slightly better than the results under "perfect knowledge" operations. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 10% of the time. This suggests that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs are not possible with Alternative 3c reservoir specifications (170,000 acre-foot reservoir and 3800 cfs pump).
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 32 from the without project to the "with project" condition. An improvement of 54 occurrences over the simple operations, and 13 over the "perfect knowledge" operations.
- The flow duration curve for the "with project" conditions shows some raggedness corresponding to several small steps at specified operation breakpoints. It is an improvement over the simple operations in appearance and over other operation schemes explored in performance. The occurrences of flows of less than 450 cfs to the estuary reduces to approximately 8% of the time over the 36 year simulation period for Alternative 3c with the preferred operations, a significant improvement over the "without project" condition and an improvement over both bounding operation schemes.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 5 under the "with project" condition. Similarly the

number of consecutive days with no flows to the estuary reduced sharply. From 189 days to 23 days with the reservoir in place.

For this alternative, it was possible to set a seasonal operation that provided better performance (based on the performance measures described) than the bounding operation schemes. The results obtained from these preferred operations will be used for comparing Alternative 3c to the other project alternatives. As previously noted, while it is not the optimal solution, it is considered sufficiently close and adequate for planning level analyses. A more rigorous analysis can be conducted if this alternative is selected as the preferred alternative for the project and when the project enters the design phase.

4.6 Simulation of Alternative 4

The spreadsheet was used to simulate the reservoir performance for Alternative 4. Alternative 4 represent a larger reservoir size than was identified in the Restudy. It utilizes the same pump size as Alternative 3c. The model input parameters related to reservoir size and pump size for Alternative 4were set at 220,000 acre-foot and 3,800 cfs respectively. The computational adjustments for maximum pool elevation were checked prior to simulations of operations. The approach previously described in Section 4.4 was applied to Alternative 4.

4.6.1 Simplified Operation with Minimum and Maximum S-79 Threshold

Initial analyses used the simplified operations with a defined low flow threshold and defined high flow threshold. The high flow threshold was set at 2800 cfs and the low flow threshold was set at 450 cfs. Examination of the performance under this operational regime shows improvement over the "without project" condition. This performance represents the lower bound on performance expected from Alternative 4. The performance measures for a high flow threshold of 2800 cfs and a low flow threshold of 450 cfs are presented below (Figure 23).

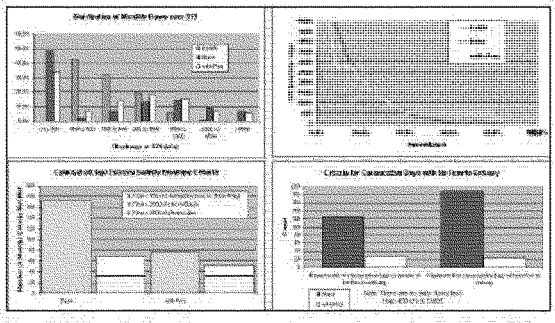


Figure 23. Alternative 4 performance measures for reservoir operations based on high flow (2800 cfs) and low flow (450 cfs) thresholds.

- The histogram showed some improvement in the low flow range over the "without project" condition but flows lower than 450 cfs still occurred about 34% of the time.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 76 from the without project to the "with project" condition.
- The flow duration curve for the "with project" conditions shows two steps corresponding to the selected high flow and low flow threshold, 2800 and 450 cfs respectively. The period of time when flows over S-79 equaled or exceeded 450 cfs was extended from below 45 % of the time under the "without project" condition to approximately 80% of the time under the "with project" conditions.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 28 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 25 days with the reservoir in place.

4.6.3 Operations Based on EST05

The performance measures for Alternative 4 using the EST05 based "perfect knowledge" operations are shown below (Figure 24). As described previously (Section 4.3.2) this operational strategy assumes perfect knowledge and delivers the restoration target flows to the Estuary subject to availability of water within the reservoir and pump and release structure capacities. As the reservoir size and pump capacity increases, this operation scheme approaches delivery of EST05 flows over S-79. EST05 operations for Alternative 4 should yield superior performance that should be difficult to surpass with other operation schemes.

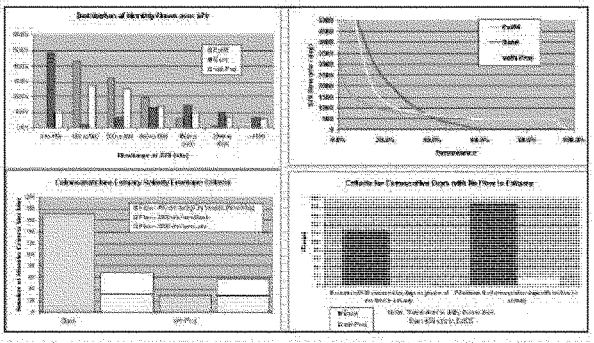


Figure 24. Alternative 4 performance measures for reservoir operations based on matching estuary target flow series EST05.

- The histogram showed some improvement in the low and mid flow range over both the simplified operations and the "without project" condition. There are occurrences of flows lower than 450 cfs but these were reduced to approximately 10% of the time. A 220,000 acre foot reservoir with a 3800 cfs inflow pump is still insufficient to prevent the estuary from having low flows event with average monthly flows of less than 450 cfs over the 36 year simulation period.
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 29 from the without project to the "with project" condition. A significant improvement (47 less occurrences) over the results for simplified operations.
- The flow duration curve for the "with project" conditions shows no steps but a gradual merge of the plot under the "with project" conditions to the EST05 plot until the reservoir becomes incapable of delivering 450 cfs. The occurrences of flows of less than 450 cfs to the estuary reduces to below 8% of the time over the 36 year simulation period for Alternative 4 with EST05 based operations. cfs or greater approximately 92.6% of the time over the 36 year simulation period, a significant improvement over the "without project" condition and a clear improvement over simplified operations.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 7 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 21 days with the reservoir in place.

Below (Figure 25) shows a plot of flows over S-79 for a portion of the simulation and illustrates the operations under this release strategy. This figure represents the same

period depicted in Figures 12, 17 and 21. Note that while each of the previous plots show the reservoir dry at the end of the dry season, Figure 25 shows that with a 220,000 acre foot reservoir, there is adequate storage to prevent a reservoir dry out during the period depicted. For a period with 1986 like conditions, the larger reservoir and pump specified in Alternative 4 was sufficient to meet and exceed the 450 cfs minimum to the estuary. Please note that the reservoir experienced dry-out periods when extended dry conditions as were observed in 1977 or 1981/1982 were simulated.

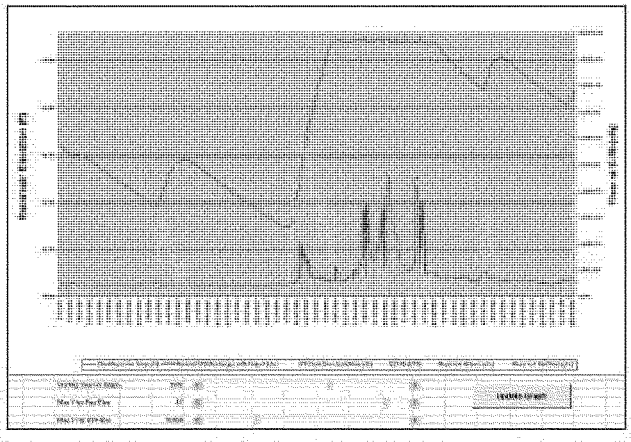


Figure 25. Flow over S-79 and reservoir stage showing reservoir fill and release actions and resulting modifications to pre-project S-79 flows under EST05 driven operations for Alternative 4.

4.6.3 Preferred Operation – Based on Seasonality and Reservoir State

The procedure for implementing seasonal operations described in Section 4.3.3 was implemented for Alternative 4. The iterative procedure involved specification and perturbation of the seasonal fill and release operations as well as state parameters that describe the state (full, medium or empty) of the reservoir. For each of the iterations, the resulting flow series over S-79 was compared to previous iterations and results form EST05 driven operations. The parameters resulting in the better performance was recorded and further perturbed until performance from the seasonal operations surpassed the "perfect knowledge" EST05 based operations. The best performing set of operations and parameters is the preferred operations.

The performance measures observed using the preferred operations for Alternative 4 are presented below (Figure 26).

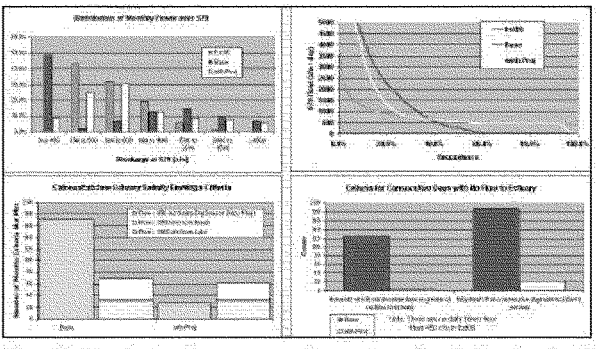


Figure 26. Alternative 4 performance measures for reservoir operations based on the preferred operation (considering seasonality and reservoir state).

- The histogram showed greater improvement in the low and mid flow range over both the simplified operations and the "without project" condition and is slightly better than the results under "perfect knowledge" operations. There are still occurrences of flows lower than 450 cfs but this was reduced to approximately 8.6% of the time. This suggests that even under this operational scenario, reservoir operations to prevent occurrences of flows below 450 cfs are not possible with Alternative 4 reservoir specifications (220,000 acre-foot reservoir and 3800 cfs pump).
- Considering dry season flows, the number of occurrences of less than 450 cfs was reduced from 172 to 27 from the without project to the "with project" condition. An improvement of 49 occurrences over the simple operations, and 2 over the "perfect knowledge" operations.
- The flow duration curve for the "with project" conditions show occurrences of flows of less than 450 cfs to the estuary reduces to less than 7% of the time over the 36 year simulation period for Alternative 4 with the preferred operations, a significant improvement over the "without project" condition and an improvement over both bounding operation schemes.
- There was a marked reduction in the count of number of events with 10 consecutive days or greater of no flows to the estuary from 125 under the "without project" condition to 5 under the "with project" condition. Similarly the number of consecutive days with no flows to the estuary reduced sharply, from 189 days to 23 days with the reservoir in place.

For this alternative, while difficult, it was possible to set a seasonal operation that provided marginally better performance (based on the performance measures described) than the EST05 based operation scheme. The results obtained from the preferred

operations will be used for comparing Alternative 4 to the other project alternatives. As previously noted, while it is not the optimal solution, it is considered sufficiently close and adequate for planning level analyses. A more rigorous analysis can be conducted if this alternative is selected as the preferred alternative for the project and when the project enters the design phase.

Section 5 – Discussion of Results

The four alternatives, Alternative 2, Alternative 3b, Alternative 3c and Alternative 4 are compared using the four quantitative performance measures previously described. The no-action or future without CERP condition is presented along with the target restoration flow series (EST05) where appropriate. Section 5 shows the results of the comparison.

5.1 Average Monthly Flows to Estuary

The first performance measure is the histogram of the distribution of average monthly flows (over S-79) to the estuary for the purpose of ensuring suitable salinity distribution for flora and fauna in the estuary. The daily distribution generated by the spreadsheet for each alternative is used to generate the corresponding average monthly flows over S-79 for each project alternative. The resulting distribution is plotted, along with the no-action alternative and the target distribution. This performance measure is first described in Section 4.1.1.

The alternatives are contrasted and the alternative that shows the closest match to the target distribution (EST05) across the entire flow range is considered a better alternative based on this performance measure. A visual comparison is made and emphasis is placed first on the ability of the alternative scenario to match the low tail of the distribution (low flows) then on the ability to match the preferred flow range and finally the ability to match the high tail (high flows) of the distribution. At each tail, the desired shift is a reduction in frequency of extreme flows.

Below (Figure 27) shows the average monthly flows over S-79 resulting from the 4 simulated alternative project configurations.

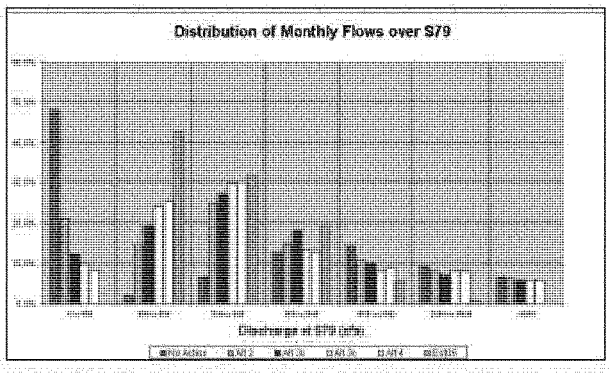


Figure 27. Distribution of average monthly flows over S-79 for the No Action alternative, Alternative 2, Alternative 3b, Alternative 3c, Alternative 4 and the EST05 target flow series.

An examination of the results show that none of the alternatives match EST05 for zero occurrences in the 0 – 450 cfs average monthly flow range. Similarly, all alternative were marginal in reduction of occurrence of high flows; monthly average greater than 2800 cfs. Over the entire range of flows, the results were consistently worse for Alternative 2 and mixed for Alternatives 3b, 3c and 4.

5.1.1 Alternative 2

The monthly average flows resulting from Alternative 2 were consistently farthest from the target distribution for all ranges with the exception of the 800 cfs to 1500 cfs range where it outperformed Alternatives 3c and 4. While Alternative 2 was an improvement over the no-action alternative, it clearly underperformed Alternatives 3b, 3c and 4 on this measure.

5.1.2 Alternative 3b

The monthly average flows resulting from Alternative 3b were consistently closer to the target flows than both the no-action and Alternative 2 results. Alternative 3b came closest to matching the target in the 800 cfs to 1500 cfs flow windows as well as for flows greater than 2800 cfs from the target distribution for all ranges with the exception of the 800 cfs to 1500 cfs range where it outperformed Alternatives 3c and 4.

5.1.3 Alternative 3c

The monthly average flows resulting from Alternative 3c were consistently closer to the target flows than the no-action alternative and Alternative 2 and 3b. Alternative 3c

underperformed Alternative 3b for the 800 – 1500 cfs range as well as for flows over 2800 cfs. Alternative 3c came closest to matching EST05 in the 1500 to 2800 cfs range.

5.1.4 Alternative 4

Based on the visual examination of the results, Alternative 4 appears to perform best overall and was marginally better than Alternative 3c in every flow range with the exception of the 800 to 1500 cfs and the 1500 to 2800 cfs ranges. This alternative resulted in the minimum number of flows in the 0 – 450 cfs range. The performance of Alternatives 3c and 4 is very similar overall.

5.1.5 Quantitative Measure of Match to EST05

To augment the qualitative visual assessment of the alternatives presented above, a quantitative measure of fit was developed. A dimensionless index of fit that scales between one for the flows resulting from the no-action alternative to zero for flows that match the EST05 time series perfectly was established. An index score closer to one is poorer and approaches the no-action alternative and a score closer to zero is better and approaches the target restoration flow series as specified by EST05. The index was created by taking the absolute value of the difference between the frequency of flow for each range from the alternative and the target series, and scaling that difference by the absolute value of the difference between the no-action alternative and the target series for the corresponding flow range. The resulting value was then averaged for the 7 flow ranges shown. The resulting index is shown in below (Table 6). As previously noted, an index score that approaches zero minimizes the difference in distribution of flows over S-79 between the project alternative receiving that score and the EST05 flow series. The comparison shown below (Table 6) assigns equal importance to every range in the distribution by assigning an equal weight to each.

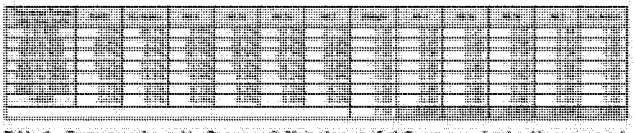


Table 6. Frequency of monthly flow over S-79 in the specified flow ranges for the Alternatives and quantitative comparison of match between each alternative and EST05 target series.

A second scoring was developed that emphasizes the tails and more specifically, the 0 to 500 cfs flow range and the range above 2800 cfs by assigning larger weights to these flow ranges. The intent was to incorporate information previously provided by users of the modeling results that suggests that meeting the critical low flows were very important to achieving desirable salinity distribution in the Caloosahatchee Estuary. Similarly larger weights were assigned to reduction in the damaging high flows based on concerns raised by ecologists. Below (Table 7) shows the index scores for each alternative based on a weighted average as well as the weights assigned to each flow range.

Discharge Range (cfs) Over S-79	Weight	Alt 4	Alt 3c	Alt 3b	Alt 2	No Action
0 to 450	5.00	0.89	1.03	1.27	2.19	5.00
450 to 500	4.00	1.70	1.84	2.32	2.79	4.00
500 to 800	1.50	0.10	0.11	0.26	0.42	1.50
800 to 1500	1.00	0.96	0.89	0.18	0.68	1.00
1500 to 2800	1.00	0.37	0.31	0.52	0.68	1.00
2800 to 4500	3.00	2.59	2.68	2.27	2.59	3.00
>4500	3.00	2.69	2.69	2.59	2.79	3.00
Weight / Index	18.50	0.503	0.516	0.509	0.651	1.000

Table 7. Quantitative comparison of match between project alternatives and target flow series using weighted average for each flow range.

The quantitative assessment confirms the findings from the visual examination of Figure 27. Table 6 shows that Alternatives 3c and 4 have lower index scores for the majority of the flow ranges, Alternative 3b however was better in the 800 to 1500 cfs flow range. With the equal weights or assumption of equal importance for each of the reported ranges, the lowest summary index was observed with Alternative 3b. This result is mostly due to the quality of its match of EST05 in the 800 to 1500 cfs flow range. Using weights that emphasize the tails, Alternative 4 provided the lowest summary index (0.503), closely followed by Alternative 3b (0.509) and Alternative 3c (0.516). The lowest index for a project alternative was Alternative 2 with an index score of 0.651.

Considering the quantitative measure presented above (Tables 6 and 7), Alternative 3b represent the best combined performance. Alternative 3b significantly outperforms both Alternative 3c and Alternative 4 using the un-weighted index and only marginally underperforms Alternative 4 but still outperforms Alternative 3c with weighted index. Combining this quantitative assessment with the qualitative assessment presented in Sections 5.1.1 to 5.1.4, Alternative 4 appears to be the best performing alternative overall but only marginally outperforms Alternative 3b and 3c.

5.2 Caloosahatchee Estuary Salinity Envelope

The second performance measure is the estuary salinity envelope criteria previously described in Section 4.1.2. This performance measure is a reproduction of a measure used with the regional simulation model for quantifying regional impact to the estuary from the CERP projects. The measure shows the count of exceedance of a low flow (lower than 450 cfs) during dry season months (November through May) as well as a count of exceedance of a high flow threshold (2800 cfs) for each of the project alternatives as well as the no-action alternative. A project alternative that minimizes either or both counts is a better performing alternative. A project alternative that results in the lower count of low flow events and high flow events represent a better alternative based on this criterion. Note that EST05 has no occurrences of flows below 450 cfs and establishes a target count of zero for the low flow portion of this measure. The results for the salinity envelope criteria are presented below (Figure 28).

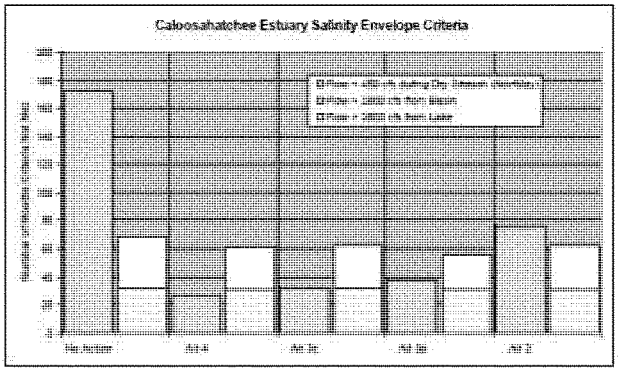


Figure 28. Salinity envelope criteria for project alternative 2, 3b, 3c and 4 and the no-action alternative (Future without project).

Considering the low flow criterion, Alternative 4 minimizes the number of events less than 450 cfs during the dry season. Alternative 3c provides the next best results followed by Alternative 3b. Alternative 2 had the poorest performance but is a significant improvement over the future without project or no-action alternative. Considering the high flow criteria, Alternative 3b resulted in the greatest reduction in flows over 2800 cfs, closely followed by Alternatives 4, 3c and 2 in that order. There wasn't much of a difference in this criterion across the projects alternatives as none significantly reduces the occurrence of high flows from the future without project conditions. This result was not expected, since Alternative 3b has a smaller inflow pump than both Alternative 3c and 4 which intuitively based on the larger pumps should have impacted the higher flows more. Examination of the model output in detail shows that the result can be explained. Below (Figure 29) shows hydrographs of flow over S-79 for Alternative 3b and Alternative 3c. As can be noted in the figure, Alternative 3b was able to prevent occurrence of any flow event over 2800 cfs in the year shown while Alternative 3c had flows in excess of 2800 cfs a few times. A closer examination of the results show the reason, under Alternative 3c with the larger pumps, the reservoir was filled faster. Once full and during wet events, the project could not reduce flows to the estuary since there was no capacity to store the flows in and occasionally, the project contributed flow to S-79 in excess of the base when runoff resulting from rainfall on the full reservoir is discharged. This illustration explains the superior performance of Alternative 3b with the smaller pump in reduction of high flow count. It is important to note that the ability to fill the reservoir early and capture more water during a high flow event (due to the larger pump) is also responsible for better performance of the alternatives with the larger pumps on the low flow criteria. Below (Figure 29) shows the reservoir in Alternative 3c did not run dry during the period depicted while the same sized reservoir went dry twice and was

unable to supply the 450 cfs to the estuary on each of those two occasions because the smaller pump was unable to maximize capture of dry season high flows.

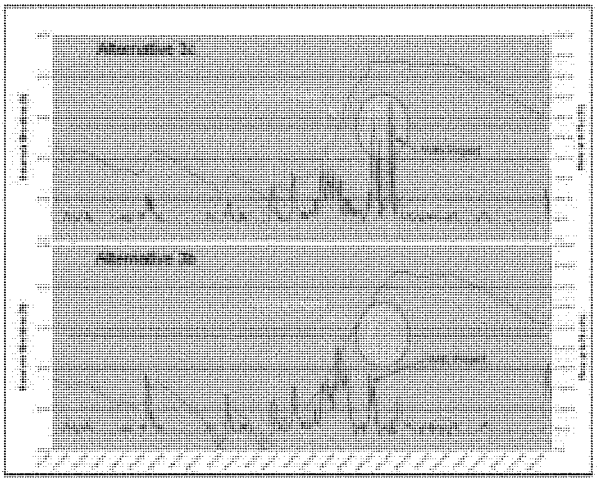


Figure 29. Flow over S-79 and reservoir stage for Alternatives 3b and 3c showing effects of larger pumps on the Estuary Salinity Envelope criteria under 1978 like conditions.

5.3 Caloosahatchee Estuary Salinity Envelope

The third performance measure are the flow duration curves derived by sorting and plotting the daily flow over rate at S-79 for each project alternative against the percentage of time that the flow is equaled or exceeded and comparing the resulting curve to the flow duration curve for the no action alternative and the target flow series (EST05). This performance measure was first described in Section 4.1.3. The project alternative that more closely matches EST05 represents the better performing alternative. Note that for this measure, the seasonality of the flow is lost and a 450 cfs occurrence in the wet season is not distinguished from a 450 cfs occurrence in the dry season. Below (Figure 30) is the flow duration curve for the four project alternatives, the no action alternative and the target flow series. The plot shows, for each alternative, the ability of the "with project" condition to extend availability of low flows towards the EST05 conditions (with no occurrences of flows less than 450 cfs.)

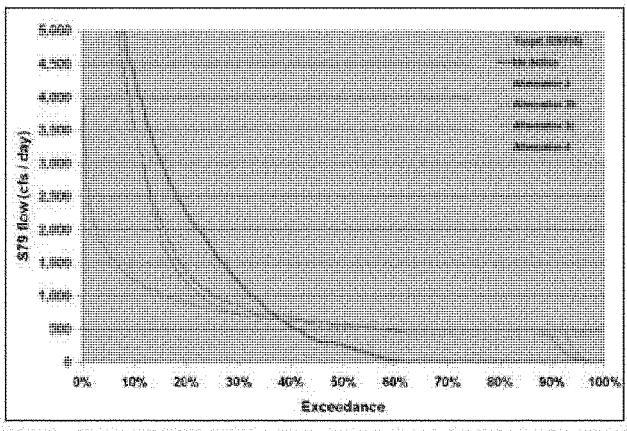


Figure 30. Flow over S-79 and reservoir stage for Alternatives 3b and 3c showing effects of larger pumps on the Estuary Salinity Envelope criteria under 1978 like conditions.

The results show that Alternative 4 performs best on the low flow end by extending the percentage of time when daily flow rates of 450 cfs or more can be delivered to the estuary. This is expected and is consistent with the expected performance of a bigger reservoir with larger storage capacity. Close in performance to Alternative 4 was Alternative 3c, middle sized reservoir with a larger pump, which was just short of Alternative 4 in ability to deliver daily flows of 450 cfs or more to the estuary. Alternative 3b lagged Alternative 3c in performance and Alternative 2, while much superior to the no action alternative was the poorest performing of the project alternatives evaluated.

The performance on the high flows was much closer for the four alternatives. All four showed improvement over the no action alternative, but none came close to matching EST05, especially for flows over 2000 cfs. Alternative 3c is the closest in the 800 to 2000 cfs range. All the project alternatives were essentially identical in performance for daily flows above 4000 cfs.

5.4 Consecutive Days with No Flows to Estuary

The fourth performance measure is the count of consecutive days with no flows to the estuary. This measure was previously described in Section 4.1.4. As noted in Section 4.1.4, this measure counts a 30 day no flow event as one occurrence and a 30 day dry event with some flows to the estuary introduced on the 15th day alone as two occurrences.

The measure also presents the maximum number of consecutive days with no flow under the "with project" and "without project" conditions. The project alternative that results in lower count of number of consecutive days of no flows and reduces the extent of the maximum number of consecutive no-flow days represents a more desirable alternative. Below (Figure 31) shows both criteria for the no action alternative as well as four project alternatives.

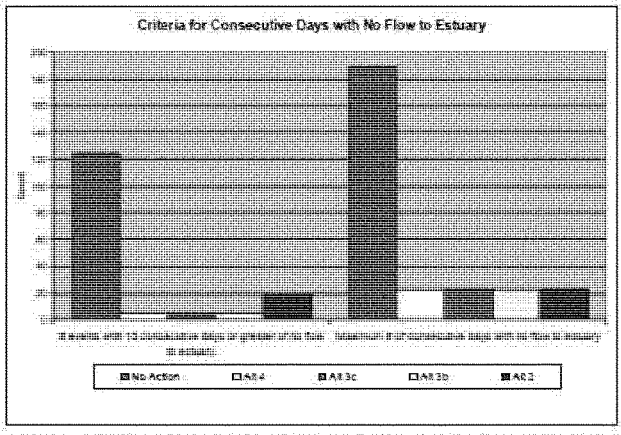


Figure 31. Flow over S-79 and reservoir stage for Alternatives 3b and 3c showing effects of larger pumps on the Estuary Salinity Envelope criteria under 1978 like conditions.

With the exception of Alternative 2, each of the project alternatives performed essentially identically on this measure. All show marked improvement over the no action alternative and were able to reduce the occurrence of 10 or more consecutive days with no flows to the estuary as well as the maximum number of consecutive days with no flows to the estuary. This measure should be interpreted with caution, since as previously stated in Section 4.1.4, release from the reservoir equal to the volume of rainfall in a day on the reservoir will count as flow to the estuary though it might be significantly less than the 450 cfs target restoration minimum flow. Also as computed by this measure, a release of 30 cfs from one project alternative counts a break in no-flow events as a release of 450 cfs from another alternative. The measure is still useful in showing that with the project alternatives, some flows, no mater how low, are sent to the estuary every 20 or so days over the 36 year simulation while the future without project condition has at least one occurrence of more than 180 days with nothing but the base flow to the estuary.

Section 6 – Discussion of Results

The four alternatives, Alternative 2, Alternative 3b, Alternative 3c and Alternative 4 were compared using performance measures as described in Section 5. The do-nothing or future without CERP condition was presented along with the target restoration flow series (EST05) where appropriate. This section discusses the results of the comparison with reference to the stated purpose of the project and the specified objective of the effort provided to IMC by the PDT.

The purpose of the C- 43 Storage Reservoir Phase I Project is to improve water deliveries to the estuary, provide for dry season flows, reduce magnitude of wet season high flows, restore downstream salinity levels and ensure the availability of water for the natural system needs of the Caloosahatchee Estuarine System.

The objective of this analyses presented in this report is to utilize the simplified spreadsheet model to evaluate the final array of alternatives using the 2050 (NAI) conditions for the purpose of confirming earlier plan selection exercise presented to the AFB. The result of the spreadsheet modeling will be used as input for the ecological analyses for plan selection.

6.1 Water Deliveries to the Estuary

The "with project" alternatives all significantly extend the period of deliveries of daily flows equal to or in excess of 450 cfs to the estuary over the no action alternative. The flow duration curves for 2050 scenarios show a shift in the percent of time flow to the estuary exceeds 450 cfs in the order of 42 to 52 percent depending on the project alternative. In order of performance, Alternatives 4 (best performance), 3c and 3b had superior performance and the improvement in deliveries to the estuary should be reflected in the ecological modeling effort to establish habitat units. The best buy project for meeting this project objective will be determined using the habitat units and project costs as determined by the PDT. None of the alternatives were able to prevent period of no flow over S-79; it is expected that additional improvements will have to be addressed in Phase II of the PIR.

6.2 Magnitude of Wet Season Flows

The results suggest more modest improvement in the area of high flows to the estuary across all the alternatives, a reduction in percent exceedance in the order of 4 to 5 percent at daily flow of 2800 cfs. Using the daily flows and the exceedance curves, Alternative 3c had the best hydrologic performance on high flows. Based on the monthly average flows, Alternative 3b had superior hydrologic performance of the four alternatives. The habitat units computed for comparison of the alternatives will incorporate effects of high flows and coupled with cost will be the basis for selecting the best alternative. The pump capacity and reservoir volume were determined to be limiting factors in the reduction of high flows. Without off line, long term storage (such as is projected to be capable

through aquifer storage and recovery,) or significantly larger storage and pumps, the reservoir fills quickly and high flow events pass by unhindered. To significantly affect the high flow conditions, other efforts such as CERP project components that result in a reduction in releases to the watershed from the regional system, along with the planned second phase of the C-43 Reservoir project will need to be implemented.

6.3 Retention of Water for Natural System

The results as presented in Section 4 and 5 show that the final array of alternatives all meet the objective of storing water for the natural system.

Section 7 – Conclusions and Recommendations

The IMC has developed and implemented a spreadsheet model of the C-43 Basin Storage Reservoir, Phase I project. The spreadsheet model based on a water budget of the reservoir and flows over S-79 stores excess flow during high flow events for release during low flow event with the objective of achieving to the extent possible restoration flows to the Caloosahatchee Estuary. IMC used the spreadsheet model for evaluation of the final array of alternatives provided by the C-43 PDT.

The following are conclusions that can be derived from the results of the analyses completed using the model:

1) The project specifications for Alternative 2, 3b, 3c and 4, provided by the C-43 PDT will provide significant benefit during low flow conditions by augmenting flows to the estuary. Alternative 4 based on hydrologic measures alone provided the most benefit.
2) The project specifications for Alternative 2, 3b, 3c and 4, will significantly minimize zero flow conditions to the estuary and will reduce the frequency of occurrence of less that 450 cfs, minimum restoration flows, over the no action or future without project conditions. Alternative 4 based on hydrologic measures alone resulted in the best performance.
3) The project specifications for Alternative 2, 3b, 3c and 4, will have modest improvement in reduction of high flow. Alternative 3c and Alternative 3b had better performance depending on consideration of daily flows or monthly averaged flows.
4) While the frequency of high flow events were less than what occurs under the no action or future without project condition, the frequency of high flow events will still significantly exceed the target frequency unless additional efforts beyond the alternatives presented as the final array of alternatives for the C-43 West Phase I reservoir project are implemented.
5) Ranked based on hydrologic measures, Alternative 4 was the best performing alternative followed by Alternative 3c and 3b which were close and may switch

based on the measure considered. Alternative 2 underperformed the other alternatives based on the analyses.

APPENDIX I

RESERVOIR PREFERRED OPERATIONS USED IN THE SPREADSHEET ANALYSES

The seasonal operations implemented in the spreadsheet for each of the alternatives that make up the final array of alternatives are presented in this section.

Alternative 2

Seasons

Early wet season was defined as June to July
Late Wet season was defined as August to October
Early Dry season was defined as November to January
Late Dry season was defined as February to May

The definitions of these seasons are in the operations "Ops Worksheet" in the spreadsheet. See below (Figure I-1).

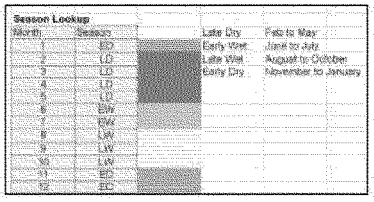


Figure I-1. Season lookup table for Alternative 2

Reservoir State

The state of the reservoir, empty, medium or full is defined in the "Ops Worksheet" and can be changed within the spreadsheet. The reservoir state definitions applied to Alternative 2 are shown in below (Figure I-2). Of the possible three states, two were used. Reservoir stages between 19.2 and 29 feet NAVD (corresponding to the bottom 10 feet of the reservoir) were considered in the empty state and reservoir operations defined for empty reservoir is applied in the analyses. Reservoir stage above 29 feet NAVD feet was considered middle to full and was operated based on operations specified for the middle state.

FINAL Page 56 of 77

Reservoir Breakpoints			
Stage	Storage		
29	575384		
33.58	100021		
19.2	to	29.0	Empty
29.0	to	33.6	Mid
33.6	to	NA	Full

Figure I-2. Reservoir break points and corresponding storage for defining reservoir state, Alternative 2.

Flow Decision Breakpoints

A series of ranges of flow were established at which fill decision or release decisions will be made. These ranges differ for fill or release but were limited to 11 categories for the fill decision (to accommodate larger pumps) and 9 categories for the release decisions. Below (Figure I-3) shows the flow at which operational decision changes occurred within the model.

Operations Parameters			
	S79 flow		
	Fill	Drain	Category
	520.01	250.01	1
	850.01	350.01	2
	950.01	450.01	3
	1000.01	550.01	4
	1200.01	800.01	5
	1500.01	1000.01	6
	2000.01	1500.01	7
	2800.01	2800.01	8
	3800.01	99999	9
	5000.01		10
	99999		11

Figure I-3. Flow decision breakpoints

The preferred operation rules for Alternative 2 following iterations to achieve better performance than the EST05 based operations and best possible performance within the time frame of the project for filling and releasing from the reservoir are presented below. (Table I-1 and Table I-2). Note that due to specified reservoir breakpoints, only operations specified for the two lower zones are used.

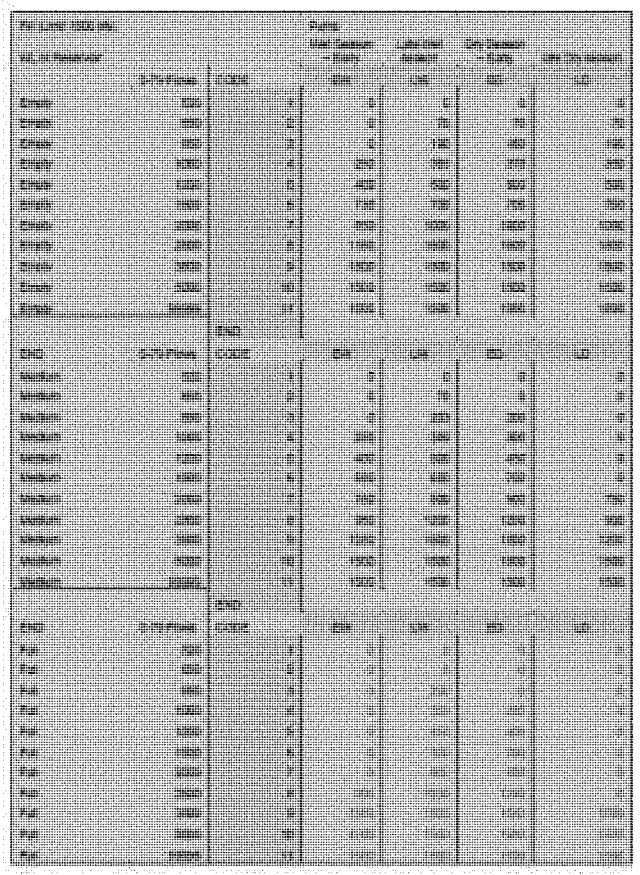


Table 6-1. Alternative 3 preferred operation rules for filling reservoir based on season, flows over S-79 and recovery zone (flow values in red = this defined zone not used due to recovery zone condition).

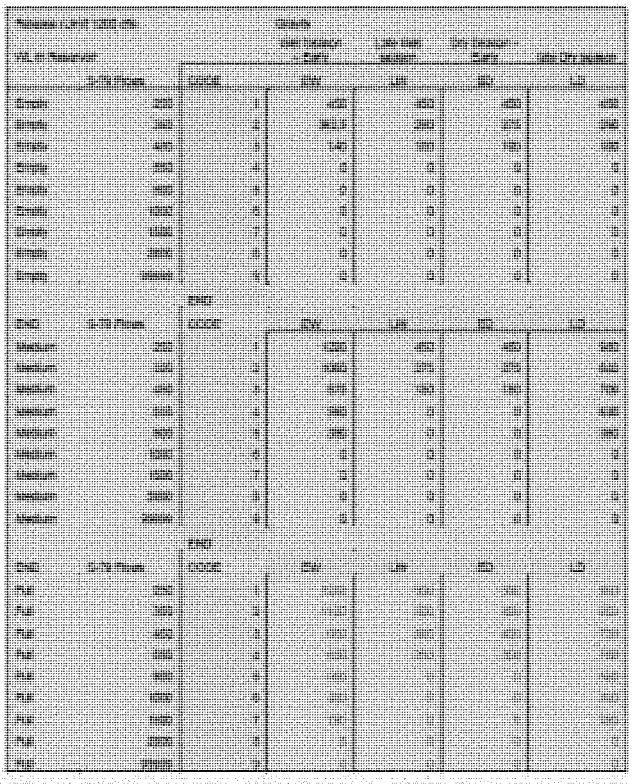
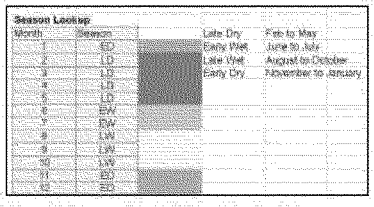


Table I-2. Alternative 2 preferred operation rules for making releases from reservoir based on season, flows over S-79 and reservoir state (Note values in red while defined were not used due to reservoir state condition).

Alternative 3b

Seasons

Early wet season was defined as June to July
Late Wet season was defined as August to October
Early Dry season was defined as November to January
Late Dry season was defined as February to May
The definitions of these seasons are in the operations "Ops Worksheet" in the spreadsheet. See below (Figure I-4).



Season Lookup				
Month	Season			
1	ED		Late Dry	Feb to May
2	LD		Early Wet	June to July
3	LD		Late Wet	August to October
4	LD		Early Dry	November to January
5	LD			
6	EW			
7	EW			
8	LW			
9	LW			
10	LW			
11	ED			
12	ED			

Figure I-4. Season lookup table for Alternative 3b

Reservoir State

The state of the reservoir, empty, medium or full is defined in the "Ops Worksheet" and can be changed within the spreadsheet. The reservoir state definitions applied to Alternative 3b are shown in below (Figure I-5). Of the possible three states, two were used. Reservoir stages between 19.2 and 29 feet NAVD (corresponding to the bottom 10 feet of the reservoir) were considered in the empty state and reservoir operations defined for empty reservoir is applied in the analyses. Reservoir stage above 29 feet NAVD was considered middle to full and was operated based on operations specified for the middle state. The normal pool elevation corresponding to 170,000 acre feet was 41.1 feet.

Reservoir Breakpoints				
Stage	Storage			
29	57534			
41.08	170012			
19.2	to	29.0	Empty	
29.0	to	41.1	Mid	
41.1	to	NA	Full	

Figure I-5. Reservoir break points and corresponding storage for defining reservoir state, Alternative 3b.

Flow Decision Breakpoints

FINAL Page 60 of 77

A series of ranges of flow were established at which fill decision or release decisions will be made. These ranges differ for fill or release but were limited to 11 categories for the fill decision (to accommodate larger pumps) and 9 categories for the release decisions. Below (Figure I-6) shows the flow at which operational decision changes occurred within the model.

Operations Parameters

S79 flow

Fill	Drain	Category
520.01	250.01	1
650.01	350.01	2
850.01	450.01	3
1000.01	550.01	4
1200.01	800.01	5
1500.01	1000.01	6
2000.01	1500.01	7
2800.01	2800.01	8
3800.01	99999	9
5000.01		10
99999		11

Figure I-6. Flow decision breakpoints for Alternative 3b

The preferred operation rules for Alternative 3b following iterations to achieve better performance than the EST05 based operations and best possible performance within the time frame of the project for filling and releasing from the reservoir are presented below (Table I-3 and Table I-4). Note that due to specified reservoir breakpoints, only operations specified for the two lower zones are used.

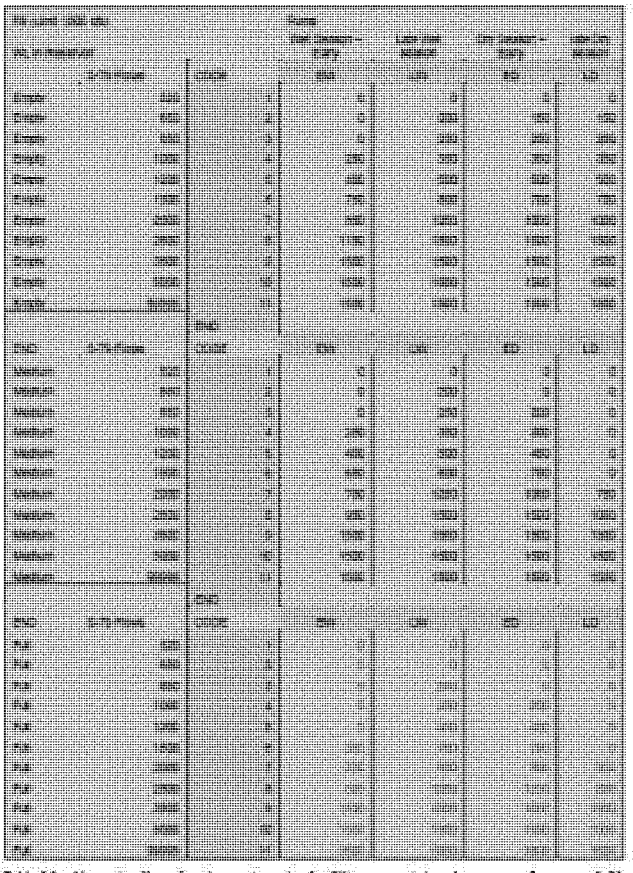


Table I-3. Alternative 3b preferred operation rules for filling reservoir based on season, flows over S-79 and reservoir state (Note values in red while defined were not used due to reservoir state condition)

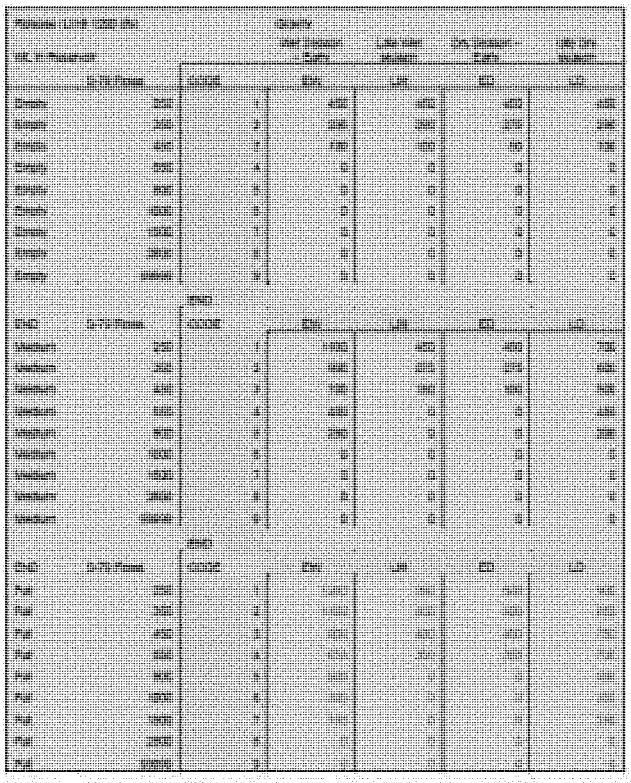


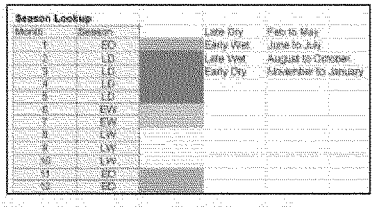
Table I-4. Alternative 3b preferred operation rules for making releases from reservoir based on season, flows over S-79 and reservoir state (Note values in red while defined were not used due to reservoir state condition).

FINAL Page 63 of 77

Alternative 3c

Seasons

Early wet season was defined as June to July
Late Wet season was defined as August to October
Early Dry season was defined as November to January
Late Dry season was defined as February to May
The definitions of these seasons are in the operations "Ops Worksheet" in the spreadsheet. See below (Figure I-7).

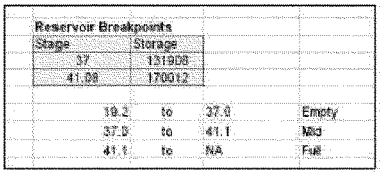


Season Lookup				
Month	Season			
1	ED		Late Dry	Feb to May
2	LD		Early Wet	June to July
3	LD		Late Wet	August to October
4	LD		Early Dry	November to January
5	LD			
6	EW			
7	EW			
8	LW			
9	LW			
10	LW			
11	ED			
12	ED			

Figure I-7. Season lookup table for Alternative 3c.

Reservoir State

The state of the reservoir, empty, medium or full is defined in the "Ops Worksheet" and can be changed within the spreadsheet. The reservoir state definitions applied to Alternative 3c are shown in below (Figure I-8). Of the possible three states, two were used. Reservoir stages between 19.2 and 37 feet NAVD (corresponding to the bottom 10 feet of the reservoir) were considered in the empty state and reservoir operations defined for empty reservoir is applied in the analyses. Reservoir stage above 37 feet NAVD was considered middle to full and was operated based on operations specified for the middle state. The normal pool elevation corresponding to 170,000 acre feet was 41.1 feet.



Reservoir Breakpoints				
Stage	Storage			
37	131908			
41.08	170012			
19.2	to	37.0	Empty	
37.0	to	41.1	Mid	
41.1	to	NA	Full	

Figure I-8. Reservoir break points and corresponding storage for defining reservoir state, Alternative 3c.

Flow Decision Breakpoints

A series of ranges of flow were established at which fill decision or release decisions will be made. These ranges differ for fill or release but were limited to 11 categories for the fill decision (to accommodate larger pumps) and 9 categories for the release decisions. Below (Figure I-9) shows the flow at which operational decision changes occurred within the model.

Operations Parameters

S79 flow

Fill	Drain	Category
520.01	250.01	1
650.01	350.01	2
850.01	450.01	3
1000.01	550.01	4
1200.01	800.01	5
1500.01	1000.01	6
2000.01	1500.01	7
2800.01	2800.01	8
3800.01	99999	9
5000.01		10
99999		11

Figure I-9. Flow decision breakpoints for Alternative 3c.

The preferred operation rules for Alternative 3c following iterations to achieve better performance than the EST05 based operations and best possible performance within the time frame of the project for filling and releasing from the reservoir are presented below. (Table I-5 and Table I-6). Note that due to specified reservoir breakpoints, only operations specified for the two lower zones are used.

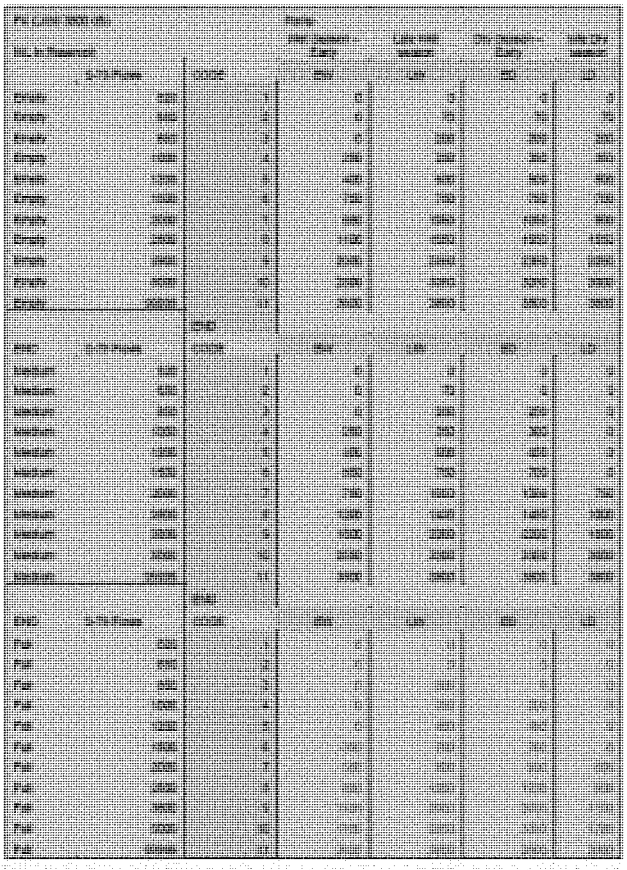


Table 1-1. Alternative 1c preferred operation rules for filling reservoir based on season, flows over L-79 and reservoir state (Note values in red while defined were not used due to reservoir state condition).

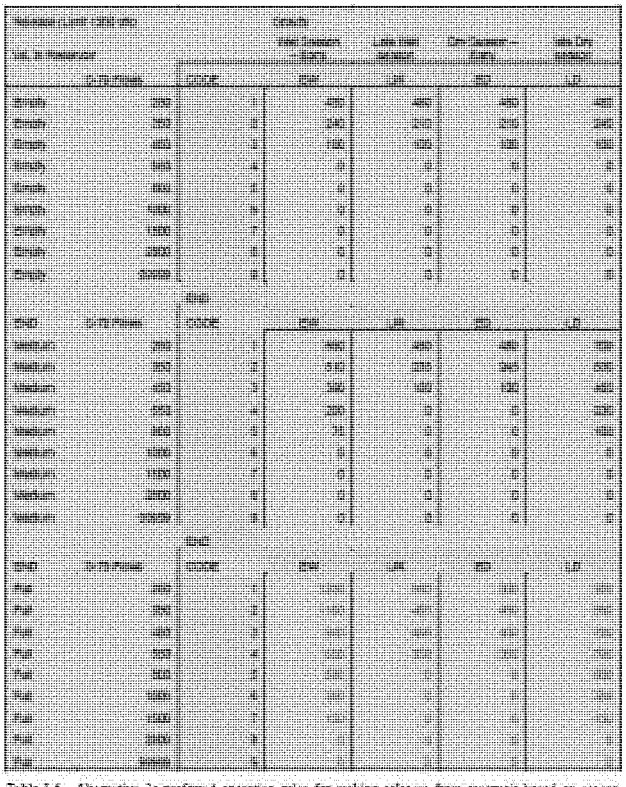
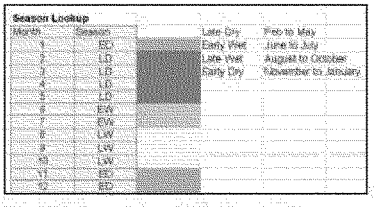


Table I-6. Alternative 3c preferred operation rules for making releases from reservoir based on season, flows over S-79 and reservoir state (Note values in red while defined were not used due to reservoir state condition).

Alternative 4

Seasons

Early wet season was defined as June to July
Late Wet season was defined as August to October
Early Dry season was defined as November to January
Late Dry season was defined as February to May
The definitions of these seasons are in the operations "Ops Worksheet" in the spreadsheet. See below (Figure I-10).

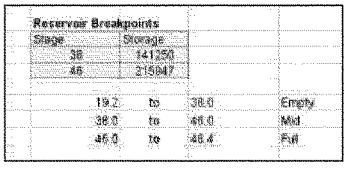


Season Lookup				
Month	Season		Late Dry	Feb to May
1	ED		Early Wet	June to July
2	LD		Late Wet	August to October
3	LD		Early Dry	November to January
4	LD			
5	LD			
6	EW			
7	EW			
8	LW			
9	LW			
10	LW			
11	ED			
12	ED			

Figure I-10. Season lookup table for Alternative 4.

Reservoir State

The state of the reservoir, empty, medium or full is defined in the "Ops Worksheet" and can be changed within the spreadsheet. The reservoir state definitions applied to Alternative 4 are shown in below (Figure I-11). Reservoir stages between 19.2 and 38 feet NAVD (corresponding to the bottom 10 feet of the reservoir) were considered in the empty state and reservoir operations defined for empty reservoir is applied for stages in this range. Reservoir stages between 38 and 46 feet NAVD were considered in the middle or medium state and reservoir operations defined for medium reservoir is applied for stages in this range. Reservoir stage above 46 feet NAVD was considered full and was operated based on operations specified for the full state. The normal pool elevation corresponding to 220,000 acre feet of storage was 46.4 feet.



Reservoir Breakpoints				
Stage	Storage			
38	141250			
46	215047			
19.2		to	38.0	Empty
38.0		to	46.0	Mid
46.0		to	46.4	Full

Figure I-11. Reservoir break points and corresponding storage for defining reservoir state, Alternative 4.

Flow Decision Breakpoints

A series of ranges of flow were established at which fill decision or release decisions will be made. These ranges differ for fill or release but were limited to 11 categories for the fill decision (to accommodate larger pumps) and 9 categories for the release decisions. Below (Figure I-12) shows the flow at which operational decision changes occurred within the model.

Operations Parameters

S79 flow

Fill	Drain	Category
5201.01	250.01	1
850.01	350.01	2
950.01	450.01	3
1000.01	550.01	4
1200.01	800.01	5
1501.01	1000.01	6
2000.01	1500.01	7
2900.01	2600.01	8
3800.01	99999	9
5000.01		10
99999		11

Figure I-12. Flow decision breakpoints for Alternative 4.

The preferred operation rules for Alternative 4 following iterations to achieve better performance than the EST05 based operations and best possible performance within the time frame of the project for filling and releasing from the reservoir are presented below. (Table I-7 and Table I-8).

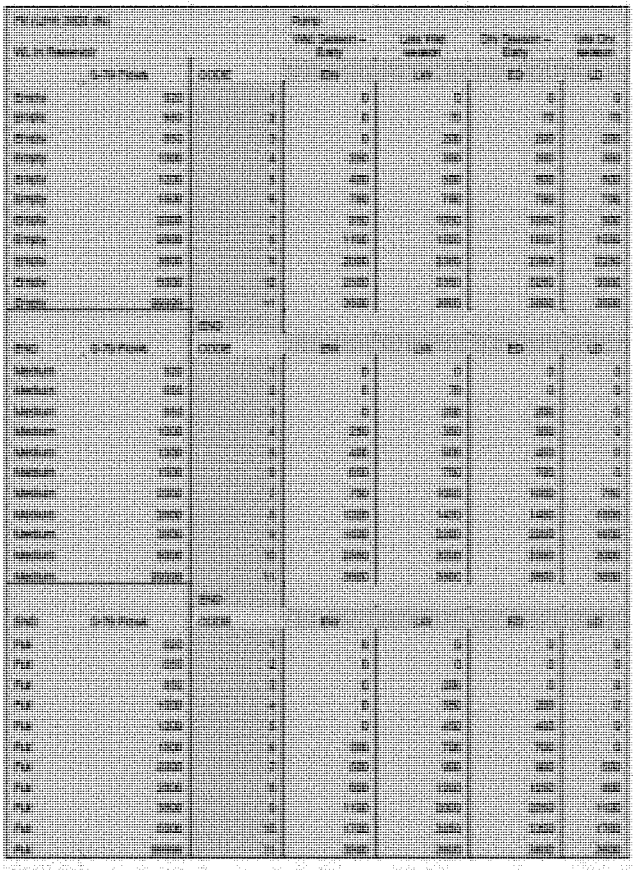
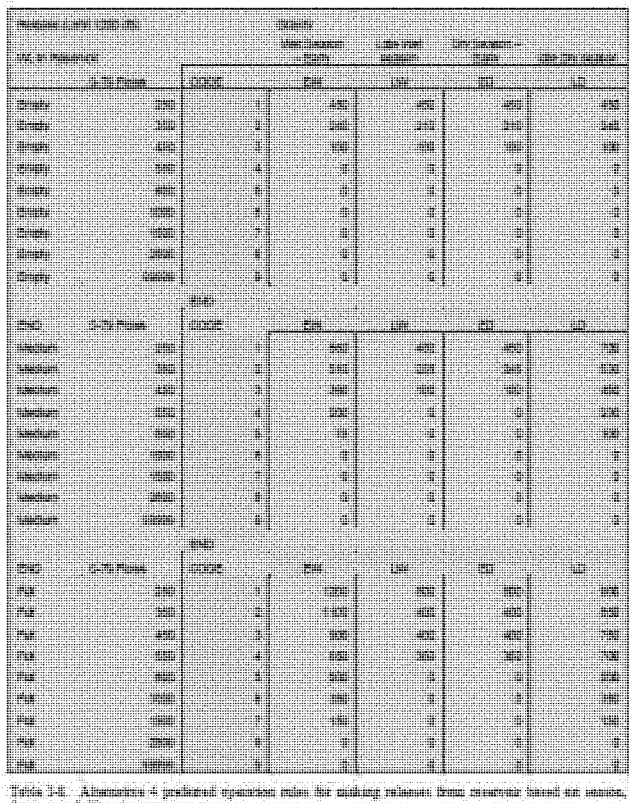


Table I-7. Alternative 4 preferred operation rules for filling reservoir based on season, flows over S-79 and reservoir state.

FINAL Page 70 of 72



APPENDIX II

SATISFACTION OF CUSTOMER REQUIREMENTS TOOL FEATURE CHECKLIST

FINAL Page 72 of 77

Customer Requirements

The IMC has fulfilled the objectives of this project and has met the customer requirements.

The objectives of the study conducted by the IMC are as follows.

1) Develop a spreadsheet tool suitable for meeting the requirements identified in the customer requirements section (1.3) of this report and submitted as attachment to MSR 264 by the C-43 PDT.

The IMC has developed a spreadsheet suitable for meeting the requirements identified in the customer requirements section of this report. The IMC has demonstrated the application of the spreadsheet tool using the C-43 Basin Storage Reservoir, Phase 1 Project.

2) Utilize the spreadsheet to evaluate the project alternative scenario using the 2050 (NAI) condition for the purposes of plan selection

The IMC has used the spreadsheet model to evaluate the final array of alternatives, Alternative 2, Alternative 3b, Alternative 3c and Alternative 4, using 2050 (NAI) conditions for the purpose of supporting plan selection, specifically confirmation of analyses previously developed by the PDT and presented at the projects' Alternative Formulation Briefing (AFB).

3) Deliver the spreadsheet with a user guide and model results to PDT team for subsequent analyses.

The IMC has delivered the spreadsheet to the PDT and the results of the spreadsheet for subsequent analyses.

4) Deliver the spreadsheet results to the PDT for further analyses and computation of habitat units.

The IMC has delivered the model results to the PDT for subsequent analyses.

5) Document the spreadsheet and provide a project report describing the analyses, the key assumptions, limitations and application to the PDT.

The IMC has documented the work effort by developing and delivering a technical memo detailing the work completed under MSR 264.

FINAL Page 74 of 77

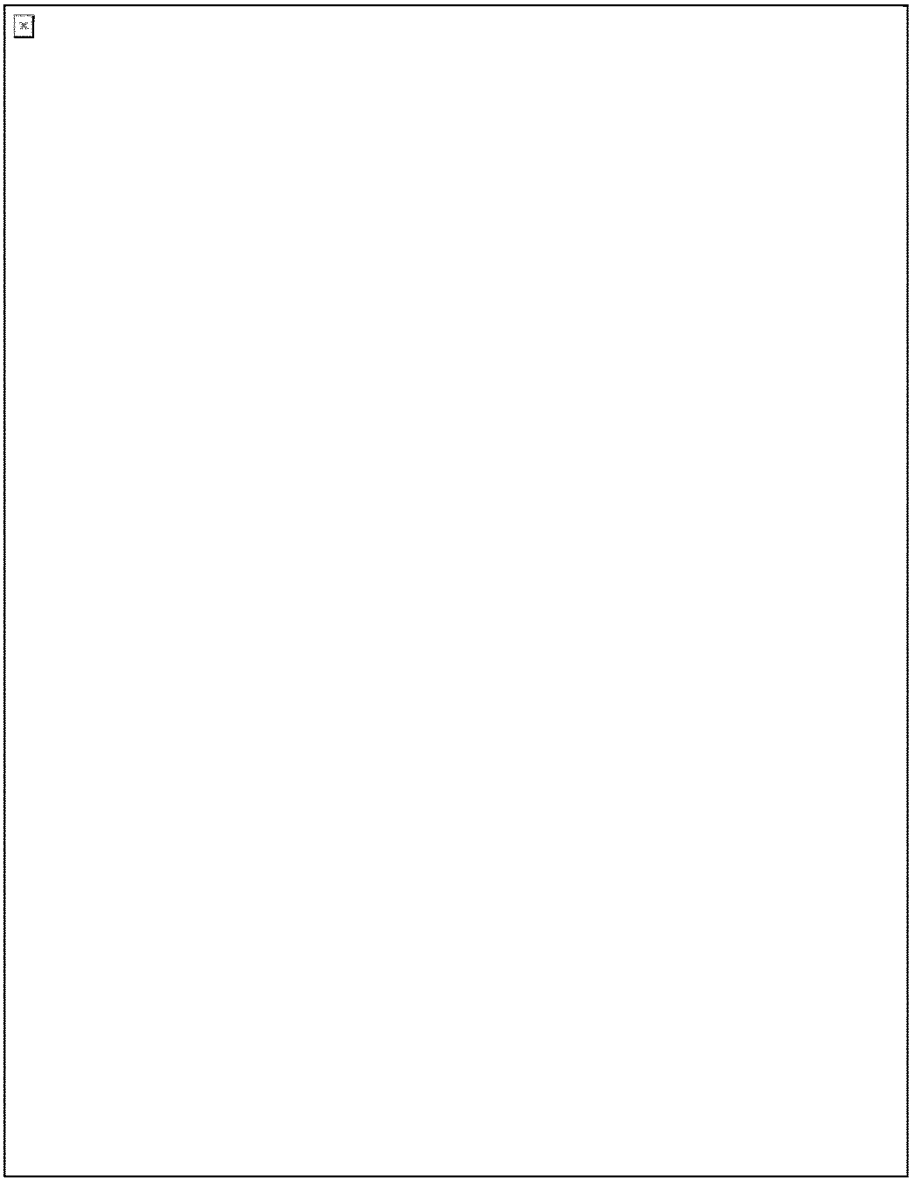
Features Checklist

- Flow data for Future Without-Project Condition, (plus each of the 4 alternatives individually) is derived from South Florida Water Management Model run 2050 RD.
- 4 alternatives were analyzed:
  - Alternative 2 100,000 ac-ft with 1500 cfs pump
  - Alternative 3b 170,000 ac-ft with 1500 cfs pump
  - Alternative 3c 170,000 ac-ft with 3800 cfs pump
  - Alternative 4 220,000 ac-ft with 3800 cfs pump
- ET from reservoir will be included. The mass balance terms for the reservoir are reservoir inflow, reservoir releases, reservoir seepage will be assumed to be zero, ET losses, and perhaps reservoir direct precipitation.
- System losses from the river to groundwater from the point of release of the reservoir to S-79 will be factored into the spreadsheet analysis. (Evaluation of relevant available data indicates that use of 100% efficiency is reasonable for this project).
- No agricultural or urban water supply deliveries are supplied by the reservoir these demands continue to be supplied from Lake Okeechobee or current groundwater sources.
- Water will be pumped into the reservoir only when there are excess flows over S-79. Excess will be treated initially as high flows over some threshold that will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Releases from the reservoir are made when flows over S-79 are below desirable levels (450 cfs). Releases will be refined through iterations of the spreadsheet to obtain the best performance in meeting estuary targets (EST 05).
- Including basic seasonal operational variability in the spreadsheet for filling and draining the reservoir is preferable.
- Capacity to simulate varying pump and reservoir sizes implemented in spreadsheet.
- Hydrologic performance graphics for comparing alternatives built into spreadsheet.

FINAL Page 76 of 77

TECHNICAL MEMORANDUM FOR SPILLWAY DESIGN

The following Technical Memorandum documents the analysis used to determine the spillway width for the Caloosahatchee River (C-43) West Basin Storage Reservoir. This memorandum was prepared by Stanley Consultants for SFWMD and was provided to CESAJ for inclusion in the Final PIR. Hydrologic modeling was used to determine the peak reservoir levels with various spillway widths for the critical Inflow Design Flood (IDF). Larger spillways reduce the peak reservoir levels and required dam height. The added cost of the larger spillway is somewhat offset by reduced dam construction costs. The hydrologic modeling results were used in a cost analysis to determine the optimum spillway width. A description of the hydrologic modeling and input used to populate these tables are provided in a different technical memo, titled "Final Technical Memorandum on Freeboard Analysis.



Spillway Width Analysis Modeling Results		
Spillway Width (ft)	Dam Height Reduction (ft) (Preliminary Results)	Dam Height Reduction (ft) MIKE SHE Results[4]
10	0	0
20	0.09	-
30	0.17	-
40	0.23	-
50	0.29	0.33
100	0.49	-
200	0.75	0.79

[4] The average peak elevations for Cells 1 and 2 were used.

The modeled dam height reductions were used in a cost analysis to determine the overall project costs for each scenario. The results presented below show increasing the spillway width above the 10-foot width significantly increases the project cost and is not recommended. Consideration of a narrower width is not recommended due to potential clogging concerns. The final recommendation is to use a spillway width of 10 feet for both C43CS-1 and C43CS-2.

SUMMARY OF FINDINGS RELATED TO ALTERNATIVE SPILLWAY ANALYSIS IN RESPONSE TO DRCHECKS COMMENT NO. 18279

Spillway Width (ft)	Increased Flows Over C43CS-1 and C43CS2 Combined (cfs)	Dam Height Reduction[1] (ft)	SAVINGS $$			ADDITIONAL COSTS $$[2]			Project Savings
			Embankment	Soil Cement	Total	Spillway C43CS-1	Spillway C43CS-2	Total	
10	0	0.00	*As presented in the PDR - 30% Design*						
20	394	0.09	$171,368	$180,000	$351,368	$288,000	$203,000	$491,000	-$139,632
30	774	0.17	$323,695	$340,000	$663,695	$576,000	$406,000	$982,000	-$318,305
40	1,144	0.23	$437,940	$460,000	$897,940	$864,000	$609,000	$1,473,000	-$575,060
50	1,534	0.29	$552,185	$580,000	$1,132,185	$1,152,000	$812,000	$1,964,000	-$831,815
100	3,084	0.49	$933,002	$980,000	$1,913,002	$2,592,000	$1,827,000	$4,419,000	-$2,505,998
200	5,792	0.75	$1,428,065	$1,500,000	$2,928,065	$5,472,000	$3,857,000	$9,329,000	-$6,400,935

Notes: 1. Based on reducing dam height from the 90% design dam elevation.
2. Based on upgrades beyond the 30% Design.
3. Additional costs for enlarging downstream structures C43S-10, C43S-11, the Perimeter Canal, the Townsend Canal or improvements to the SR-80 bridge have not been included.

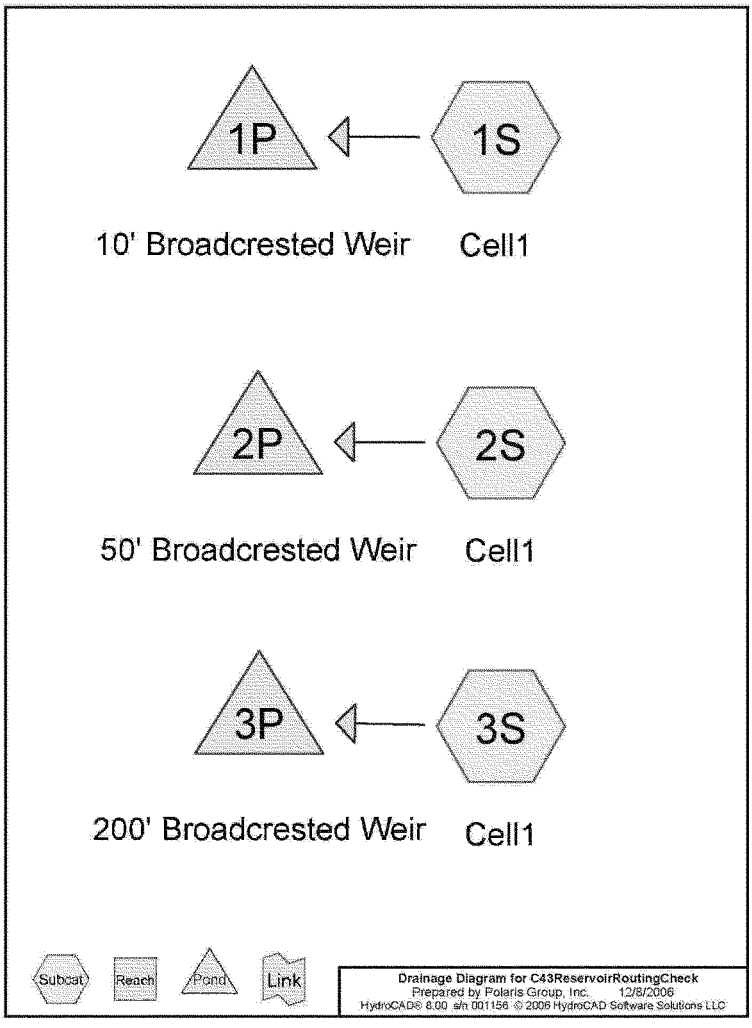
It should be made clear that the "spillway width" listed in the table above is a broad-crested weir that represents the width of the spillway structure through the dam. It is not the "weir length" of the u-shaped weir used in the

SC5022

30% design. The 30% design recognized, as indicated in the table above, that there is no cost savings advantage in increasing the spillway structure width through the dam. Therefore, the 30% design and future design submittals, will recommend a minimum practical width (10 feet) for the spillway structure.

This design, with a spillway width of 10 feet, takes advantage of a u-shaped weir at the inlet of the structure to maximize flows through the structure. The spillway structure has been designed to meet the 100-year allowable discharge. The combination of the u-shaped weir length (approximately 50 feet) and the width of the spillway structure (10 feet) have been designed to ensure that the "post" project flows never exceed the "pre" project flows in storm events. This is to protect the integrity of the SR-80 Bridge and to prevent flooding along the Townsend Canal.

SC5022


1P
1S
10' Broadcrested Weir
Cell1
2P
2S
50' Broadcrested Weir
Cell1
3P
3S
200' Broadcrested Weir
Cell1
Subcat
Reach
Pond
Link
Drainage Diagram for C43ReservoirRoutingCheck
Prepared by Polaris Group, Inc. 12/8/2006
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC

C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 2
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Subcatchment 1S: Cell1

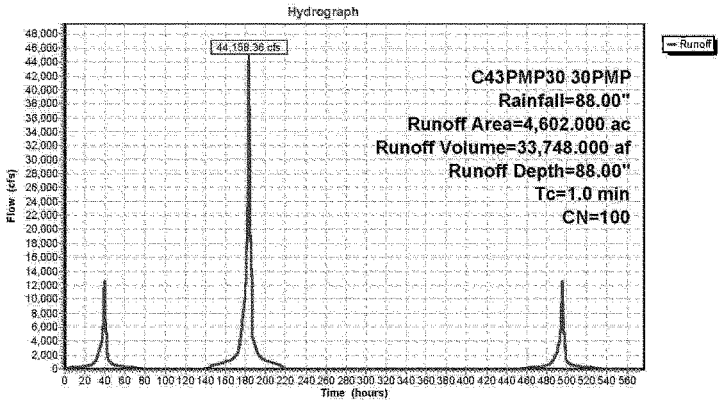
Runoff = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af, Depth=88.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
C43PMP30 30PMP Rainfall=88.00"

Area (ac)	CN	Description
4,602.000	100	pond
4,602.000		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment 1S: Cell1



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 3
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Subcatchment 2S: Cell1

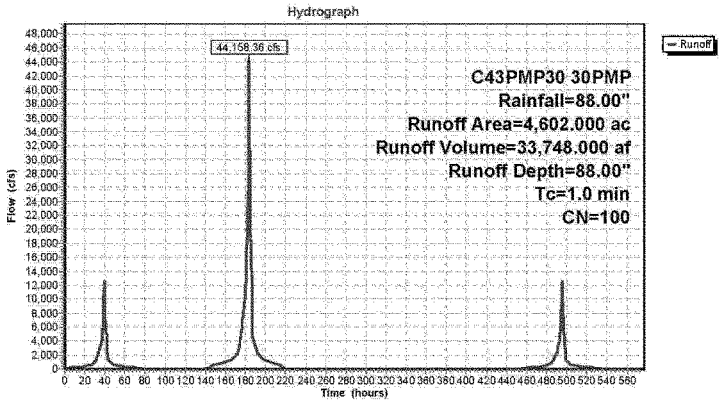
Runoff = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af, Depth=88.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
C43PMP30 30PMP Rainfall=88.00"

Area (ac)	CN	Description
4,602.000	100	pond
4,602.000		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment 2S: Cell1



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 4
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Subcatchment 3S: Cell1

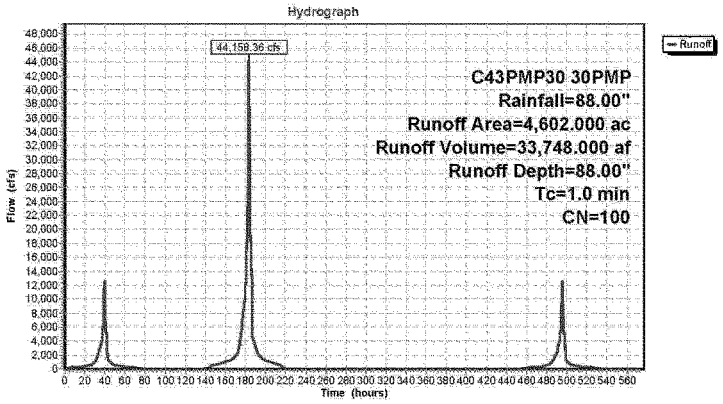
Runoff = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af, Depth=88.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
C43PMP30 30PMP Rainfall=88.00"

Area (ac)	CN	Description
4,602.000	100	pond
4,602.000		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment 3S: Cell1



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 5
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Pond 1P: 10' Broadcrested Weir

Inflow Area = 4,602.000 ac, Inflow Depth = 88.00" for 30PMP event
Inflow = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af
Outflow = 855.03 cfs @ 204.55 hrs, Volume= 31,105.528 af, Atten= 98%, Lag= 1,264.3 min
Primary = 855.03 cfs @ 204.55 hrs, Volume= 31,105.528 af

Routing by Stor-Ind method, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
Starting Elev= 42.00' Surf.Area= 4,551.500 ac Storage= 108,528.000 af
Peak Elev= 45.61' @ 204.55 hrs Surf.Area= 4,564.816 ac Storage= 124,857.347 af (16,329.347 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 4,473.2 min (17,278.5 - 12,805.3)

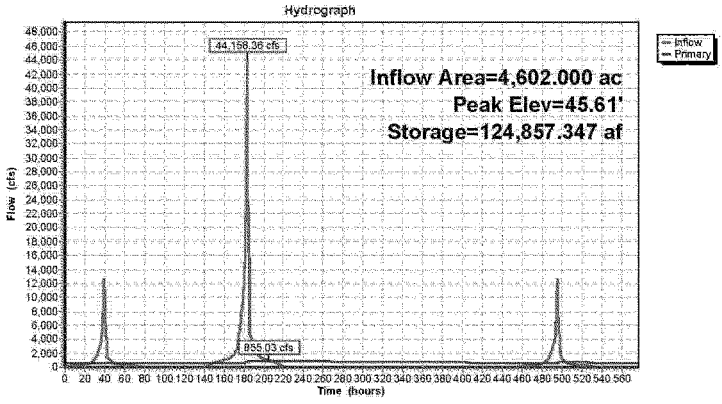
Volume	Invert	Avail.Storage	Storage Description
#1	18.00'	144,704,000 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
18.00	4,463.000	0.000	0.000
50.00	4,581.000	144,704.000	144,704.000

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**6.00' W x 5.00' H Vert. Orifice/Grate X 2.00** C= 0.260
#2	Primary	42.00'	**10.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=854.90 cfs @ 204.55 hrs HW=45.61' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 627.08 cfs @ 10.45 fps)
└—**2=Broad-Crested Rectangular Weir** (Weir Controls 227.82 cfs @ 6.31 fps)

Pond 1P: 10' Broadcrested Weir



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 7
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Pond 2P: 50' Broadcrested Weir

Inflow Area = 4,602.000 ac, Inflow Depth = 88.00" for 30PMP event
Inflow = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af
Outflow = 1,619.18 cfs @ 197.78 hrs, Volume= 35,211.879 af, Atten= 96%, Lag= 858.5 min
Primary = 1,619.18 cfs @ 197.78 hrs, Volume= 35,211.879 af

Routing by Stor-Ind method, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
Starting Elev= 42.00' Surf.Area= 4,551.500 ac Storage= 108,528.000 af
Peak Elev= 45.33' @ 197.78 hrs Surf.Area= 4,563.768 ac Storage= 123,571.827 af (15,043.827 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 3,779.4 min (16,584.7 - 12,805.3)

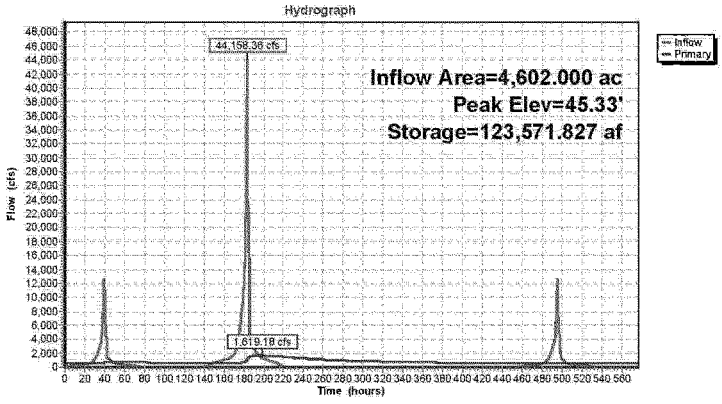
Volume	Invert	Avail.Storage	Storage Description
#1	18.00'	144,704.000 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
18.00	4,463.000	0.000	0.000
50.00	4,581.000	144,704.000	144,704.000

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**6.00' W x 5.00' H Vert. Orifice/Grate X 2.00** C= 0.260
#2	Primary	42.00'	**50.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=1,618.17 cfs @ 197.78 hrs HW=45.33' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 623.51 cfs @ 10.39 fps)
└—**2=Broad-Crested Rectangular Weir** (Weir Controls 994.66 cfs @ 5.98 fps)

Pond 2P: 50' Broadcrested Weir



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 9
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Pond 3P: 200' Broadcrested Weir

Inflow Area = 4,602.000 ac, Inflow Depth = 88.00" for 30PMP event
Inflow = 44,156.36 cfs @ 183.48 hrs, Volume= 33,748.000 af
Outflow = 3,743.05 cfs @ 188.62 hrs, Volume= 39,370.281 af, Atten= 92%, Lag= 308.6 min
Primary = 3,743.05 cfs @ 188.62 hrs, Volume= 39,370.281 af

Routing by Stor-Ind method, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
Starting Elev= 42.00' Surf.Area= 4,551.500 ac Storage= 108,528.000 af
Peak Elev= 44.89' @ 188.62 hrs Surf.Area= 4,562.172 ac Storage= 121,615.407 af (13,087.407 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 2,827.6 min (15,633.0 - 12,805.3)

Volume	Invert	Avail.Storage	Storage Description
#1	18.00'	144,704.000 af	**Custom Stage Data (Prismatic)** Listed below

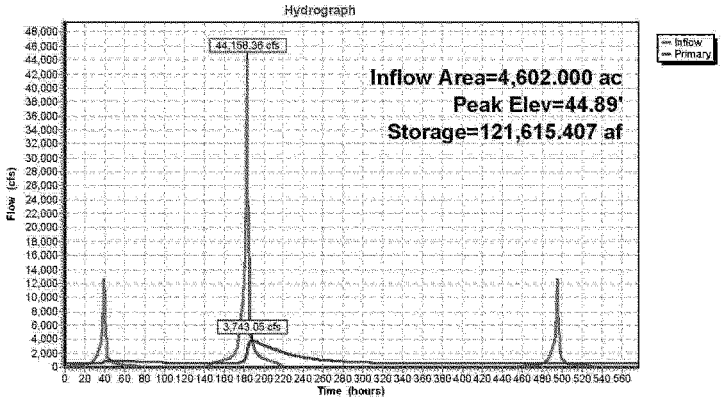
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
18.00	4,463.000	0.000	0.000
50.00	4,581.000	144,704.000	144,704.000

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**6.00' W x 5.00' H Vert. Orifice/Grate X 2.00** C= 0.260
#2	Primary	42.00'	**200.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=3,741.90 cfs @ 188.62 hrs HW=44.89' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 618.04 cfs @ 10.30 fps)
└—**2=Broad-Crested Rectangular Weir** (Weir Controls 3,123.86 cfs @ 5.40 fps)

C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 10
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

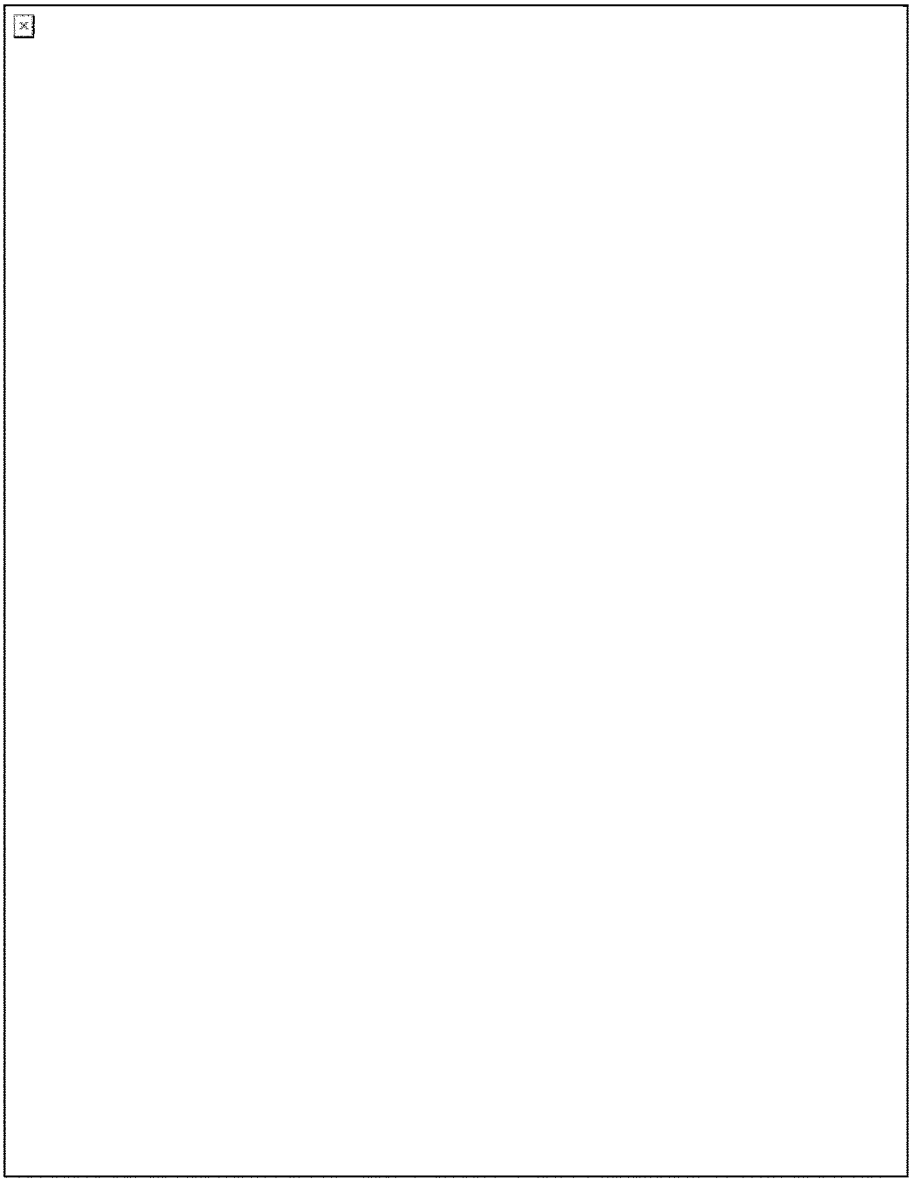
Pond 3P: 200' Broadcrested Weir



A.11 FINAL TECHNICAL MEMORANDUM–C-43 WEST STORAGE RESERVOIR FREEBOARD ANALYSIS AND RECOMMENDATIONS

The following Technical Memorandum was prepared by Stanley Consultants for the SFWMD and was provided to CESAJ for inclusion in the PIR. The memorandum documents the analyses necessary to provide an estimate of the required freeboard for the 60% design of the C-43 West Storage Reservoir located in northwest Hendry County, Florida in accordance with the SFWMD Design Criteria Memorandum: DCM-2, Wind and Precipitation Design Criteria for Freeboard (SFWMD, 2006).

Freeboard is additional embankment height that is provided above a water surface level to assure that failure of the dam will not result from overtopping due to factors that may permanently or temporarily increase the water surface elevation in the reservoir. Freeboard also provides a safety factor to account for uncertainties in analytical procedures and the function of the facility in critical situations.



Spillway Width Analysis Modeling Results		
Spillway Width (ft)	Dam Height Reduction (ft) (Preliminary Results)	Dam Height Reduction (ft) MIKE SHE Results[1]
10	0	0
20	0.09	-
30	0.17	-
40	0.23	-
50	0.29	0.33
100	0.49	-
200	0.75	0.79

[1] The average peak elevations for Cells 1 and 2 were used.

The modeled dam height reductions were used in a cost analysis to determine the overall project costs for each scenario. The results presented below show increasing the spillway width above the 10-foot width significantly increases the project cost and is not recommended. Consideration of a narrower width is not recommended due to potential clogging concerns. The final recommendation is to use a spillway width of 10 feet for both C43CS-1 and C43CS-2.

SUMMARY OF FINDINGS RELATED TO ALTERNATIVE SPILLWAY ANALYSIS IN RESPONSE TO DRCHECKS COMMENT NO. 18279

Spillway Width (ft)	Increased Flows Over C43CS-1 and C43CS2 Combined (cfs)	Dam Height Reduction[1] (ft)	SAVINGS $$			ADDITIONAL COSTS $$[2]			Project Savings
			Embankment	Soil Cement	Total	Spillway C43CS-1	Spillway C43CS-2	Total	
10	0	0.00	As presented in the PDR - 30% Design						
20	394	0.09	$171,968	$180,000	$351,968	$288,000	$205,000	$491,000	-$139,032
30	774	0.17	$323,695	$340,000	$663,695	$576,000	$406,000	$982,000	-$318,305
40	1,144	0.23	$437,940	$460,000	$897,940	$864,000	$609,000	$1,473,000	-$575,060
50	1,534	0.29	$552,185	$580,000	$1,132,185	$1,152,000	$812,000	$1,964,000	-$831,815
100	3,084	0.49	$933,002	$980,000	$1,913,002	$2,592,000	$1,827,000	$4,419,000	-$2,505,998
200	5,792	0.75	$1,428,065	$1,500,000	$2,928,065	$5,472,000	$3,857,000	$9,329,000	-$6,400,935

Notes: 1. Based on reducing dam height from the 30% design dam elevation.
2. Based on upgrades beyond the 30% Design.
3. Additional costs for enlarging downstream structures C43S-10, C43S-11, the Perimeter Canal, the Townsend Canal or improvements to the SR-80 bridge have not been included.

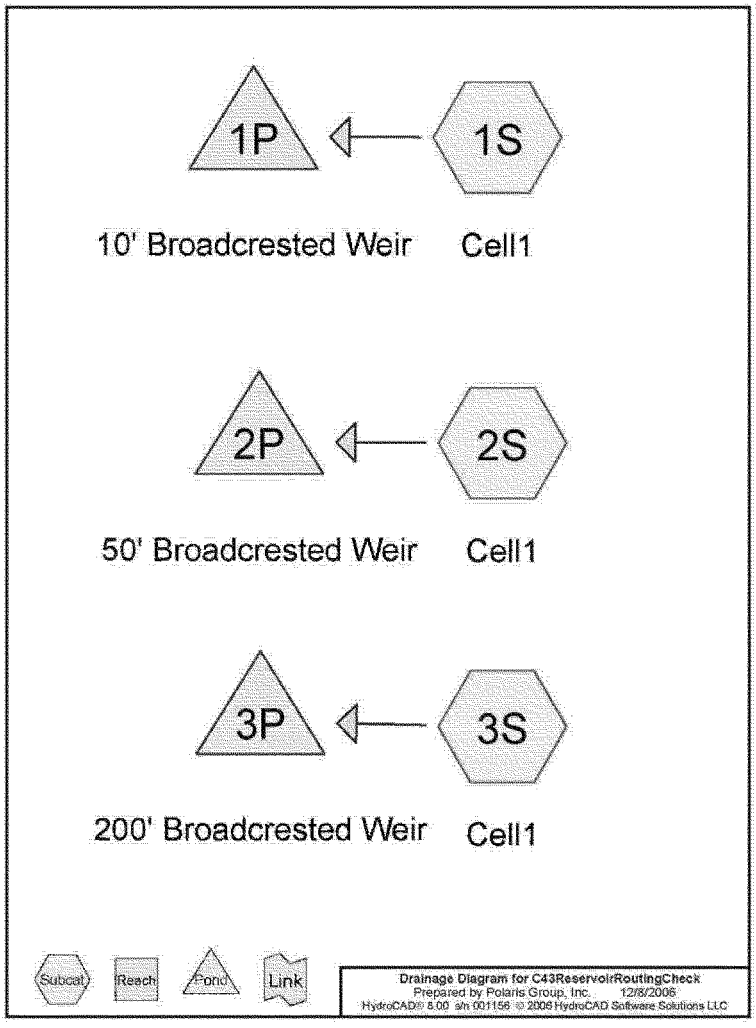
It should be made clear that the "spillway width" listed in the table above is a broad-crested weir that represents the width of the spillway structure through the dam. It is not the "weir length" of the u-shaped weir used in the

SD5022

30% design. The 30% design recognized, as indicated in the table above, that there is no cost savings advantage in increasing the spillway structure width through the dam. Therefore, the 30% design and future design submittals, will recommend a minimum practical width (10 feet) for the spillway structure.

This design, with a spillway width of 10 feet, takes advantage of a u-shaped weir at the inlet of the structure to maximize flows through the structure. The spillway structure has been designed to meet the 100-year allowable discharge. The combination of the u-shaped weir length (approximately 50 feet) and the width of the spillway structure (10 feet) have been designed to ensure that the "post" project flows never exceed the "pre" project flows in storm events. This is to protect the integrity of the SR-80 Bridge and to prevent flooding along the Townsend Canal.

SC5022


1P
1S
10' Broadcrested Weir
Cell1
2P
2S
50' Broadcrested Weir
Cell1
3P
3S
200' Broadcrested Weir
Cell1
Subcat
Reach
Pond
Link
Drainage Diagram for C43ReservoirRoutingCheck
Prepared by Polaris Group, Inc. 12/8/2006
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC

C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 2
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Subcatchment 1S: Cell1

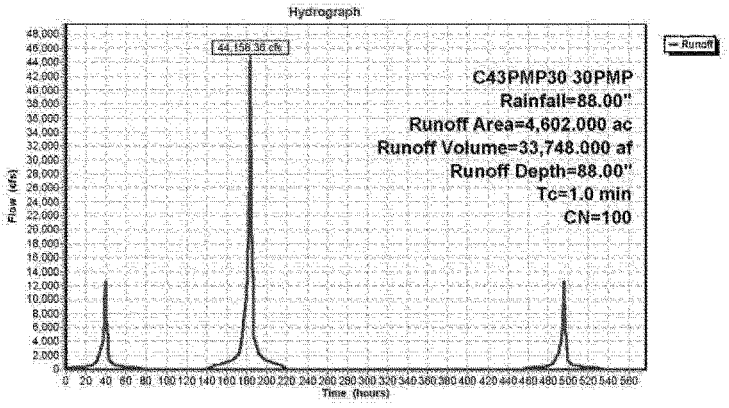
Runoff = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af, Depth=88.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
C43PMP30 30PMP Rainfall=88.00"

Area (ac)	CN	Description
4,602.000	100	pond
4,602.000		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment 1S: Cell1



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 3
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Subcatchment 2S: Cell1

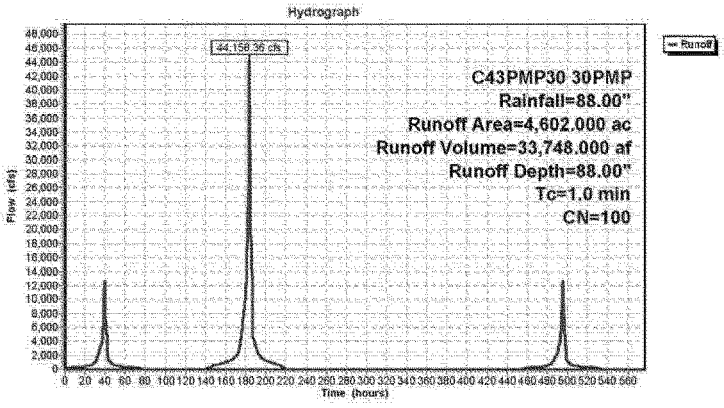
Runoff = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af, Depth=88.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
C43PMP30 30PMP Rainfall=88.00"

Area (ac)	CN	Description
4,602.000	100	pond
4,602.000		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment 2S: Cell1



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 4
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Subcatchment 3S: Cell1

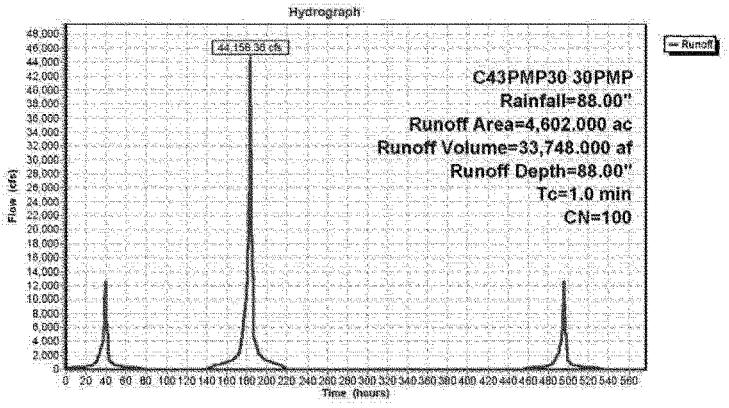
Runoff = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af, Depth=88.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
C43PMP30 30PMP Rainfall=88.00"

Area (ac)	CN	Description
4,602.000	100	pond
4,602.000		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.0					Direct Entry,

Subcatchment 3S: Cell1



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 5
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Pond 1P: 10' Broadcrested Weir

Inflow Area = 4,602.000 ac, Inflow Depth = 88.00" for 30PMP event
Inflow = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af
Outflow = 855.03 cfs @ 204.55 hrs, Volume= 31,105.528 af, Atten= 98%, Lag= 1,264.3 min
Primary = 855.03 cfs @ 204.55 hrs, Volume= 31,105.528 af

Routing by Stor-Ind method, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
Starting Elev= 42.00' Surf.Area= 4,551.500 ac Storage= 108,526.000 af
Peak Elev= 45.61' @ 204.55 hrs Surf.Area= 4,564.816 ac Storage= 124,857.347 af (16,329.347 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 4,473.2 min (17,278.5 - 12,805.3)

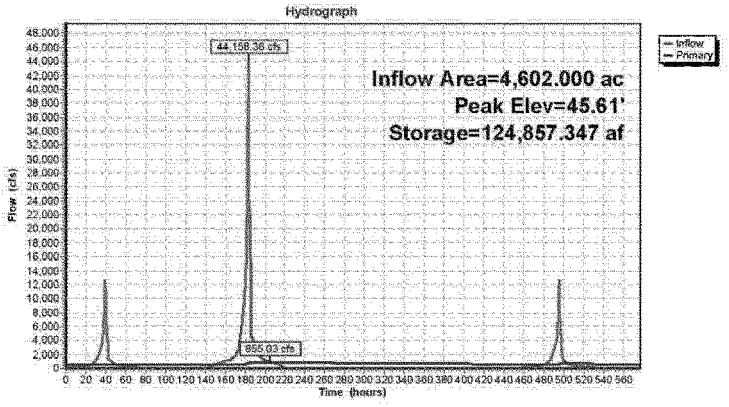
Volume	Invert	Avail.Storage	Storage Description
#1	18.00'	144,704.000 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
18.00	4,463.000	0.000	0.000
50.00	4,581.000	144,704.000	144,704.000

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**6.00' W x 5.00' H Vert. Orifice/Grate X 2.00 C= 0.260**
#2	Primary	42.00'	**10.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=854.90 cfs @ 204.55 hrs HW=45.61' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 627.08 cfs @ 10.45 fps)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 227.82 cfs @ 6.31 fps)

Pond 1P: 10' Broadcrested Weir



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 7
HydroCAD® 8.00 s/n 001156 © 2005 HydroCAD Software Solutions LLC 12/8/2006

Pond 2P: 50' Broadcrested Weir

Inflow Area = 4,602.000 ac, Inflow Depth = 88.00" for 30PMP event
Inflow = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af
Outflow = 1,619.18 cfs @ 197.78 hrs, Volume= 35,211.879 af, Atten= 96%, Lag= 858.5 min
Primary = 1,619.18 cfs @ 197.78 hrs, Volume= 35,211.879 af

Routing by Stor-Ind method, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
Starting Elev= 42.00' Surf.Area= 4,551.500 ac Storage= 108,528.000 af
Peak Elev= 45.33' @ 197.78 hrs Surf.Area= 4,563.768 ac Storage= 123,571.827 af (15,043.827 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 3,779.4 min (16,584.7 - 12,805.3)

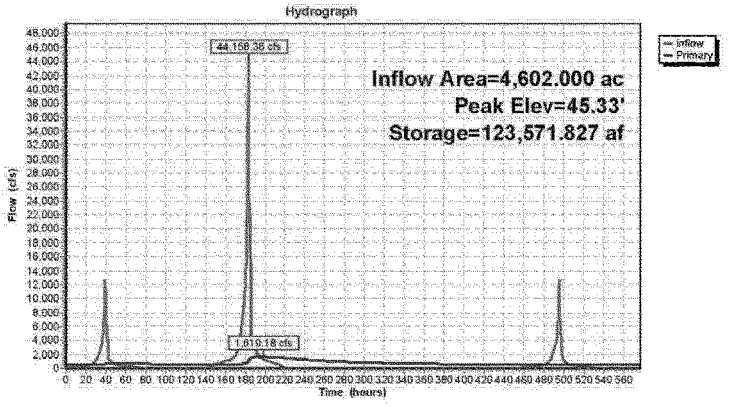
Volume	Invert	Avail.Storage	Storage Description
#1	18.00'	144,704.000 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
18.00	4,463.000	0.000	0.000
50.00	4,581.000	144,704.000	144,704.000

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**6.00' W x 5.00' H Vert. Orifice/Grate X 2.00 C= 0.260**
#2	Primary	42.00'	**50.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.86 2.85 3.07 3.20 3.32

Primary OutFlow Max=1,618.17 cfs @ 197.78 hrs HW=45.33' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 623.51 cfs @ 10.39 fps)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 994.66 cfs @ 5.98 fps)

Pond 2P: 50' Broadcrested Weir



C43ReservoirRoutingCheck *C43PMP30 30PMP Rainfall=88.00"*
Prepared by Polaris Group, Inc. Page 9
HydroCAD® 8.00 s/n 001156 © 2006 HydroCAD Software Solutions LLC 12/8/2006

Pond 3P: 200' Broadcrested Weir

Inflow Area = 4,602.000 ac, Inflow Depth = 88.00" for 30PMP event
Inflow = 44,158.36 cfs @ 183.48 hrs, Volume= 33,748.000 af
Outflow = 3,743.05 cfs @ 188.62 hrs, Volume= 39,370.281 af, Atten= 92%, Lag= 308.6 min
Primary = 3,743.05 cfs @ 188.62 hrs, Volume= 39,370.281 af

Routing by Stor-Ind method, Time Span= 0.00-576.00 hrs, dt= 0.30 hrs
Starting Elev= 42.00' Surf.Area= 4,551.500 ac Storage= 108,526.000 af
Peak Elev= 44.89' @ 188.62 hrs Surf.Area= 4,562.172 ac Storage= 121,615.407 af (13,087.407 af above start)

Plug-Flow detention time= (not calculated: initial storage excedes outflow)
Center-of-Mass det. time= 2,827.6 min (15,633.0 - 12,805.3)

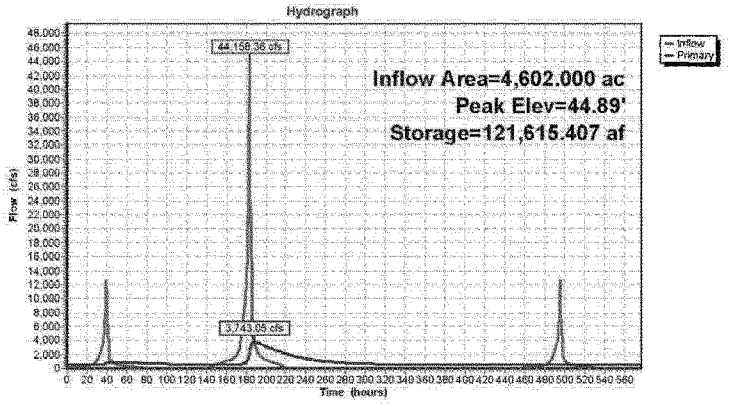
Volume	Invert	Avail.Storage	Storage Description
#1	18.00'	144,704.000 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
18.00	4,463.000	0.000	0.000
50.00	4,581.000	144,704.000	144,704.000

Device	Routing	Invert	Outlet Devices
#1	Primary	18.00'	**6.00' W x 5.00' H Vert. Orifice/Grate X 2.00 C= 0.260**
#2	Primary	42.00'	**200.0' long x 2.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 Coef. (English) 2.54 2.61 2.61 2.60 2.66 2.70 2.77 2.89 2.88 2.85 3.07 3.20 3.32

Primary OutFlow Max=3,741.90 cfs @ 188.62 hrs HW=44.89' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 618.04 cfs @ 10.30 fps)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 3,123.86 cfs @ 5.40 fps)

Pond 3P: 200' Broadcrested Weir



A.12 FINAL TECHNICAL MEMORANDUM–C-43 WEST STORAGE RESERVOIR FREEBOARD ANALYSIS AND RECOMMENDATIONS

The following Technical Memorandum was prepared by Stanley Consultants for the SFWMD and was provided to CESAJ for inclusion in the PIR. The memorandum documents the analyses necessary to provide an estimate of the required freeboard for the 60% design of the C-43 West Storage Reservoir located in northwest Hendry County, Florida in accordance with the SFWMD Design Criteria Memorandum: DCM-2, Wind and Precipitation Design Criteria for Freeboard (SFWMD, 2006).

Freeboard is additional embankment height that is provided above a water surface level to assure that failure of the dam will not result from overtopping due to factors that may permanently or temporarily increase the water surface elevation in the reservoir. Freeboard also provides a safety factor to account for uncertainties in analytical procedures and the function of the facility in critical situations.

TABLE OF CONTENTS

Page

1 INTRODUCTION 1

1.1 Purpose of Memorandum 1

1.2 Project Area and Location 1

1.3 Project Description 1

1.4 Reservoir Hazard Potential Classification 1

2 FREEBOARD DESIGN 4

2.1 Introduction 4

2.2 Freeboard Components and Camber 4

2.2.1 Provisions for the Malfunction of the Spillway and/or Outlet Works 6

2.2.2 Landslide Induced Wave Height 6

2.2.3 Wind Setup 6

2.2.4 Wave Height and Wave Runup 6

2.2.5 Surcharge Pool Depth 6

2.2.6 Camber and Embankment Settlement 7

2.3 Design Freeboard Criteria 7

2.4 Preliminary Design Freeboard Approach and Methodology 7

2.4.1 Design Wind Speed 8

2.4.1.1 Design Wind Speed Data Conversion 8

2.4.1.2 Wind Speed Duration Adjustments 9

2.4.1.3 Over Water Wind Speed Adjustment 9

2.4.1.4 Fetch Limited Duration 9

2.4.1.5 Wind Speed Fetch Limited Duration Adjustment 10

2.4.1.6 Wind Speed Stability Correction 10

2.4.1.7 Wind Stress Factor 10

2.4.2 Wind Setup 10

2.4.3 Wave Height 11

2.4.3.1 Deep Water Wave Calculations 11

2.4.3.2 Effective Depth 11
2.4.3.3 Wave Classification 12
2.4.3.4 Shallow Water Wave Calculations 12
2.4.3.5 Significant Wave Height 13
2.4.3.6 Zero Overwash Wave Height 13
2.4.3.7 Wave Breaking Height 13
2.4.3.8 Equivalent Deep Water Wave Height, H'_o 14
2.4.4 Wave Runup 14
2.4.4.1 Smooth Surface Wave Runup 14
2.4.4.2 Correction Factor due to Scale Effects 16
2.4.4.3 Correction Factor Due to Dam Surface Roughness 17
2.4.4.4 Correction Factor due to Fetch Angle 17
2.5 Freeboard Parameters 18
2.5.1 Normal Full Storage Level 18
2.5.2 Fetch 18
2.5.2.1 Fetch Length 19
2.5.2.2 Fetch Angle 19
2.5.3 Effective Depth 20
2.5.4 Dam Embankments 20

3 PRELIMINARY DESIGN FREEBOARD ANALYSES 21

3.1 Determination of Design Freeboard Components and Camber 21
3.1.1 Camber and Embankment Settlement 21
3.1.2 Provisions for the Malfunction of the Spillway and/or Outlet Works 22
3.1.3 Landslide Induced Wave Height 22
3.1.4 Wind Setup 22
3.1.5 Wave Height and Wave Runup 23
3.1.6 Surcharge Pool Depth 23
3.1.6.1 Case 1: 100-Yr Wind + Probable Maximum Precipitation 23
3.1.6.2 Case 2: Category 5 Wind + 100-Yr Precipitation 24
3.1.6.3 Case 3: PMW + Normal Full Storage Level 25

3.1.6.4 Case 4: Hurricane Easy 25
3.2 Summary of Preliminary Design Freeboard with Camber Calculations 25
3.2.1 Cell 1 25
3.2.1.1 Fetch 1A Analysis 25
3.2.1.2 Fetch 1B Analysis 26
3.2.2 Cell 2 26
3.2.2.1 Fetch 2A Analysis 26
3.2.2.2 Fetch 2B Analysis 27
3.2.3 Preliminary Embankment Freeboard Results and Recommendations 27

4 FINAL DESIGN STWAVE/ACES FREEBOARD ANALYSES 28
4.1 Introduction 28
4.2 Design Freeboard and Overtopping Rate Criteria 28
4.2.1 Overtopping Rate Field Tests 28
4.2.2 External Embankment Overtopping Rate Criterion 31
4.2.3 Internal Embankment Overtopping Rate Criterion 31
4.3 Design Freeboard Approach and Methodology 32
4.3.1 Computer Models 32
4.3.2 Steady State Spectral Wave (STWAVE) Model 33
4.3.3 Automated Costal Engineering System (ACES) Model 33
4.4 STWAVE Analyses 33
4.4.1 Bathymetry 33
4.4.1.1 Bathymetric Data 33
4.4.1.2 Grid Orientation 33
4.4.2 Wave and Wind Data 34
4.4.3 STWAVE Results 34
4.5 ACES Analyses 34
4.5.1 Wave Runup 34
4.5.2 Wave Overtopping 35
4.5.3 Summary of Manual Freeboard Calculations 37
4.5.4 Summary of Wave Overtopping Analyses 37

4.6 Internal Embankments 38
4.6.1 Internal Embankment Design Height 38
4.7 Summary of Embankment Design 38

5 REFERENCES 39

LIST OF FIGURES

Page

Figure 1: Location Map 2
Figure 2: Site Map 3
Figure 3: Design Freeboard Components [Figure DCM 2-1, DCM-2] 5
Figure 4: 50-Yr to 100-Yr, 3-Second Gust Wind Speed [Figure DCM 2-2, DCM-2] 8
Figure 5: Regression Curves for Figure 7-10 (d_s/H'_o~0.8) [SMP Vol. II] 15
Figure 6: Regression Curves for Figure 7-11(d_s/H'_o~2.0) [SMP Vol. II] 15
Figure 7: Regression Curves for Figure 7-12 (d_s/H'_o>3.0) [SMP Vol. II] 16
Figure 8: Correction Factor Due to Scale Effects [Figure 7-13, SPM Vol. II] 17
Figure 9: Correction Factor Due to Fetch Angle [Figure 8, ACER No. 2] 18
Figure 10: Calculating Fetch Length 19
Figure 11: Settlement Zones [Figure 8A-3, C-43 BODR] 21
Figure 12: All Season PMP (72-hr, 10 sq. mi.) [Figure 22, HR 51, NOAA] 23
Figure 13: 100-Year, 3-Day Precipitation [Figure DCM 2-3, DCM-2] 24
Figure 14: Grass Cover on Sections of Hoover Dike (Lake Okeechobee). 29
Figure 15: Overtopping Rate Field Tests. 30
Figure 16: Washout with Outwash Rate of 0.01 cfs/ft. 31
Figure 17: Variation of Q*o (Cnoidal vs. Linear Waves) [Figure 7-34, SPM Vol. II] 36

LIST OF TABLES

Page

Table 1: Fetch Parameters 19
Table 2: Effective Depths for Cell Analyses 20
Table 3: Embankment Settlement Data 22
Table 4: Cell 1 (Fetch 1A) Freeboard Analysis Summary 25
Table 5: Cell 1 (Fetch 1B) Freeboard Analysis Summary 26
Table 6: Cell 2 (Fetch 2A) Freeboard Analysis Summary 26
Table 7: Cell 2 (Fetch 2B) Freeboard Analysis Summary 27
Table 8: Summary of Calculated Manual Freeboard Requirements 37
Table 9: Summary of Cell 1 and Cell 2 Overtopping Analyses 37
Table 10: Summary of Internal Embankment Overtopping Analysis 38

LIST OF APPENDICES

Appendix A: Reservoir Storm Hydrology
Appendix B: Fetch Length and Water Depth Calculation Exhibits
Appendix C: C-43 Manual Freeboard Calculations
Appendix D: Step-by-Step Freeboard Calculation References
Appendix E: Regression Analyses for Wave Runup Calculations
Appendix F: STWAVE and ACES Analyses
Appendix G: C-43 WSR Overwash Rate Memo

1 INTRODUCTION

1.1 Purpose of Memorandum

The purpose of this technical memorandum is to document the analyses necessary to provide an estimate of the required freeboard for the 60% design of the C-43 West Basin Storage Reservoir located in northwest Hendry County, Florida in accordance with the South Florida Water Management District (SFWMD) *Design Criteria Memorandum: DCM-2, Wind and Precipitation Design Criteria for Freeboard* (SFWMD, 2006).

1.2 Project Area and Location

The C-43 West Basin Storage Reservoir is located in northwest Hendry County, south of the Caloosahatchee River, approximately 3 miles west of Labelle, Florida, and southwest of the intersection of SR80 and SR29 (Figures 1 and 2). The existing site and surrounding area is sparsely populated and primarily developed as citrus groves or similarly used for agriculture. The site is relatively flat and laced with irrigation ditches and canals. It is anticipated that the area surrounding the project site will be commercially and/or residentially developed in the future.

1.3 Project Description

According to the Central and Southern Florida Project Comprehensive Everglades Restoration Plan (CERP), the purpose of the C-43 West Basin Storage Reservoir Project is to improve water deliveries to the estuary for dry season flow, restore downstream salinity levels and ensure the availability of water for the natural system needs of the Caloosahatchee Estuarine System. The proposed facility is approximately 12,000 acres in size and will primarily consist of a two-cell reservoir with a combined minimum storage capacity of 170,000 acre-ft, a perimeter channel, reservoir spillways, and two pumping stations. Other appurtenances, support facilities, and channel improvements necessary for the operation of the facility will also be provided.

1.4 Reservoir Hazard Potential Classification

The hazard potential for a dam is defined by the possible consequences that may result from the release of stored water due to dam failure or mis-operation of the dam or appurtenances during both normal and flood flow conditions. According to the SFWMD Design Criteria Manual: DCM-1, there are three classification levels of the hazard potential for a dam: Low Hazard Potential, Significant Hazard Potential and High Hazard Potential (SFWMD, 2005).

Low Hazard Potential dams are generally defined as dams where failure or mis-operation results in low economic and/or environmental losses, no disruption of essential services and no probable loss of human life.

Significant Hazard Potential dams are generally defined as dams where failure or mis-operation can cause high economic loss, loss of valued environmental ecosystems, disruption of essential services or access, or can impact other valued concerns but results in no probable loss of life.

High Hazard Potential dams are defined as dams where failure or mis-operation will probably cause loss of human life, disruption of critical facilities and access, and major economic and environmental losses.

Based upon this classification system, the proposed C-43 West Basin Storage Reservoir has been classified as a high hazard potential impoundment. As part of the C-43 West Storage Reservoir Basis of Design Report (BODR), a dam break analysis indicated that a dam failure would compromise the safety of existing residents living near the proposed reservoir possibly resulting in the loss of life. In addition, the proximity of a major highway (SR80), the anticipated future development of areas near the facility, along with the size of the facility and volume of impounded water would all likely increase the potential for loss of life and high economic and infrastructure losses.

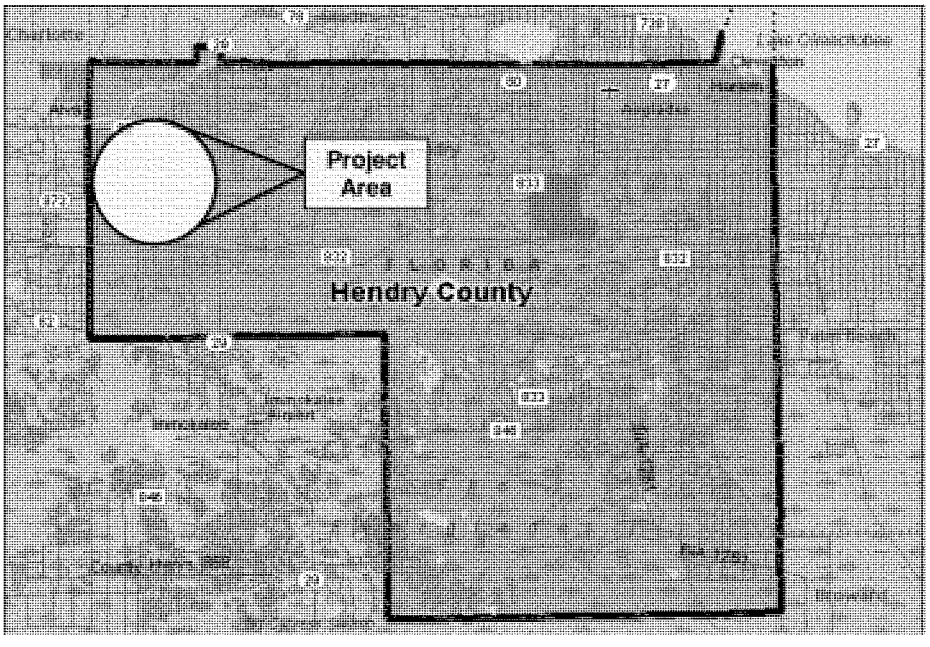


Figure 1: Location Map

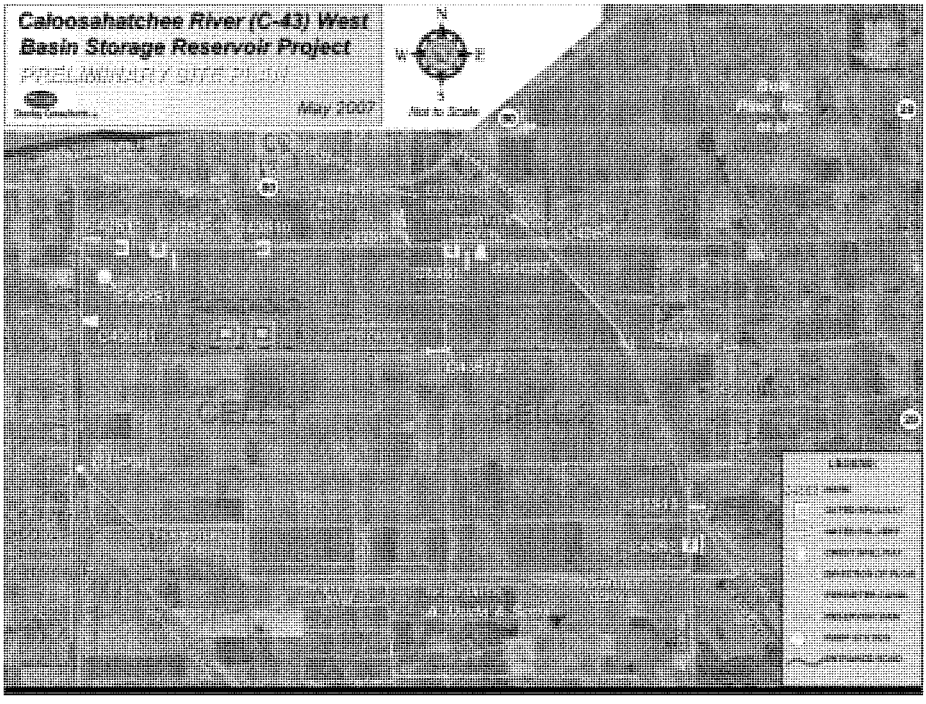


Figure 2: Site Map

2 FREEBOARD DESIGN

2.1 Introduction

The High Hazard Potential classification of the C-43 West Basin Storage Reservoir requires specific freeboard design criteria be applied to ensure the integrity and safety of the impoundment. This criteria is detailed in the South Florida Water Management District Design Criteria Memorandum 2 (DCM-2). This section presents the criteria and analyses used for the determination of design freeboard for the C-43 Reservoir.

The preliminary design of freeboard requirements and the evaluation of design alternatives were performed using manual calculations in accordance with guidelines provided in the DCM-2. For final design, the DCM-2 and the U.S. Army Corp of Engineers (USACE) require that a final assessment of freeboard requirements be based upon USACE Steady-State Spectral Wave Model (STWAVE) and the Automated Coastal Engineering System (ACES) computer model analyses.

While the computer analyses for final design require comparable input data and utilize similar methodologies, the models do not have the same computational transparency as do the manual calculations. Consequently, the detailed methodologies and approaches presented in this report in Sections 2 and 3 are primarily a discussion of the manual calculations and the preliminary design analysis. While this information is relevant to the computer analyses, actual final design analyses are presented and discussed separately in Section 4.

2.2 Freeboard Components and Camber

Freeboard is additional embankment height that is provided above a water surface level to assure that failure of the dam will not result from overtopping due to factors that may permanently or temporarily increase the water surface elevation in the reservoir. Freeboard also provides a safety factor to account for uncertainties in analytical procedures and the function of the facility in critical situations.

The DCM-2 presents conflicting information on what comprises freeboard mainly with regard to the issue of settlement and camber. However, the Bureau of Reclamation defines *freeboard* and *camber* as they relate to dams, levees and/or embankments as:

> ***Freeboard.*** *The difference in elevation between the maximum water surface in the reservoir and the dam crest. The vertical distance between a stated water level and the top of a dam, without camber. Thus "net freeboard," "dry freeboard," or "flood freeboard" is the vertical distance between the maximum water surface and the top of the dam. "Gross freeboard" or "total freeboard" is the vertical distance between the normal water surface and the top of the dam. That part of the "gross freeboard"*

attributable to the depth of flood surcharge is sometimes referred to as the "wet freeboard," but this term is not recommended as it is preferable that freeboard be stated with reference to the top of dam.

Camber. *The extra height added to the crest of embankment dams to ensure that the freeboard will not be diminished by foundation settlement or embankment consolidation. The amount of camber is different for each dam and is dependent on the amount of foundation settlement and embankment expected to occur.*

[U.S.B.R., http://www.usbr.gov/library/glossary]

Figure 3 (Figure DCM 2-1, DCM-2) is consistent with the above definition of camber and identifies the camber provided for settlement as component of embankment height separate from freeboard. Contrary to Figure 3, however, the DCM-2 example calculations and text include settlement as a component of freeboard.

For clarity and for purposes of this project, the definition and components that comprise freeboard will be consistent with the USBR definition. Design freeboard will be defined as the vertical distance between the normal full storage level (NFSL) and the top of the dam (excluding camber). Required freeboard will be comprised of the surcharge pool depth (resulting from the routing of the inflow design flood, IDF), wind setup, wave height/wave runup, wave height induced by potential landslides, and provisions for the malfunction of spillway and/or outlet works. Camber provided above freeboard to account for settlement will be considered separate from freeboard but will be included in the determination of the internal and external reservoir embankment heights.

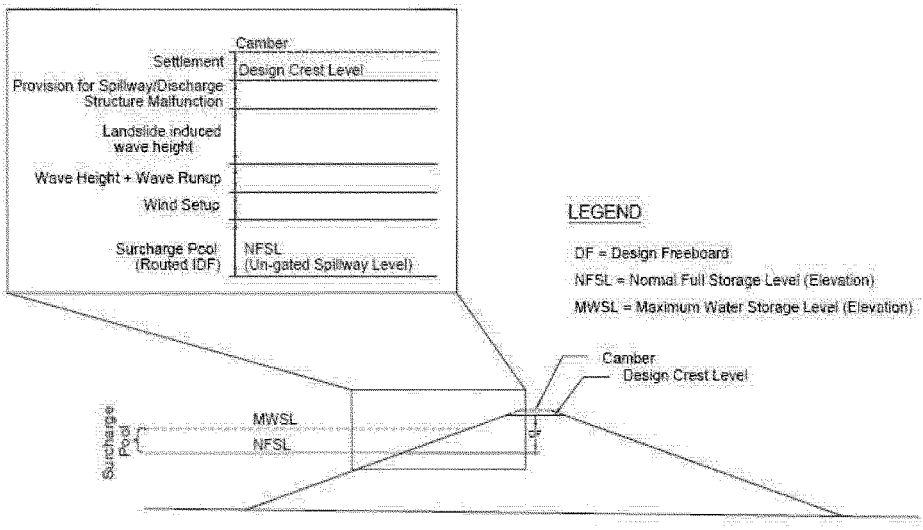


Figure 3: Design Freeboard Components [Figure DCM 2-1, DCM-2]

2.2.1 Provisions for the Malfunction of the Spillway and/or Outlet Works

Additional freeboard may be required based upon the potential for malfunctioning of the reservoir outlet facilities. While no provision for additional freeboard is directly made for this component, it is indirectly provided in the determination of the flood pool surcharge. When routing storm events through the reservoir, it is conservatively assumed that all mechanically operated outlet structures are closed for the duration of the storm event thereby increasing the maximum estimated reservoir surcharge.

2.2.2 Landslide Induced Wave Height

Landslide induced wave height arises from a sudden mass displacement of water resulting from a landslide. The C-43 reservoir is an above ground impoundment. Any significant landslide could only result from a catastrophic failure of the dam embankment which would result in the release of water from the reservoir. Consequently, it is assumed that there is no potential for landslides and no provision for additional freeboard is made for this component.

2.2.3 Wind Setup

Wind setup is the vertical distance above a stillwater level (normal full storage level) that is the result of the horizontal stress exerted by wind blowing over a water surface. In a confined body of water, the effect results in an increase in the water level at the leeward end and a lowering of the water level at the windward end. The effect of wind setup is included in the C-43 design freeboard. The design criteria and guidelines for the determination of wind setup are presented in the DCM-2. Calculations consistent with the DCM-2 design criteria and guidelines for wind setup are presented in this report.

2.2.4 Wave Height and Wave Runup

Wave run-up is the maximum vertical extent of wave up-rush on a beach or structure above the stillwater level (normal full storage level). Wave runup is a primarily a function of wave height, wave period, wave length, embankment slope and embankment surface roughness. The effect of both wave height and wave runup is included in the C-43 design freeboard. The design criteria and guidelines for the determination of wave height and wave runup are outlined in DCM-2. Calculations consistent with the DCM-2 for wave height and wave run up are presented in this report.

2.2.5 Surcharge Pool Depth

The surcharge pool depth results from the routing of an inflow design flood (IDF) hydrograph through the reservoir. Surcharge is an increase in water surface elevation above the normal full storage level resulting from the volume of inflow exceeding the volume of outflow from the reservoir. This increase in depth is included as a component of the C-43 design freeboard and depends upon the routed IDF. DCM-2 identifies several different IDFs that must be considered in conjunction with the analysis for wind

setup and wave height/wave runup. The analyses to route IDFs through the flood pool for the determination of surcharge pool depth are presented in the Appendix A.

2.2.6 Camber and Embankment Settlement

The potential for short and/or long term settlement of the dam is addressed for by providing camber or additional embankment height to account for settlement of the external and internal embankments. A settlement analysis for the reservoir site was conducted separate from this report as part of the C-43 West Storage Reservoir Basis of Design Report (BODR). A table of estimated settlement for the reservoir embankments from the BODR analyses is provided in Section 3.1.1.

2.3 Design Freeboard Criteria

Design freeboard requirements for wind setup, wave height/runup and flood surcharge are calculated based upon guidelines and criteria presented in the DCM-2. The manual requires that freeboard be assessed under the following four wind speed and inflow design flood/precipitation/reservoir level cases:

Case 1: 100-Yr wind combined with the Probable Maximum Precipitation

Case 2: Category 5 winds combined with the 100-Yr Precipitation

Case 3: Probable Maximum Wind (PMW) combined with the Normal Full Storage Level

Case 4: A storm specific wind and precipitation (Hurricane Easy in 1950)

2.4 Preliminary Design Freeboard Approach and Methodology

The general design methodologies in this section are summarized from the DCM-2 and are the basis of preliminary design freeboard calculations and alternative assessment analyses. Freeboard analyses provided in the Appendices B, C and D provide detailed step-by-step manual calculations, additional background information and references.

With the exception of the calculation of design wind speed, freeboard calculations for all four design cases follow the same methodology and approach. For the design wind speed calculations, the approach differs only slightly in the first few calculations due to the nature of initial wind speed data. Differences in recurrence interval, wind duration, and whether data is provided over water or over land determine whether certain adjustment factors are required to determine the design wind speed.

2.4.1 Design Wind Speed

The over water wind speed influences the calculation of both wind setup and wave properties. The design wind speed calculations and adjustments will vary slightly depending upon each case scenario but generally the purpose is to determine the maximum over water wind speed for the design recurrence interval and compute the wind stress factor.

2.4.1.1 Design Wind Speed Data Conversion

For Case 1, the 100-year wind speed data is derived from 50-year to 100-year, 3-second gust wind speeds (Figure 4). Data from this figure is conservatively assumed to be the 50-year gust wind speed and therefore must be converted to a 100-year wind by multiplying the 50-year wind by a factor of 1.07 (Table DCM 2-2, DCM-2).

For Case 4, the Hurricane Easy 125 mph wind speed was recorded as a maximum 3-second gust wind and is a storm specific case. Therefore, the conversion factor adjusted by return period is not relevant for this case.

For Cases 2-3, the available wind speed data is the design wind speed data and requires no data conversion.

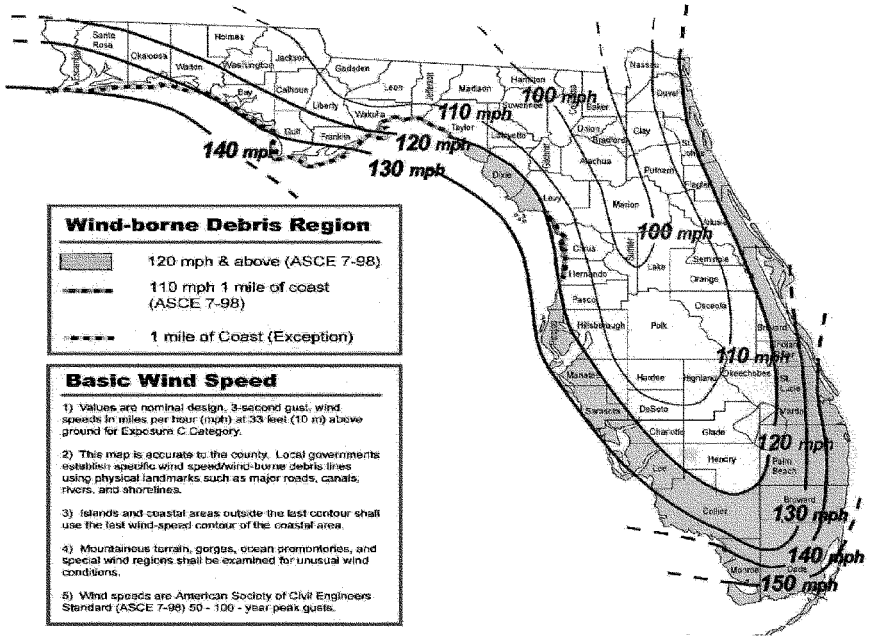


Figure 4: 50-Yr to 100-Yr, 3-Second Gust Wind Speed [Figure DCM 2-2, DCM-2]

2.4.1.2 Wind Speed Duration Adjustments

For design calculations, it is necessary to adjust and relate wind speeds to a standard average wind speed of one-hour in duration. The ratio of wind speeds of various durations to the one-hour average wind speed is approximated using the following equations:

$$For\ t \le 3{,}600: \qquad U_t / U_{3600} = 1.277 + 0.296 \tanh\left(0.9 \log_{10}\left(\frac{45}{t}\right)\right)$$

$$For\ 3{,}600 \le t \le 36{,}000: \quad U_t / U_{3600} = -0.15 \log_{10}(t) + 1.5334$$

Where:

t = duration time (seconds)
U_t = wind speed (mph) at time t (seconds)
U_{3600} = 1-hour average wind speed (mph)

[Equations 1 & 2, DCM-2, 2006]

With the exception of Case 2, all initial wind speed data for the design cases are converted to one-hour wind speed durations using the above equations. For Case 2, the Category 5, one-hour adjusted wind speed of 125 mph is provided by Table DCM 2-3 making an adjustment calculation unnecessary (Category 5 reference wind speed is 156 mph for a duration of 60 seconds).

The above equations are also used to adjust one hour wind speeds to wind speeds for a fetch limited duration time (Section 2.4.1.5).

2.4.1.3 Over Water Wind Speed Adjustment

When wind data is obtained overland, it is necessary to adjust the data to an over water wind speed. For fetch lengths less than 10 miles, the ratio of over water wind speed to overland wind speed is 1.2 (Figure II-2-20, CEM, 2003). When wind data is obtained over water, no adjustment is required.

For Cases 1 and 4, the initial wind speed data is for over land and an over water wind speed adjustment of 1.2 is required.

For Cases 2 and 3, the initial wind speed data is for over water and no adjustment is required (a factor of 1.0 is used) (DCM-2, 2006).

2.4.1.4 Fetch Limited Duration

For a given wind speed and fetch length, there is an associated wind duration that, if exceeded, will not increase the wave size because of the limiting effect of the fetch and

depth (DCM-2, 2006). This "fetch limited" duration is the duration required to develop the full wave height and can be estimated by the following equation:

$$t_{x,u} = 112\frac{X^{0.67}}{u^{0.34}} \qquad \textit{[Equation 4, DCM-2, 2006]}$$

Where:

t = wind duration time (minutes)
X = fetch length (miles)
u = wind velocity (mph)

2.4.1.5 Wind Speed Fetch Limited Duration Adjustment

As just previously mentioned, development of the full wave height for a given wind speed and fetch length is achieved at the fetch limited duration time (Section 2.4.1.4). Design wind speeds are therefore adjusted from a one-hour duration to an equivalent wind speed of fetch limited duration using the equations in Section 2.4.1.2.

2.4.1.6 Wind Speed Stability Correction

Under some conditions, it is necessary to adjust wind speed for stability of the boundary layer (between water and air) due to air-water temperature differences. This correction, however, is not necessary if the fetch is less than 10 miles in length. Estimated fetch length for both cells of the C-43 reservoir are less than 10 miles subsequently a stability factor of 1.0 (no correction) is applied (CEM, 2003).

2.4.1.7 Wind Stress Factor

Wave growth formulas and nomographs are expressed in terms of wind stress factor (USACE, SPM Vol. I, 1984). After all the appropriate wind speed adjustments and conversion are made, the wind speed may be converted to a wind stress factor by the following equation:

$$U_A = 0.589U^{1.23} \qquad \textit{[Equation 4, SPM Vol. I, 1984]}$$

Where:

U_A = wind stress factor (mph)
U = wind speed (mph)

2.4.2 Wind Setup

The DCM-2 identifies for different equations to consider when estimating wind setup: the Zeider Zee Equation, the Sibul Equation, the Bretschneider Equation, and an average of the Zeider Zee and Sibul Equations. However, the DCM-2 guidelines indicate that for impoundments greater than 16 feet in depth, the Zeider Zee is recommended.

The Zeider Zee equation is expressed as:

$$S = \frac{U^2 F}{1400 d} \qquad \textit{[Equation 5, DCM-2, 2006]}$$

Where:

S = wind setup (feet) above the stillwater level
U = wind speed (mph)
F = fetch length (miles)
d = average depth of water (to include surcharge depth) taken generally along fetch line (ft)

2.4.3 Wave Height

The determination of wave height involves an assessment of wave properties to determine the wave classification and the conditions that control wave height. The assessment involves determining the deep water wave properties, wave classification, calculation of shallow water wave properties (if necessary), the assessment of controlling significant wave height based upon the depth limited wave breaking height and finally the computation of an equivalent deep water wave height.

As previously mentioned, wave height calculations are the same for all design cases required by the DCM-2.

2.4.3.1 Deep Water Wave Calculations

The determination of the deep water wave properties within the impoundment is the first step in the determination of wave height. The deep water wave equations are:

$H_{mo} = 0.000282 U_A F^{1/2}$ *[Eqn. 3-33c, SPM Vol. I]*
$T_o = 0.02825 (U_A F)^{1/3}$ *[Eqn. 3-34c, SPM Vol. I]*
$L_o = 5.12 T_o^2$ *[Eqn. 2-8b, SPM Vol. I]*

Where:

H_{mo} = deep water significant wave height (feet)
T_o = deep water wave period (seconds)
L_o = deep water wave length (feet)
U_A = wind stress factor (mph)
F = fetch length (in feet)

2.4.3.2 Effective Depth

For purposes of this project, the effective depth is defined as the normal full storage level (NFSL) depth plus the surcharge depth resulting from the routing of a design storm event through the reservoir. Section 2.5.3 discusses in more detail the determination of effective depth as part of this project.

2.4.3.3 Wave Classification

Waves are classified by the water depth at which they travel. Wave classification is based upon the ratio of the effective depth to the deep water wave length (d/L_o). If $d/L_o > 0.5$, the waves are classified as deep water. If $d/L_o \leq 0.5$, the waves are classified as shallow water or transitional and shallow wave properties need to be computed.

For the C-43 West Storage Reservoir, waves are considered shallow water/transitional.

2.4.3.4 Shallow Water Wave Calculations

The shallow water equation for wave period is:

$$T = 7.54 \tanh\left(0.833\left(\frac{gd}{U_A^{\,2}}\right)^{\frac{3}{8}}\right) \tanh\left(\frac{0.0379\left(\frac{gF}{U_A^{\,2}}\right)^{\frac{1}{3}}}{\tanh\left(0.833\left(\frac{gd}{U_A^{\,2}}\right)^{\frac{3}{8}}\right)}\right) \frac{U_A}{g}$$

Where:

T = shallow water wave period (seconds)
g = 32.2 ft/s^2
d = effective depth (feet)
U_A = wind stress factor (ft/s)
F = fetch length (feet)

[Eqn. 3-40, SPM Vol. I]

The shallow water equation for significant wave height is:

$$H = 0.283 \tanh\left(0530\left(\frac{gd}{U_A^{\,2}}\right)^{\frac{3}{4}}\right) \tanh\left(\frac{0.00565\left(\frac{gF}{U_A^{\,2}}\right)^{\frac{1}{2}}}{\tanh\left(0.530\left(\frac{gd}{U_A^{\,2}}\right)^{\frac{3}{4}}\right)}\right) \frac{U_A^{\,2}}{g}$$

Where:

H = shallow water significant wave height (feet)
g = 32.2 ft/s^2
d = effective depth (feet)
U_A = wind stress factor (ft/s)
F = fetch length (feet)

[Eqn. 3-39, SPM Vol. I]

2.4.3.5 Significant Wave Height

The value of the significant wave height depends upon the wave classification. Since the C-43 West Storage Reservoir waves are classified as shallow water/transitional waves, the significant wave height is equivalent to the calculated shallow water wave height.

2.4.3.6 Zero Overwash Wave Height

The DCM-2 establishes the freeboard height that results in zero overwash as the design criteria for high and significant hazard dams. However, for purposes of preliminary case analyses of alternative embankment designs, the "zero overwash wave height" is assumed to be comparable to a wave height with a 2% frequency of occurrence. The computation of this preliminary "zero overwash wave height" is given by the following equations:

$$\overline{H} = H_{rms}\left(-Ln\left(\frac{n}{N}\right)\right)^{\frac{1}{2}} \qquad \textit{[Eqn. 3-7, SPM Vol. I]}$$

Where:

$\overline{H}$ = zero overwash wave height (feet)

n/N = 0.02, the probability of being overtopped

$H_{rms} = \frac{H_s}{\sqrt{2}}$ = the root mean square wave height *[Eqn. 3-10, SPM Vol. I]*

H_s = significant wave height (feet)

For final design, an "overtopping rate" will be estimated using STWAVE/ACES. Geotechnical documentation assuring embankment integrity and agency approval will also be provided for any overtopping rate exceeding zero.

2.4.3.7 Wave Breaking Height

Theoretically, the maximum wave height cannot exceed 0.78 D, where D is the depth of water without wave action (EM-1110-2-1420, 1997). At this height, the wave breaks and then reforms at a lower height within a few wave lengths. The calculated zero overwash wave height is compared to the calculated wave breaking height to confirm it does not exceed the theoretical maximum sustainable wave height.

For the C-43 West Storage Reservoir, the calculated zero overwash wave height for both cells is less than the wave breaking height in all cases. Therefore, the maximum wave height is not limited by wave breaking and the calculated zero overwash wave height is used for wave runup analyses.

2.4.3.8 Equivalent Deep Water Wave Height, H'_o

Curves used to estimate wave runup were developed in reference to deep water equivalent wave height. Since waves within the C-43 West Basin Storage Reservoir are classified as shallow water/transitional waves, to estimate wave runup, it is necessary to compute an equivalent deep water wave height (H'_o). Table C-1 of the Shore Protection Manual Volume II, provides an estimate of the ratio of shallow wave height to equivalent deep water wave height (H/H'_o) based upon the ratio of effective depth to the deep water wave length (d/L_o). The equivalent deep water wave height (H'_o)is calculated by dividing the shallow water wave height (H) by the ratio obtained from Table C-1 (H/H'_o).

2.4.4 Wave Runup

The approach for determining wave runup is the same for all design case scenarios. Wave runup varies based upon the wave height, slope and roughness of the runup surface, and the incident angle of the wind to the slope surface. The approximation of wave runup is based upon design curves of empirical data from numerous small scale laboratory tests of the runup of regular (monochromatic) waves on smooth impermeable slopes (SPM Vol. II, 1984). For practical application, the results need to be corrected for scale effects and slope surface roughness. A correction is also necessary for waves impacting the slope surface at an angle other than normal to the embankment axis.

2.4.4.1 Smooth Surface Wave Runup

Figures 7-8 to 7-12 in the *Shore Protection Manual, Vol. II*, are based upon small scale laboratory tests on runup of regular waves on smooth impermeable slopes. The figures provide an estimate for the relative runup (ratio of wave runup to equivalent deepwater wave height (R/H'_o) as a function of structure slope ($\cot\theta$) and deepwater wave steepness (H'_o/gT^2) for a specified ratio of water depth to equivalent deepwater wave height (d_s/H'_o). Multiplying the relative runup by the equivalent deep water wave height yields the smooth surface wave runup.

For the C-43 West Basin Storage Reservoir, the deepwater wave steepness (H'_o/gT^2) for various cases analyses varies from 0.014 to 0.017. These values all exceed the largest value of 0.0124 observed in all the test data. For purposes of the preliminary design calculations, it was decided to perform a regression analysis to better estimate wave runup curve ratios. Given the approximate nature of regression analyses, it was assumed that a regression analysis performed on a single H'_o/gT^2 value would provide a suitable approximation. Consequently, a single value of $H'_o/gT^2 = 0.016$ was selected and assumed to provide a reasonable for the entire range of values.

For the regression analyses, data was obtained from each figure. For each figure, the ratio of R/H'_o was estimated for every H'_o/gT^2 value given a constant value for $\cot\theta = 3$ (the typical embankment slope of 3H:1V). The R/H'_o and H'_o/gT^2 data was then plotted and regression curves fitted to the data using derived logarithmic, exponential and power equations. A curve of the average of the three regression methods was also

developed from the data. The average appeared to best fit the data and therefore was used to estimate R/H'_o values for $H'_o/gT^2 = 0.016$ for each figure. The curves for each figure are shown in Figures 5, 6 and 7. Supporting documentation, calculations and more detailed figures of the regression curves are provided in the Appendix E.

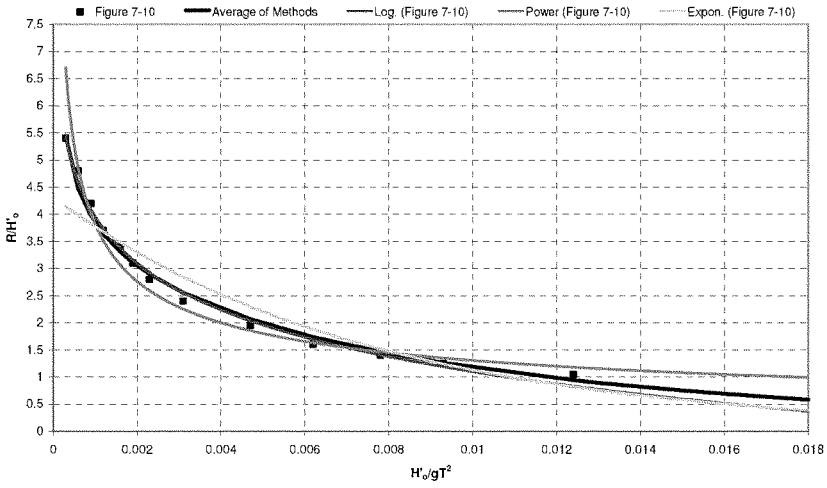


Figure 5: Regression Curves for Figure 7-10 (d_s/H'_o~0.8) [SMP Vol. II]

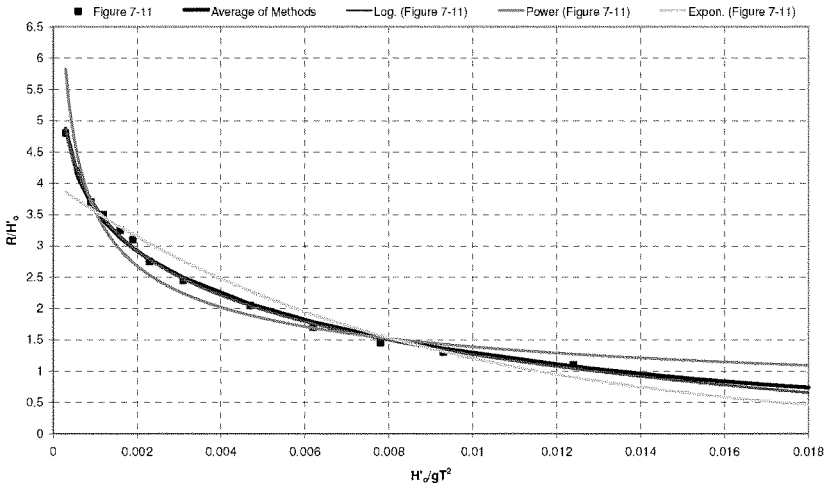


Figure 6: Regression Curves for Figure 7-11(d_s/H'_o~2.0) [SMP Vol. II]

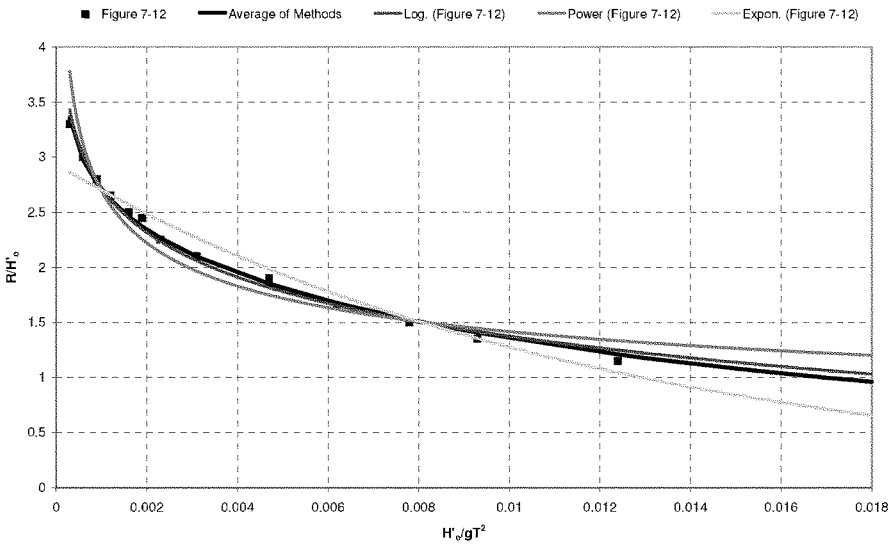


Figure 7: Regression Curves for Figure 7-12 ($d_s/H'_o \geq 3.0$) [SMP Vol. II]

In addition to the regression of curve data, the values for the ratio of d_s/H'_o for wave runup calculations generally fall between the d_s/H'_o values for which each curve was developed requiring an interpolation of results between figures in order to determine the relative runup (see detailed calculations in Appendix E).

2.4.4.2 Correction Factor due to Scale Effects

A correction is applied to the estimated smooth surface wave runup to account for the inability of small scale laboratory tests to model surface roughness effects. Consequently, it is expected that results based upon small scale lab tests will be smaller than prototype results or in natural conditions (SPM Vol. II). Figure 8 (Figure 7-13, SPM Vol. II, 1984) provides an estimate for the correction factor as a function of surface slope.

Given that the surface slope for the reservoir is consistently 3:1 (H:V), the wave runup scale correction factor for all C-43 West Storage Reservoir calculations is approximately 1.12.

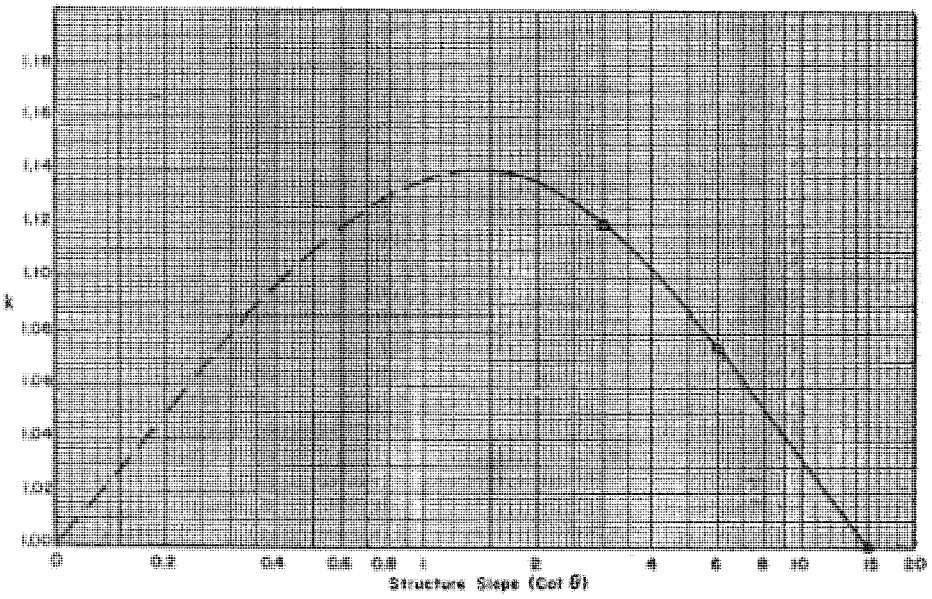


Figure 8: Correction Factor Due to Scale Effects [Figure 7-13, SPM Vol. II].

2.4.4.3 Correction Factor Due to Dam Surface Roughness

For practical application, the wave runup value derived from small scale laboratory tests on smooth surface slopes should be corrected to account for roughness of the runup surface. If there is more than one surface roughness on the slope length subjected to runup, it is recommended the surface roughness correction factor be adjusted or weighted based upon the fraction of the length of each surface roughness (subjected to runup) to the total slope length subjected to wave runup (SPM, Vol. II, 1984). The calculated smooth surface wave runup is multiplied by the adjusted surface roughness correction factor to determine an adjusted wave runup height.

The proposed dam embankments consist of 3:1 (H:V) soil cement slopes with a 3:1 stepped soil cement embankment (1' vertical steps) above the normal full storage level. For stepped embankments, a surface roughness coefficient of 0.7 is applied (Table 2-2, EM 1110-2-1614). Since the entire wave runup surface will consist of a stepped soil embankment, no subsequent weighted adjustment of the correction factor for different roughness surfaces is required.

2.4.4.4 Correction Factor due to Fetch Angle

Wave runup is most severe when a wave strikes perpendicular to the runup surface. The fetch angle is used to adjust wave height and runup for a less severe approach.

The correction factor can be estimated based upon the estimated fetch angle and from Figure 9 (Figure 8, ACER Tech Memo No. 2, USBR, 1992).

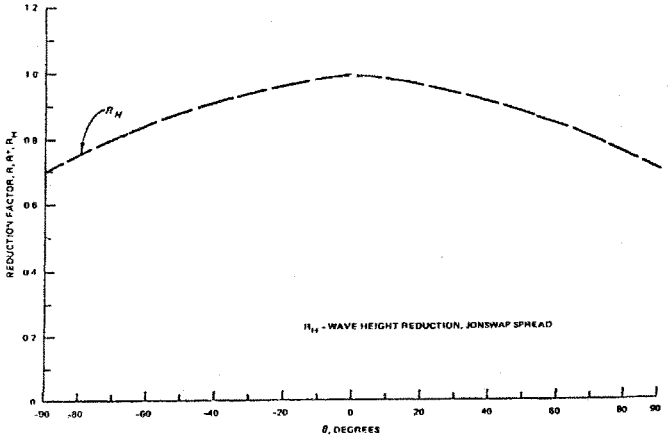


Figure 9: Correction Factor Due to Fetch Angle [Figure 8, ACER No. 2]

2.5 Freeboard Parameters

2.5.1 Normal Full Storage Level

Cell 1 and Cell 2 of the C-43 West Basin Storage Reservoir will be connected by a reinforced concrete box culvert (RCBC) through an internal embankment. The culvert will allow for the free flow of water between the two cells in order to maintain an equilibrium water surface elevation. The normal full storage level for the C-43 West Storage Reservoir is set at an elevation of 42.0 feet.

2.5.2 Fetch

The characteristics of wind-generated waves and setup are influenced by the distance that wind moves over the water surface in the "fetch" direction. Fetch is the straight line distance across a body of water subject to wind forces and is a major factor used in calculating wave heights. It is assumed that along the fetch, waves are generated by a wind having a constant wind direction and speed. Both the fetch length and the fetch angle factor into wave generation.

For both Cell 1 and Cell 2 of the C-43 West Basin Storage Reservoir, two fetches are evaluated. Table 1 provides summary information of each cell fetch evaluated. Supporting documentation of fetch lengths, angles and average depth (a component of effective depth, see Section 2.5.3) are provided in Appendix B.

Table 1: Fetch Parameters

Cell	Fetch	Fetch Length (miles)	Fetch Angle	Average Depth[1] (ft)
Cell 1	1A	3.51	0°	20.4
	1B	3.04	7°	20.2
Cell 2	2A	3.40	42°	17.5
	2B	3.62	45°	17.1

1. Based upon an Normal Full Storage Level (NFSL) elevation of 42.0 feet.

2.5.2.1 Fetch Length

The fetch length in a confined body of water is generally the longest average linear path across the water surface from one side of an impoundment to the other. The fetch lengths for the C-43 West Basin Storage Reservoir were calculated based upon guidelines published by the U.S. Bureau of Reclamation (USBR, 1992). The recommended procedure consists of drawing a center radial from one side of the impoundment to the other then drawing four radials on each side of the center radial spaced at an interval of 3° (Figure 10). The fetch length is then estimated as the average of the nine of the radial path lengths. This process is performed several times to determine the 24° spread that results in the longest set of radials and thereby longest fetch length.

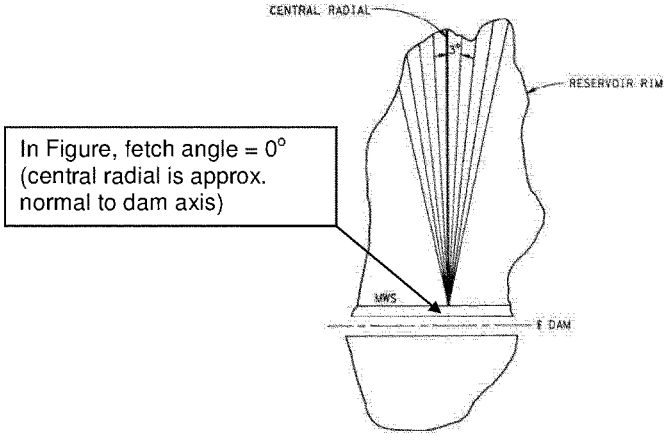


Figure 10: Calculating Fetch Length

2.5.2.2 Fetch Angle

The incident angle between the fetch (taken to be the center radial of the fetch length calculations) and a line normal to the axis of the embankment is the fetch angle. Wave runup is most severe when a wave strikes the embankment perpendicular to the

embankment. The fetch angle is used to adjust wave height and runup for a less severe approach.

2.5.3 Effective Depth

The effective depth of water along the fetch also influences the estimated wave height/wave runup. The effective depth is estimated to be the average normal full storage level (NFSL) depth along the center radial used to estimate fetch length (see Table 1), plus the surcharge depth associated with the routing of the design storm event through the reservoir. Since inflow to the reservoir is limited to forced pumping and precipitation falling directly on the reservoir itself, the maximum surcharge depth that can be realized is equal to the total depth of rainfall falling on the impoundment during the design event (it is assumed that during the threat of an extreme storm event, pumping into the basin will be ceased). However, routing the design storm event through the reservoir provides a more realistic estimate of actual surcharge depth and helps reduce required freeboard.

For Case 1 and Case 2, the hydrologic scenarios presented in the DCM-2 are routed PMP through the reservoir cells to estimate flood surcharge. Case 3 is not associated with any precipitation event and therefore no surcharge is realized. As subsequently discussed in Section 3.1.6.4., for Case 4, the maximum flood surcharge is conservatively assumed to be (at most) equal to the routing of the PMP as in Case 1. Table 2 provides the effective depths used for the wind setup and wave runup analyses for the freeboard case scenarios.

Table 2: Effective Depths for Cell Analyses

Cell - Fetch	Average NFSL Depth[1] (ft)	Surcharge Depth (ft)				Effective Depth (ft)			
		Case 1: PMP[2]	Case 2: 100-Yr[3]	Case 3: PMW[3]	Case 4: EASY[4]	Case 1: PMP	Case 2: 100-Yr	Case 3: PMW	Case 4: EASY
Cell 1 - 1A	20.36	4.13	0.77	0.0	3.77	24.49	21.13	20.36	24.13
Cell 1 - 1B	20.22	4.13	0.77	0.0	3.77	24.35	20.99	20.22	23.99
Cell 2 - 2A	17.51	4.13	0.77	0.0	3.77	21.64	18.28	17.51	21.28
Cell 2 - 2B	17.06	4.13	0.77	0.0	3.77	21.19	17.83	17.06	20.83

Note:
1. Based upon NFSL elevation = 42.0 & estimated average bottom elevation along fetch center radial (see Appendix B)
2. Based upon routing of design storm event (see calculations)
3. Based upon maximum precipitation or routing of design storm event (see calculations)
4. Based upon maximum possible surcharge for PMP (see discussion in Section 3.1.6.4)

2.5.4 Dam Embankments

The slope and roughness of the dam embankment has a significant influence on wave runup. The proposed dam embankments consist of 3:1 (H:V) soil cement slopes with a stepped soil cement embankment (1' vertical steps) above the normal full storage level.

3 PRELIMINARY DESIGN FREEBOARD ANALYSES

3.1 Determination of Design Freeboard Components and Camber

The freeboard components of surcharge depth, wind setup and wave height/wave runup all vary between different fetch and/or case analyses. Camber provided above freeboard to account for embankment settlement varies based upon the total estimated embankment height.

3.1.1 Camber and Embankment Settlement

The estimated amount of embankment settlement varies depending upon the proposed embankment location and height. A settlement analysis conducted as part of the C-43 West Storage Reservoir BODR estimates embankment settlement in various zones around the reservoir perimeter and for a range of embankment heights. Settlement zones are shown in Figure 11. To approximate embankment settlement around the perimeter of Cell 1, settlement data for Zones A, C and D are averaged. For Cell 2, settlement data for Zones A, C and E are averaged. Results from the settlement analyses are provided in Table 3.

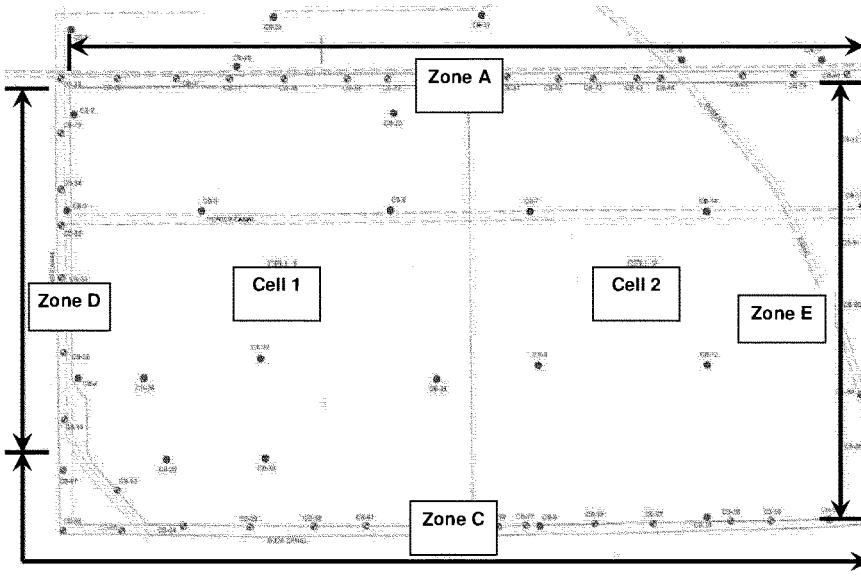


Figure 11: Settlement Zones [Figure 8A-3, C-43 BODR]

Table 3: Embankment Settlement Data

Embankment Height (ft)	Settlement (inches)					
	Section A	Section C	Section D	Section E	Average Cell 1[1]	Average Cell 2[2]
25	4.26	4.15	4.68	3.50	4.4	4.0
26	4.75	5.20	4.89	4.21	4.9	4.7
27	5.65	6.32	5.46	5.33	5.8	5.8
28	6.90	7.42	6.43	6.60	6.9	7.0
29	8.17	7.72	7.84	8.17	7.9	8.0
30	9.41	8.99	9.05	9.41	9.2	9.3
31	10.61	10.23	10.22	10.61	10.4	10.5
32	11.78	11.43	11.37	11.78	11.5	11.7
33	12.93	12.60	12.49	12.93	12.7	12.8
34	14.04	13.75	13.58	14.04	13.8	13.9
35	15.13	14.86	14.64	15.13	14.9	15.0
36	16.19	15.95	15.68	16.19	15.9	16.1
37	17.23	16.16	17.01	16.70	16.8	16.7
38	18.24	17.02	18.05	17.69	17.8	17.7
39	19.23	17.86	19.06	18.66	18.7	18.6
40	20.20	18.69	20.05	19.61	19.6	19.5
41	21.15	19.50	21.02	20.54	20.56	20.40
42	22.08	20.29	21.97	21.46	21.45	21.28
43	23.00	21.07	22.90	22.35	22.32	22.14
44	23.89	21.83	23.81	23.23	23.18	22.98

1. Average of Zones A, C and D
2. Average of Zones A, C and E

3.1.2 Provisions for the Malfunction of the Spillway and/or Outlet Works

No additional freeboard is directly provided for the potential malfunction of the C-43 spillway and/or outlet works. However, as previously mentioned in Section 2.2.1, this component is indirectly accounted for in the determination of the flood pool surcharge. When routing design storm events through the reservoir, it is conservatively assumed that all mechanically operated outlet structures are closed for the duration of the storm event thereby increasing the maximum estimated reservoir surcharge.

3.1.3 Landslide Induced Wave Height

It is assumed that the potential for catastrophic landslides is negligible and therefore no additional freeboard is provided for potential landslide induced wave height.

3.1.4 Wind Setup

Detailed calculations for the determination of wind setup for each fetch and case analysis are presented in the Appendix C of this memorandum.

3.1.5 Wave Height and Wave Runup

Detailed calculations for the determination of wave height and wave runup for each fetch and case analysis are presented in the Appendix C of this memorandum.

3.1.6 Surcharge Pool Depth

The routing of inflow design floods through the reservoir system based on the DCM-2 design criteria and guidelines is presented in the Appendix A.

3.1.6.1 Case 1: 100-Yr Wind + Probable Maximum Precipitation

For Case 1, the DCM-2 identifies two flood routing scenarios based upon the Probable Maximum Precipitation (PMP) that must each be assessed. Both scenarios include sequential storm events occurring over an extended period of time separated by brief dry periods. The PMP for the C-43 West Basin Storage Reservoir site is approximately 55.7 inches (Figure 11). Since the reservoir area is greater than 10 square miles, the PMP was adjusted to 54.95 inches for the 72-hr PMP for the two scenarios.

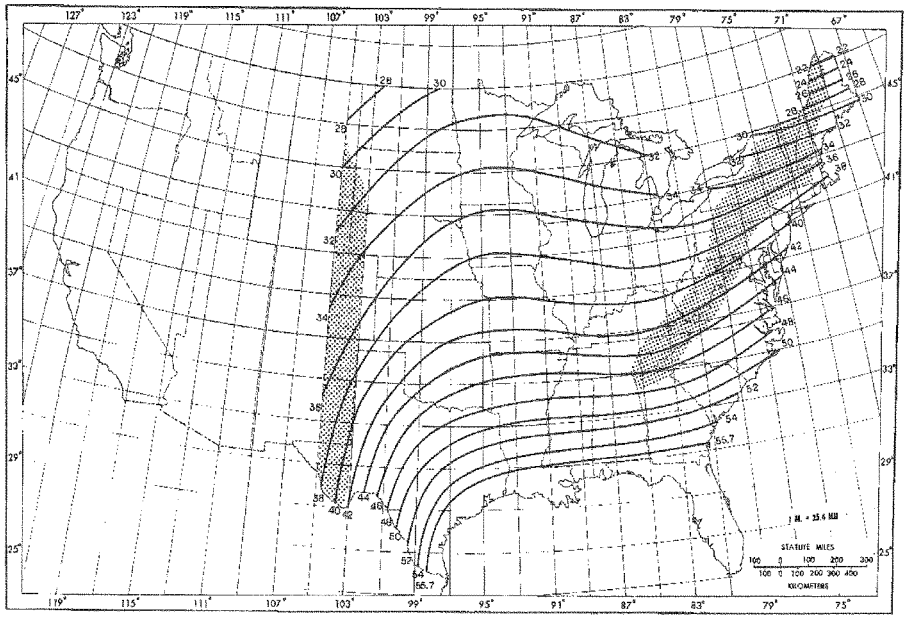


Figure 12: All Season PMP (72-hr, 10 sq. mi.) [Figure 22, HR 51, NOAA]

The preliminary hydrologic analyses to route both PMP scenarios through the reservoir are discussed in detail and documented in the Appendix A. The results of the analyses indicate that the maximum surcharge pool depth for Case 1 is approximately 4.13 for both Cell 1 and Cell 2.

3.1.6.2 Case 2: Category 5 Wind + 100-Yr Precipitation

For Case 2, the 100-year, 3-day precipitation is the design storm event (DCM-2, 2006). The 100-year, 3-day precipitation for the C-43 West Basin Storage reservoir site is approximately 13 inches (Figure 12). A preliminary hydrologic analysis routing of the 100-year event through the reservoir indicated that the maximum surcharge pool depth for Case 2 is approximately 0.77 for both Cell 1 and Cell 2.

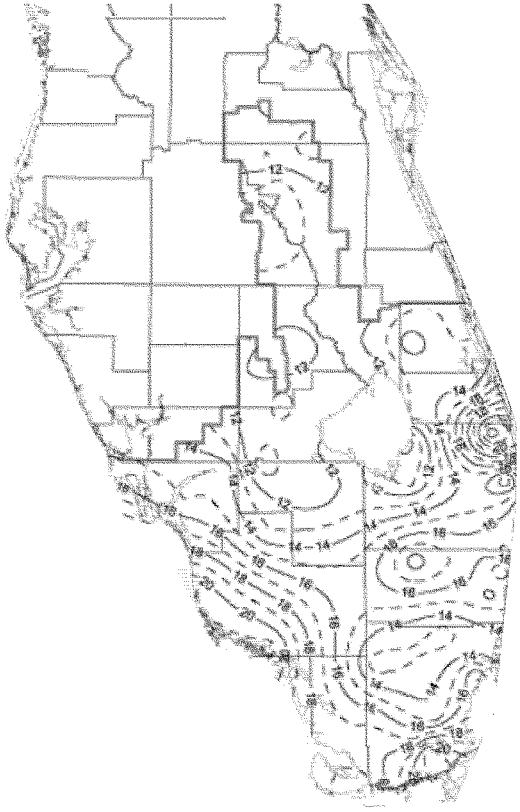


Figure 13: 100-Year, 3-Day Precipitation [Figure DCM 2-3, DCM-2]

3.1.6.3 Case 3: PMW + Normal Full Storage Level

There is no precipitation event associated with this case. Design freeboard is based solely upon the assessment of other freeboard components, therefore, there is no surcharge pool depth for Case 3 analyses.

3.1.6.4 Case 4: Hurricane Easy

For Case 4, the design storm event is based upon the recorded rainfall from Hurricane Easy in 1950. During this event, a peak 24-hr rainfall of 38.7 inches was recorded, with a 72-hr rainfall depth of 45.2 inches (3.77 ft) (DCM-2, 2006). Routing of this event was not warrant for this case. It was therefore conservatively assumed that the maximum surcharge would be equivalent to the cumulative rainfall for the 72-hr event. Therefore, a maximum surcharge depth of 45.2 inches is assumed for both cells.

3.2 Summary of Preliminary Design Freeboard with Camber Calculations

3.2.1 Cell 1

Two fetches were analyzed for Cell 1 (see Section 2.5.2). Fetch 1A represents the most severe freeboard conditions of Cell 1. Fetch 1B was considered the second most severe freeboard condition. Fetch 1B was analyzed to determine if there was a possibility to reduce embankment height (for reduced freeboard requirements) in less severe fetch conditions around the perimeter embankment of Cell 1.

3.2.1.1 Fetch 1A Analysis

The freeboard analysis for Fetch 1A results in the most conservative estimate of preliminary freeboard requirements in Cell 1.

Table 4: Cell 1 (Fetch 1A) Freeboard Analysis Summary

Freeboard Component	Case1 100-Yr Wind and PMP	Case 2 Category 5 and 100-Yr Precip.	Case 3 PMW and NFSL	Case 4 Hurricane Easy
Surcharge Depth	4.13	0.77	0.00	3.77
Wind Setup	1.03	1.86	3.21	1.03
Wave Height / Wave Runup	8.00	8.62	10.04	7.92
Landslide Induced Wave Height	0.00	0.00	0.00	0.00
Provisions for Malfunction of the Spillway and/or Outlet Works	0.00	0.00	0.00	0.00
Minimum Required Freeboard	**13.16**	**11.26**	**13.25**	**12.72**
Embankment Settlement	1.24	1.06	1.24	1.24
Minimum Required Freeboard plus Camber	**14.4**	**12.3**	**14.5**	**14.0**

3.2.1.2 Fetch 1B Analysis

Fetch 1B is a less severe condition than Fetch 1A and is used to assess the potential for reducing embankment heights around the southwest perimeter of Cell 1.

Table 5: Cell 1 (Fetch 1B) Freeboard Analysis Summary

Freeboard Component	Case1 100-Yr Wind and PMP	Case 2 Category 5 and 100-Yr Precip.	Case 3 PMW and NFSL	Case 4 Hurricane Easy
Surcharge Depth	4.13	0.77	0.00	3.77
Wind Setup	0.90	1.63	2.81	0.90
Wave Height / Wave Runup	7.15	7.61	8.91	7.07
Landslide Induced Wave Height	0.00	0.00	0.00	0.00
Provisions for Malfunction of the Spillway and/or Outlet Works	0.00	0.00	0.00	0.00
Minimum Required Freeboard	**12.18**	**10.01**	**11.72**	**11.74**
Embankment Settlement	1.15	0.96	1.06	1.15
Minimum Required Freeboard plus Camber	**13.3**	**11.0**	**12.8**	**12.9**

3.2.2 Cell 2

Two fetches were analyzed for Cell 2 of the C-43 Storage Reservoir (see Section 2.5.2).

3.2.2.1 Fetch 2A Analysis

The freeboard analysis for Fetch 2A provides a slightly lower and less conservative preliminary estimate of freeboard requirements than Fetch 2B in Cell 2.

Table 6: Cell 2 (Fetch 2A) Freeboard Analysis Summary

Freeboard Component	Case1 100-Yr Wind and PMP	Case 2 Category 5 and 100-Yr Precip.	Case 3 PMW and NFSL	Case 4 Hurricane Easy
Surcharge Depth	4.13	0.77	0.00	3.77
Wind Setup	1.12	2.09	3.61	1.13
Wave Height / Wave Runup	6.63	7.62	8.82	6.56
Landslide Induced Wave Height	0.00	0.00	0.00	0.00
Provisions for Malfunction of the Spillway and/or Outlet Works	0.00	0.00	0.00	0.00
Minimum Required Freeboard	**11.89**	**10.48**	**12.44**	**11.46**
Embankment Settlement	0.87	0.67	0.87	0.78
Minimum Required Freeboard plus Camber	**12.8**	**11.2**	**13.3**	**12.2**

3.2.2.2 Fetch 2B Analysis

The freeboard analysis for Fetch 2B provides a slightly higher and more conservative preliminary estimate of freeboard requirements than Fetch 2A in Cell 2.

Table 7: Cell 2 (Fetch 2B) Freeboard Analysis Summary

Freeboard Component	Case1 100-Yr Wind and PMP	Case 2 Category 5 and 100-Yr Precip.	Case 3 PMW and NFSL	Case 4 Hurricane Easy
Surcharge Depth	4.13	0.77	0.00	3.77
Wind Setup	1.22	2.27	3.94	1.23
Wave Height / Wave Runup	7.06	7.62	9.53	6.99
Landslide Induced Wave Height	0.00	0.00	0.00	0.00
Provisions for Malfunction of the Spillway and/or Outlet Works	0.00	0.00	0.00	0.00
Minimum Required Freeboard	**12.41**	**10.67**	**13.47**	**11.98**
Embankment Settlement	0.87	0.67	0.98	0.78
Minimum Required Freeboard plus Camber	**13.3**	**11.3**	**14.5**	**12.8**

3.2.3 Preliminary Embankment Freeboard Results and Recommendations

Per the DCM-2, Case 3 is used only for sensitivity analysis and should not be used as the design conditions (DCM-2, 2006). Excluding Case 3, Case 1 resulted in the largest preliminary estimate of freeboard requirements.

For Cell 1, the freeboard analysis for Fetch 1A is the most conservative estimate of freeboard requirements. The results of the Fetch 1B analysis indicated that the difference in freeboard requirements was not sufficient to merit a significant reduction in embankment heights (due to decreased freeboard requirements) in less severe fetch condition around the perimeter of Cell 1. Based upon the Cell 1 freeboard analysis for Case 1, the preliminary minimum required freeboard for Cell 1 external perimeter dam embankments is approximately 14.4 feet.

For Cell 2, Fetch 2B provides a slightly higher freeboard requirement (than Fetch 2A) and serves as the basis for preliminary freeboard requirements for Cell 2. Based upon the Cell 2 freeboard analysis, the preliminary minimum required freeboard for Cell 2 perimeter dam embankments is approximately set at 13.3 feet.

As previously noted, the preliminary calculations presented in this section and Section 2 were used during the preliminary design to estimate freeboard requirements. These manual calculations were updated during subsequent design phases as necessary to provide a check to the results of less transparent computer analyses required for final design. Final design analyses are discussed and presented in Section 4.

3.2.2.2 Fetch 2B Analysis

The freeboard analysis for Fetch 2B provides a slightly higher and more conservative preliminary estimate of freeboard requirements than Fetch 2A in Cell 2.

Table 7: Cell 2 (Fetch 2B) Freeboard Analysis Summary

Freeboard Component	Case1 100-Yr Wind and PMP	Case 2 Category 5 and 100-Yr Precip.	Case 3 PMW and NFSL	Case 4 Hurricane Easy
Surcharge Depth	4.13	0.77	0.00	3.77
Wind Setup	1.22	2.27	3.94	1.23
Wave Height / Wave Runup	7.06	7.62	9.53	6.99
Landslide Induced Wave Height	0.00	0.00	0.00	0.00
Provisions for Malfunction of the Spillway and/or Outlet Works	0.00	0.00	0.00	0.00
Minimum Required Freeboard	**12.41**	**10.67**	**13.47**	**11.98**
Embankment Settlement	0.87	0.67	0.98	0.78
Minimum Required Freeboard plus Camber	**13.3**	**11.3**	**14.5**	**12.8**

3.2.3 Preliminary Embankment Freeboard Results and Recommendations

Per the DCM-2, Case 3 is used only for sensitivity analysis and should not be used as the design conditions (DCM-2, 2006). Excluding Case 3, Case 1 resulted in the largest preliminary estimate of freeboard requirements.

For Cell 1, the freeboard analysis for Fetch 1A is the most conservative estimate of freeboard requirements. The results of the Fetch 1B analysis indicated that the difference in freeboard requirements was not sufficient to merit a significant reduction in embankment heights (due to decreased freeboard requirements) in less severe fetch condition around the perimeter of Cell 1. Based upon the Cell 1 freeboard analysis for Case 1, the preliminary minimum required freeboard for Cell 1 external perimeter dam embankments is approximately 14.4 feet.

For Cell 2, Fetch 2B provides a slightly higher freeboard requirement (than Fetch 2A) and serves as the basis for preliminary freeboard requirements for Cell 2. Based upon the Cell 2 freeboard analysis, the preliminary minimum required freeboard for Cell 2 perimeter dam embankments is approximately set at 13.3 feet.

As previously noted, the preliminary calculations presented in this section and Section 2 were used during the preliminary design to estimate freeboard requirements. These manual calculations were updated during subsequent design phases as necessary to provide a check to the results of less transparent computer analyses required for final design. Final design analyses are discussed and presented in Section 4.

4 FINAL DESIGN STWAVE/ACES FREEBOARD ANALYSES

4.1 Introduction

For final design, the DCM-2 and the U.S. Army Corp of Engineers (USACE) require that a final assessment of wave runup component of the freeboard requirements be based upon USACE Steady-State Spectral Wave Model (STWAVE) and the Automated Coastal Engineering System (ACES) computer model analyses. This section discusses the computer analyses and presents the analyses results and final design recommendations for required freeboard and reservoir embankment heights.

4.2 Design Freeboard and Overtopping Rate Criteria

Based upon the preliminary design and alternative evaluation, the Case 1: 100-year Wind combined with the Probably Maximum Precipitation freeboard criteria was shown to result in the most conservative freeboard requirements be the limiting case scenario (Case 3 is excluded and used only for sensitivity analyses per DCM-2) . For final design, the reservoir storage cells will be analyzed using only the Case 1 scenarios.

The final design criteria also has an additional embankment overtopping rate restriction which may dictate a higher embankment heights than necessary to simply meet the freeboard requirements as determined based on the previously discussed components of freeboard (wind setup, wave runup, flood surcharge, etc...). While embankment overtopping is an important consideration in determining the embankment height, the DCM-2 does not provide specific design criteria or guidelines for establishing the maximum allowable overtopping rate for reservoir embankments. This is possibly due to the fact that allowable overtopping rates can vary significantly based upon embankment design, embankment material and the possible presence of erosion resistant vegetative cover. It would seem that the most appropriate means of establishing an allowable embankment overtopping rate criteria would be based upon a geotechnical assessment of the embankment material and design and/or field testing.

4.2.1 Overtopping Rate Field Tests

To assist in establishing an allowable embankment overtopping rate necessary to determine minimum freeboard and embankment heights, field tests were conducted in the C-43 test cell site to evaluate the integrity of the proposed C-43 embankment designs under various overtopping conditions. The testing consisted of discharging water at a range of rates (0.01, 0.005 and 0.001 cfs/ft) down a vegetated and non-vegetated embankment slopes for a period of 8 hours. The vegetated condition consisted of a "natural" grass cover which was considered comparable to the vegetated condition around the Lake Okeechobee dam (see Figure 14) and would likely resemble the vegetated slopes of the C-43 embankments after 5-10 years of maintenance.



Figure 14: Grass Cover on Sections of Hoover Dike (Lake Okeechobee).

The test results revealed several findings (see Figure 15). At a rate of 0.01 cfs/ft, even a vegetated slope would experience sufficient erosion to compromise the integrity of the embankment (see Figure 16). However, at overtopping rates of 0.005 cfs/ft and 0.001 cfs/ft, the vegetated slope did not appear to experience any significant erosion that might threaten the integrity of the embankment. A bare, non-vegetated slope was tested at a rate of 0.005 cfs/ft and resulted in significant erosion and loss of embankment integrity.

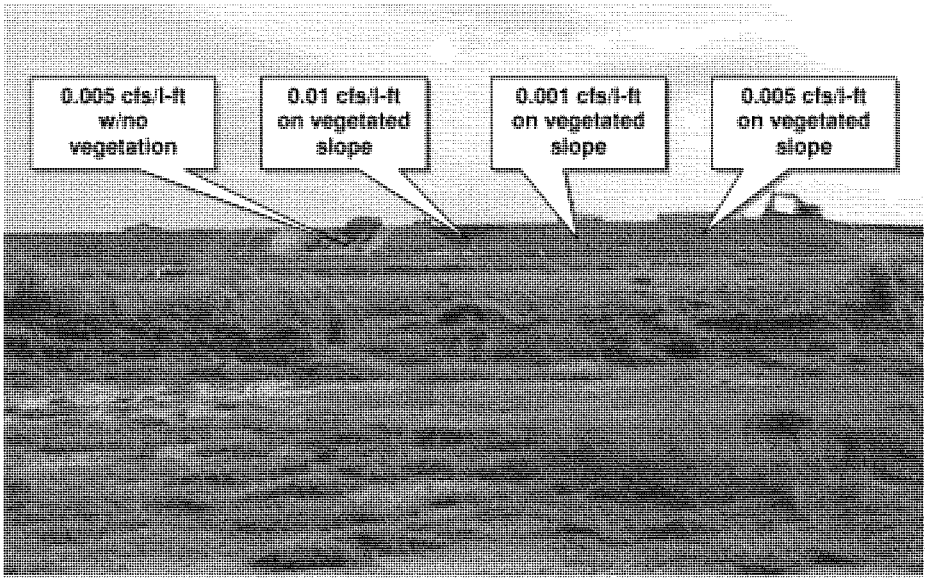


Figure 15: Overtopping Rate Field Tests.



Figure 16: Washout with Outwash Rate of 0.01 cfs/ft.

4.2.2 External Embankment Overtopping Rate Criterion

Based upon the results of the field tests, it was concluded that the embankment slopes necessarily needed to be vegetated and that after 5-10 years of continued maintenance, the C-43 embankment vegetation would be sufficiently established to provide long term erosion protection with minimal maintenance. With little difference between an overtopping rate of 0.001 cfs/ft and 0.005 cfs/ft under the vegetated conditions, it was concluded that a maximum overtopping rate of 0.005 cfs/ft would be acceptable provided that the embankment slope would be continuously maintained for several years or until the establishment of viable long-term embankment vegetation. While 0.005 cfs/ft is being considered as the embankment overtopping design criteria (see C-43 WSR Overwash Rate Memo, Appendix G), overtopping rates of 0.1, 0.01, and 0.001 cfs/ft were still assessed and the results presented in this report.

4.2.3 Internal Embankment Overtopping Rate Criterion

Unlike the external embankment, failure of the internal embankment between the two cells of the C-43 reservoir does not pose a direct threat to human life, critical facilities or economic or environmental concerns. In addition, the design of the internal embankment will include a hardened, erosion resistant soil cement layer to resist continual exposure to waves during periods of normal reservoir operation.

Tests on a soil cement embankment were not performed nor were they considered necessary. Soil cement is a durable material that is readily used for high channel velocity conditions (as much as 15 ft/s). Consequently, the internal embankment is expected to be able to withstand much higher overtopping rates (relative to external embankments) for an extended period of time with essentially no adverse effects.

Consideration of the allowable overtopping rate of the internal embankment was therefore based upon possible concerns by the SFWMD that excessive overtopping of the internal embankment, from one cell into the other, may result in additional excessive surcharge in one cell thereby possibly compromising the integrity of the external embankments.

Under that assumption, the impact of an overtopping rate of 1.0 cfs/ft was evaluated. It was estimated that if flow were to leave one cell for the other at a rate of 1.0 cfs/ft for a duration of 1 hour, and no flow left the cells by any other means, Cell 1 would either increase by 0.29 feet or Cell 2 could increase by 0.27 feet. Given the conservative approach taken in all aspects of the reservoir design including the coincidence of extreme weather and operational conditions and the amount of freeboard provided along the external embankments (~14 ft), it is not anticipated that such an increase in either cell would have any significant adverse impact that might compromise the integrity of the external embankments. Consequently, an overtopping rate of 1.0 cfs/ft was considered acceptable for the internal embankment.

4.3 Design Freeboard Approach and Methodology

Determination of the final design freeboard requirements differs from the preliminary design only in that computer models are used to determine the wave runup component of freeboard. Other freeboard components discussed previously in Section 2.2 are still applicable and use the same approaches and methodologies.

4.3.1 Computer Models

CEDAS Version 4.03 was used for the final design analyses. STWAVE and ACES have been integrated into a design and analysis system called the Coastal Engineering Design and Analysis System (CEDAS) developed by Veri-Tech. CEDAS is comprised of a comprehensive collection of coastal engineering and design software developed by and/or for the USACE and organized as modules into a single interactive Windows-based software system.

4.3.2 Steady State Spectral Wave (STWAVE) Model

STWAVE is a two dimensional finite-difference wave transformation computer model that quantifies the change in wave parameters such as height, period, direction and spectral shape, between offshore/deep water and nearshore/shallow water. For this project, STWAVE is used to determine significant wave heights and wave periods. This data is subsequently used to estimate wave runup and overtopping rates using ACES.

4.3.3 Automated Costal Engineering System (ACES) Model

ACES is an integrated collection coastal engineering design and analysis applications. Included in ACES is an application for the determination of Wave Runup and Overtopping on Impermeable Structures. This application estimates wave runup and overtopping rates on rough and smooth slope surfaces that are assumed to be impermeable.

To estimate the minimum freeboard requirements as presented in Sections 2 and 3, the ACES derived estimate of wave runup is included along with other freeboard components to establish minimum freeboard requirements.

To investigate embankment heights for a range of overtopping rates, significant wave heights and wave periods determined using STWAVE were used as input along with other physical embankment and reservoir data. Overtopping analyses based on the results of manual calculations were not performed during the preliminary design, however, ACES was used to estimate embankment heights for various overtopping rates based on the calculated significant wave heights and wave periods in this report.

4.4 STWAVE Analyses

STWAVE requires bathymetric, wind, and wave data in order to model wave characteristics. The required input and assumptions for the STWAVE analyses are briefly discussed below.

4.4.1 Bathymetry

4.4.1.1 Bathymetric Data

Bathymetric data was developed using point data site surveys and a digital terrain model (DTM) of the proposed grading of the C-43 West Basin Storage Reservoir. This point data was triangulated and converted into square grids composed of 10' x 10' elements.

4.4.1.2 Grid Orientation

During preliminary analyses using STWAVE, it was found that the grid orientation (direction of x-axis of bathymetry) in relation to the wind direction had an impact on the calculated results. Discussions with VeriTech indicated that even though wind direction for a specific grid orientation can vary +/- 90 degrees from the x-axis, analyses should be limited at most to +/-45 degrees from the x-axis. A sensitivity analysis conducted on wind angles indicated that wind blowing at a 45 degree angle (NW-SE) to the grid orientation (N-S) generally produced wave height results that were ~3-5% less than if both the wind and grid were oriented in the same direction. Though the critical fetches identified during preliminary design tend to be approximately +/-45 degrees from the developed grid orientation (N-S), given the theoretical nature of the analyses, it was assumed that the results would be within the range of acceptability.

To organize files and results, grid orientation and wind directions were labeled in a counterclockwise direction with north being considered zero degrees. (e.g. south would be 180 degrees, northeast would be 315 degrees)

4.4.2 Wave and Wind Data

The development of wave spectra based upon wave and wind data is greatly simplified by the fact that the reservoir does not have or require near shore wave or current information. The water surface of the reservoir is assumed to be smooth prior to the application of wind stress. Consequently, wave data is input to reflect no initial waves prior to the application of the wind speed.

The wind speed used for the final analyses is based upon the Case 1 100-year wind speed adjusted to the fetch limited duration wind speed. For all four fetches analyzed in manual freeboard calculations, the Case 1 adjusted fetch limited duration wind speed is 100 mph (44.7 m/s). Consequently, a 100 mph wind speed was used for all STWAVE Case 1 analyses for all wind directions.

4.4.3 STWAVE Results

Case 1 significant wave heights and wave periods estimated using STWAVE are provided in Appendix F.

4.5 ACES Analyses

ACES requires reservoir and embankment data such as water depth, embankment height, slope and roughness along with significant wave height and wave period data. In addition, calculations are dependent upon several empirically derived coefficients to account for slope roughness and to estimate overtopping rates.

4.5.1 Wave Runup

ACES estimates wave runup using a different methodology than the graphical method presented in the preliminary design manual calculations. The ACES rough slope wave runup calculations are based on an empirical equation derived by Ahrens and McCartney (ACES, 1992). The Ahrens and McCartney rough slope wave runup equation is:

$$R = H_i \frac{a\xi}{1 + b\xi}$$

Where:

H_i = incident wave height (feet)

a,b = empirical slope roughness coefficients associated with specific types of armor units (table provided in program)

ξ = $\dfrac{\tan\theta}{\sqrt{\dfrac{H_i}{L_o}}}$

θ = angle between structure seaward face and horizontal (a measure of structure slope)

L_o = deepwater wavelength

[Equation 1, ACES pg 5-2-3l]

Stepped slope embankments are not included in the slope roughness coefficient tables provided by the ACES program, therefore, the values for riprap, which provided the most conservative wave runup results of the available coefficient data was used.

4.5.2 Wave Overtopping

The calculation of wave overtopping is dependent upon empirically derived overtopping coefficients α and Q^*_o. An estimate for the coefficient α can be calculated automatically by ACES or by using the equation:

$$\alpha = 0.06 - 0.0143\ln(\sin\theta) \quad \textit{[Equation 7-13, SPM II, pg 7-54]}$$

Where:

α = an overtopping rate coefficient

θ = angle between structure seaward face and horizontal

While the overtopping coefficient α can readily be calculated, there is a great deal of uncertainty and limited available information on the how to best estimate Q^*_o. Figures for specific structure configurations provided in the Shore Protection Manual Volume II (Chapter 7) can potentially be used to estimate data pairs of α and Q^*_o based upon the relative wave height (d_s/H'_o) and wave steepness (H'_o/gT^2) ratios. These figures were generally considered not applicable due to either the embankment configuration and/or the lack of empirical data pairs within the range or even in close proximity to project calculations of wave height and wave steepness ratios.

However, Figure 7-34 of the Shore Protection Manual Vol. II does provide a means to estimate Q^*_o between waves conforming to cnoidal wave theory and linear wave theory (Figure 17). While this figure does not consider the configuration and slope of the embankment, it was considered the best available means to approximate the overtopping coefficient Q^*_o. Values of Q^*_o for a range of relative wave height (d_s/H'_o) and wave steepness (H'_o/gT^2) ratios were estimated from Figure 17. For d_s/H'_o exceeding 3.0, it was assumed that values would continue to follow the linear theory within the project range of H'_o/gT^2 values (generally from 0.010 to 0.016) as demonstrated by the d_s/H'_o =4.0 (assumed) line imposed on the graph in Figure 17.

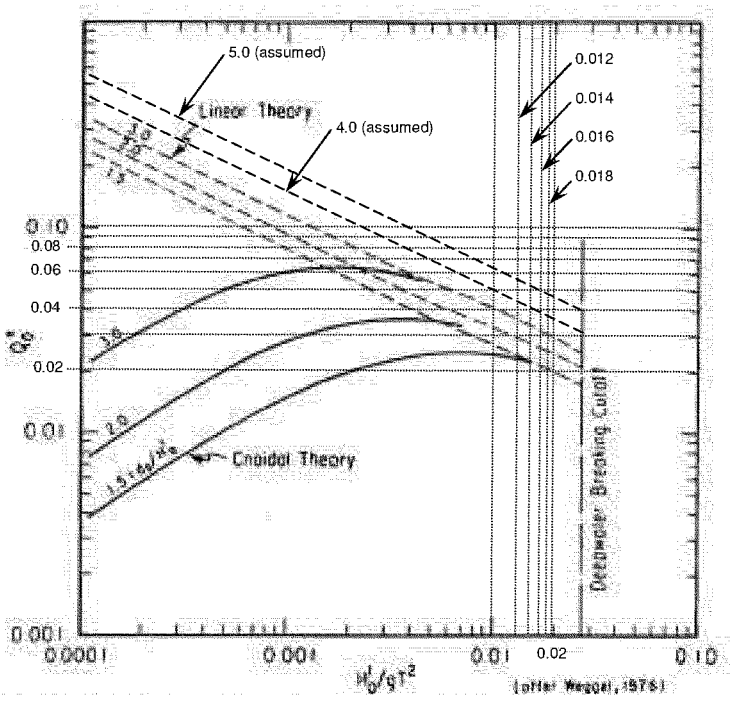


Figure 17: Variation of Q*o (Cnoidal vs. Linear Waves) [Figure 7-34, SPM Vol. II]

4.5.3 Summary of Manual Freeboard Calculations

Table 8 presents a summary comparison of the freeboard requirements based upon manual calculations. Supporting documentation is provided in Appendix C.

Table 8: Summary of Calculated Manual Freeboard Requirements

Description	Cell 1		Cell 2	
	Fetch 1A	Fetch 1B	Fetch 2A	Fetch 2B
Wave Runup (ft)	8.00	7.15	6.63	7.06
Flood Surcharge (ft)	4.13	4.13	4.13	4.13
Wind Setup (ft)	1.03	0.90	1.12	1.22
Required Freeboard (ft)	13.16	12.18	11.88	12.41
Average Normal Full Storage Level Depth[1] (ft)	20.36	20.22	17.51	17.06
Embankment Height (w/freeboard only) (ft)	33.52	32.40	29.39	29.47
Camber for Settlement (ft)	1.24	1.15	0.88	0.88
Embankment Height (ft) (w/freeboard and camber)	34.76	33.55	30.26	30.34
Proposed Embankment Elevation (NFSL=42.0) (ft)	56.40	55.33	54.75	55.28
Note: 1. Based the average depth along fetch determined in manual calculations.				

4.5.4 Summary of Wave Overtopping Analyses

The summary results of the overtopping analyses for Cell 1 and Cell 2 based upon STWAVE/ACES analyses are shown in Table 9. Detailed results and additional supporting documentation are provided in Appendix F.

Table 9: Summary of Cell 1 and Cell 2 Overtopping Analyses

Cell	Wind Direction (0=North)	Embankment Structure Height/Elevation at Overtopping Rate of							
		0.1 cfs/ft		0.01 cfs/ft		0.005 cfs/ft		0.001 cfs/ft	
		Ht (ft)	Elev. (ft)	Ht (ft)	Elev. (ft)	Ht (ft)	Elev. (ft)	Ht (ft)	Elev. (ft)
1	45 (Fetch 1A)	37.17	54.54	38.73	56.25	39.12	**56.64**	39.86	57.46
1	135 (Fetch 1B)	33.51	54.38	35.15	56.18	35.56	**56.59**	36.33	57.44
2	45 (Fetch 2A)	33.27	54.71	34.93	56.51	35.27	**56.72**	36.12	57.78
2	315 (Fetch 2B)	29.69	54.32	31.33	56.16	31.73	**56.56**	32.50	57.42

Note: 1. Elevation values include camber (see detailed results in Appendix F)

4.6 Internal Embankments

4.6.1 Internal Embankment Design Height

Table 10 provides a summary of the minimum internal embankment height based upon STWAVE/ACES analyses and an overtopping rate of 1.0 cfs/ft. Additional analyses including overtopping rates of 0.1 cfs/ft, 0.01 cfs/ft, 0.005 cfs/ft and 0.001 cfs/ft are provided and summarized in Appendix F.

Table 10: Summary of Internal Embankment Overtopping Analysis

Description	Wave		Embankment Toe			Embankment at 1.0 cfs/ft Overtopping		
	Ht (ft)	Period (s)	Elev. (ft)	Wind Setup (ft)	Water Depth (ft)	Height (ft)	Camber (ft)	Elev. (ft)
Wind blowing West (90 for Cell 2)	6.27	4.0	21.42	0.87	25.58	29.21	0.77	51.40
Wind blowing East (270 for Cell 1)	6.27	4.0	21.95	0.78	24.96	28.59	0.76	51.30

As previously discussed in Section 4.2.3, it is estimated that the maximum rise in the water surface elevation in Cell 1 and Cell 2 due to 1.0 cfs/ft overtopping for a duration of 1 hour is approximately 0.29 ft and 0.27 ft, respectively. Given the conservative approach taken in all aspects of the reservoir design and the amount of freeboard provided along the external embankments (~14 ft), it is not anticipated that such an increase in either cell would have any significant adverse impact that might compromise the integrity of the external embankments.

4.7 Summary of Embankment Design

Based upon the results of the STWAVE analyses, the external embankment height is dictated by the maximum overtopping criterion. To meet an overtopping rate criterion of 0.005 cfs/ft, a minimum external embankment elevation of 56.64 and 56.72 are required for Cell 1 and Cell 2, respectively.

For the internal embankment, an embankment elevation of 51.40 feet will meet the preliminary established criteria of limiting the internal embankment overtopping rate to less than 1.0 cfs/ft.

5 REFERENCES

1. Ahrens, J. P., and McCartney B. L. 1975, "Wave Period Effect on the Stability of Riprap", *Proceedings of Civil Engineering in the Oceans/III, American Society of Civil Engineers*, pp 1019-1034.

2. American Society of Engineers, *Minimum Design Loads for Buildings and Other Structures, SEI/ASCE 7-02*, 2003.

3. Federal Emergency Management Agency, *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*, October 1998.

4. National Oceanographic and Atmospheric Administration, National Weather Service, *Hydrometeorlogical Report 51, Probable Maximum Precipitation Estimates, United States East of 105th Meridian.*

5. South Florida Water Management District, *Design Criteria Memorandum: DCM-1, Hazard Potential Classification*, September 12, 2005.

6. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Wind and Precipitation Design Criteria for Freeboard*, February 6, 2006.

7. Stanley Consultants, *C-43 Basin Storage Reservoir Basis of Design Report (BODR)*, January 2005.

8. U. S. Army Corps of Engineers, *Automated Coastal Engineering System, Technical Reference, Version 1.07,* September 1992.

9. U. S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-1100, July 31, 2003.*

10. U. S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-1100, June 1, 2006.*

11. U. S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads, EM 1110-2-1614*, 1995.

12. U. S. Army Corps of Engineers, *Engineering and Design – Design of Coastal Revetments, Seawalls, and Bulkheads, EM 1110-2-1614*, June 1995.

13. U. S. Army Corps of Engineers, *Engineering and Design – Hydrologic Engineering Requirements for Reservoirs, EM 1110-2-1420*, October, 1997

14. U. S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.

15. U. S. Army Corps of Engineers, S*hore Protection Manual: Volume I & Volume II,* Published by Waterways Experiment Station (WES), 1984.

16. U. S. Army Corps of Engineers, *STWAVE: Steady-State Spectral Wave Model User's Manual for STWAVE, Version 3.0,* February 2001.

17. U. S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior, 1992..

18. U. S. Bureau of Reclamation, *Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams, ACER Technical Memorandum No. 2*,

19. U. S. Bureau of Reclamation Website Glossary, *http://www.usbr.gov/library/glossary.*

20. Veri-Tech, Inc., *Coastal Engineering Design and Analysis System, Version 4.02*, 2006.

21. Weggel, J.R., "Wave Overtopping Equation", *Proceedings of the 15th Coastal Engineering Conference,* ASCE, Honolulu, Hawaii, 1976, pp. 2737-2755.

LIST OF APPENDICES

Appendix A:
Reservoir Storm Hydrology

Appendix B:
Fetch Length and Water Depth Calculation Exhibits

Appendix C:
C-43 Manual Freeboard Calculations

Appendix D:
Step-by-Step Freeboard Calculation References

Appendix E:
Regression Analyses for Wave Runup Calculations

Appendix F:
STWAVE and ACES Analyses

Appendix G:
C-43 WSR Overwash Rate Memo

Appendix A: Reservoir Storm Hydrology

1939

Reservoir Storm Hydrology

Reservoir Storm Hydrology

1. General

This section evaluates the following:

- Flood Routing for PMP storm events
- Location and capacity of spillway structure

2. Hydrologic Analyses

The flood routing analyses are based on the probable maximum precipitation (PMP) and associated probable maximum flood values (PMF) values according to the procedures given in the U.S. Department of Commerce/National Oceanic Atmospheric Administration (NOAA) Hydrometeorological Reports (HMR) 51, 52, and 53.

For the C-43 West Storage Reservoir (WSR), the PMF is taken as the PMP event multiplied by the contributing reservoir area, which includes the embankment crest, interior slopes (above water surface), and water surface area. DHI's MIKE SHE/MIKE 11 software (Abbott et al, 1986) was used to route the floods through the reservoir's outlet structures.

For the WSR Reservoir, the model results provide the following information:

- A design basis for sizing un-gated spillway structures
- The peak reservoir stage that occurs during the PMP design storm event.

3. Design Flood - Reservoir

The MIKE SHE/MIKE 11 model follows the routing scenarios outlined in Design Criteria Memorandum No. 2 (DCM-2). In DCM-2 (Acceler8, 2006), Case 1 is identified as a 100-year wind event in combination with the 72-hour PMP storm event.

The United States Army Corps of Engineers (USACE) generated the rainfall files used in the PMP. The 72-hour PMP storm event for the WSR was developed in accordance with HMR-51 (NOAA) and HMR-52 (NOAA).

The first step in this process was to determine the "all-season" PMP values for the 72-hour duration events based on a 10 square mile area using HMR-51. Figure 22 of HMR-51 indicates that the appropriate 72-hour event is equal to 55.7 inches of rain.

However, the area of the WSR is approximately 15 square miles, meaning the total rainfall distributed over the area should be less than 55.7 inches. The USACE used an internal program called "Probable Maximum Storm (HMR52)" to calculate an appropriate storm for this analysis. Key inputs into the program included the basin area of 14.8 square miles, the orientation of the storm isohytes at 270 degrees, and the storm

center coordinates centered over the reservoir. The result of the program run (WSR_T1.doc) is attached. This run calculated that the maximum precipitation applied to isohyet "A" would equal 54.95 inches over 72 hours. The results of the calculation are shown in Table 1.

The calculated maximum rainfall event was then normalized and broken down into 30-minute intervals (Table 2). This rainfall hyetograph is shown in Figure 1 and a cumulative rainfall hyetograph is shown in Figure 2.

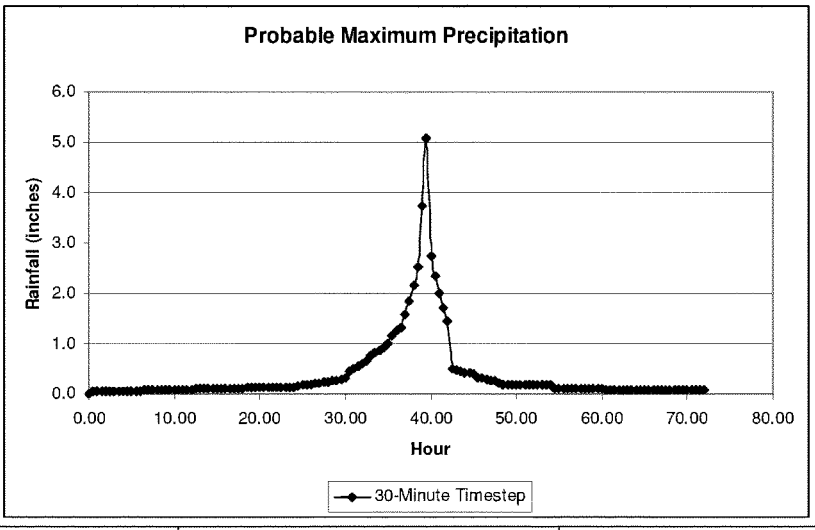
Figure 3 shows the distribution of rainfall isohyets over the freshwater Caloosahatchee River basin. The heaviest intensity of rainfall occurs in isohyets A and decreases away from the center of the storm. Table 1 shows the depth of rainfall calculated by the program for each of the isohyets within the watershed.

Table 1. Depth vs. Duration Relationships by length of PMP storm and Isohyet for distributed rainfall.

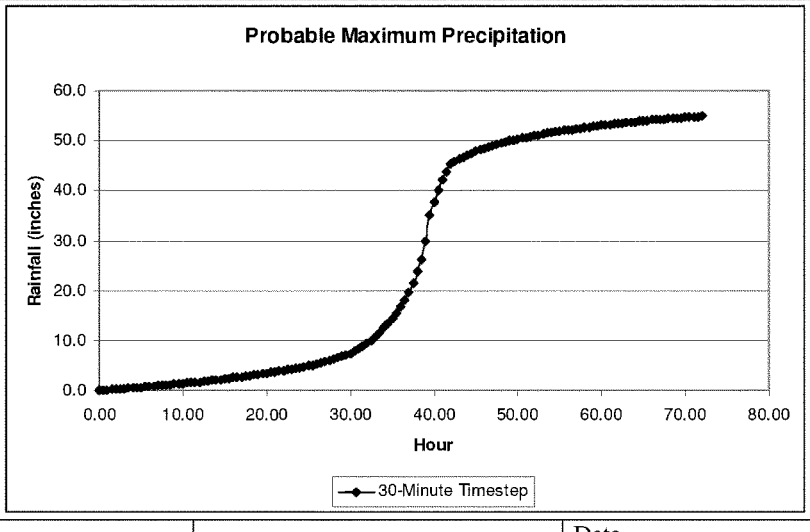
	DEPTH VS. DURATION																		
ISOHYET	5MIN	10MIN	15MIN	30MIN	1-HR	2-HR	3-HR	6-HR	12-HR	18-HR	24-HR	30-HR	36-HR	42-HR	48-HR	54-HR	60-HR	66-HR	72-HR
A	1.67	3.35	5	9.63	15.53	20.04	23.61	30.62	38.43	42.42	45.11	47.16	48.8	50.18	51.37	52.42	53.34	54.18	54.95
B	1.55	3.11	4.64	8.94	14.42	18.63	21.95	28.52	35.95	39.86	42.55	44.6	46.24	47.62	48.81	49.86	50.78	51.62	52.39
C	0.35	0.71	1.06	2.13	4.24	8.36	12.17	20.12	25.57	28.52	30.52	32.04	33.27	34.3	35.18	35.96	36.65	37.28	37.85
D	0.27	0.55	0.82	1.64	3.28	6.45	9.4	15.61	20.08	22.47	24.1	25.34	26.34	27.17	27.89	28.52	29.08	29.59	30.05
E	0.23	0.45	0.68	1.36	2.71	5.34	7.79	12.91	16.55	18.46	19.77	20.76	21.56	22.23	22.81	23.31	23.76	24.17	24.54
F	0.18	0.36	0.54	1.07	2.14	4.22	6.14	10.21	13.16	14.74	15.82	16.64	17.3	17.85	18.32	18.74	19.11	19.45	19.75
G	0.15	0.29	0.44	0.88	1.76	3.47	5.05	8.41	10.87	12.21	13.13	13.82	14.38	14.85	15.26	15.61	15.93	16.21	16.47
H	0.12	0.23	0.35	0.69	1.38	2.72	3.96	6.61	8.58	9.64	10.37	10.92	11.37	11.74	12.06	12.34	12.59	12.82	13.02
I	0.09	0.18	0.27	0.54	1.07	2.1	3.06	5.1	6.62	7.47	8.05	8.49	8.84	9.14	9.39	9.62	9.82	10	10.16
J	0.06	0.13	0.19	0.38	0.75	1.47	2.14	3.6	4.78	5.45	5.91	6.25	6.53	6.77	6.97	7.15	7.31	7.45	7.58
K	0.04	0.07	0.11	0.22	0.43	0.84	1.23	2.1	2.9	3.35	3.66	3.9	4.09	4.24	4.38	4.5	4.61	4.7	4.79
L	0.02	0.03	0.05	0.09	0.18	0.36	0.52	0.9	1.28	1.48	1.61	1.71	1.8	1.87	1.92	1.98	2.02	2.07	2.1
M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Q	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Normalized PMP Rainfall Time Series

PMP Normalized Time Series		PMP Inches	PMP Normalized Time Series		PMP Inches	PMP Normalized Time Series		PMP Inches
Time (hrs)	Normalized Incremental Rainfall	54.95	Time (hrs)	Normalized Incremental Rainfall	54.95	Time (hrs)	Normalized Incremental Rainfall	54.95
0.00	0.00000	0.000	24.00	0.00253	0.139	48.00	0.00397	0.218
0.50	0.00116	0.064	24.50	0.00298	0.164	48.50	0.00316	0.174
1.00	0.00116	0.064	25.00	0.00318	0.175	49.00	0.00316	0.174
1.50	0.00116	0.064	25.50	0.00337	0.185	49.50	0.00316	0.174
2.00	0.00116	0.064	26.00	0.00357	0.196	50.00	0.00316	0.174
2.50	0.00116	0.064	26.50	0.00377	0.207	50.50	0.00316	0.174
3.00	0.00116	0.064	27.00	0.00397	0.218	51.00	0.00316	0.174
3.50	0.00116	0.064	27.50	0.00417	0.229	51.50	0.00316	0.174
4.00	0.00116	0.064	28.00	0.00437	0.240	52.00	0.00316	0.174
4.50	0.00116	0.064	28.50	0.00476	0.262	52.50	0.00316	0.174
5.00	0.00116	0.064	29.00	0.00496	0.273	53.00	0.00316	0.174
5.50	0.00116	0.064	29.50	0.00516	0.284	53.50	0.00316	0.174
6.00	0.00116	0.064	30.00	0.00595	0.327	54.00	0.00316	0.174
6.50	0.00142	0.078	30.50	0.00794	0.436	54.50	0.00212	0.116
7.00	0.00142	0.078	31.00	0.00893	0.491	55.00	0.00212	0.116
7.50	0.00142	0.078	31.50	0.00992	0.545	55.50	0.00212	0.116
8.00	0.00142	0.078	32.00	0.01092	0.600	56.00	0.00212	0.116
8.50	0.00142	0.078	32.50	0.01191	0.654	56.50	0.00212	0.116
9.00	0.00142	0.078	33.00	0.01389	0.764	57.00	0.00212	0.116
9.50	0.00142	0.078	33.50	0.01489	0.818	57.50	0.00212	0.116
10.00	0.00142	0.078	34.00	0.01588	0.873	58.00	0.00212	0.116
10.50	0.00142	0.078	34.50	0.01687	0.927	58.50	0.00212	0.116
11.00	0.00142	0.078	35.00	0.01806	0.993	59.00	0.00212	0.116
11.50	0.00142	0.078	35.50	0.02084	1.145	59.50	0.00212	0.116
12.00	0.00142	0.078	36.00	0.02283	1.254	60.00	0.00212	0.116
12.50	0.00182	0.100	36.50	0.02416	1.328	60.50	0.00159	0.087
13.00	0.00182	0.100	37.00	0.02854	1.569	61.00	0.00159	0.087
13.50	0.00182	0.100	37.50	0.03361	1.847	61.50	0.00159	0.087
14.00	0.00182	0.100	38.00	0.03941	2.166	62.00	0.00159	0.087
14.50	0.00182	0.100	38.50	0.04599	2.527	62.50	0.00159	0.087
15.00	0.00182	0.100	39.00	0.06788	3.730	63.00	0.00159	0.087
15.50	0.00182	0.100	39.50	0.09250	5.083	63.50	0.00159	0.087
16.00	0.00182	0.100	40.00	0.04958	2.725	64.00	0.00159	0.087
16.50	0.00182	0.100	40.50	0.04260	2.341	64.50	0.00159	0.087
17.00	0.00182	0.100	41.00	0.03652	2.007	65.00	0.00159	0.087
17.50	0.00182	0.100	41.50	0.03099	1.703	65.50	0.00159	0.087
18.00	0.00182	0.100	42.00	0.02627	1.444	66.00	0.00159	0.087
18.50	0.00253	0.139	42.50	0.00893	0.491	66.50	0.00127	0.070
19.00	0.00253	0.139	43.00	0.00854	0.469	67.00	0.00127	0.070
19.50	0.00253	0.139	43.50	0.00814	0.447	67.50	0.00127	0.070
20.00	0.00253	0.139	44.00	0.00774	0.425	68.00	0.00127	0.070
20.50	0.00253	0.139	44.50	0.00754	0.414	68.50	0.00127	0.070
21.00	0.00253	0.139	45.00	0.00695	0.382	69.00	0.00127	0.070
21.50	0.00253	0.139	45.50	0.00595	0.327	69.50	0.00127	0.070
22.00	0.00253	0.139	46.00	0.00556	0.305	70.00	0.00127	0.070
22.50	0.00253	0.139	46.50	0.00536	0.294	70.50	0.00127	0.070
23.00	0.00253	0.139	47.00	0.00476	0.262	71.00	0.00127	0.070
23.50	0.00253	0.139	47.50	0.00457	0.251	71.50	0.00127	0.070
						72.00	0.00127	0.070



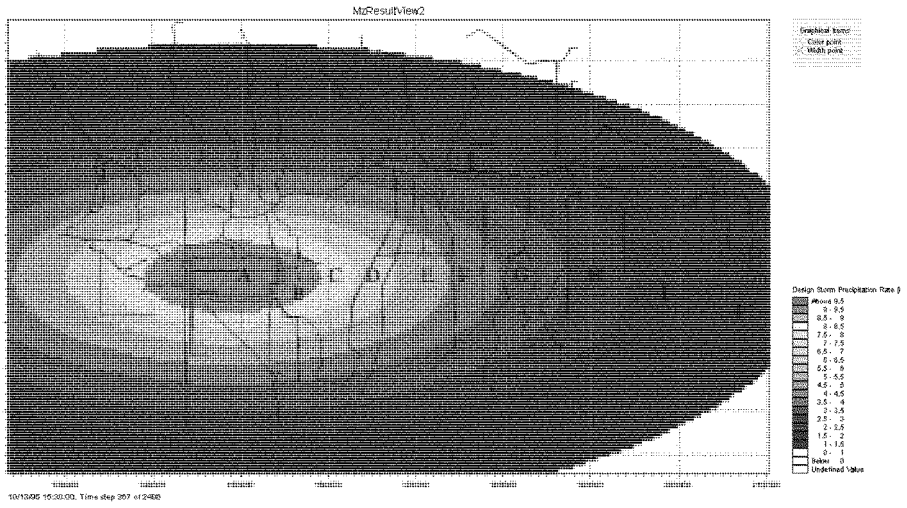
	30-Minute Increment Hyetograph of 72-hour PMP Storm Event	Date March 30, 2007 Figure **1**



	30_Minute Cumulative Hyetograph of 72-hour PMP Storm Event	Date March 30, 2007 Figure **2**

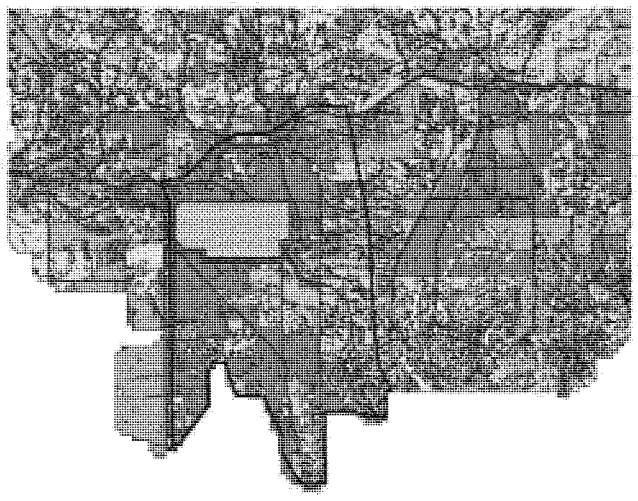
4. Flood Routing - Reservoir

For use in the MIKE SHE model, the 72-hour PMP storm event was built into a distributed, grid-based, model input file. First, isohyetal ellipses were built in GIS to define the distribution of the rainfall. The ellipses were then rotated and centered over the reservoir in accordance with HMR-52 results. The GIS ellipses were then converted into a MIKE SHE dfs2 grid file format. Finally this dfs2 file was then merged with the time series of the PMP event to generate spatially distributed precipitation files for use in the model. The spatial distribution of rainfall at the peak of the PMP storm event is shown in Figure 3. The rainfall amount applied to each isohyt is shown in Table 1.



	Probable Maximum Precipitation Peak Rainfall Intensity (in/hr)	Date March 30, 2007
		Figure **3**

The WSR is an "off-line" structure. Water enters the reservoir via pumping or direct precipitation. In addition to the groundwater and overland components, the MIKE SHE model includes the surface water network. This network includes the reservoir, multiple streams that route water around the reservoir, and multiple gates, pumps, and overflow spillways to manage water within the system. This system around the reservoir is shown in Figure 4.



	West Storage Reservoir Location	Date March 30, 2007
		Figure **4**

The Normal Full Surface Level (NFSL) is at elevation 42 feet, NAVD 88. The primary structures of concern in this task are the Service and Auxiliary spillways located in Cells 1 and 2 of the reservoir. Three different spillway configurations were considered during the design process. The alternatives are described as follows:

Alternative 1 Spillway Description:

In Alternative 1, the service spillways for Cells 1 and 2 consists of a 100-foot wide broad-crested weir at an elevation of 42.25 feet.

The auxiliary spillway for Cell 1 consists of a 250-foot wide broad-crested weir at an elevation of 42.75 feet. The auxiliary spillway for Cell 2 consists of a 125-foot wide broad-crested weir at an elevation of 42.75 feet.

Alternative 2 Spillway Description:

In Alternative 2, the Cell 1 service spillway consists of a double weir structure. The first is a notched weir with a 20-foot wide opening at an elevation of 42 feet, that opens an additional 250 feet at an elevation of 42.25 feet. This weir spills into a large box with a bottom elevation of approximately 35 feet. The second weir, width of 10 feet, is set at an elevation of 35.5 feet and controls flow out of the box structure. An identical structure would be located in Cell 2.

The auxiliary spillway in Cell 1 consists of a 180-foot long chimney drain (or similar weir structure) with a crest elevation of 42.75 feet. The Cell 2 auxiliary spillway consists of an 80-foot long chimney drain (or similar weir structure) with a crest elevation of 42.75 feet.

Alternative 3 Spillway Description:

In Alternative 3, the Cell 1 service spillway consists of a double weir structure. The first is a broad crested weir with a 54-foot wide opening at an elevation of 42 feet. This weir spills into a large box with a bottom elevation of approximately 37 feet. The second weir, width of 10 feet, is set at an elevation of 38 feet and controls flow out of the box structure. An identical structure would be located in Cell 2.

As specified by DCM-2, the governing conditions include the following two scenarios:

1. Routing starts at normal full storage level (uncontrolled spillway crest level),

    a. Route 30 percent of the 72-hour PMF (Time scale 0-hr to 72-hr): un-gated spillway flows, gated structures are in-operable.

    b. A 3-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 72-hr to 144-hr).

    c. Route 100 percent of the 72-hour PMF (Time scale 144-hr to 216-hr): un-gated spillway flows, gated structures are in-operable.

    d. A 10-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 216-hr to 456-hr).

    e. Route 30 percent of the 72-hour PMF (Time scale 456-hr to 528-hr): un-gated spillway flows, gated structures are in-operable.

2. Routing starts at normal full storage level (uncontrolled spillway crest level),

    a. Route 40 percent of the 72-hour PMF (Time scale 0-hr to 72-hr): un-gated spillway flows, gated structures are in-operable.

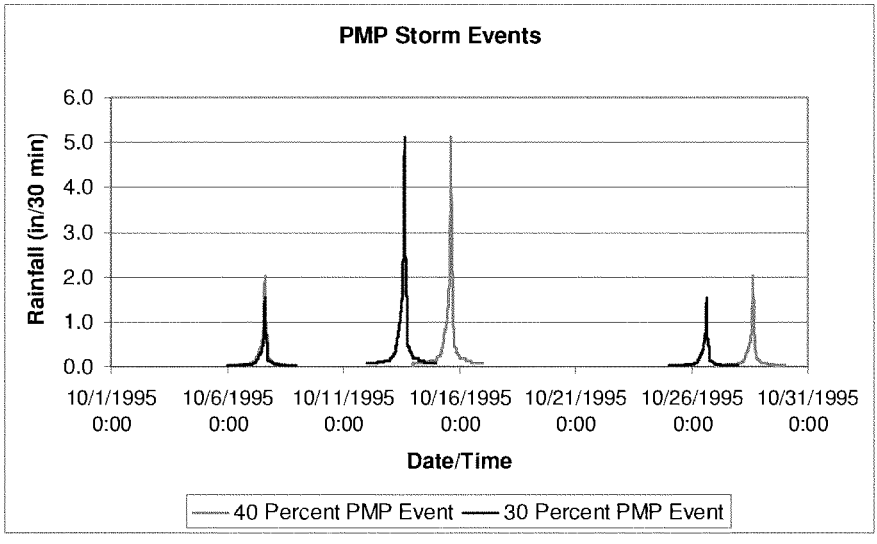
    b. A 5-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 72-hr to 192-hr).

c. Route 100 percent of the 72-hour PMF (Time scale 192-hr to 264-hr): un-gated spillway flows, gated structures are in-operable.

d. A 10-day dry interval with un-gated spillway flow, gated structures are operable (Time scale 264-hr to 504-hr).

e. Route 40 percent of the 72-hour PMF (Time scale 504-hr to 576-hr): un-gated spillway flows, gated structures are in-operable.

For these simulations, the PMP storm event was applied using initial conditions associated with the storm event of October 6, 1995. The 30- and 40-percent PMP series of storm events are shown in Figure 5. The reservoir water surface elevation started close to the NFSL for each simulation.



	30 Percent and 40 Percent Series of PMP Storm Events	Date March 30, 2007
		Figure **5**

4.1 **Routing Series of Storms**

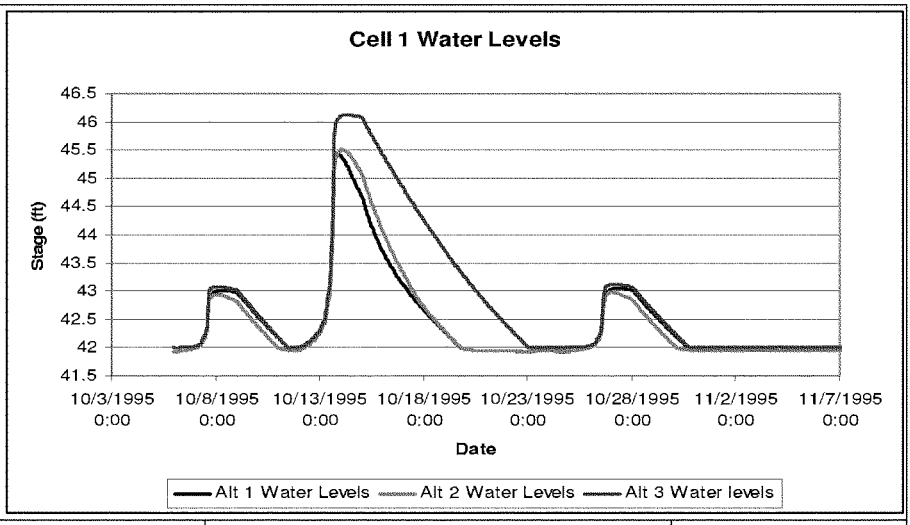
For each alternative spillway design, continuous rainfall events, developed to meet the Scenario 1 (30-percent PMP series of storms) and Scenario 2 (40-percent PMP series of storms) requirements were applied to the model. Initial conditions for the entire catchment were defined by the storm event of October 6, 1995. The beginning reservoir water surface

elevation was at an elevation of approximately 42 feet. In these simulations, the pumps and gated outlet structures were considered inoperable during rainfall periods and were allowed to operate during dry periods to bring the water surface elevation back to the NFSL. The only source of water into the reservoir was direct precipitation.

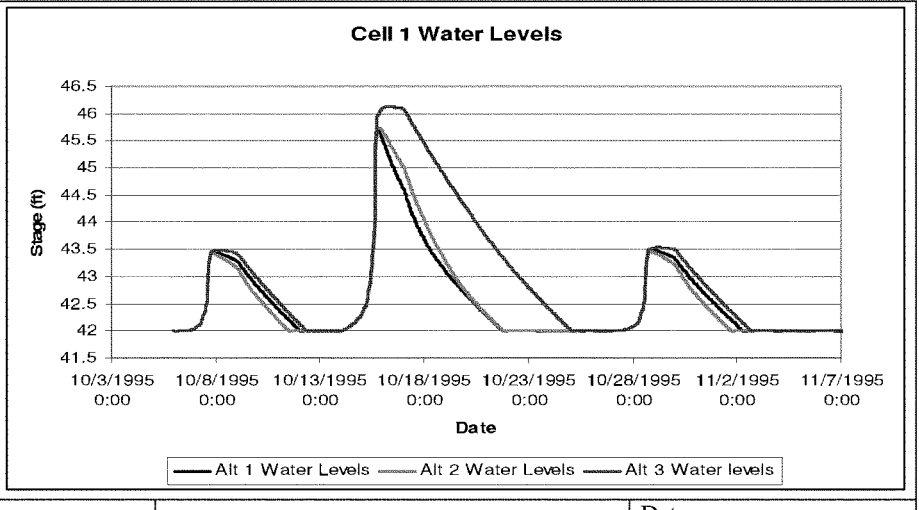
The rainfall was applied using the Scenario 1 and Scenario 2 series of storms and dry periods described above.

The results of these simulations are presented in Figures 6 – 19 and in Tables 4 – 6.

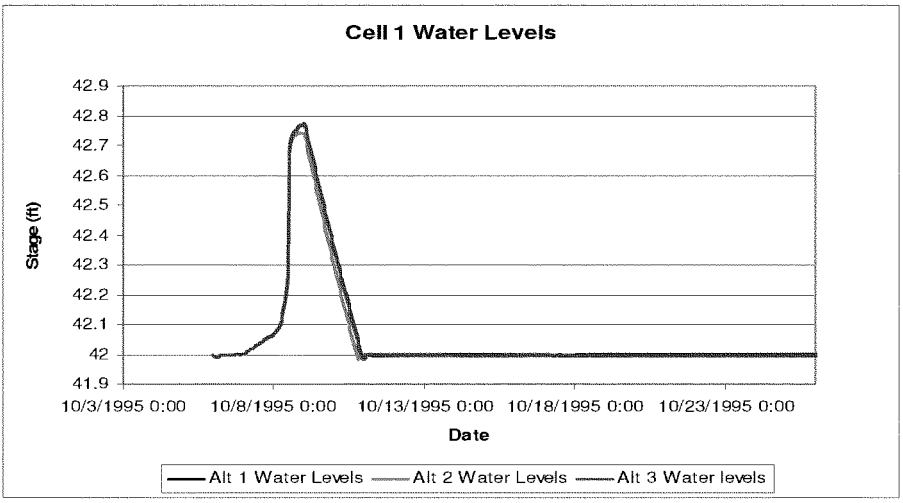
In addition to the 30- and 40-percent PMP series of storms, the 100-year storm was applied to each alternative design. These results are presented in Figures 20 – 26 and Table 7.



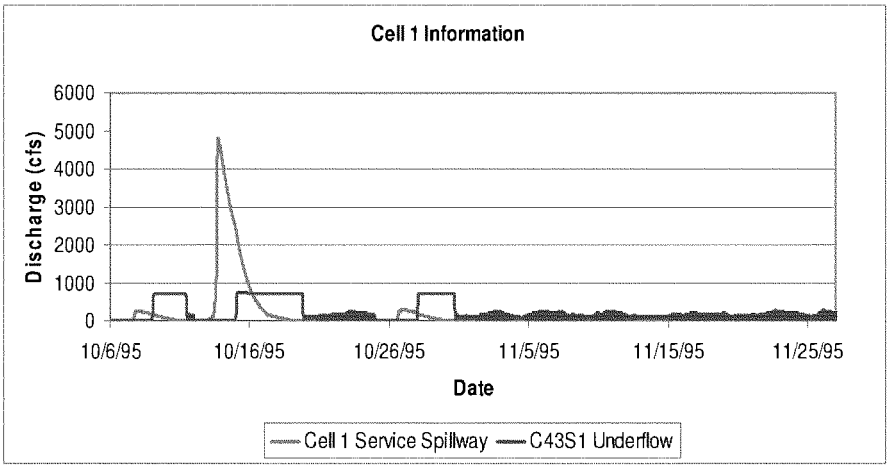
	Reservoir Water Level During 30 Percent PMP Storm Event	Date March 30, 2007 Figure **6**



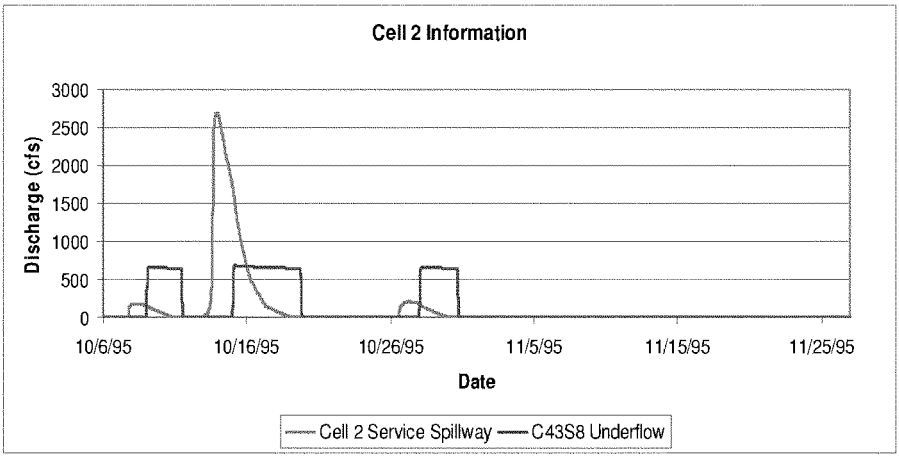
	Reservoir Water Level During 40 Percent PMP Storm Event	Date March 30, 2007 Figure **7**



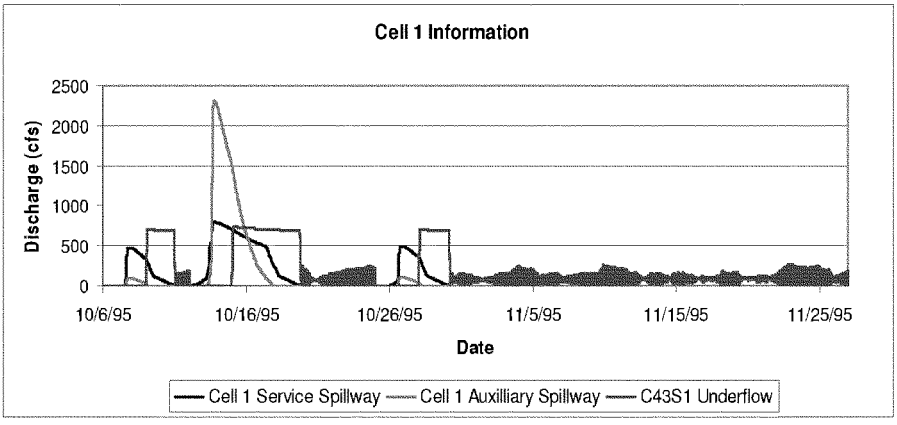
	Reservoir Water Level During 40 Percent PMP Storm Event	Date March 30, 2007
		Figure **8**



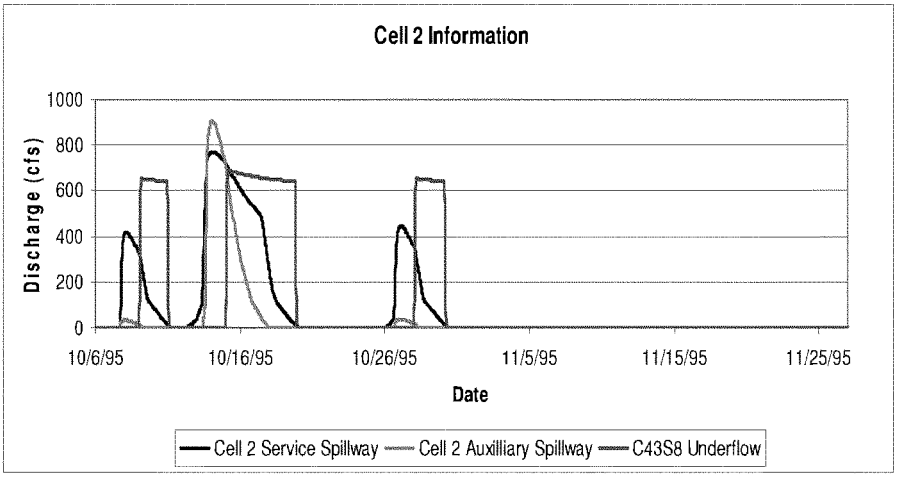
	Alternative 1 Spillway Design Cell 1 Discharge 30 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **9**



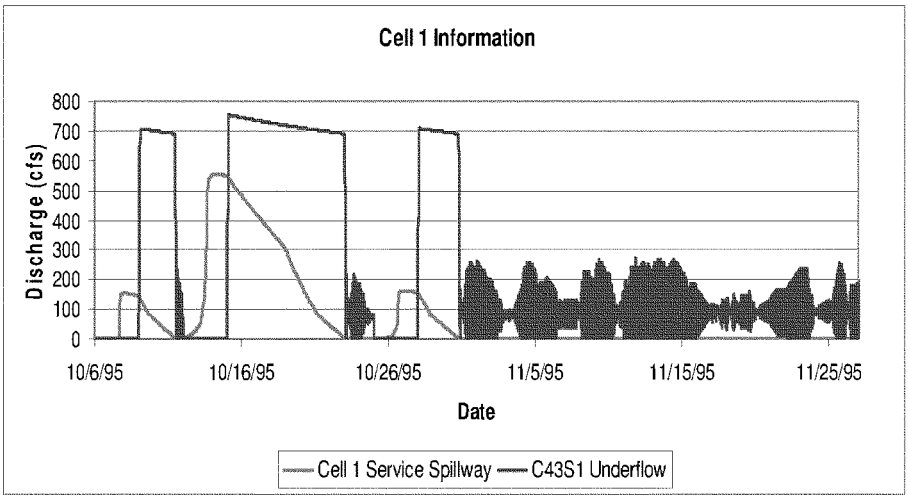
	Alternative 1 Spillway Design Cell 2 Discharge 30 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **10**



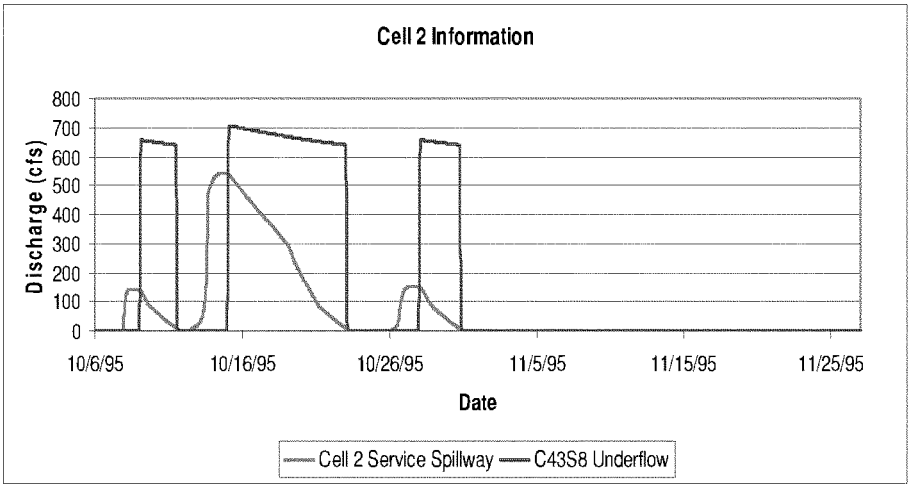
	Alternative 2 Spillway Design Cell 1 Discharge 30 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **11**



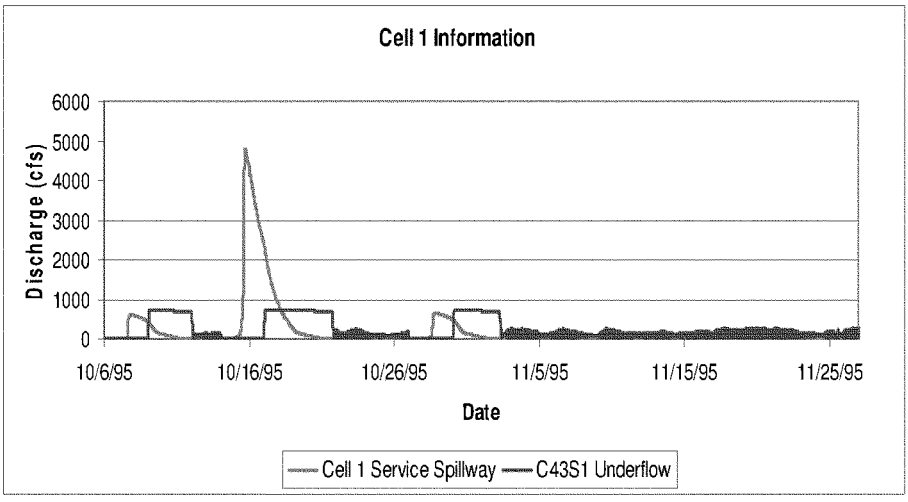
	Alternative 2 Spillway Design Cell 2 Discharge 30 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **12**



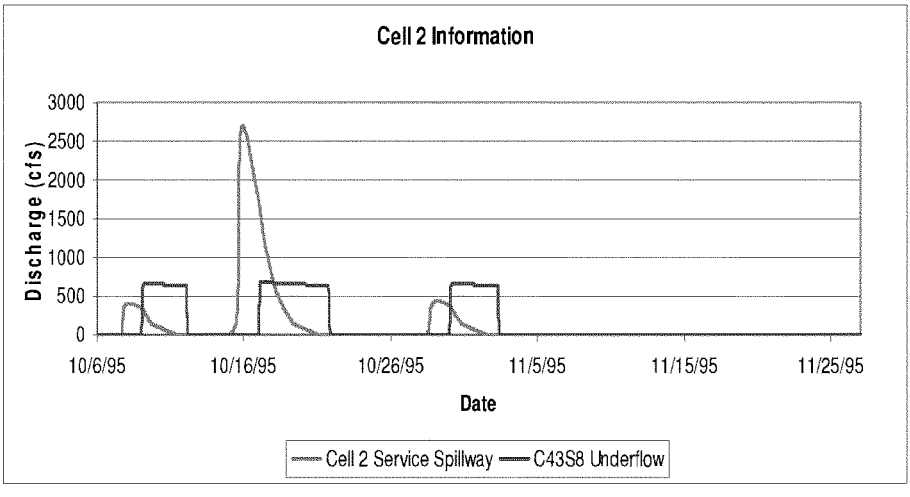
	Alternative 3 Spillway Design Cell 1 Discharge 30 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **13**



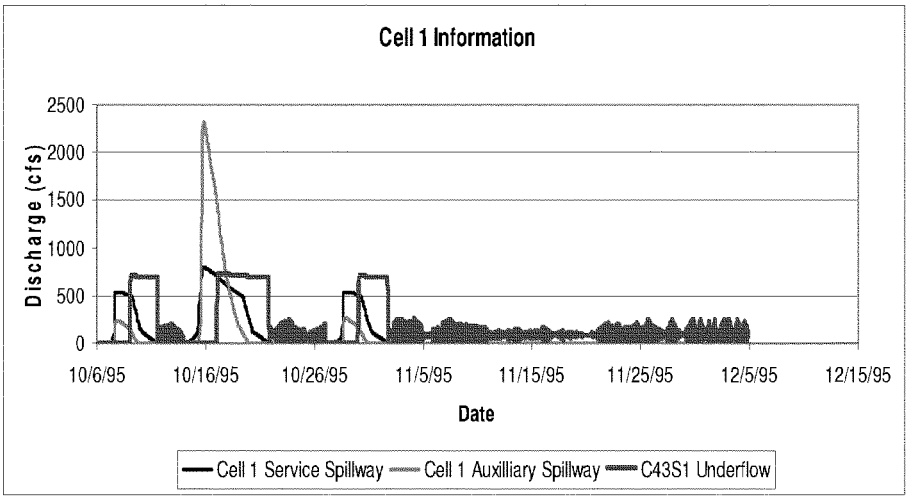
	Alternative 3 Spillway Design Cell 2 Discharge 30 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **14**



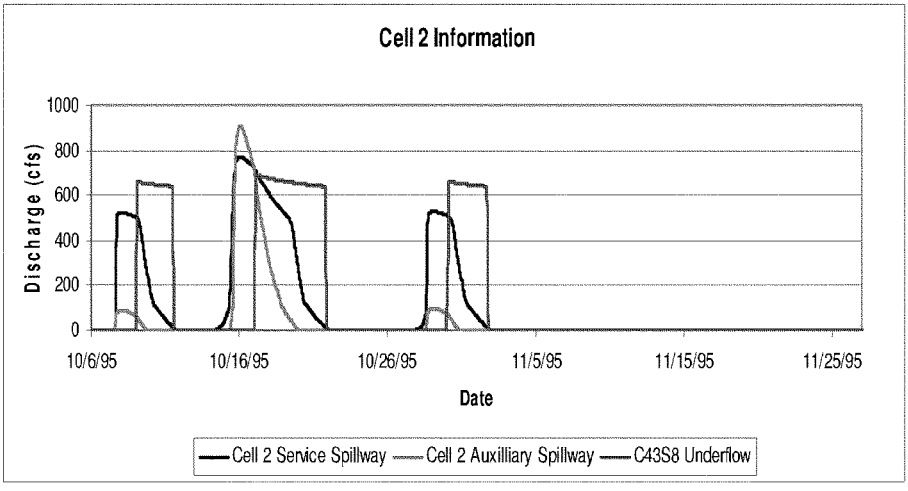
	Alternative 1 Spillway Design Cell 1 Discharge 40 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **15**



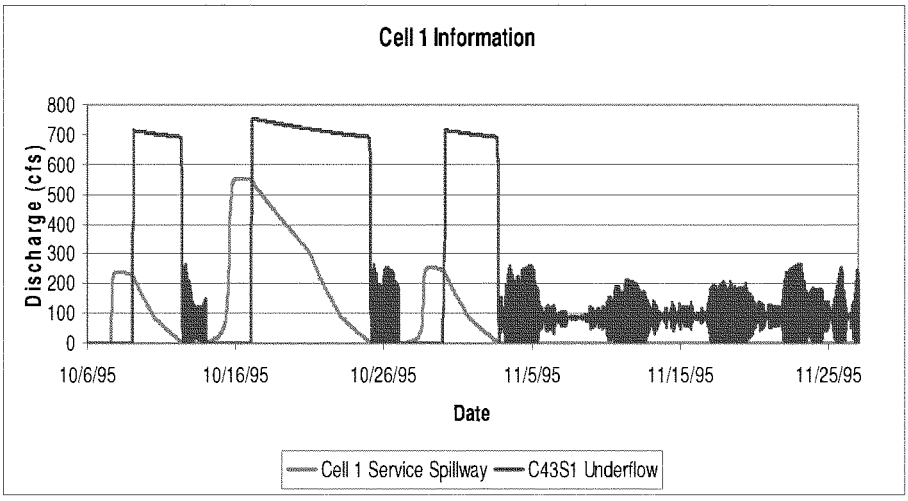
	Alternative 1 Spillway Design Cell 2 Discharge 40 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **16**



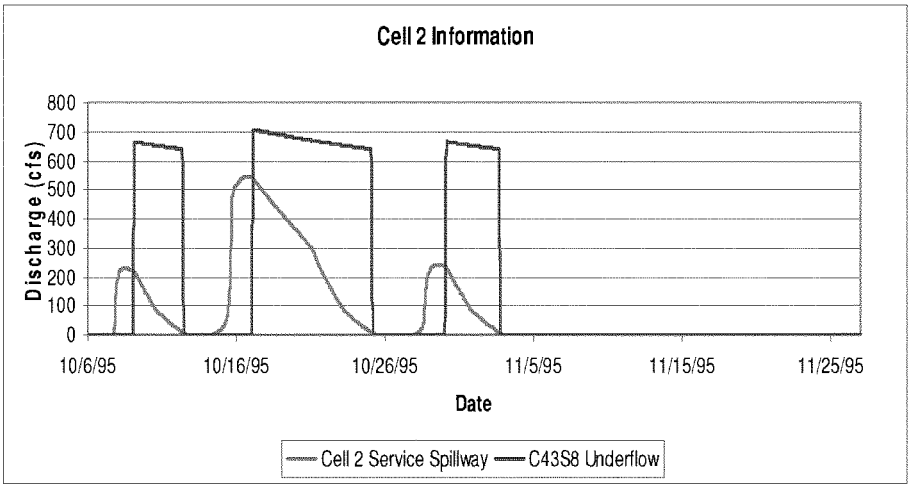
	Alternative 2 Spillway Design Cell 1 Discharge 40 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **17**



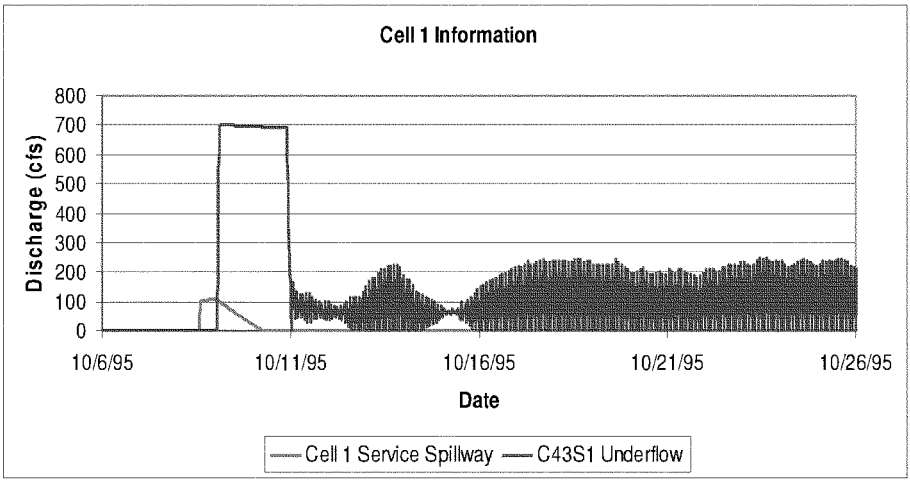
	Alternative 2 Spillway Design Cell 2 Discharge 40 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **18**



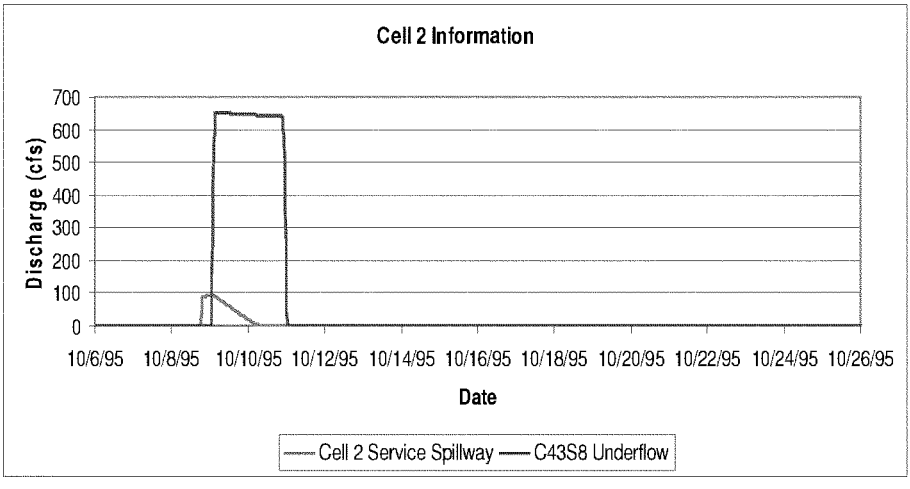
	Alternative 3 Spillway Design Cell 1 Discharge 40 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **19**



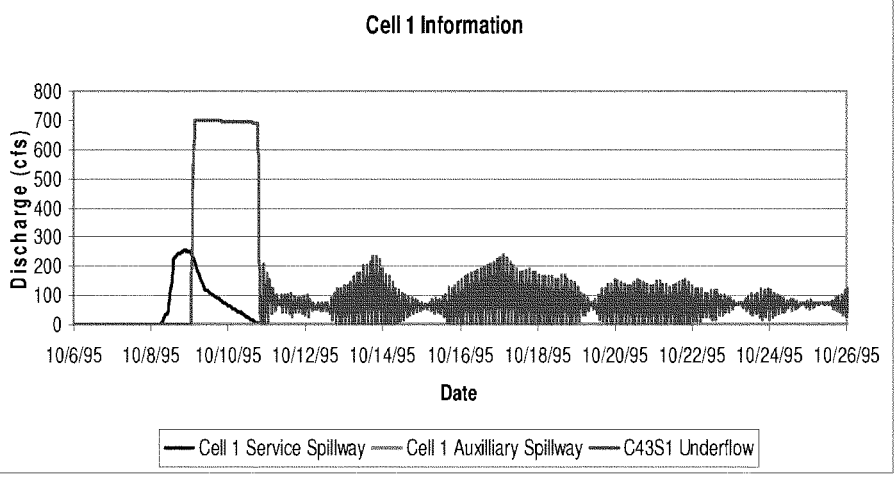
	Alternative 3 Spillway Design Cell 2 Discharge 40 Percent Series of PMP Storm Events	Date March 30, 2007 Figure **20**



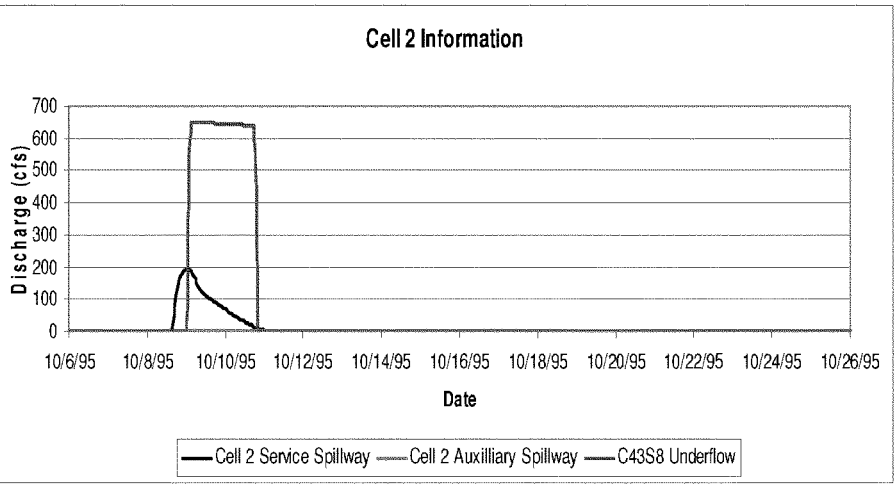
	Alternative 1 Spillway Design Cell 1 Discharge 100 Year Storm Event	Date March 30, 2007 Figure **21**



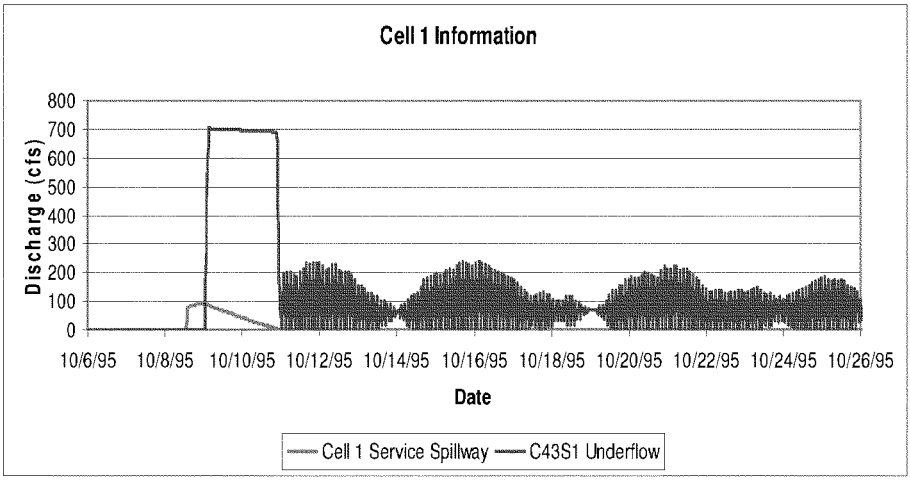
	Alternative 1 Spillway Design Cell 2 Discharge 100 Year Storm Event	Date March 30, 2007 Figure **22**



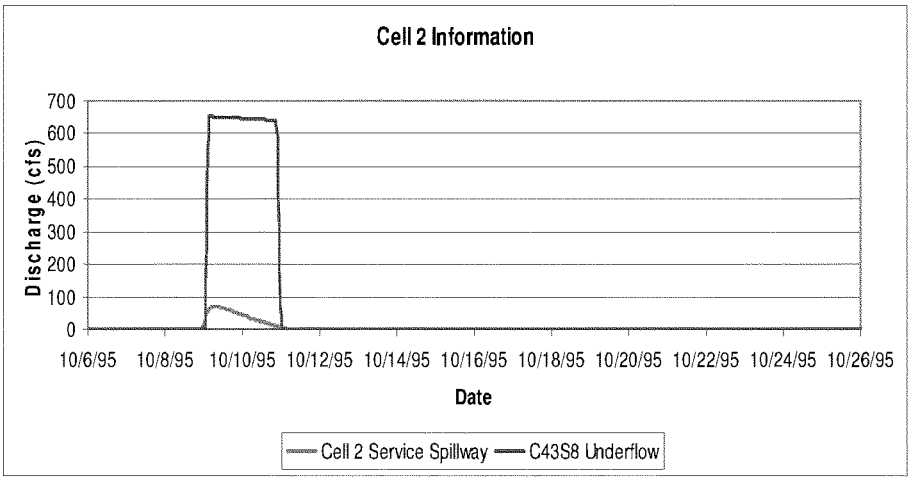
	Alternative 2 Spillway Design Cell 1 Discharge 100 Year Storm Event	Date March 30, 2007 Figure **23**



	Alternative 2 Spillway Design Cell 2 Discharge 100 Year Storm Event	Date March 30, 2007 Figure **24**



	Alternative 3 Spillway Design Cell 1 Discharge 100 Year Storm Event	Date March 30, 2007 Figure **25**



	Alternative 3 Spillway Design Cell 2 Discharge 100 Year Storm Event	Date March 30, 2007 Figure **26**

Table 4. MIKE SHE/MIKE11 Results for 30 Percent of PMP Storm

Simulation Result	Alt 1	Alt 2	Alt 3
Rainfall (inches)	16.49	16.49	16.49
Peak Water Surface Elevation – Cell 1 (ft)	43.07	43.02	43.08
Peak Water Surface Elevation – Cell 2 (ft)	43.01	42.99	43.02
Combined Peak Discharge – Cell 1 (cfs)	946.43	1275.38	860.32
Combined Peak Discharge – Cell 2 (cfs)	831.15	1155.83	799.11
Post Water Surface Elevation – Cell 1 (ft)	41.98	41.98	41.99
Post Water Surface Elevation – Cell 2 (ft)	41.96	41.92	41.95

Table 5. MIKE SHE/MIKE11 Results for 40 Percent of PMP Storm

Simulation Result	Alt 1	Alt 2	Alt 3
Rainfall (inches)	23.63	23.63	23.63
Peak Water Surface Elevation – Cell 1 (ft)	43.45	43.41	43.49
Peak Water Surface Elevation – Cell 2 (ft)	43.37	43.31	43.43
Combined Peak Discharge – Cell 1 (cfs)	1185.07	1479.92	953.46
Combined Peak Discharge – Cell 2 (cfs)	1066.87	1271.11	890.85
Post Water Surface Elevation – Cell 1 (ft)	41.98	41.98	41.98
Post Water Surface Elevation – Cell 2 (ft)	41.93	41.93	41.93

Table 6. MIKE SHE/MIKE11 Results for 100 Percent of PMP Storm

Simulation Result	Alt 1	Alt 2	Alt 3
Rainfall (inches)	54.95	54.95	54.95
Peak Water Surface Elevation – Cell 1 (ft)	45.74	45.74	46.13
Peak Water Surface Elevation – Cell 2 (ft)	45.42	45.52	46.04
Combined Peak Discharge – Cell 1 (cfs)	5533.09	3837.57	1306.52
Combined Peak Discharge – Cell 2 (cfs)	3378.38	2364.70	1249.89
Post Water Surface Elevation – Cell 1 (ft)	41.98	41.98	41.99
Post Water Surface Elevation – Cell 2 (ft)	41.93	41.93	41.94

Table 7. MIKE SHE/MIKE11 Results for 100 - Year Storm

Simulation Result	Alt 1	Alt 2	Alt 3
Rainfall (inches)	13.00	13.00	13.00
Peak Water Surface Elevation – Cell 1 (ft)	42.77	42.74	42.77
Peak Water Surface Elevation – Cell 2 (ft)	42.71	42.68	42.71
Combined Peak Discharge – Cell 1 (cfs)	808.63	953.26	792.96
Combined Peak Discharge – Cell 2 (cfs)	745.40	848.16	722.22
Post Water Surface Elevation – Cell 1 (ft)	41.99	41.99	41.99
Post Water Surface Elevation – Cell 2 (ft)	41.93	41.93	41.93

5. References

Abbott, M.B., J.C. Bathurst, J.A. Cunge, P.E. O'Connell, and J. Rasmussen; 1986a; An introduction to the European hydrological system – Systeme Hydrologique Europeen (SHE). History and Philosophy of a physically based distributed modeling system; Journal of Hydrology; 87; pages 45 – 77.

Acceler8 Reference #: P 599, Design Criteria Memorandum: DCM-2, Wind and Precipitation Design Criteria for Freeboard, February 6, 2006.

United States Army Corps of Engineers, WSR_T3.doc (results of HMR52 Probable Maximum Storm Calculation for C43 West Storage Reservoir), March 31, 2006.

U. S. Department of Commerce National Oceanic and Atmospheric Administration, U. S. Department of the Army Corps of Engineers, Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States, East of the 105th Meridian, June 1978.

U. S. Department of Commerce National Oceanic and Atmospheric Administration, U. S. Department of the Army Corps of Engineers, Hydrometeorological Report No. 52, Application of Probable Maximum Precipitation Estimates – Unites States East of the 105th Meridian, August 1982.

Ho, Francis P. and John T. Riedel, U. S. Department of Commerce National Oceanic and Atmospheric Administration, National Weather Service, Hydrometeorological Report No. 53, Seasonal Variation of 10 Square Mile Probable Maximum Precipitation Estimates, United States East of the 105th Meridian, April 1980.

```
1****************************************                ****************************************
 *                                      *                *                                      *
 *    PROBABLE MAXIMUM STORM  (HMR52)   *                *    U.S. ARMY CORPS OF ENGINEERS      *
 *            NOVEMBER 1982             *                *  THE HYDROLOGIC ENGINEERING CENTER   *
 *          REVISED  APRIL 91           *                *         609 SECOND STREET            *
 *                                      *                *       DAVIS, CALIFORNIA 95616        *
 *  RUN DATE 03/31/2006    TIME 12:50:54 *                *  (916) 551-1748 OR (FTS) 460-1748    *
 *                                      *                *                                      *
 ****************************************                ****************************************

                                        H     H  M     M  RRRRRR   5555555   22222
                                        H     H  MM   MM  R     R  5        2     2
                                        H     H  M M M M  R     R  5              2
                                        HHHHHHH  M  M  M  RRRRRR   555555        2
                                        H     H  M     M  R   R          5     2
                                        H     H  M     M  R    R   5     5   2
                                        H     H  M     M  R     R   55555   2222222
1                                    HEC PROBABLE MAXIMUM STORM (HMR52) INPUT DATA                                    PAGE   1

          LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

             1           ID   HMR52 PROBABLE MAXIMUM STORM CALCULATION FOR C43 WEST STORAGE RESERVOIR
             2           ID   ACCELER8 WEST STORAGE RESERVOIR as of 060308
             3           ID   This run performed by Graham Story CESAJ-EN-WM 060331
                         ** Acceler8 provided CADD file "C43 Baseline.dwg" representing the embankment
                         ** centerline which was used as follows:
                         ** Per definitions in Section 1.3 of HMR-52, the area within the embankment
                         ** centerline represents the "Drainage" used for development of the
                         ** "Drainage-averaged PMP" in this run.
 *** FREE ***

             4           BN  C43WSR
                         ** SCALE OF BOUNDARY COORDINATES IN MILES PER COORDINATE UNIT
             5           BS0.000189
                         ** BASIN BOUNDARY XY FL State Plane 83 East (feet)
                         ** Points entered Counter Clockwise.
                         ** The points in the BX BY cards for the WSR Drainage were visually picked off
                         ** the CADD drawing. Rounded corners in the CADD drawing were ignored.
```

```
          6          BX  475254      474360      474402      476835      482292      482372      492644      502651      502610
    504489
          7          BX  504472
          8          BY  860715      859812      850840      848490      848523      845940      845800      846114      851387
    851445
          9          BY  860914
                     **PREFERRED MAXIMUM STORM ORIENTATION FROM HMR 52 Figure 8
         10          HO     195
                     **DEPTH AREA DURATION DATA from HMR51
         11          HP      10    32.0    38.7    47.1    51.8    55.7
         12          HP     200    24.6    31.2    39.5    44.3    48.8
         13          HP    1000    18.2    24.9    33.2    37.7    41.3
         14          HP    5000    10.1    15.0    21.9    26.6    30.7
         15          HP   10000     7.6    11.8    17.6    22.5    26.5
         16          HP   20000     5.6     9.2    13.6    18.0    22.0
                     **STORM AREA AND ORIENTATION
                     ** Field 1 is the PMP Storm Pattern (sq-mi) per HMR-52 definition.
                     ** Field 2 is the PMP Storm Pattern orientation in degrees clockwise
                     ** from North.
                     ** If these fields are set to zero, program will optimize these
                     ** parameters to produce maximum precipitation.
         17          SA       0       0
                     **STORM CENTER COORDINATES
                     ** SC card for C43 basin run used 489015 853421 (user estimated WSR centroid).
                     ** In this reservoir only run, SC card is not used so that program will
                     ** find WSR reservoir centroid.
                     **TEMPORAL DISTRIBUTION OF THE PMS FOR INTERVALS LESS THAN 6 HRS
         18          ST      60    .270
                     **PLOT CONTROL OF DRAINAGE BASIN BOUNDARY AND PMS ISOHYETS
         19          PL       3
                     **WRITE PMS TO DSS
         20          ZW   A=C43WSR    B=RESERV   C=PRECIP-INC   D=30MAR2006   F=PMP
         21          ZZ
1****************************************                                    ****************************************
 *                                      *                                   *                                      *
 *    PROBABLE MAXIMUM STORM  (HMR52)   *                                   *    U.S. ARMY CORPS OF ENGINEERS      *
 *           NOVEMBER 1982              *                                   *  THE HYDROLOGIC ENGINEERING CENTER   *
 *          REVISED  APRIL 91           *                                   *         609 SECOND STREET            *
 *                                      *                                   *       DAVIS, CALIFORNIA 95616        *
 *  RUN DATE 03/31/2006    TIME 12:50:54 *                                   *  (916) 551-1748 OR (FTS) 460-1748    *
 *                                      *                                   *                                      *
 ****************************************                                    ****************************************
```

HMR52 PROBABLE MAXIMUM STORM CALCULATION FOR C43 WEST STORAGE RESERVOIR
ACCELER8 WEST STORAGE RESERVOIR as of 060308
This run performed by Graham Story CESAJ-EN-WM 060331

PMP DEPTHS FROM HMR 51

AREA (SQ. MI.)	DURATION 6-HR	12-HR	24-HR	48-HR	72-HR
10.	32.00	38.70	47.10	51.80	55.70
200.	24.60	31.20	39.50	44.30	48.80
1000.	18.20	24.90	33.20	37.70	41.30
5000.	10.10	15.00	21.90	26.60	30.70
10000.	7.60	11.80	17.60	22.50	26.50
20000.	5.60	9.20	13.60	18.00	22.00

STORM AREA	PMP DEPTHS FOR 6-HOUR INCREMENTS											
10.	31.75	7.63	3.94	2.68	2.03	1.63	1.37	1.18	1.03	.92	.83	.76
25.	30.02	7.58	3.95	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76
50.	28.59	7.52	3.96	2.71	2.06	1.66	1.39	1.20	1.05	.94	.85	.77
100.	26.49	7.45	3.97	2.73	2.08	1.68	1.41	1.21	1.07	.95	.86	.78
175.	24.78	7.40	3.98	2.74	2.09	1.69	1.42	1.22	1.08	.96	.87	.79
300.	22.75	7.48	3.95	2.70	2.06	1.66	1.39	1.20	1.05	.94	.85	.77
450.	21.12	7.55	3.92	2.67	2.02	1.63	1.37	1.17	1.03	.92	.83	.75
700.	19.36	7.63	3.88	2.62	1.98	1.60	1.34	1.15	1.01	.90	.81	.74
1000.	17.94	7.69	3.85	2.59	1.95	1.57	1.31	1.13	.99	.88	.79	.72
1500.	15.92	7.13	3.74	2.55	1.94	1.56	1.31	1.13	.99	.88	.80	.72
2150.	14.11	6.66	3.63	2.51	1.92	1.55	1.31	1.13	.99	.88	.80	.73
3000.	12.46	6.21	3.52	2.47	1.91	1.55	1.31	1.13	1.00	.89	.80	.73
4500.	10.44	5.65	3.38	2.42	1.89	1.55	1.31	1.14	1.01	.90	.82	.74
6500.	9.00	5.12	3.21	2.35	1.85	1.53	1.30	1.13	1.00	.90	.82	.75
10000.	7.50	4.48	2.98	2.23	1.79	1.49	1.28	1.12	1.00	.90	.82	.75
15000.	6.41	3.85	2.67	2.05	1.66	1.40	1.21	1.06	.95	.86	.78	.72
20000.	5.65	3.40	2.45	1.91	1.57	1.33	1.16	1.02	.92	.83	.76	.70

1

BOUNDARY COORDINATES FOR C43WSR

X	475254.0	474360.0	474402.0	476835.0	482292.0	482372.0	492644.0	502651.0	502610.0	504489.0
Y	860715.0	859812.0	850840.0	848490.0	848523.0	845940.0	845800.0	846114.0	851387.0	851445.0

X	504472.0
Y	860914.0

SCALE = .0002 MILES PER COORDINATE UNIT

BASIN AREA = 14.8 SQ. MI.

BASIN CENTROID COORDINATES, X = 489770.1, Y = 853805.7

1

1966

VARYING STORM AREA SIZE AND FIXED ORIENTATION

STORM AREA	ORIEN-TATION	BASIN-AVERAGED INCREMENTAL DEPTHS FOR 6-HR PERIODS												SUM OF DEPTHS FOR 3 PEAK 6-HR PERIODS
10.	272.	29.78	7.16	3.70	2.51	1.91	1.53	1.29	1.11	.97	.86	.78	.71	40.63
25.	272.	30.26	7.74	3.98	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76	41.98
50.	272.	29.96	7.87	4.01	2.71	2.06	1.66	1.39	1.20	1.05	.94	.85	.77	41.85
100.	272.	29.35	7.98	4.05	2.73	2.08	1.68	1.41	1.21	1.07	.95	.86	.78	41.38
175.	272.	29.15	8.08	4.08	2.74	2.09	1.69	1.42	1.22	1.08	.96	.87	.79	41.31
300.	272.	28.35	8.28	4.08	2.70	2.06	1.66	1.39	1.20	1.05	.94	.85	.77	40.70
450.	272.	27.36	8.41	4.03	2.64	2.01	1.62	1.35	1.16	1.02	.91	.82	.75	39.80
700.	272.	26.24	8.49	3.95	2.56	1.94	1.56	1.31	1.12	.98	.88	.79	.72	38.67
1000.	272.	25.42	8.52	3.86	2.49	1.88	1.51	1.26	1.08	.95	.84	.76	.69	37.81
1500.	272.	23.81	7.74	3.65	2.38	1.81	1.46	1.22	1.05	.92	.82	.74	.68	35.21
2150.	272.	22.05	7.04	3.42	2.25	1.72	1.39	1.17	1.01	.89	.79	.72	.65	32.51
3000.	272.	20.00	6.27	3.16	2.10	1.62	1.32	1.11	.96	.85	.76	.68	.62	29.44
4500.	272.	18.60	5.78	3.04	2.06	1.61	1.32	1.12	.97	.85	.77	.69	.63	27.42
6500.	272.	17.62	5.29	2.90	1.99	1.57	1.30	1.10	.96	.85	.76	.69	.63	25.81
10000.	272.	16.49	4.70	2.70	1.90	1.52	1.27	1.09	.95	.85	.76	.69	.64	23.89
15000.	272.	15.62	4.08	2.43	1.74	1.41	1.19	1.03	.90	.81	.73	.66	.61	22.13
20000.	272.	14.81	3.62	2.23	1.63	1.34	1.13	.98	.87	.78	.71	.65	.59	20.66

FIXED STORM AREA SIZE AND VARYING ORIENTATION

STORM AREA	ORIEN-TATION	BASIN-AVERAGED INCREMENTAL DEPTHS FOR 6-HR PERIODS												SUM OF DEPTHS FOR 3 PEAK 6-HR PERIODS
25.	140.	28.86	7.43	3.85	2.61	1.98	1.60	1.34	1.15	1.01	.90	.81	.74	40.13
25.	150.	28.42	7.34	3.80	2.58	1.96	1.58	1.32	1.14	1.00	.89	.80	.73	39.56
25.	160.	28.01	7.25	3.76	2.55	1.94	1.56	1.31	1.13	.99	.88	.80	.72	39.02
25.	170.	27.71	7.18	3.73	2.53	1.92	1.55	1.30	1.12	.98	.87	.79	.72	38.62
25.	180.	27.61	7.15	3.72	2.52	1.92	1.55	1.30	1.11	.98	.87	.79	.72	38.48
25.	190.	27.67	7.17	3.73	2.53	1.92	1.55	1.30	1.12	.98	.87	.79	.72	38.57
25.	200.	27.89	7.22	3.75	2.55	1.93	1.56	1.31	1.12	.99	.88	.79	.72	38.86
25.	210.	28.22	7.29	3.78	2.57	1.95	1.57	1.32	1.13	1.00	.89	.80	.73	39.30
25.	220.	28.66	7.39	3.83	2.60	1.97	1.59	1.33	1.15	1.01	.90	.81	.74	39.87
25.	230.	29.12	7.49	3.87	2.62	1.99	1.61	1.35	1.16	1.02	.91	.82	.74	40.48
25.	240.	29.56	7.59	3.91	2.65	2.01	1.62	1.36	1.17	1.03	.92	.83	.75	41.06
25.	250.	29.90	7.66	3.94	2.67	2.03	1.63	1.37	1.18	1.03	.92	.83	.76	41.51

25.	260.	30.16	7.72	3.97	2.68	2.04	1.64	1.38	1.19	1.04	.93	.84	.76	41.85
25.	270.	30.26	7.74	3.98	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76	41.98
25.	280.	30.21	7.73	3.97	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76	41.91
25.	290.	30.04	7.69	3.96	2.68	2.03	1.64	1.37	1.18	1.04	.92	.83	.76	41.69
25.	300.	29.72	7.62	3.93	2.66	2.02	1.63	1.36	1.17	1.03	.92	.83	.75	41.27
25.	310.	29.31	7.53	3.89	2.64	2.00	1.61	1.35	1.16	1.02	.91	.82	.75	40.73
25.	265.	30.25	7.74	3.98	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76	41.96
25.	275.	30.25	7.74	3.98	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76	41.96

1

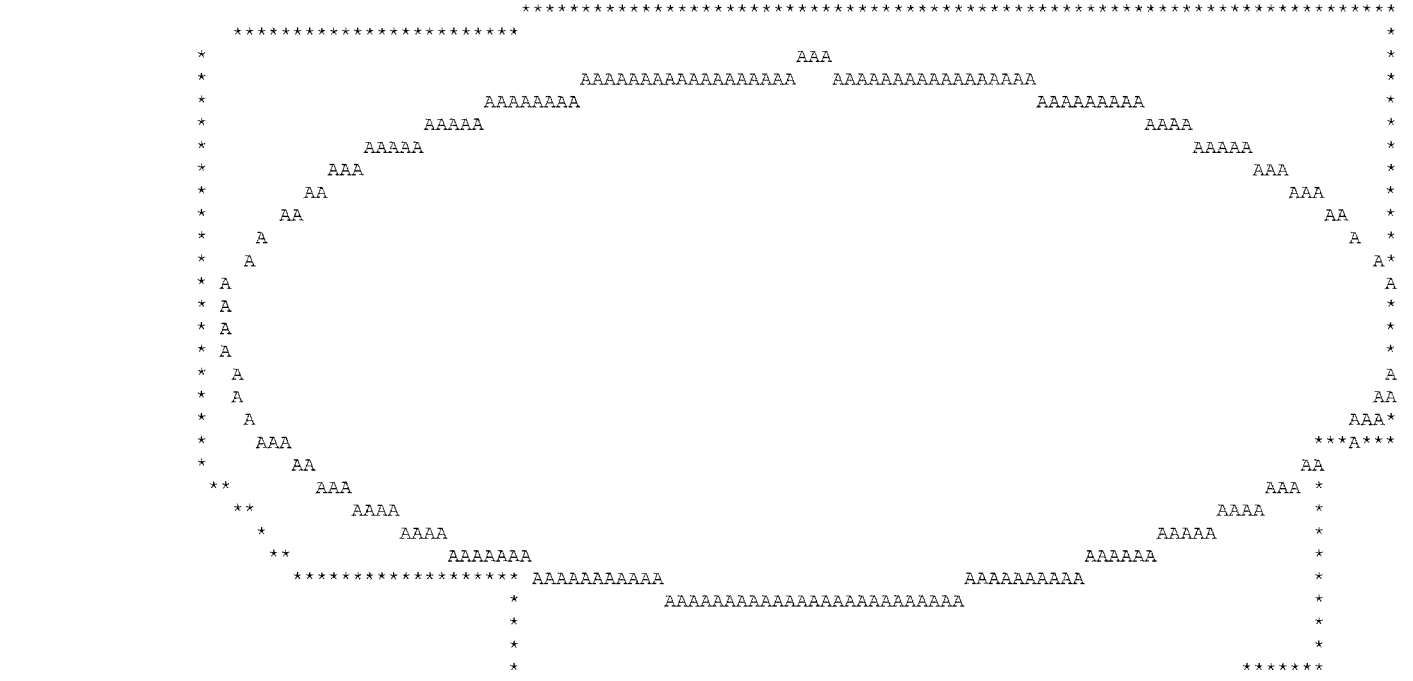
PROBABLE MAXIMUM STORM FOR C43WSR

STORM AREA = 25. SQ. MI., ORIENTATION = 270., PREFERRED ORIENTATION = 195.

STORM CENTER COORDINATES, X = 489770.1, Y = 853805.7

ISOHYET AREA (SQ.MI.)	AREA WITHIN BASIN (SQ.MI.)	DEPTHS (INCHES) FOR 6-HOUR INCREMENTS OF PMS 1	2	3	4	5	6	7	8	9	10	11	12
A 10.	10.	30.62	7.81	3.99	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76
B 25.	15.	28.52	7.43	3.91	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76
C 50.	15.	20.12	5.46	2.94	2.00	1.52	1.23	1.03	.89	.78	.69	.62	.57
D 100.	15.	15.61	4.47	2.39	1.63	1.24	1.00	.84	.72	.63	.56	.51	.46
E 175.	15.	12.91	3.64	1.92	1.31	.99	.80	.67	.58	.51	.45	.41	.37
F 300.	15.	10.21	2.96	1.58	1.08	.82	.66	.55	.48	.42	.37	.34	.31
G 450.	15.	8.41	2.46	1.34	.91	.69	.56	.47	.40	.35	.32	.28	.26
H 700.	15.	6.61	1.97	1.07	.73	.55	.44	.37	.32	.28	.25	.23	.21
I 1000.	15.	5.10	1.52	.85	.58	.44	.35	.30	.26	.22	.20	.18	.16
J 1500.	15.	3.60	1.17	.67	.46	.35	.28	.23	.20	.18	.16	.14	.13
K 2150.	15.	2.10	.80	.45	.31	.23	.19	.16	.14	.12	.11	.10	.09
L 3000.	15.	.90	.38	.20	.13	.10	.08	.07	.06	.05	.05	.04	.04
M 4500.	15.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
N 6500.	15.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
O 10000.	15.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
P 15000.	15.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Q 25000.	15.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
R 40000.	15.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
S 60000.	15.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AVERAGE DEPTH		30.26	7.74	3.98	2.69	2.04	1.65	1.38	1.19	1.04	.93	.84	.76

1



1970

1

TIME INTERVAL = 60. MINUTES
1-HR TO 6-HR RATIO FOR ISOHYET A AT 20000 SQ. MI. = .270

DEPTH VS. DURATION

ISOHYET	5MIN	10MIN	15MIN	30MIN	1-HR	2-HR	3-HR	6-HR	12-HR	18-HR	24-HR	30-HR	36-HR	42-HR	48-HR	54-HR	60-HR	66-HR	72-HR
A	1.67	3.35	5.00	9.63	15.53	20.04	23.61	30.62	38.43	42.42	45.11	47.16	48.80	50.18	51.37	52.42	53.34	54.18	54.95
B	1.55	3.11	4.64	8.94	14.42	18.63	21.95	28.52	35.95	39.86	42.55	44.60	46.24	47.62	48.81	49.86	50.78	51.62	52.39
C	.35	.71	1.06	2.13	4.24	8.36	12.17	20.12	25.57	28.52	30.52	32.04	33.27	34.30	35.18	35.96	36.65	37.28	37.85
D	.27	.55	.82	1.64	3.28	6.45	9.40	15.61	20.08	22.47	24.10	25.34	26.34	27.17	27.89	28.52	29.08	29.59	30.05
E	.23	.45	.68	1.36	2.71	5.34	7.79	12.91	16.55	18.46	19.77	20.76	21.56	22.23	22.81	23.31	23.76	24.17	24.54
F	.18	.36	.54	1.07	2.14	4.22	6.14	10.21	13.16	14.74	15.82	16.64	17.30	17.85	18.32	18.74	19.11	19.45	19.75
G	.15	.29	.44	.88	1.76	3.47	5.05	8.41	10.87	12.21	13.13	13.82	14.38	14.85	15.26	15.61	15.93	16.21	16.47
H	.12	.23	.35	.69	1.38	2.72	3.96	6.61	8.58	9.64	10.37	10.92	11.37	11.74	12.06	12.34	12.59	12.82	13.02
I	.09	.18	.27	.54	1.07	2.10	3.06	5.10	6.62	7.47	8.05	8.49	8.84	9.14	9.39	9.62	9.82	10.00	10.16
J	.06	.13	.19	.38	.75	1.47	2.14	3.60	4.78	5.45	5.91	6.25	6.53	6.77	6.97	7.15	7.31	7.45	7.58
K	.04	.07	.11	.22	.43	.84	1.23	2.10	2.90	3.35	3.66	3.90	4.09	4.24	4.38	4.50	4.61	4.70	4.79
L	.02	.03	.05	.09	.18	.36	.52	.90	1.28	1.48	1.61	1.71	1.80	1.87	1.92	1.98	2.02	2.07	2.10
M	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
N	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
O	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
P	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Q	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
R	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
S	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
AVERAGE	1.65	3.30	4.94	9.51	15.34	19.80	23.32	30.26	38.00	41.98	44.67	46.71	48.36	49.74	50.93	51.97	52.90	53.74	54.50

1

PROBABLE MAXIMUM STORM FOR C43WSR

DAY 1

TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL
0100	.13	.13	0700	.15	.92	1300	.20	1.89	1900	.27	3.16
0200	.13	.25	0800	.15	1.07	1400	.20	2.09	2000	.27	3.43
0300	.13	.38	0900	.15	1.23	1500	.20	2.29	2100	.27	3.70
0400	.13	.51	1000	.15	1.38	1600	.20	2.48	2200	.27	3.98
0500	.13	.64	1100	.15	1.54	1700	.20	2.68	2300	.27	4.25
0600	.13	.76	1200	.15	1.69	1800	.20	2.88	2400	.27	4.53
6-HR TOTAL	.76			.93			1.19			1.65	

DAY 2

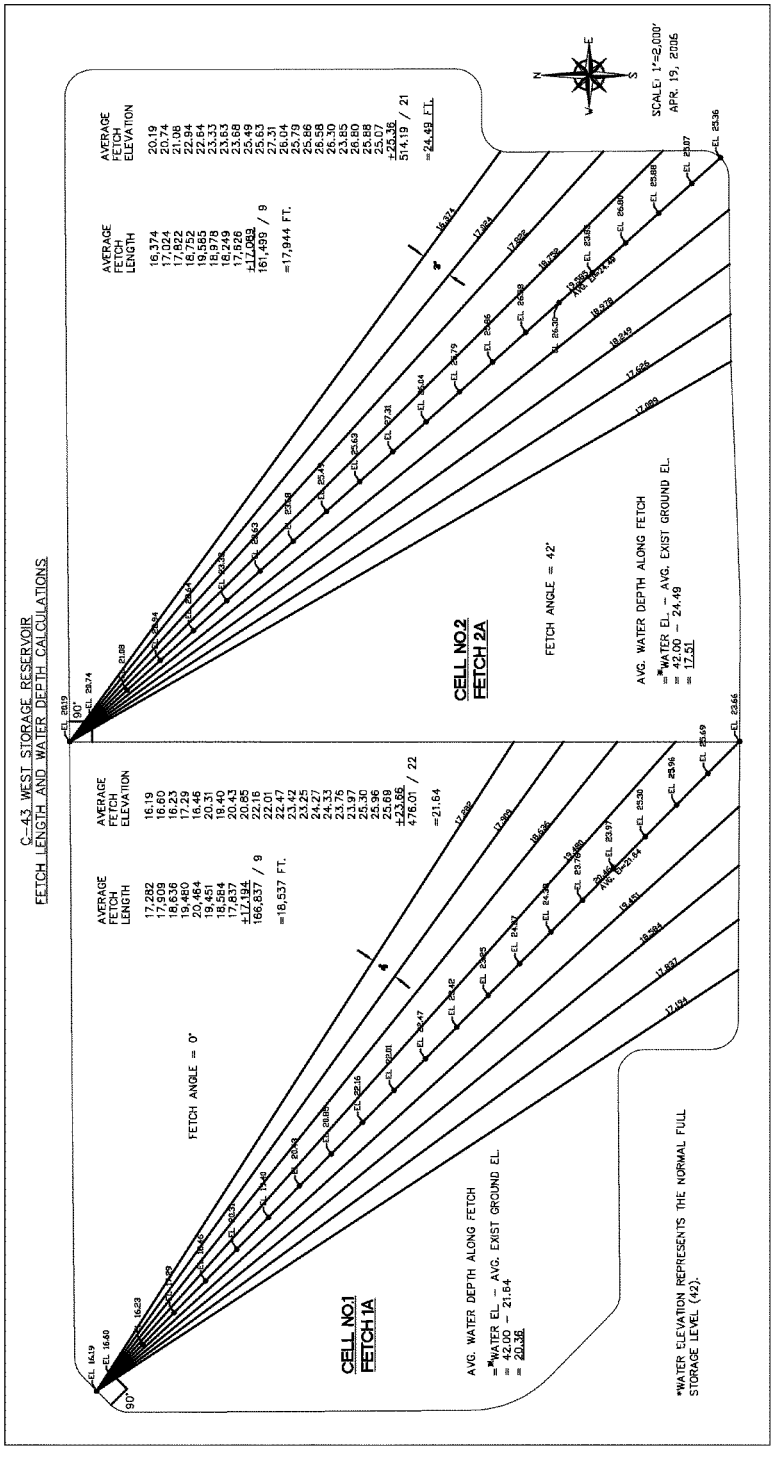
TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL
0100	.39	4.92	0700	.95	8.17	1300	1.91	16.87	1900	.83	46.05
0200	.41	5.33	0800	1.10	9.27	1400	2.67	19.55	2000	.74	46.79
0300	.43	5.76	0900	1.24	10.50	1500	4.46	24.01	2100	.67	47.47
0400	.46	6.22	1000	1.37	11.87	1600	15.34	39.35	2200	.62	48.08
0500	.48	6.70	1100	1.49	13.36	1700	3.53	42.87	2300	.57	48.66
0600	.52	7.22	1200	1.60	14.96	1800	2.35	45.22	2400	.54	49.20
6-HR TOTAL	2.69			7.74			30.26			3.98	

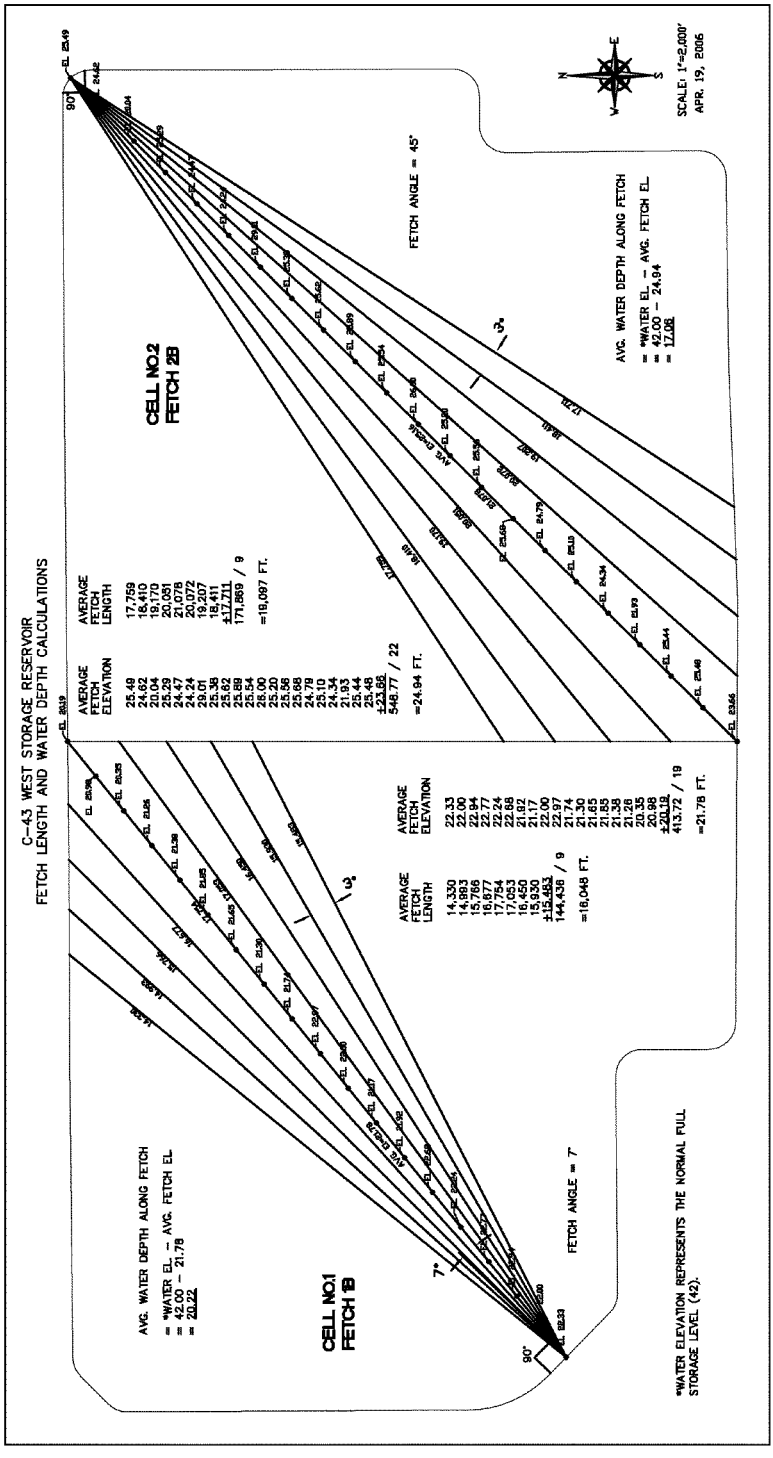
DAY 3

TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL	TIME	PRECIPITATION INCR	PRECIPITATION TOTAL
0100	.34	49.54	0700	.23	51.47	1300	.17	52.80	1900	.14	53.81
0200	.34	49.88	0800	.23	51.70	1400	.17	52.97	2000	.14	53.95
0300	.34	50.22	0900	.23	51.93	1500	.17	53.15	2100	.14	54.09
0400	.34	50.56	1000	.23	52.16	1600	.17	53.32	2200	.14	54.23
0500	.34	50.90	1100	.23	52.39	1700	.17	53.49	2300	.14	54.36
0600	.34	51.24	1200	.23	52.62	1800	.17	53.67	2400	.14	54.50
6-HR TOTAL	2.04			1.38			1.04			.84	

```
    -----DSS---ZOPEN:  New File Opened,  File: HMRDSS.DSS
                       Unit:  71;  DSS Version: 6-FO
 -----DSS---ZWRITE Unit  71; Vers.    1:  /C43WSR/RESERV/PRECIP-INC/01MAR2006/1HOUR/PMP/
 -----DSS---ZWRITE Unit  71; Vers.    1:  /C43WSR/RESERV/PRECIP-INC/01APR2006/1HOUR/PMP/
1
    -----DSS---ZCLOSE Unit:  71,   File: HMRDSS.DSS
              Pointer Utilization:   .25
              Number of Records:      2
              File Size:     17.0  Kbytes
              Percent Inactive:    .0
```

Appendix B: Fetch Length and Water Depth Calculations


C-43 WEST STORAGE RESERVOIR
FETCH LENGTH AND WATER DEPTH CALCULATIONS
CELL NO.1
FETCH 1A
CELL NO.2
FETCH 2A
FETCH ANGLE = 0°
FETCH ANGLE = 42°
AVG. WATER DEPTH ALONG FETCH
=*WATER EL. - AVG. EXIST GROUND EL.
= 42.00 - 21.64
= 20.36
AVG. WATER DEPTH ALONG FETCH
=*WATER EL. - AVG. EXIST GROUND EL.
= 42.00 - 24.49
= 17.51
*WATER ELEVATION REPRESENTS THE NORMAL FULL STORAGE LEVEL (42).
AVERAGE FETCH LENGTH
AVERAGE FETCH ELEVATION
166,837 / 9
=18,537 FT.
=21.64
161,499 / 9
=17,944 FT.
=24.49 FT.
SCALE: 1"=2,000'
APR. 19, 2005


C-43 WEST STORAGE RESERVOIR
FETCH LENGTH AND WATER DEPTH CALCULATIONS
CELL NO.2
FETCH 2B
CELL NO.1
FETCH 1B
AVERAGE FETCH ELEVATION
AVERAGE FETCH LENGTH
25.49 17,759
24.62 18,410
20.04 19,170
25.29 20,081
24.47 21,078
24.24 19,072
24.01 19,077
25.36 18,411
25.62 ±17,711
25.89 171,869 / 9
25.54
26.00 =19,097 FT.
25.20
25.56
25.85
24.79
25.10
24.34
21.93
25.44
25.48 ±23.86
546.77 / 22
=24.94 FT.
AVG. WATER DEPTH ALONG FETCH
= *WATER EL. – AVG. FETCH EL.
= 42.00 – 24.94
= 17.06
FETCH ANGLE = 45°
AVG. WATER DEPTH ALONG FETCH
= *WATER EL. – AVG. FETCH EL.
= 42.00 – 21.78
= 20.22
FETCH ANGLE = 7°
AVERAGE FETCH ELEVATION
AVERAGE FETCH LENGTH
22.33 14,330
22.00 14,893
22.94 15,766
22.77 16,877
22.24 17,754
22.64 17,053
21.82 16,450
21.17 15,930
22.00 ±15,483
22.97 144,436 / 9
21.74
21.30 =16,048 FT.
21.65
21.85
21.38
21.28
20.35
20.98 ±20.19
413.72 / 19
=21.78 FT.
*WATER ELEVATION REPRESENTS THE NORMAL FULL STORAGE LEVEL (42).
SCALE: 1"=2,000'
APR. 19, 2006

Appendix C: C-43 Manual Freeboard Calculations

Fetch 1A Analyses

Summary of Freeboard Analyses Case Scenarios Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1A)				
Freeboard Component	Case 1: PMP Combined with 100-Year Wind (ft)	Case 2: 100-Year Precip. Combined with Category 5 Winds (ft)	Case 3: Normal Full Storage Combined with Probable Max. Wind (ft)	Case 4: Hurricane Easy Storm Specific Wind and Precipitation (ft)
Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	0.77	0.00	3.77
Wind Setup =	1.03	1.86	3.21	1.03
Wave Height & Runup =	8.00	8.62	10.04	7.92
Waves Induced by Potential Landslides =	0.00	0.00	0.00	0.00
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	0.00	0.00	0.00
Minimum Required Freeboard =	**13.16**	**11.26**	**13.25**	**12.72**
Camber or Embankment Settlement =	1.24	1.06	1.24	1.24
Minimum Required Freeboard with Camber =	**14.4**	**12.3**	**14.5**	**14.0**

Notes:
Minimum Required Freeboard rounded up to the next 0.01 foot.
Minimum Required Freeboard with Camber rounded up to the next 0.1 foot.
Case 1 - Surcharge depth is based upon routing of design storm event(s) through the reservoir.
Case 2 - Surcharge depth is based upon routing of design storm event through the reservoir.
Case 3 - Case 3 is to be used only for "sensitivity identification" and not as a selected design condition (pg 14 of 25, DCM-2)
Case 4 - Surcharge depth is assumed to be equal to the total precipitation of Hurricane Easy (45.2").

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1A)

Step 1: Select 50-Yr, 3-Sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$

Project Location =	C-43 Cell No. 1 (Fetch 1A)		
50-yr, 3-sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(Fig. 6-1b, ASCE 7-02)*

Step 2: Determine 100-Yr, 3-Sec Gust Wind Speed, $U_{100\text{-}yr,3\text{-}sec}$

$U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(see Step 1)*
$U_{50\text{-}yr}$ to $U_{100\text{-}yr}$ Conversion Factor =	1.07		*(Table DCM 2-2, DCM-2)*
$U_{100\text{-}yr,3\text{-}sec} = U_{50\text{-}yr,3\text{-}sec}$ x Conversion Factor =	125.7	mph	

Step 3: Determine 100-Yr, 1-Hr Wind Speed, $U_{100\text{-}yr,1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
$U_t = U_{100\text{-}yr,\ 3\text{-}sec}$ =	125.73	mph	*(see Step 2)*
$U_{100\text{-}yr,\ 3600\text{-}sec} = U_{100\text{-}yr,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	83.3	mph	

Step 4: Determine 100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.51	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
$U_{100\text{-}yr,1\text{-}hr,land}$ =	83.3		*(see Step 3)*
$U_{100\text{-}yr,1\text{-}hr,water} = U_{100\text{-}yr,1\text{-}hr,land}$ x (U_{water}/U_{land}) =	100.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.51	miles	*(see Step 4)*
Wind Velocity (in mph), U =	100.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	54	min.	*(Eqn. 4, DCM-2)*
	3257	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3257	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	54	min.	*(see Step 5)*
100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$ =	100.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(see Step 6)*
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100\text{-}yr,1\text{-}hr,water}$ x U_t/U_{3600} =	100	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.51	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: $R_T = 1.0$	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Flg.3-14, SPM)* *(pg 3-30, SPM)*
$U_{100\text{-}yr,fetch\text{-}min,water}$ =	100	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{100\text{-}yr,fetch\text{-}min,water,\ stability\ adjusted} = U_{100\text{-}yr,fetch\text{-}min,water}$ x R_T =	100	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{100\text{-}yr,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	100	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	170	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	249	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Wind Setup and Wave Properties Analysis - Site C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	ft	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100-yr,fetch,over}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_s (ft/s) =	249	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.030282)U_s F^{1/2}$ = 9.67 feet *(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_s F)^{1/3}$ = 4.71 sec *(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12 T_o^2$ = 113 feet *(Eqn. 2-8b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

	24.49	feet	
Relative Depth = d/L_o =	0.216		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T *(Eqn. 3-40, SPM)*

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_s/g$
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_s^2)^{3/4}$ =	0.1619		
$B = 0.0379(gF/U_s^2)^{1/3}$ =	0.0806		
$C = \tanh(0.833(gd/U_s^2)^{3/4})$ =	0.1605		
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_s/g$ =	3.34	sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H *(Eqn. 3-39, SPM)*

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_s^2/g$
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_s^2)^{3/4}$ =	0.0200		
$B = 0.00563(gF/U_s^2)^{1/2}$ =	0.0175		
$C = \tanh(0.530(gd/U_s^2)^{3/4})$ =	0.0200		
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_s^2/g$ =	7.70	feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Zero Overwash Wave Height for Significant Wave Height

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.70	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, m/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{1/2} H_s$ =	5.44	feet	*(Eqn. 3-16, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-Ln(m/N)]^{1/2}$ =	10.65	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup.
Zeidler Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeidler Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{100-yr,over}$ =	100	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	24.49	feet	*(see Step 14)*
Zeidler Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	1.03	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0002244(F/d)^{1.25}(U^2/F_E)^{1.25(d/F)^{-0.375}}$ =	0.25	feet	*(Eqn. 7, DCM-2)*
Average of Zeidler Zee & Sibul: Wind Setup, $S = (S_{Zeidler\ Zee} + S_{Sibul})/2$ =	0.64	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Delta[(K_u F \Delta x)/(g d^2)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeidler Zee, Sibul, Average, Bretschneider)* =	Zeidler Zee		
Computed Wind Set-Up, S =	1.03	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_t = Effective Depth + Wind Set-Up = d + S = 25.52 feet *(pg. A6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_s = d_t$ =	25.52	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_s) = $d_s/1.28$ =	19.93	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_b (step 20) $\leq H^*$ (step 17) then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	10.65	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	24.49	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	113	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.216		
H/H'_o =	0.9221		*(Table C-1, SPM Vol II)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	19.93	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.65	feet	*(see Step 17)*
H/H'_o =	0.9221		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H'o = H/(H/H'o)$ =	11.55	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	11.55	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_t/H'_o

Water Depth at Toe of Structure, d_t =	25.52	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	11.55	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_t/H'_o =	2.21		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	feet	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100\text{-}yr,fetch\text{-}limit}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	249	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.03	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	11.55	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.71	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.21		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	11.55	feet	*(see Step 22)*
Gravitational Constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.71	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.016		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	2.21		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-12		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-11 with ds/H'o <= 2.21

$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
ds/H'o <=2.21 from Fig. 7-11 =	2		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.84		*(Fig. 7-11, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-12 with ds/H'o >= 2.21

$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
ds/H'o >=2.21 from Fig. 7-12 =	3.0		*(Fig. 7-12, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-12 =	1.04		*(Fig. 7-12, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	2.21		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.88		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.88		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	11.55		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	10.20	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-9 thru 7-12 or Figures 7-14 thru 7-19 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	10.20	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	11.42	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	11.42	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	8.00	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	0	degrees	
Angle Correction Factor =	1.00		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	8.00		*(see Step 30)*
Angle Correction Factor =	1.00		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	8.0	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	1.03	ft	*(see Step 18)*
Wave Height & Runup =	8.00	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	13.16	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.36	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	13.16	ft	*(see Step 33)*
Minimum Embankment Height (not including camber) =	33.52	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	13.16	ft	*(see Step 33)*
Embankment Settlement =	1.24	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	34.76	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	14.41	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1A)

Steps 1-3: Adjustments not necessary for Case 2

Project Location =	C-43 Cell No. 1 (Fetch 1A)		
Category 5, Duration Adjusted Wind Speed (1-hr average), $U_{Cat5,1-hr}$ =	125.0	mph	*(Table DCM 2-3, DCM-2)*

The Category 5 wind speed from Table DCM 2-3, DCM-2 corresponds to an over-water wind speed per DCM-2 page 10.

Step 4: Determine Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1-hr,water}$

Fetch Length (in miles), X =	3.51	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{Cat5,1-hr,land}$ =	-		*(see Step 3)*
$U_{Cat5,1-hr,water} = U_{Cat5,1-hr,land}$ x (U_{water}/U_{land}) =	125.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

	3.51	miles	*(see Step 4)*
Wind Velocity (in mph), U =	125.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	50	min.	*(Eqn. 4, DCM-2)*
	3019	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3019	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(4.5/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.002		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	50	min.	*(see Step 5)*
Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1-hr,water}$ =	125.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.002		*(see Step 6)*
Category 5, Fetch Limited Wind Speed Over Water = $U_{Cat5,1-hr,water}$ x U_t/U_{3600} =	125	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.51	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence	does not apply		*(Fig.3-14, SPM)*
of temperature information, assume RT = 1.1			*(pg 3-30, SPM)*
$U_{Cat5,fetch-min,water}$ =	125	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{Cat5,fetch-min,water,\ stability\ adjusted} = U_{Cat5,fetch-min,water}$ x R_T =	125	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{Cat5,fetch-min,water,\ stability\ adjusted} = U$ =	125	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	224	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = 1.467U_A (mph) =	329	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Wind Setup and Wave Properties Analysis - Site C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	ft	
Category 5, Fetch Limited Wind Speed Over Water = $U_{(Cat5,fetch-lim)}$ =	125	mph	*(see Step 7)*
Wind Stress Factor: U_* (ft/s) =	329	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_*F^{1/2}$ =	12.02	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_*F)^{1/3}$ =	5.16	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_o^2$ =	136	feet	*(Eqn. 3-8b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-8, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

	21.13	feet	
Relative Depth = d/L_o =	0.155		*(pg 2-8, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54\tanh(A)\tanh(B/C)\,U_*/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.833(gdU_*^{-2})^{0.375}$ =	0.1245		
$B = 0.0379(gF/U_*^2)^{1/3}$ =	0.6670		
$C = \tanh(0.833(gd/U_*^2)^{0.375})$ =	0.1239		
Shallow-Water Wave Period, $T = 7.54\tanh(A)\tanh(B/C)\,U_*/g$ =	4.71	sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283\tanh(A)\tanh(B/C)\,U_*^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.530(gdU_*^{-2})^{0.75}$ =	0.0118		
$B = 0.00565(gF/U_*^2)^{0.5}$ =	0.0133		
$C = \tanh(0.530(gd/U_*^2)^{0.75})$ =	0.0118		
Shallow-Water Significant Wave Height, $H = 0.283\tanh(A)\tanh(B/C)\,U_*^2/g$ =	9.09	feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	9.09	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2}H_s$ =	6.43	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-\ln(n/N)]^{1/2}$ =	12.57	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup.
Zeidler Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<15 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeidler Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{(Cat5,fetch-lim)}$ =	125	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	21.13	feet	*(see Step 14)*
Zeidler Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	1.86	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s^2): $S = 0.0006244d(F/d)^{1.65}(U^2/Fg)^{1.65F^{0.07}/d^{0.07}}$ =	0.50	feet	*(Eqn. 7, DCM-2)*
Average of Zeidler Zee & Sibul: Wind Setup, $S = (S_{Zeidler\ Zee} + S_{Sibul})/2$ =	1.18	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Delta[(kU^2\Delta x)/(gd^2)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeidler Zee, Sibul, Average, Bretschneider)* =	Zeidler Zee		
Computed Wind Set-Up, S =	1.86	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S =	22.99	feet	*(pg. A6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of Interest is at Toe of Structure, $d_s = d_s$ =	22.99	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_s) = (d_s/1.28) =	17.96	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_s [step 20] $\leq H^*$ [step 17] then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	12.57	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/H'o (shallow water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	21.13	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	136	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.155		
H/H'_o =	0.9131		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Breaking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	17.96	feet	*(see Step 20)*
Significant Wave Height, H_s =	12.57	feet	*(see Step 17)*
H/H'_o =	0.9131		*(see Step 21)*
If Shallow-Water, Equivalent Deep-Water Wave Height, $H'o = H/(H/H'o)$ =	13.77	feet	
If Deep Water, Equivalent Deep Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking, Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	13.77	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H'_o

Water Depth at Toe of Structure, d_s =	22.99	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	13.77	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.67		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00b*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	feet	
Category 5, Fetch Limited Wind Speed Over Water = $U_{CAT5,fetch-ltd}$ =	125	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	329	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.86	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	13.77	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	5.16	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.67		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	13.77	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	5.16	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.016		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.67	*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
Face Slope Material =	Stop-Faced Slope	*Embankment Design*
Runup Face Slope (H:1V) =	3	*Embankment Design*
Runup Face Slope (Θ) =	18.4 degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10	*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11	*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.67

$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
ds/H'o <=1.67 from Fig. 7-10 =	0.6	*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.69	*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.67

$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
ds/H'o >=1.67 from Fig. 7-11 =	2.0	*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.84	*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.67	*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.80	*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.80	*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	13.77	*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	11.00 feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-16 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	11.00	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-13 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	12.32	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Stop-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	12.32	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	8.62	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	0	degrees	
Angle Correction Factor =	1.00		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	8.62		*(see Step 30)*
Angle Correction Factor =	1.00		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	8.6	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	0.77	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	1.86	ft	*(see Step 18)*
Wave Height & Runup =	8.62	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	11.26	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.36	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	11.26	ft	*(see Step 33)*
Minimum Embankment Height (not including camber) =	31.62	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	11.26	ft	*(see Step 33)*
Embankment Settlement =	1.06	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	32.68	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	12.32	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1A)

Steps 1-2: Not necessary for Case 3

Project Location =	C-43 Cell No. 1 (Fetch 1A)		
Probable Maximum Wind (PMW) Speed, $U_{PMW,60\text{-}sec,water}$ =	200.0	mph	*(pg 13, DCM-2)*

For Case 3, the 200 mph assumed PMW corresponds to an over-water 1-minute average wind speed. *(pg 13, DCM-2)*

Step 3: Determine PMW, 1-Hr Wind Speed, $U_{PMW,1\text{-}hr}$

Initial wind speed duration, t =	60	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
U_t/U_{3600} =	1.24		*(Eqn. 1, DCM-2)*
$U_t = U_{PMW,60\text{-}sec}$ =	200.00	mph	*(see Step 2)*
$U_{PMW,3600\text{-}sec} = U_{PMW,1\text{-}hr} = U_t/(U_t/U_{3600})$ =	160.8	mph	

Step 4: Determine PMW, 1-Hr Wind Speed Over Water, $U_{PMW,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.51	miles	

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{PMW,1\text{-}hr,land}$ =	-		*(see Step 3)*
$U_{PMW,1\text{-}hr,water} = U_{PMW,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	160.8	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =			
Wind Velocity (in mph), U =	160.8	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	46	min.	*(Eqn. 4, DCM-2)*
	2771	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2771	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.004		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	46	min.	*(see Step 5)*
PMW, 1-Hr Wind Speed Over Water, $U_{PMW,1\text{-}hr,water}$ =	160.8	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.004		*(see Step 6)*
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW,1\text{-}hr,water} \times U_t/U_{3600}$ =	161	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.51	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{PMW,1\text{-}min,water}$ =	161	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U_{PMW,fetch\text{-}min,water} \times R_T$ =	161	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	161	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	306	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	449	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Wind Setup and Wave Properties Analysis - Sta C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	(see Step 5)
Fetch Length, F =	18,537	ft	
PMW, Fetch Limited Wind Speed Over Water = $U_{(F)(2)(3)(1.43)}$ =	161	mph	(see Step 7)
Wind Stress Factor, U_A (ft/s) =	449	ft/s	(see Step 10)

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, H_{mo} = (0.000282)$U_A F^{1/2}$ =	17.23	feet	(Eqn. 3-33c, SPM)

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, T_o = 0.02825$(U_A F)^{1/2}$ =	5.72	sec	(Eqn. 3-34c, SPM)

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, L_o = 5.12T_o^2 =	168	feet	(Eqn. 2-8b, SPM)

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. (pg 2-9, SPM)
If $d/L_o > 0.5$, waves are classified as deep water. (pg 2-9, SPM)

	20.38	feet	
Relative Depth = d/L_o =	0.121		(pg 2-9, SPM)
Wave Classification =	Transitional/Shallow-Water		(pg 2-9, SPM)

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, T = 7.54 tanh(A) tanh(B/C) U_A/g (Eqn. 3-40, SPM)

where: F = Fetch Length (ft) (step 5) U_A = Wind Stress Factor (step 10) g = 32.2 ft/s^2

A = 0.493$(gd/U_A^2)^{0.75}$ =	0.0072		
B = 0.0379$(gF/U_A^2)^{0.75}$ =	0.0544		
C = tanh(0.833$(gd/U_A^2)^{0.375}$) =	0.0969		
Shallow-Water Wave Period, T = 7.54 tanh(A) tanh(B/C) U_A/g =	5.19	sec	(Eqn. 3-40, SPM)

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, H = 0.283 tanh(A) tanh(B/C) U_A^2/g (Eqn. 3-39, SPM)

where: F = Fetch Length (ft) (step 5) U_A = Wind Stress Factor (step 10) g = 32.2 ft/s^2

A = 0.530$(gd/U_A^2)^{0.75}$ =	0.0072		
B = 0.00565$(gF/U_A^2)^{0.5}$ =	0.0097		
C = tanh(0.530$(gd/U_A^2)^{0.375}$) =	0.0072		
Shallow-Water Significant Wave Height, H =0.283 tanh(A) tanh(B/C) U_A^2/g =	11.17	feet	(Eqn. 3-39, SPM)

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	11.17	feet	(see Step 11 or 16)
Required probability of wave height being exceeded, n/N =	0.02		(see Step 17 discussion)
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2} H_s$ =	7.90	feet	(Eqn. 3-10, SPM)
Wave Height which is exceeded at given probability, $H^* = H_{rms} [-\ln(n/N)]^{1/2}$ =	15.44	feet	(Eqn. 3-7, SPM)

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.51	miles	(see Step 5)
Fetch Length, F =	18,537	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{(F)(2)(3)(1.43)}$ =	161	mph	(pg A6, DCM-2)(see Step 7)
Average Depth of Water along Fetch Line, D = Effective Depth =	20.38	feet	(see Step 14)
Zeider Zee Eqn: [Note: F=miles]: Wind Set-Up, S = $U^2F/(1400D)$ =	3.21	feet	(Eqn. 5, DCM-2)
Sibul Eqn (Note: Fetch, g=32.2 ft/s^2): S = $0.0000244d(F/d)^{0.67}(U^2/Fg)^{1/(2(0.67)-1.0)}$ =	0.96	feet	(Eqn. 7, DCM-2)
Average of Zeider Zee & Sibul: Wind Setup, S = $(S_{Zeider\ Zee} + S_{Sibul})/2$ =	2.09	feet	
Bretschneider Eqn [Note, Calcs provided separately in Step 18a]: S = $\Sigma^2[(kU^2/x)/(gd^2)]$ =	n/a	feet	(Eqn. 6, DCM-2)(Step 18a)
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	3.21	feet	(Eqn. 5, DCM-2)

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S =	23.57	feet	(pg. A6, DCM-2)

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. (pg. 15-4, EM-1110-2-1420)

Depth of interest is at Toe of Structure, $d_i = d_s$ =	23.57	feet	(see Step 19)
Wave Breaking Height, H_b (for depth d_b) = (d_b/1.28) =	18.41	feet	(Eqn. 2-91 & 3-50, SPM)
Is max wave height limited by breaking? (If H_s (step 20) $\leq H^*$ (step 17) then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_s (step 20)) Maximum Wave Height =	15.44	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	20.38	feet	(see Step 14)
Deep-Water Wave Length, L_o =	168	feet	(see Step 13)
Ratio of effective depth to deep-water wave length, d/L_o =	0.121		
H/H'_o =	0.9200		(Table C-1, SPM Vol 2)

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	18.41	feet	(see Step 20)
Significant Wave Height, H_s =	15.44	feet	(see Step 17)
H/H'_o =	0.9200		(see Step 21)
If Shallow-Water: Equivalent Deep-Water Wave Height, H'o = H/(H/H'o) =	16.79	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a		
Equivalent Deep-Water Wave Height =	16.79	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H'_o

Water Depth at Toe of Structure, d_s =	23.57	feet	(see Step 19)
Equivalent Deep-Water Wave Height, H'_o =	16.79	feet	(see Step 22)
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.40		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual, Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	*(see Step 5)*
Fetch Length, F =	18,537	feet	
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW,fetch-min}$ =	161	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	449	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	3.21	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	16.79	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	5.72	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.40		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	16.79	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	5.72	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.016		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.40		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.4

$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
ds/H'o <=1.4 from Fig. 7-10 =	0.6		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.69		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.4

$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
ds/H'o >=1.4 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.84		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.40		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.77		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.77		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	16.79		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	12.80	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	12.80	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	14.34	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	14.34	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	10.04	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	0	degrees	
Angle Correction Factor =	1.00		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	10.04		*(see Step 30)*
Angle Correction Factor =	1.00		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	10.0	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routad Flood Event) =	0.00	ft	*(no surcharge, normal full storage level elevation assumed)*
Wind Setup =	3.21	ft	*(see Step 18)*
Wave Height & Runup =	10.04	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	13.25	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.36	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	13.25	ft	*(see Step 33)*
Minimum Embankment Height (not including camber) =	33.61	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	13.25	ft	*(see Step 33)*
Embankment Settlement =	1.24	ft	*(see Technical Memorandum Table 3 or BODR Section 8E.)*
Minimum Embankment Height (with camber) =	34.85	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	14.50	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1A)

Step 1-2: Select EASY, 3-Sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$

Project Location =	C-43 Cell No. 1 (Fetch 1A)		
EASY, 3-sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$ =	125.0	mph	*(pg. 14, DCM-2)*

The Hurricane Easy, 125 mph, 3-sec gust wind speed is a storm specific case. Therefore, it is assumed that the Step 2 conversion factor adjustment is not relevant for this case.

Step 3: Determine EASY, 1-Hr Wind Speed, $U_{EASY,1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
	$U_t = U_{EASY,3\text{-}sec}$ =	125.0	mph	*(see Step 2)*
	$U_{EASY,3600\text{-}sec} = U_{EASY,1\text{-}hr} = U_t/(U_t/U_{3600})$ =	82.8	mph	

Step 4: Determine EASY, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.51	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)		does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles:	U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles:	See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
	U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
	$U_{Easy,1\text{-}hr,land}$ =	82.8		*(see Step 3)*
	$U_{EASY,1\text{-}hr,water} = U_{EASY,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	99.4	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.51	miles	*(see Step 4)*
Wind Velocity (in mph), U =	99.4	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	54	min.	*(Eqn. 4, DCM-2)*
	3264	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3264	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	54	min.	*(see Step 5)*
EASY-Yr, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$ =	99.4	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(see Step 6)*
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,1\text{-}hr,water} \times U_t/U_{3600}$ =	99	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.51	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles:	R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles:	Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
	$U_{EASY,fetch\text{-}min,water}$ =	99	mph	*(see Step 7)*
	Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
	$U_{EASY,fetch\text{-}min,water,\ stability\ adjusted} = U_{EASY,fetch\text{-}min,water} \times R_T$ =	99	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{EASY,Fetch\text{-}min,water,\ stability\ adjusted} = U$ =	99	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	169	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	248	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Wind Setup and Wave Properties Analysis - Site C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	ft	
EASY, Fetch Limited Wind Speed Over Water = $U_{(x)=U_{(10)}/R_L}$ =	99	mph	*(see Step 7)*
Wind Stress Factor, U_f, (ft/s) =	248	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.0002821)U_f F^{1/2}$ = 9.61 feet *(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_f F)^{1/3}$ = 4.69 sec *(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_o^2$ = 113 feet *(Eqn. 2-4b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

	24.13	feet	
Relative Depth = d/L_o =	0.214		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_f/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_f = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_f^2)^{3/4}$ =	0.1619	
$B = 0.0379(gF/U_f^2)^{1/3}$ =	0.0809	
$C = \tanh(0.893(gd/U_f^2)^{3/4})$ =	0.1605	
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_f/g$ =	4.33 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_f^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_f = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_f^2)^{3/4}$ =	0.0200	
$B = 0.00565(gF/U_f^2)^{1/2}$ =	0.0176	
$C = \tanh(0.530(gd/U_f^2)^{3/4})$ =	0.0200	
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_f^2/g$ =	7.62 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.62	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{1/2}H_s$ =	5.39	feet	*(Eqn. 3-16, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-\ln(n/N)]^{1/2}$ =	10.54	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup.
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{(x)=U_{(10)}/R_L}$ =	99	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	24.12666667	feet	*(see Step 14)*
Zeider Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	1.03	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0002244(F/d)^{1.06}(U^2F/g)^{0.25(F/d)^{-0.075}}$ =	0.25	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	0.64	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = 2.5[(kU^2/x)(gd^2)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	1.03	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_t = Effective Depth + Wind Set-Up = d + S = 25.16 feet *(pg. A6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_s = d_t$ =	25.16	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_s) = $(d_s/1.28)$ =	19.65	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_b (step 20) $\leq H^*$ (step 17) then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	10.54	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/H'o (shallow-water wave height/equivalent deep water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	24.12666667	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	113	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.214		
H/H'_o =	0.9215		*(Table C-1, SPM Vol II)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	19.65	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.54	feet	*(see Step 17)*
H/H'_o =	0.9215		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H'o = H/(H/H'o)$ =	11.44	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	11.44	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_t/H'_o

Water Depth at Toe of Structure, d_t =	25.16	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	11.44	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_t/H'_o =	2.20		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*. U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.51	miles	*(see Step 4)*
Fetch Length, F =	18,537	feet	
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,fetchmin}$ =	99	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	248	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.03	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	11.44	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.69	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.20		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	11.44	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.69	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.016		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	2.20		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-12		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-11 with ds/H'o <= 2.2

$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
ds/H'o <=2.2 from Fig. 7-11 =	2		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.84		*(Fig. 7-11, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-12 with ds/H'o >= 2.2

$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
ds/H'o >=2.2 from Fig. 7-12 =	3.0		*(Fig. 7-12, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-12 =	1.04		*(Fig. 7-12, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	2.20		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.88		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.88		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	11.44		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	10.10	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	10.10	feet	*(see Step 26)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	11.31	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	11.31	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.92	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	0	degrees	
Angle Correction Factor =	1.00		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.92		*(see Step 30)*
Angle Correction Factor =	1.00		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.9	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	3.77	ft	*(conservatively assumed to be total EASY precipitation of 45.2")*
Wind Setup =	1.03	ft	*(see Step 18)*
Wave Height & Runup =	7.92	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	12.72	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.36	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	12.72	ft	*(see Step 33)*
Minimum Embankment Height (not including camber) =	33.08	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	12.72	ft	*(see Step 33)*
Embankment Settlement =	1.24	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	34.32	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	13.97	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

Fetch 1B Analyses

Summary of Freeboard Analyses Case Scenarios Site C-43: Cell 1 (Fetch 1B)				
Freeboard Component	Case 1: PMP Combined with 100-Year Wind (ft)	Case 2: 100-Year Precip. Combined with Category 5 Winds (ft)	Case 3: Normal Full Storage Combined with Probable Max. Wind (ft)	Case 4: Hurricane Easy Storm Specific Wind and Precipitation (ft)
Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	0.77	0.00	3.77
Wind Setup =	0.90	1.63	2.81	0.90
Wave Height & Runup =	7.15	7.61	8.91	7.07
Waves Induced by Potential Landslides =	0.00	0.00	0.00	0.00
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	0.00	0.00	0.00
Minimum Required Freeboard =	**12.18**	**10.01**	**11.72**	**11.74**
Camber or Embankment Settlement =	1.15	0.96	1.06	1.15
Minimum Required Freeboard with Camber =	**13.3**	**11.0**	**12.8**	**12.9**

Notes:
Minimum Required Freeboard rounded up to the next 0.01 foot.
Minimum Required Freeboard with Camber rounded up to the next 0.1 foot.
Case 1 - Surcharge depth is based upon routing of design storm event(s) through the reservoir.
Case 2 - Surcharge depth is based upon routing of design storm event through the reservoir.
Case 3 - Case 3 is to be used only for "sensitivity identification" and not as a selected design condition (pg 14 of 25, DCM-2)
Case 4 - Surcharge depth is assumed to be equal to the total precipitation of Hurricane Easy (45.2").

1997

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1B)

Step 1: Select 50-Yr, 3-Sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$

Project Location =	C-43 Cell No. 1 (Fetch 1B)		
50-yr, 3-sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(Fig. 6-1b, ASCE 7-02)*

Step 2: Determine 100-Yr, 3-Sec Gust Wind Speed, $U_{100\text{-}yr,3\text{-}sec}$

$U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(see Step 1)*
$U_{50\text{-}yr}$ to $U_{100\text{-}yr}$ Conversion Factor =	1.07		*(Table DCM 2-2, DCM-2)*
$U_{100\text{-}yr,3\text{-}sec} = U_{50\text{-}yr,3\text{-}sec}$ x Conversion Factor =	125.7	mph	

Step 3: Determine 100-Yr, 1-Hr Wind Speed, $U_{100\text{-}yr,1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
$U_t = U_{100\text{-}yr,\ 3\text{-}sec}$ =	125.73	mph	*(see Step 2)*
$U_{100\text{-}yr,\ 3600\text{-}sec} = U_{100\text{-}yr,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	83.3	mph	

Step 4: Determine 100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.04	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
$U_{100\text{-}yr,1\text{-}hr,land}$ =	83.3		*(see Step 3)*
$U_{100\text{-}yr,1\text{-}hr,water} = U_{100\text{-}yr,1\text{-}hr,land}$ x (U_{water}/U_{land}) =	100.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.04	miles	*(see Step 4)*
Wind Velocity (in mph), U =	100.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	49	min.	*(Eqn. 4, DCM-2)*
	2957	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2957	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	49	min.	*(see Step 5)*
100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$ =	100.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(see Step 6)*
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100\text{-}yr,1\text{-}hr,water}$ x U_t/U_{3600} =	100	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.04	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, $\Delta T_{as} = T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{100\text{-}yr,fetch\text{-}min,water}$ =	100	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{100\text{-}yr,fetch\text{-}min,water,\ stability\ adjusted} = U_{100\text{-}yr,fetch\text{-}min,water}$ x R_T =	100	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{100\text{-}yr,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	100	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	170	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = 1.467U_A (mph) =	250	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Wind Setup and Wave Properties Analysis - Site C-43: Cell 1 (Fetch 1B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	ft	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100yr,fetch,over}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_s (ft/s) =	259	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_s F^{1/2}$ =	8.62	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_s F)^{1/2}$ =	4.48	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_o^2$ =	103	feet	*(Eqn. 3-6b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

Effective Depth, d =	24.35	feet	
Relative Depth = d/L_o =	0.236		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54\tanh(A)\tanh(B/C)\,U_s/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_s^2)^{3/4}$ =	0.1614	
$B = 0.037(gF/U_s^2)^{1/3}$ =	0.0767	
$C = \tanh(0.833(gd/U_s^2)^{3/4})$ =	0.1600	
Shallow-Water Wave Period, $T = 7.54\tanh(A)\tanh(B/C)\,U_s/g$ =	4.17 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283\tanh(A)\tanh(B/C)\,U_s^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_s^2)^{3/4}$ =	0.0139	
$B = 0.00565(gF/U_s^2)^{1/2}$ =	0.0163	
$C = \tanh(0.530(gd/U_s^2)^{3/4})$ =	0.0139	
Shallow-Water Significant Wave Height, $H = 0.283\tanh(A)\tanh(B/C)\,U_s^2/g$ =	7.35 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Zero Overwash Wave Height for Significant Wave Height

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero-overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.35	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2}H_s$ =	5.20	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-\ln(n/N)]^{1/2}$ =	10.16	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup.
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn. Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{100yr,over}$ =	100	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	24.35	feet	*(see Step 14)*
Zeider Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	0.90	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0000244(F/d)^{1.25}(U^2/g)^{2.5(F/d)^{-0.375}}$ =	0.23	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	0.56	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Sigma[(KU^2Lx)/(gd^2)]$ =	n/a	feet	*(Eqn. 8, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	0.90	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S =	25.25	feet	*(pg. A6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_s = d_s$ =	25.25	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_s) = $(d_s/1.28)$ =	19.72	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_s [step 20] $\leq H^*$ [step 17] then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	10.16	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow water wave height/equivalent deep water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	24.35	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	103	feet	*(see Step 12)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.236		
H/H^*_o =	0.9279		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H^*_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	19.72	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.16	feet	*(see Step 17)*
H/H^*_o =	0.9279		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H^*o = H/(H/H^*o)$ =	10.95	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	10.95	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H^*_o

Water Depth at Toe of Structure, d_s =	25.25	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H^*_o =	10.95	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H^*_o =	2.30		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.06g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2009.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	feet	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{(100\text{-}yr,fetch\text{-}ltd)}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	250	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	0.90	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	10.95	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.49	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.30		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	10.95	feet	*(see Step 22)*
Gravitational Constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.49	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.017		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	2.30		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-12		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-11 with ds/H'o <= 2.3

$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
ds/H'o <=2.3 from Fig. 7-11 =	2		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.78		*(Fig. 7-11, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-12 with ds/H'o >= 2.3

$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
ds/H'o >=2.3 from Fig. 7-12 =	3.0		*(Fig. 7-12, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-12 =	1.00		*(Fig. 7-12, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	2.30		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.85		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.85		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	10.95		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	9.30	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	9.30	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	10.42	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	10.42	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.29	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	7	degrees	
Angle Correction Factor =	0.98		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.29		*(see Step 30)*
Angle Correction Factor =	0.98		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.1	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	0.90	ft	*(see Step 18)*
Wave Height & Runup =	7.15	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	12.18	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.22	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	12.18	ft	*(see Step 33)*
Embankment Height (not including camber) =	32.40	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	12.18	ft	*(see Step 33)*
Embankment Settlement =	1.15	ft	*(see Technical Memorandum Table 3 or BODR Section 8E.)*
Minimum Embankment Height (with camber) =	33.55	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	13.33	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1B)

Steps 1-3: Adjustments not necessary for Case 2

Project Location =	C-43 Cell No. 1 (Fetch 1B)		
Category 5, Duration Adjusted Wind Speed (1-hr average), $U_{Cat5,1\text{-}hr}$ =	125.0	mph	*(Table DCM 2-3, DCM-2)*

The Category 5 wind speed from Table DCM 2-3, DCM-2 corresponds to an over-water wind speed per DCM-2 page 10.

Step 4: Determine Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.04	miles	
Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:			
If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{Cat5,1\text{-}hr,land}$ =	-		*(see Step 3)*
$U_{Cat5,1\text{-}hr,water} = U_{Cat5,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	125.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.04	miles	*(see Step 4)*
Wind Velocity (in mph), U =	125.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{2.67}/U^{0.34})$ =	46	min.	*(Eqn. 4, DCM-2)*
	2741	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2741	sec.	*(see Step 5)*
Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}			
For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.004		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	46	min.	*(see Step 5)*
Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1\text{-}hr,water}$ =	125.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.004		*(see Step 6)*
Category 5, Fetch Limited Wind Speed Over Water = $U_{Cat5,1\text{-}hr,water} \times U_t/U_{3600}$ =	125	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.04	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	
Stability Correction Factor, R_T			
For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as} See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{Cat5,fetch\text{-}min,water}$ =	125	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{Cat5,fetch\text{-}min,water,\ stability\ adjusted} = U_{Cat5,fetch\text{-}min,water} \times R_T$ =	125	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{Cat5,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	125	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	225	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	329	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Wind Setup and Wave Properties Analysis - Site C-43; Cell 1 (Fetch 18)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	ft	
Category 5, Fetch Limited Wind Speed Over Water = $U_{(F=5,fetch,over)}$ =	125	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	329	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, H_{mo} = (0.000282)$U_*F^{1/2}$ =	11.77	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, T_o = 0.02825$(U_*F)^{1/2}$ =	4.92	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, L_o = 5.12T_o^2 =	124	feet	*(Eqn. 2-6b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

Effective Depth, d =	20.99	feet	
Relative Depth = d/L_o =	0.169		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, T = 7.54 tanh(A) tanh(B/C) U_*/g *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

A = 0.833$(gd/U_*^2)^{3/4}$ =	0.1240		
B = 0.0379$(gF/U_*^2)^{1/3}$ =	0.0630		
C = tanh(0.833$(gd/U_*^2)^{3/4}$] =	0.1234		
Shallow-Water Wave Period, T = 7.54 tanh(A) tanh(B/C) U_*/g =	4.82	sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, H = 0.283 tanh(A) tanh(B/C) U_*^2/g *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

A = 0.530$(gd/U_*^2)^{3/4}$ =	0.0118		
B = 0.00565$(gF/U_*^2)^{1/2}$ =	0.0123		
C = tanh(0.530$(gd/U_*^2)^{3/4}$] =	0.0118		
Shallow-Water Significant Wave Height, H = 0.283 tanh(A) tanh(B/C) U_*^2/g =	0.76	feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height
Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	0.76	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2}H_s$ =	0.19	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-Ln(n/N)]^{1/2}$ =	12.11	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup:
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{(F=5,over)}$ =	125	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	20.99	feet	*(see Step 14)*
Zeider Zee Eqn: (Note: F=miles): Wind Set-Up, S = $U^2F/(1400D)$ =	1.63	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): S = $0.0000244d(F/d)^{1.45}(U^2/g)^{(2.02F/d^{0.23})}$ =	0.45	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, S = $(S_{Zeider\ Zee} + S_{Sibul})/2$ =	1.04	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): S = $\Sigma[(KU^2/\pi)(gd/\pi)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	1.63	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S =	22.62	feet	*(pg. A6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of Interest is at Toe of Structure, d_s = d_s =	22.62	feet	*(see Step 19)*
Wave Breaking Height, H_b *(for depth d_s)* = $(d_s/1.28)$ =	17.67	feet	*(Eqn. 2-91 & 3-90, SPM)*
Is max. wave height limited by breaking? *(If H_s (step 20) $\leq H^*$ (step 17) then yes, else no)* =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	12.11	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height), is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	20.99	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	124	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.169		
H/H'_o =	0.9133		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17)
then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	17.67	feet	*(see Step 20)*
Significant Wave Height, H_s =	12.11	feet	*(see Step 17)*
H/H'_o =	0.9133		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H'o = H(H/H'o)$ =	13.26	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	13.26	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H'_o

Water Depth at Toe of Structure, d_s =	22.62	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	13.26	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.71		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District. *Design Criteria Memorandum: DCM-2, Revision #01.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers. *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers. *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers. *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers. *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	feet	
Category 5, Fetch Limited Wind Speed Over Water = $U_{CAT5,fetch-min}$ =	125	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	329	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.63	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	13.26	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.92	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.71		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(gT_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	13.26	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.92	sec	*(see Step 12)*
$H'_o/(gT_o^2)$ =	0.017		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.71		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.017		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.71

$H'_o/(gT_o^2)$ =	0.017		*(see Step 24)*
ds/H'o <=1.71 from Fig. 7-10 =	0.8		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.63		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.71

$H'_o/(gT_o^2)$ =	0.017		*(see Step 24)*
ds/H'o >=1.71 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.78		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.71		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.017		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.74		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.74		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	13.26		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	9.90	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-16 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	9.90	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	11.09	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	11.09	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.76	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	7	degrees	
Angle Correction Factor =	0.98		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.76		*(see Step 30)*
Angle Correction Factor =	0.98		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.6	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	0.77	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	1.63	ft	*(see Step 18)*
Wave Height & Runup =	7.61	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	10.01	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.22	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	10.01	ft	*(see Step 33)*
Embankment Height (not including camber) =	30.23	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	10.01	ft	*(see Step 33)*
Embankment Settlement =	0.96	ft	*(see Technical Memorandum Table 3 or BODR Section 8E.)*
Minimum Embankment Height (with camber) =	31.19	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	10.97	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1B)

Steps 1-2: Not necessary for Case 3

Project Location =	C-43 Cell No. 1 (Fetch 1B)		
Probable Maximum Wind (PMW) Speed, $U_{PMW,60\text{-}sec,water}$ =	200.0	mph	*(pg 13, DCM-2)*

For Case 3, the 200 mph assumed PMW corresponds to an over-water 1-minute average wind speed. *(pg 13, DCM-2)*

Step 3: Determine PMW, 1-Hr Wind Speed, $U_{PMW,\ 1\text{-}hr}$

Initial wind speed duration, t =	60	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
U_t/U_{3600} =	1.24		*(Eqn. 1, DCM-2)*
$U_t = U_{PMW,\ 60\text{-}sec}$ =	200.00	mph	*(see Step 2)*
$U_{PMW,\ 3600\text{-}sec} = U_{PMW,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	160.8	mph	

Step 4: Determine PMW, 1-Hr Wind Speed Over Water, $U_{PMW,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.04	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{PMW,1\text{-}hr,land}$ =	-		*(see Step 3)*
$U_{PMW,1\text{-}hr,water} = U_{PMW,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	160.8	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =			
Wind Velocity (in mph), U =	160.8	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	42	min.	*(Eqn. 4, DCM-2)*
	2516	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2516	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.005		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	42	min.	*(see Step 5)*
PMW, 1-Hr Wind Speed Over Water, $U_{PMW,1\text{-}hr,water}$ =	160.8	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.005		*(see Step 6)*
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW,1\text{-}hr,water} \times U_t/U_{3600}$ =	162	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.04	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{PMW,1\text{-}min,water}$ =	162	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U_{PMW,fetch\text{-}min,water} \times R_T$ =	162	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	162	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	307	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	450	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Wind Setup and Wave Properties Analysis - Site C-43: Cell 1 (Fetch 1B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 5)*
Fetch Length, F =	16,048	ft	
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW(fetch-lim)}$ =	162	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	450	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = [0.0002821]U_*F^{1/2}$ = 16.07 feet *(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_*F)^{1/2}$ = 5.46 sec *(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_o^2$ = 153 feet *(Eqn. 3-8b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

Effective Depth, d =	20.22	feet	
Relative Depth = d/L_o =	0.132		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_*/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_*^2)^{3/8}$ =	0.0659
$B = 0.0379(gF/U_*^2)^{1/3}$ =	0.9510
$C = \tanh(0.833(gd/U_*^2)^{3/8})$ =	0.0665
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_*/g$ =	4.99 sec *(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_*^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_*^2)^{3/4}$ =	0.0072
$B = 0.00565(gF/U_*^2)^{1/2}$ =	0.0690
$C = \tanh(0.530(gd/U_*^2)^{3/4})$ =	0.0072
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_*^2/g$ =	10.84 feet *(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height
Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	10.84	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, risk =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2}H_s$ =	7.67	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-\ln(risk)]^{1/2}$ =	14.99	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.04	miles	*(see Step 5)*
Fetch Length, F =	16,048	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{PMW(fetch-lim)}$ =	162	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	20.22	feet	*(see Step 14)*
Zeider Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	2.81	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0600244e(F/g)^{4/5}(U^2/g)^{2.02(F/g)^{-0.225}}$ =	0.67	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	1.64	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = 3.5[(kU^2/s)^2/(gF)^2]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	2.81	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S = 23.03 feet *(pg. A6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_i = d_s$ =	23.03	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_s) = $(d_s/1.28)$ =	17.99	feet	*(Eqn. 2-91 & 3-30, SPM)*
Is max. wave height limited by breaking? (If H_b [step 20] $\leq H^*$ [step 17] then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	14.99	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/H'o (shallow-water wave height:equivalent deep water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	20.22	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	153	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.132		
H/H'_o =	0.9164		*(Table C-1, SPM Vol II)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	17.99	feet	*(see Step 20)*
Significant Wave Height, H_s =	14.99	feet	*(see Step 17)*
H/H'_o =	0.9164		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H'o = H/(H/H'o)$ =	16.36	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	16.36	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H'_o

Water Depth at Toe of Structure, d_s =	23.03	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	16.36	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.41		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum, DCM-2, Revision 001.00g*. October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 5)*
Fetch Length, F =	16,048	feet	
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW,fetch-min}$ =	162	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	450	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	2.81	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	16.36	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	5.46	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.41		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	16.36	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	5.46	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.017		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.41		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
Face Slope Material =	Stone-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.41

$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
ds/H'o <=1.41 from Fig. 7-10 =	0.8		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.63		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.41

$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
ds/H'o >=1.41 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.78		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.41		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.71		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.71		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	16.36		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	11.60	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	11.60	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	12.99	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Stone-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	12.99	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	9.09	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	7	degrees	
Angle Correction Factor =	0.98		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	9.09		*(see Step 30)*
Angle Correction Factor =	0.98		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	8.9	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*. U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routad Flood Event) =	0.00	ft	*(no surcharge, normal full storage level elevation assumed)*
Wind Setup =	2.61	ft	*(see Step 18)*
Wave Height & Runup =	8.91	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	11.72	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.22	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	11.72	ft	*(see Step 33)*
Embankment Height (not including camber) =	31.94	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	11.72	ft	*(see Step 33)*
Embankment Settlement =	1.06	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	33.00	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	12.78	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input:
The cells with analysis output:

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Design Wind Speed Analysis - Site C-43: Cell 1 (Fetch 1B)

Step 1-2: Select EASY, 3-Sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$

Project Location =	C-43 Cell No. 1 (Fetch 1B)		
EASY, 3-sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$ =	125.0	mph	*(pg. 14, DCM-2)*

The Hurricane Easy, 125 mph, 3-sec gust wind speed is a storm specific case. Therefore, it is assumed that the Step 2 conversion factor adjustment is not relevant for this case.

Step 3: Determine EASY, 1-Hr Wind Speed, $U_{EASY,\ 1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
	$U_t = U_{EASY,\ 3\text{-}sec}$ =	125.0	mph	*(see Step 2)*
	$U_{EASY,\ 3600\text{-}sec} = U_{EASY,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	82.8	mph	

Step 4: Determine EASY, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.04	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)		does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles:	U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles:	See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
	U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
	$U_{EASY,1\text{-}hr,land}$ =	82.8		*(see Step 3)*
	$U_{EASY,1\text{-}hr,water} = U_{EASY,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	99.4	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.04	miles	*(see Step 4)*
Wind Velocity (in mph), U =	99.4	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/(U^{0.34})$ =	49	min.	*(Eqn. 4, DCM-2)*
	2963	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2963	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	49	min.	*(see Step 5)*
EASY-Yr, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$ =	99.4	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(see Step 6)*
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,1\text{-}hr,water} \times U_t/U_{3600}$ =	100	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.04	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles:	R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles:	Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
	$U_{EASY,fetch\text{-}min,water}$ =	100	mph	*(see Step 7)*
	Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
	$U_{EASY,fetch\text{-}min,water,\ stability\ adjusted} = U_{EASY,fetch\text{-}min,water} \times R_T$ =	100	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{EASY,Fetch\text{-}min,water,\ stability\ adjusted} = U$ =	100	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	169	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	248	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (34.7") & 72 hr (45.2") Rainfall Durations)
Wind Setup and Wave Properties Analysis - Stn C-43: Cell 1 (Fetch 1B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	ft	
EASY, Fetch Limited Wind Speed Over Water = $U_{(EASY,Fetch,Max)}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_s (ft/s) =	248	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_s F^{1/2}$ =	3.86	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_s F)^{1/3}$ =	4.48	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length: $L_o = 5.12 T_o^2$ =	103	feet	*(Eqn. 2-4b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

Effective Depth, d =	23.86	feet	
Relative Depth = d/L_o =	0.234		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period: $T = 7.54 \tanh(A) \tanh(B/C) U_s/g$ *(Eqn. 3-40, SPM)*
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.530(gd/U_s^2)^{3/4}$ =	0.1613		
$B = 0.0379(gF/U_s^2)^{1/2}$ =	0.0770		
$C = \tanh(0.833(gd/U_s^2)^{3/8})$ =	0.1599		
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C) U_s/g$ =	3.16	sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C) U_s^2/g$ *(Eqn. 3-39, SPM)*
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.530(gd/U_s^2)^{3/4}$ =	0.0199		
$B = 0.00565(gF/U_s^2)^{1/2}$ =	0.0184		
$C = \tanh(0.530(gd/U_s^2)^{3/8})$ =	0.0199		
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C) U_s^2/g$ =	7.26	feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height
Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.26	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{1/2} H_s$ =	5.15	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms} [-\ln(n/N)]^{1/2}$ =	10.07	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{(EASY,Fetch,Max)}$ =	100	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	23.86666667	feet	*(see Step 14)*
Zeider Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2 F/(1400D)$ =	0.00	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, $g=32.2$ ft/s^2): $C = 0.0000244 d(F/d)^{1.25}(U^2/g)^{2.5(F/d)^{-0.375}}$ =	0.23	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul, Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	0.56	feet	
Bretschneider Eqn (Note: Coles provided separately in Step 18a): $S = 2[(kU^2/g)(g/\sigma)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup: *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	0.00	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S =	24.89	feet	*(pg. A6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of Interest is at Toe of Structure, $d_i = d_s$ =	24.89	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_b) = $(d_b/1.28)$ =	19.44	feet	*(Eqn. 2-91 & 3-30, SPM)*
Is max. wave height limited by breaking? (If H_b [step 20] $\leq H^*$ [step 17] then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	10.07	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/H'o (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	23.86666667	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	103	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.234		
H/H'_o =	0.9273		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Breaking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	19.44	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.07	feet	*(see Step 17)*
H/H'_o =	0.9273		*(see Step 21)*
If Shallow-Water, Equivalent Deep-Water Wave Height, $H'o = H/(H/H'o)$ =	10.85	feet	
If Deep Water, Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking, Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	10.85	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H'_o

Water Depth at Toe of Structure, d_s =	24.89	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	10.85	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.29		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Wave Runup Analysis - Site C-43: Cell 1 (Fetch 1B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.04	miles	*(see Step 4)*
Fetch Length, F =	16,048	feet	
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,fetch-ltd}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	248	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	0.90	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	10.85	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.48	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.29		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	10.85	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.48	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.017		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	2.29		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (R:1V) =	3		*Embankment Design*
Runup Face Slope (θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-12		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-11 with ds/H'o <= 2.29

$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
ds/H'o <=2.29 from Fig. 7-11 =	2		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.78		*(Fig. 7-11, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-12 with ds/H'o >= 2.29

$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
ds/H'o >=2.29 from Fig. 7-12 =	3.0		*(Fig. 7-12, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-12 =	1.00		*(Fig. 7-12, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	2.29		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.017		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.84		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.84		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	10.85		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	9.20	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-16 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	9.20	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	10.30	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	10.30	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.21	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	7	degrees	
Angle Correction Factor =	0.98		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.21		*(see Step 30)*
Angle Correction Factor =	0.98		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.1	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Minimum Required Freeboard - Site C-43: Cell 1 (Fetch 1B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	3.77	ft	*(conservatively assumed to be total EASY precipitation of 45.2")*
Wind Setup =	0.90	ft	*(see Step 18)*
Wave Height & Runup =	7.07	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	11.74	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	20.22	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	11.74	ft	*(see Step 33)*
Embankment Height (not including camber) =	31.96	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	11.74	ft	*(see Step 33)*
Embankment Settlement =	1.15	ft	*(see Technical Memorandum Table 3 or BODR Section 9E)*
Minimum Embankment Height (with camber) =	33.11	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	12.69	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

Fetch 2A Analyses

Summary of Freeboard Analyses Case Scenarios Site C-43: Cell 2 (Fetch 2A)				
Freeboard Component	Case 1: PMP Combined with 100-Year Wind (ft)	Case 2: 100-Year Precip. Combined with Category 5 Winds (ft)	Case 3: Normal Full Storage Combined with Probable Max. Wind (ft)	Case 4: Hurricane Easy Storm Specific Wind and Precipitation (ft)
Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	0.77	0.00	3.77
Wind Setup =	1.12	2.09	3.61	1.13
Wave Height & Runup =	6.63	7.62	8.82	6.56
Waves Induced by Potential Landslides =	0.00	0.00	0.00	0.00
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	0.00	0.00	0.00
Minimum Required Freeboard =	**11.89**	**10.48**	**12.44**	**11.46**
Camber or Embankment Settlement =	0.88	0.67	0.88	0.78
Minimum Required Freeboard with Camber =	**12.8**	**11.2**	**13.3**	**12.2**

Notes:
Minimum Required Freeboard rounded up to the next 0.01 foot.
Minimum Required Freeboard with Camber rounded up to the next 0.1 foot.
Case 1 - Surcharge depth is based upon routing of design storm event(s) through the reservoir.
Case 2 - Surcharge depth is based upon routing of design storm event through the reservoir.
Case 3 - Case 3 is to be used only for "sensitivity identification" and not as a selected design condition (pg 14 of 25, DCM-2)
Case 4 - Surcharge depth is assumed to be equal to the total precipitation of Hurricane Easy (45.2").

2015

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Design Wind Speed Analysis - Site C-43: Cell 2 (Fetch 2A)

Step 1: Select 50-Yr, 3-Sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$

Project Location =	C-43 Cell No. 2		
50-yr, 3-sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(Fig. 6-1b, ASCE 7-02)*

Step 2: Determine 100-Yr, 3-Sec Gust Wind Speed, $U_{100\text{-}yr,3\text{-}sec}$

$U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(see Step 1)*
$U_{50\text{-}yr}$ to $U_{100\text{-}yr}$ Conversion Factor =	1.07		*(Table DCM 2-2, DCM-2)*
$U_{100\text{-}yr,3\text{-}sec} = U_{50\text{-}yr,3\text{-}sec}$ x Conversion Factor =	125.7	mph	

Step 3: Determine 100-Yr, 1-Hr Wind Speed, $U_{100\text{-}yr,1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
	$U_t = U_{100\text{-}yr,\ 3\text{-}sec}$ =	125.73	mph	*(see Step 2)*
	$U_{100\text{-}yr,\ 3600\text{-}sec} = U_{100\text{-}yr,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	83.3	mph	

Step 4: Determine 100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.40	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)		does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles:	U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles:	See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
	U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
	$U_{100\text{-}yr,1\text{-}hr,land}$ =	83.3		*(see Step 3)*
	$U_{100\text{-}yr,1\text{-}hr,water} = U_{100\text{-}yr,1\text{-}hr,land}$ x (U_{water}/U_{land}) =	100.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.40	miles	*(see Step 4)*
Wind Velocity (in mph), U =	100.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	53	min.	*(Eqn. 4, DCM-2)*
	3187	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3187	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	53	min.	*(see Step 5)*
100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$ =	100.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(see Step 6)*
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100\text{-}yr,1\text{-}hr,water}$ x U_t/U_{3600} =	100	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.40	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles:	$R_T = 1.0$	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles:	Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
	$U_{100\text{-}yr,fetch\text{-}min,water}$ =	100	mph	*(see Step 7)*
	Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
	$U_{100\text{-}yr,fetch\text{-}min,water,\ stability\ adjusted} = U_{100\text{-}yr,fetch\text{-}min,water}$ x R_T =	100	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{100\text{-}yr,1\text{-}min,water,\ stability\ adjusted} = U$ =	100	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	170	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = 1.467U_A (mph) =	249	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Wind Setup and Wave Properties Analysis - Site C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	ft	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100-yr,fetch,over}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	249	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_*F^{0.5}$ = 9.42 feet *(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_*F)^{0.5}$ = 8.66 sec *(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_o^2$ = 111 feet *(Eqn. 3-4b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-8, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

Effective Depth, d =	21.64	feet	
Relative Depth = d/L_o =	0.195		*(pg 2-8, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54\ \tanh^{A}(A)\ \tanh^{(B/C)}(U_*/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_*^2)^{0.5}$ =	0.1546	
$B = 0.0379(gF/U_*^2)^{0.5}$ =	0.0797	
$C = \tanh(0.833(gd/U_*^2)^{0.5})$ =	0.1533	
Shallow-Water Wave Period, $T = 7.54\ \tanh(A)\ \tanh(B/C)\ U_*/g$ =	4.29 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283\ \tanh(A)\ \tanh(B/C)\ U_*^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_*^2)^{0.5}$ =	0.0182	
$B = 0.0565(gF/U_*^2)^{0.5}$ =	0.0172	
$C = \tanh(0.530(gd/U_*^2)^{0.5})$ =	0.0182	
Shallow-Water Significant Wave Height, $H = 0.283\ \tanh(A)\ \tanh(B/C)\ U_*^2/g$ =	7.35 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Zero Overwash Wave Height for Significant Wave Height

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.35	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-0.5}H_s$ =	5.20	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-Ln(n/N)]^{0.5}$ =	10.17	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{100-yr,over}$ =	100	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	21.64	feet	*(see Step 14)*
Zeider Zee Eqn: (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	1.12	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0000244(F/d)^{0.67}(U^2/g)^{1.23\cdot(d/F)^{0.25}}$ =	0.28	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	0.70	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Sigma[(KU^2/x)(gd^2)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	1.12	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_t = Effective Depth + Wind Set-Up = d + S = 22.76 feet *(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 1-5, EM-1110-2-1420)*

Depth of Interest is at Toe of Structure, $d_i = d_t$ =	22.76	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_i) = $(d_i/1.28)$ =	17.78	feet	*(Eqn. 2-91 & 2-90, SPM)*
Is max. wave height limited by breaking? *(If H_s (step 20) $\leq H^*$ (step 17) then yes, else no)* =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	10.17	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	21.64	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	111	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.195		
H/H^*_o =	0.917		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H^*_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Breaking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	17.78	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.17	feet	*(see Step 17)*
H/H^*_o =	0.9170		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H^*o = H/(H/H^*o)$ =	11.09	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	11.09	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_t/H^*_o

Water Depth at Toe of Structure, d_t =	22.76	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H^*_o =	11.09	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_t/H^*_o =	2.05		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers. *Coastal Engineering Manual, EM-1110-2-110, July 31, 2009.*
3. U.S. Army Corps of Engineers. *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers. *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers. *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Wave Runup Analysis -Site C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	feet	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{(100-yr,fetch-ltd)}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	249	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.12	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	11.09	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.66	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.05		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	11.09	feet	*(see Step 22)*
Gravitational Constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.66	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.016		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	2.05	*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
Face Slope Material =	Step-Faced Slope	*Embankment Design*
Runup Face Slope (H:1V) =	3	*Embankment Design*
Runup Face Slope (Θ) =	18.4 degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-11	*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-12	*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-11 with ds/H'o <= 2.05

$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
ds/H'o <=2.05 from Fig. 7-11 =	2.0	*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.84	*(Fig. 7-11, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-12 with ds/H'o >= 2.05

$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
ds/H'o >=2.05 from Fig. 7-12 =	3.0	*(Fig. 7-12, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-12 =	1.04	*(Fig. 7-12, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	2.05	*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.016	*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.95	*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.85		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	11.09		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	9.40	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	9.40	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	10.53	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	10.53	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.37	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	42	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.37		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	6.6	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

Referencas:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Minimum Required Freeboard - Site C-43: Cell 2 (Fetch 2A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	1.12	ft	*(see Step 18)*
Wave Height & Runup =	6.63	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	11.89	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.51	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	11.89	ft	*(see Step 33)*
Embankment Height (not including camber) =	29.40	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	11.89	ft	*(see Step 33)*
Embankment Settlement =	0.88	ft	*(see Technical Memorandum Table 3 or BODR Section 8E.)*
Minimum Embankment Height (with camber) =	30.28	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	12.77	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Design Wind Speed Analysis - Site C-43: Cell 2 (Fetch 2A)

Steps 1-3: Adjustments not necessary for Case 2

Project Location =	C-43 Cell No. 2		
Category 5, Duration Adjusted Wind Speed (1-hr average), $U_{Cat5,1\text{-}hr}$ =	125.0	mph	*(Table DCM 2-3, DCM-2)*

The Category 5 wind speed from Table DCM 2-3, DCM-2 corresponds to an over-water wind speed per DCM-2 page 10.

Step 4: Determine Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.40	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{Cat5,1\text{-}hr,land}$ =	-		*(see Step 3)*
$U_{Cat5,1\text{-}hr,water} = U_{Cat5,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	125.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.40	miles	*(see Step 4)*
Wind Velocity (in mph), U =	125.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	49	min.	*(Eqn. 4, DCM-2)*
	2954	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2954	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(4.5/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	49	min.	*(see Step 5)*
Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1\text{-}hr,water}$ =	125.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(see Step 6)*
Category 5, Fetch Limited Wind Speed Over Water = $U_{Cat5,1\text{-}hr,water} \times U_t/U_{3600}$ =	125	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.40	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as} See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{Cat5,fetch\text{-}min,water}$ =	125	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{Cat5,fetch\text{-}min,water,\ stability\ adjusted} = U_{Cat5,fetch\text{-}min,water} \times R_T$ =	125	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{Cat5,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	125	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	224	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) $= 1.467U_A$ (mph) =	329	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 29, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Wind Setup and Wave Properties Analysis - Stn C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	ft	
Category 5, Fetch Limited Wind Speed Over Water = $U_{Cat5,fetch-ltd}$ =	125	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	329	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_*F^{1/2}$ =	12.42	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_p

Deep-Water Wave Period, $T_p = 0.02825(U_*F)^{1/2}$ =	5.11	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_p^2$ =	133	feet	*(Eqn. 2-6b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

Effective Depth, d =	18.28	feet	
Relative Depth = d/L_o =	0.137		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

(Eqn. 3-40, SPM)

Shallow-Water Wave Period, $T = 7.54\ \tanh(A)\ \tanh(B/C)\ U_*/g$
where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_*^2)^{3/4}$ =	0.1179	
$B = 0.037(gF/U_*^2)^{1/3}$ =	0.0663	
$C = \tanh(0.833(gd/U_*^2)^{3/4})$ =	0.1174	
Shallow-Water Wave Period, $T = 7.54\ \tanh(A)\ \tanh(B/C)\ U_*/g$ =	4.62 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

(Eqn. 3-39, SPM)

Shallow-Water Significant Wave Height, $H = 0.283\ \tanh(A)\ \tanh(B/C)\ U_*^2/g$
where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_*^2)^{3/4}$ =	0.0106	
$B = 0.00565(gF/U_*^2)^{1/2}$ =	0.0131	
$C = \tanh(0.530(gd/U_*^2)^{3/4})$ =	0.0106	
Shallow-Water Significant Wave Height, $H = 0.283\ \tanh(A)\ \tanh(B/C)\ U_*^2/g$ =	0.51 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height
Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	6.51	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2}H_s$ =	6.01	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}\ [-Ln(n/N)]^{1/2}$ =	11.76	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup:
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn. Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{Cat5,fetch-ltd}$ =	125	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	18.28	feet	*(see Step 14)*
Zeider Zee Eqn: (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	2.09	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0000244d(F/d)^{1.65}(U^2/[g])^{2.0(0.57\ to\ 0.75)}$ =	0.57	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	1.33	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Sigma[(KU^2\Delta x)/(gd^*)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Eqn 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	2.09	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_t = Effective Depth + Wind Set-Up = d + S =	20.37	feet	*(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_s = d_t$ =	20.37	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_s) = $(d_s/1.28)$ =	15.91	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_b [step 20] $\leq H^*$ [step 17] then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	11.76	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height), is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	18.28	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	133	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.137		
H/H^*_o =	0.9152		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H^*_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17)
then Equivalent Deep-Water Wave Height is Wave Braking Height (irrespective of wave classification).

Wave Breaking Height, H_b =	15.91	feet	*(see Step 20)*
Significant Wave Height, H_s =	11.76	feet	*(see Step 17)*
H/H^*_o =	0.9152		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H^*o = H/(H/H^*o)$ =	12.85	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	12.85	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_t/H^*_o

Water Depth at Toe of Structure, d_t =	20.37	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H^*_o =	12.85	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_t/H^*_o =	1.59		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District. *Design Criteria Memorandum: DCM-2, Revision 001.06g*, October 28, 2005.
2. U.S. Army Corps of Engineers. *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Wave Runup Analysis - Site C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	feet	
Category 5, Fetch Limited Wind Speed Over Water = $U_{CAT5,fetch-ltd}$ =	125	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	329	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	2.09	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	12.85	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	5.11	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.58		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(gT_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	12.85	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	5.11	sec	*(see Step 12)*
$H'_o/(gT_o^2)$ =	0.015		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.58		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
Face Slope Material =	Stop-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.58

$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
ds/H'o <=1.58 from Fig. 7-10 =	0.8		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.75		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.58

$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
ds/H'o >=1.58 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.89		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.58		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.84		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.84		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	12.85		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	10.80	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	10.80	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	12.10	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Stop-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	12.10	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	8.47	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	42	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	8.47		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.6	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Minimum Required Freeboard - Site C-43: Cell 2 (Fetch 2A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	0.77	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	2.09	ft	*(see Step 18)*
Wave Height & Runup =	7.62	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	10.48	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.51	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	10.48	ft	*(see Step 33)*
Embankment Height (not including camber) =	27.99	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	10.48	ft	*(see Step 33)*
Embankment Settlement =	0.67	ft	*(see Technical Memorandum Table 3 or BODR Section 8E.)*
Minimum Embankment Height (with camber) =	28.66	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	11.15	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Design Wind Speed Analysis - Site C-43: Cell 2 (Fetch 2A)

Steps 1-2: Not necessary for Case 3

Project Location =	C-43 Cell No. 2		
Probable Maximum Wind (PMW) Speed, $U_{PMW,60\text{-}sec,water}$ =	200.0	mph	*(pg 13, DCM-2)*

For Case 3, the 200 mph assumed PMW corresponds to an over-water 1-minute average wind speed. *(pg 13, DCM-2)*

Step 3: Determine PMW, 1-Hr Wind Speed, $U_{PMW,\ 1\text{-}hr}$

Initial wind speed duration, t =	60	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
U_t/U_{3600} =	1.24		*(Eqn. 1, DCM-2)*
$U_t = U_{PMW,\ 60\text{-}sec}$ =	200.00	mph	*(see Step 2)*
$U_{PMW,\ 3600\text{-}sec} = U_{PMW,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	160.8	mph	

Step 4: Determine PMW, 1-Hr Wind Speed Over Water, $U_{PMW,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.40	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{PMW,1\text{-}hr,land}$ =	-		*(see Step 3)*
$U_{PMW,1\text{-}hr,water} = U_{PMW,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	160.8	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =			
Wind Velocity (in mph), U =	160.8	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	45	min.	*(Eqn. 4, DCM-2)*
	2711	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2711	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.004		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	45	min.	*(see Step 5)*
100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$ =	160.8	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.004		*(see Step 6)*
PMW, t-min Wind Speed Over Water = $U_{PMW,1\text{-}hr,water} \times U_t/U_{3600}$ =	161	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.40	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	° C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence	does not apply		*(Fig.3-14, SPM)*
of temperature information, assume RT = 1.1			*(pg 3-30, SPM)*
$U_{PMW,fetch\text{-}min,water}$ =	161	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U_{PMW,fetch\text{-}min,water} \times R_T$ =	161	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	161	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	306	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	449	ft/sec.	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Wind Setup and Wave Properties Analysis - Stie C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 5)*
Fetch Length, F =	17,944	ft	
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW(Fetch-Ltd)}$ =	161	mph	*(see Step 7)*
Wind Stress Factor, U_s (ft/s) =	448	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep Water Significant Wave Height, $H_{mo} = (0.0002821)U_s F^{1/2}$ =	16.96	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_s F)^{1/2}$ =	5.86	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12 T_o^2$ =	164	feet	*(Eqn. 2-8b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-8, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-8, SPM)*

Effective Depth, d =	17.51	feet	
Relative Depth = d/L_o =	0.107		*(pg 2-8, SPM)*
Wave Classification =	Transitional/Shallow Water		*(pg 2-8, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_s/g$ *(Eqn. 3-40, SPM)*
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.833(gd/U_s^2)^{3/8}$ =	0.0918		
$B = 0.0379(gF/U_s^2)^{1/3}$ =	0.0930		
$C = \tanh(0.853(gd/U_s^2)^{0.65})$ =	0.0916		
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_s/g$ =	5.39	sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_s^2/g$ *(Eqn. 3-39, SPM)*
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.530(gd/U_s^2)^{3/4}$ =	0.0964		
$B = 0.0565(gF/U_s^2)^{1/3}$ =	0.0996		
$C = \tanh(0.530(gd/U_s^2)^{0.75})$ =	0.0963		
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_s^2/g$ =	13.33	feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrance frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height
Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	10.20	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2} H_s$ =	7.29	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms} [-\ln(n/N)]^{1/2}$ =	14.25	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.40	miles	*(see Step 5)*
Fetch Length, F =	17,944	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{PMW(Fetch-Ltd)}$ =	161	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	17.51	feet	*(see Step 14)*
Zeider Zee Eqn: (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	3.61	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s^2): $S = 0.0002444(F/d)^{1/3}(U^2F/g)^{0.5[(F/d)^{1/3}-0.277d]}$ =	1.06	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	2.35	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Sigma[(kU^2\Delta x)/(gd^2)]$ =	n/a	feet	*(Eqn. 8, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	3.61	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_t = Effective Depth + Wind Set-Up = d + S =	21.12	feet	*(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_t = d_t$ =	21.12	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_t) = $(d_t/1.28)$ =	16.50	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_b (step 20) $\leq H^*$ (step 17) than yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	14.25	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	17.51	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	164	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.107		
H/H'_o =	0.9276		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17)
then Equivalent Deep-Water Wave Height is Wave Breaking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	16.50	feet	*(see Step 20)*
Significant Wave Height, H_s =	14.25	feet	*(see Step 17)*
H/H'_o =	0.9276		*(see Step 21)*
If Shallow-Water, Equivalent Deep-Water Wave Height, $H'o = H/(H/Ho)$ =	15.37	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking, Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	15.37	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_t/H'_o

Water Depth at Toe of Structure, d_t =	21.12	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	15.37	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_t/H'_o =	1.37		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual, Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Wave Runup Analysis - Site C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 5)*
Fetch Length, F =	17,944	feet	
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW,fetch-min}$ =	161	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	449	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	3.61	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	15.37	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	5.66	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.37		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	15.37	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	5.66	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.015		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.37		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
Face Slope Material =	Stop-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.37

$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
ds/H'o <=1.37 from Fig. 7-10 =	0.8		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.75		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.37

$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
ds/H'o >=1.37 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.89		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.37		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.82		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.82		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	15.37		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	12.50	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-16 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	12.50	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	14.00	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Stop-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	14.00	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	9.80	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	42	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	9.80		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	8.8	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Minimum Required Freeboard - Site C-43: Cell 2 (Fetch 2A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	0.00	ft	*(no surcharge, normal full storage level elevation assumed)*
Wind Setup =	3.61	ft	*(see Step 18)*
Wave Height & Runup =	8.82	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	12.44	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.51	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	12.44	ft	*(see Step 33)*
Embankment Height (not including camber) =	29.95	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	12.44	ft	*(see Step 33)*
Embankment Settlement =	0.88	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	30.83	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	13.32	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Design Wind Speed Analysis - Site C-43: Cell 2 (Fetch 2A)

Step 1-2: Select EASY, 3-Sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$

Project Location =	C-43 Cell No. 2		
EASY, 3-sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$ =	125.0	mph	*(pg. 14, DCM-2)*

The Hurricane Easy, 125 mph, 3-sec gust wind speed is a storm specific case. Therefore, it is assumed that the Step 2 conversion factor adjustment is not relevant for this case.

Step 3: Determine EASY, 1-Hr Wind Speed, $U_{EASY,1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
	$U_t = U_{EASY,3\text{-}sec}$ =	125.00	mph	*(see Step 2)*
	$U_{100\text{-}yr,\ 3600\text{-}sec} = U_{100\text{-}yr,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	82.8	mph	

Step 4: Determine EASY, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.40	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)		does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles:	U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles:	See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
	U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
	$U_{Easy,1\text{-}hr,land}$ =	82.8		*(see Step 3)*
	$U_{EASY,1\text{-}hr,water} = U_{EASY,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	99.4	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.40	miles	*(see Step 4)*
Wind Velocity (in mph), U =	99.4	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/(U^{0.34})$ =	53	min.	*(Eqn. 4, DCM-2)*
	3193	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3193	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	53	min.	*(see Step 5)*
EASY, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$ =	99.4	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(see Step 6)*
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,1\text{-}hr,water} \times U_t/U_{3600}$ =	100	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.40	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles:	R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles:	Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM) (pg 3-30, SPM)*
	$U_{EASY,fetch\text{-}min,water}$ =	100	mph	*(see Step 7)*
	Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
	$U_{EASY,fetch\text{-}min.water,\ stability\ adjusted} = U_{EASY,fetch\text{-}min,water} \times R_T$ =	100	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{EASY,fetch\text{-}min.water,\ stability\ adjusted} = U$ =	100	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	168	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	248	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (36.7") & 72-hr (46.2") Rainfall Durations)
Wind Setup and Wave Properties Analysis - Site C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	ft	
EASY, Fetch Limited Wind Speed Over Water = $U_{(EASY,F=Fetch)}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	246	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_*F^{1/2}$ =	9.36	feet	*(Eqn. 3-33a, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_*F)^{1/2}$ =	4.64	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_o^2$ =	110	feet	*(Eqn. 2-6b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

Effective Depth, d =	21.28	feet	
Relative Depth = d/L_o =	0.193		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_*/g$ *(Eqn. 3-40, SPM)*
where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.833(gd/U_*^2)^{3/8}$ =	0.1544	
$B = 0.0379(gF/U_*^2)^{1/3}$ =	0.0009	
$C = \tanh(0.833(gd/U_*^2)^{3/8})$ =	0.1532	
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_*/g$ =	4.26 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_*^2/g$ *(Eqn. 3-39, SPM)*
where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) $g = 32.2$ ft/s^2

$A = 0.530(gd/U_*^2)^{3/8}$ =	0.0192	
$B = 0.0565(gF/U_*^2)^{1/2}$ =	0.0179	
$C = \tanh(0.530(gd/U_*^2)^{3/8})$ =	0.0182	
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_*^2/g$ =	7.27 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.27	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2}H_s$ =	5.14	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-\ln(n/N)]^{1/2}$ =	10.06	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<15 ft).
Sibul Eqn. Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<15 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <15 ft).

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{(EASY,F=Fetch)}$ =	100	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	21.27666667	feet	*(see Step 14)*
Zeider Zee Eqn: [Note: F=miles]: Wind Set-Up, $S = U^2F/(1400D)$ =	1.13	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s^2): $S = 0.0000244(F/g)^{0.50}(U^2/g)^{1.23(F/g)^{-0.333}}$ =	0.29	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	0.70	feet	
Bretschneider Eqn [Note: Calcs provided separately in Step 12a]: $S = \Sigma[(kU^2/\sigma)x]/(gd^*)$ =	n/a	feet	*(Eqn. 8, DCM-2)(Step 18A)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	1.13	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S =	22.41	feet	*(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of Interest is at Toe of Structure, $d_i = d_s$ =	22.41	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_i) = $(d_i/1.28)$ =	17.51	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_s [step 20] $\leq H^*$ [step 17] then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b, (step 20)) Maximum Wave Height =	10.06	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	21.27666667	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	110	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.193		
H/H^*_o =	0.9167		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H^*_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	17.51	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.06	feet	*(see Step 17)*
H/H^*_o =	0.9167		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H^*_o = H/(H/H^*o)$ =	10.97	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	10.97	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H^*_o

Water Depth at Toe of Structure, d_s =	22.41	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H^*_o =	10.97	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H^*_o =	2.04		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 901.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual, Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Wave Runup Analysis - Site C-43: Cell 2 (Fetch 2A)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.40	miles	*(see Step 4)*
Fetch Length, F =	17,944	feet	
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,fetch-ltd}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	248	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.13	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	10.97	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.64	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.04		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(gT_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	10.97	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.64	sec	*(see Step 12)*
$H'_o/(gT_o^2)$ =	0.016		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	2.04		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.016		*(see Step 24)*
Face Slope Material =	Stone-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-12		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-11 with ds/H'o <= 2.04

$H'_o/(gT_o^2)$ =	0.016		*(see Step 24)*
ds/H'o <=2.04 from Fig. 7-11 =	2		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.84		*(Fig. 7-11, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-12 with ds/H'o >= 2.04

$H'_o/(gT_o^2)$ =	0.016		*(see Step 24)*
ds/H'o >=2.04 from Fig. 7-12 =	3		*(Fig. 7-12, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-12 =	1.04		*(Fig. 7-12, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	2.04		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.016		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.85		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.85		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	10.97		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	9.30	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-16 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	9.30	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	10.42	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Stone-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	10.42	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.29	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	42	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.29		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	6.6	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Minimum Required Freeboard - Site C-43: Cell 2 (Fetch 2A)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	3.77	ft	*(conservatively assumed to be total EASY precipitation of 45.2")*
Wind Setup =	1.13	ft	*(see Step 18)*
Wave Height & Runup =	6.56	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	11.46	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.51	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	11.46	ft	*(see Step 33)*
Embankment Height (not including camber) =	28.97	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	11.46	ft	*(see Step 33)*
Embankment Settlement =	0.78	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	29.75	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	12.24	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

Fetch 2B Analyses

Summary of Freeboard Analyses Case Scenarios Site C-43: Cell 2 (Fetch 2B)				
Freeboard Component	Case 1: PMP Combined with 100-Year Wind (ft)	Case 2: 100-Year Precip. Combined with Category 5 Winds (ft)	Case 3: Normal Full Storage Combined with Probable Max. Wind (ft)	Case 4: Hurricane Easy Storm Specific Wind and Precipitation (ft)
Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	0.77	0.00	3.77
Wind Setup =	1.22	2.27	3.94	1.23
Wave Height & Runup =	7.06	7.62	9.53	6.99
Waves Induced by Potential Landslides =	0.00	0.00	0.00	0.00
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	0.00	0.00	0.00
Minimum Required Freeboard =	**12.41**	**10.67**	**13.47**	**11.98**
Camber or Embankment Settlement =	0.88	0.67	0.98	0.78
Minimum Required Freeboard with Camber =	**13.3**	**11.3**	**14.5**	**12.8**

Notes:
Minimum Required Freeboard rounded up to the next 0.01 foot.
Minimum Required Freeboard with Camber rounded up to the next 0.1 foot.
Case 1 - Surcharge depth is based upon routing of design storm event(s) through the reservoir.
Case 2 - Surcharge depth is based upon routing of design storm event through the reservoir.
Case 3 - Case 3 is to be used only for "sensitivity identification" and not as a selected design condition (pg 14 of 25, DCM-2)
Case 4 - Surcharge depth is assumed to be equal to the total precipitation of Hurricane Easy (45.2").

2033

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Site C-43: Cell 2 (Fetch 2B)

Step 1: Select 50-Yr, 3-Sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$

Project Location =	C-43 Cell No. 2		
50-yr, 3-sec Gust Wind Speed, $U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(Fig. 6-1b, ASCE 7-02)*

Step 2: Determine 100-Yr, 3-Sec Gust Wind Speed, $U_{100\text{-}yr,3\text{-}sec}$

$U_{50\text{-}yr,3\text{-}sec}$ =	117.5	mph	*(see Step 1)*
$U_{50\text{-}yr}$ to $U_{100\text{-}yr}$ Conversion Factor =	1.07		*(Table DCM 2-2, DCM-2)*
$U_{100\text{-}yr,3\text{-}sec} = U_{50\text{-}yr,3\text{-}sec}$ x Conversion Factor =	125.7	mph	

Step 3: Determine 100-Yr, 1-Hr Wind Speed, $U_{100\text{-}yr,1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
	$U_t = U_{100\text{-}yr,\ 3\text{-}sec}$ =	125.73	mph	*(see Step 2)*
	$U_{100\text{-}yr,\ 3600\text{-}sec} = U_{100\text{-}yr,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	83.3	mph	

Step 4: Determine 100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.62	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, $U_{W\text{-}Site}/U_{Land}$:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)		does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles:	U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles:	See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
	U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
	$U_{100\text{-}yr,1\text{-}hr,land}$ =	83.3		*(see Step 3)*
	$U_{100\text{-}yr,1\text{-}hr,water} = U_{100\text{-}yr,1\text{-}hr,land}$ x (U_{water}/U_{land}) =	100.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.62	miles	*(see Step 4)*
Wind Velocity (in mph), U =	100.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	55	min.	*(Eqn. 4, DCM-2)*
	3323	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3323	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$:	$U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$:	$U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
	Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	55	min.	*(see Step 5)*
100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$ =	100.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(see Step 6)*
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100\text{-}yr,1\text{-}hr,water}$ x U_t/U_{3600} =	100	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.62	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	°C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	°C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles:	R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles:	Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
	$U_{100\text{-}yr,fetch\text{-}min,water}$ =	100	mph	*(see Step 7)*
	Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
	$U_{100\text{-}yr,fetch\text{-}min,water,\ stability\ adjusted} = U_{100\text{-}yr,fetch\text{-}min,water}$ x R_T =	100	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{100\text{-}yr,1\text{-}min,water,\ stability\ adjusted} = U$ =	100	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	170	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = 1.467U_A (mph) =	249	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,097	ft	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{100-yr,fetch,over}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_s (ft/s) =	249	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_s F^{1/2}$ =	9.71	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_s F)^{1/3}$ =	4.75	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12 T_o^2$ =	116	feet	*(Eqn. 2-6b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-8, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

	21.19	feet	
Relative Depth = d/L_o =	0.183		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_s/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_s^2)^{3/4}$ =	0.1534		
$B = 0.0379(gF/U_s^2)^{1/3}$ =	0.0014		
$C = \tanh(0.833(gd/U_s^2)^{3/4})$ =	0.1522		
Shallow-Water Wave Period, T = 7.54 tanh(A) tanh(B/C) U_s/g =	4.34	sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_s^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_s^2)^{3/4}$ =	0.0150		
$B = 0.0565(gF/U_s^2)^{1/3}$ =	0.0178		
$C = \tanh(0.530(gd/U_s^2)^{3/4})$ =	0.0150		
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_s^2/g$ =	7.43	feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Zero Overwash Wave Height for Significant Wave Height

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height
Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.43	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2} H_s$ =	5.25	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-\ln(n/N)]^{1/2}$ =	10.28	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeider Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (ave. depth<16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,097	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{100-yr,over}$ =	100	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	21.19	feet	*(see Step 14)*
Zeider Zee Eqn: (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	1.22	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0000244(F/d)^{1.45}(U^2/Fg)^{2.02(d/L)^{-0.218}}$ =	0.30	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibul})/2$ =	0.76	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Sigma[(\Delta U^2 \Delta x)/(gd^*)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	1.22	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_t = Effective Depth + Wind Set-Up = d + S =	22.41	feet	*(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-3, EM-1110-2-1420)*

Depth of Interest is at Toe of Structure, $d_s = d_t$ =	22.41	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_s) = $(d_s/1.28)$ =	17.51	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_b (step 20) $\leq H^*$ (step 17) then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	10.28	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	21.19	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	116	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.183		
H/H^*_o =	0.9149		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H^*_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	17.51	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.28	feet	*(see Step 17)*
H/H^*_o =	0.9149		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H^*o = H/(H/H^*o)$ =	11.23	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht = Wave Breaking Ht =	n/a	feet	
Equivalent Deep-Water Wave Height =	11.23	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_t/H^*_o

Water Depth at Toe of Structure, d_t =	22.41	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H^*_o =	11.23	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_t/H^*_o =	2.00		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District. *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers. *Coastal Engineering Manual, EM-1110-2-110, July 31, 2009.*
3. U.S. Army Corps of Engineers. *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers. *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers. *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,097	feet	
100-Yr, Fetch Limited Wind Speed Over Water = $U_{(100-yr,fetch-ltd)}$ =	100	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	249	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.22	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	11.23	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.75	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	2.00		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	11.23	feet	*(see Step 22)*
Gravitational Constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.75	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.015		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	2.00		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 2

$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
ds/H'o <=2 from Fig. 7-10 =	0.8		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.75		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 2

$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
ds/H'o >=2 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.89		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	2.00		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.89		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.89		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	11.23		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	10.00	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	10.00	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	11.20	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	11.20	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.84	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	45	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.84		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.1	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 1: PMP Combined with 100-Year Wind
Site C-43: Cell 2 (Fetch 2B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	4.13	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	1.22	ft	*(see Step 18)*
Wave Height & Runup =	7.06	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	12.41	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.06	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	12.41	ft	*(see Step 33)*
Embankment Height (not including camber) =	29.47	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	12.41	ft	*(see Step 33)*
Embankment Settlement =	0.88	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	30.35	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	13.29	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Site C-43: Cell 2 (Fetch 2B)

Steps 1-3: Adjustments not necessary for Case 2

Project Location =	C-43 Cell No. 2		
Category 5, Duration Adjusted Wind Speed (1-hr average), $U_{Cat5,1-hr}$ =	125.0	mph	*(Table DCM 2-3, DCM-2)*

The Category 5 wind speed from Table DCM 2-3, DCM-2 corresponds to an over-water wind speed per DCM-2 page 10.

Step 4: Determine Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1-hr,water}$

Fetch Length (in miles), X =	3.62	miles	

Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:

If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{Cat5,1-hr,land}$ =	-		*(see Step 3)*
$U_{Cat5,1-hr,water} = U_{Cat5,1-hr,land}$ x (U_{water}/U_{land}) =	125.0	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

	3.62	miles	*(see Step 4)*
Wind Velocity (in mph), U =	125.0	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	51	min.	*(Eqn. 4, DCM-2)*
	3080	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3080	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh\{0.9\log_{10}(4.5/t)\}$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.002		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	51	min.	*(see Step 5)*
Category 5, 1-Hr Wind Speed Over Water, $U_{Cat5,1-hr,water}$ =	125.0	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.002		*(see Step 6)*
Category 5, Fetch Limited Wind Speed Over Water = $U_{Cat5,1-hr,water}$ x U_t/U_{3600} =	125	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.62	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: $R_T = 1.0$	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{Cat5,fetch-min,water}$ =	125	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{Cat5,fetch-min,water,\ stability\ adjusted} = U_{Cat5,fetch-min,water}$ x R_T =	125	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{Cat5,fetch-min,water,\ stability\ adjusted}$ = U =	125	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	224	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = 1.467U_A (mph) =	329	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.02	miles	*(see Step 4)*
Fetch Length, F =	19,057	ft	
Category 5, Fetch Limited Wind Speed Over Water = $U_{(cat5,fetch,obt)}$ =	125	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	329	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, H_{mo} = (0.000282)$U_A F^{1/2}$ =	12.61	feet	*(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, T_o = 0.02825$(U_A F)^{1/2}$ =	5.21	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12 T_o^2$ =	139	feet	*(Eqn. 2-8b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

	17.83	feet	
Relative Depth = d/L_o =	0.128		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_A/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_A = Wind Stress Factor (step 10) g = 32.2 ft/s^2

$A = 0.833(gd/U_A^2)^{3/4}$ =	0.1169	
$B = 0.0379(gF/U_A^2)^{1/3}$ =	0.0677	
$C = \tanh(0.833(gd/U_A^2)^{3/8})$ =	0.1164	
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C)\, U_A/g$ =	4.69 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_A^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_A = Wind Stress Factor (step 10) g = 32.2 ft/s^2

$A = 0.530(gd/U_A^2)^{3/4}$ =	0.0104	
$B = 0.00565(gF/U_A^2)^{1/2}$ =	0.0135	
$C = \tanh(0.530(gd/U_A^2)^{3/8})$ =	0.0104	
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C)\, U_A^2/g$ =	8.51 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	8.51	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2} H_s$ =	6.02	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-\ln(n/N)]^{1/2}$ =	11.78	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup:
Zeitler Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<15 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeitler Zee & Sibul: Recommended for shallow impoundments (ave. depth≤16 ft) when Breitschneider has no numeric solution.
Breitschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,057	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{(cat5,fetch)}$ =	125	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	17.83	feet	*(see Step 14)*
Zeitler Zee Eqn: (Note: F=miles); Wind Set-Up, $S = U^2F/(1400D)$ =	2.27	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s^2): $S = 0.0000244(F/d)^{4/5}(U^2/F)^{2.0/3.0}(F/g)^{1.0/3.0}$ =	0.61	feet	*(Eqn. 7, DCM-2)*
Average of Zeitler Zee & Sibul: Wind Setup, $S = (S_{Zeitler\ Zee} + S_{Sibul})/2$ =	1.44	feet	
Breitschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Sigma[(KU^2/gX)(gd/U^2)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeitler Zee, Sibul, Average, Breitschneider)* =	Zeitler Zee		
Computed Wind Set-Up, S =	2.27	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_s = Effective Depth + Wind Set-Up = d + S =	20.10	feet	*(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of Interest is at Toe of Structure, $d_i = d_s$ =	20.10	feet	*(see Step 19)*
Wave Breaking Height, H_b (for depth d_b) = (d_b/1.28) =	15.71	feet	*(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_b [step 20] ≤ H^* [step 17] then yes, else no) =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	11.78	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	17.83	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	139	feet	*(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.128		
H/H^*_o =	0.9175		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H^*_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	15.71	feet	*(see Step 20)*
Significant Wave Height, H_s =	11.78	feet	*(see Step 17)*
H/H^*_o =	0.9175		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H^*o = H/(H/H^*o)$ =	12.83	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	12.83	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_s/H^*_o

Water Depth at Toe of Structure, d_s =	20.10	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H^*_o =	12.83	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H^*_o =	1.57		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District. *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers. *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers. *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers. *Shore Protection Manual, Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers. *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,097	feet	
Category 5, Fetch Limited Wind Speed Over Water = $U_{CAT5,fetch-ltd}$ =	125	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	329	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	2.27	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	12.83	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	5.21	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.57		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(gT_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	12.83	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	5.21	sec	*(see Step 12)*
$H'_o/(gT_o^2)$ =	0.015		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.57		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.57

$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
ds/H'o <=1.57 from Fig. 7-10 =	0.8		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.75		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.57

$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
ds/H'o >=1.57 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.89		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.57		*(see Step 23)*
$H'_o/(gT_o^2)$ =	0.015		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.84		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.84		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	12.83		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	10.80	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	10.80	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	12.10	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	12.10	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	8.47	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	45	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	8.47		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.6	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 2: 100-Year Precipitation Combined with Category 5 Hurricane Winds
Site C-43: Cell 2 (Fetch 2B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	0.77	ft	*(based upon max. water surface elevation of routed storm event)*
Wind Setup =	2.27	ft	*(see Step 18)*
Wave Height & Runup =	7.62	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	10.67	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.06	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	10.67	ft	*(see Step 33)*
Embankment Height (not including camber) =	27.73	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	10.67	ft	*(see Step 33)*
Embankment Settlement =	0.67	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	28.40	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	11.34	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Site C-43: Cell 2 (Fetch 2B)

Steps 1-2: Not necessary for Case 3

Project Location =	C-43 Cell No. 2		
Probable Maximum Wind (PMW) Speed, $U_{PMW,60\text{-}sec,\ water}$ =	200.0	mph	*(pg 13, DCM-2)*

For Case 3, the 200 mph assumed PMW corresponds to an over-water 1-minute average wind speed. *(pg 13, DCM-2)*

Step 3: Determine PMW, 1-Hr Wind Speed, $U_{PMW,\ 1\text{-}hr}$

Initial wind speed duration, t =	60	sec.	*(based on Step 1 Data)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
U_t/U_{3600} =	1.24		*(Eqn. 1, DCM-2)*
$U_t = U_{PMW,\ 60\text{-}sec}$ =	200.00	mph	*(see Step 2)*
$U_{PMW,\ 3600\text{-}sec} = U_{PMW,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	160.8	mph	

Step 4: Determine PMW, 1-Hr Wind Speed Over Water, $U_{PMW,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.62	miles	
If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1		*(Fig. II-2-20, CEM)*
$U_{PMW,1\text{-}hr,land}$ =	-		*(see Step 3)*
$U_{PMW,1\text{-}hr,water} = U_{PMW,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	160.8	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =			
Wind Velocity (in mph), U =	160.8	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.67}/U^{0.34})$ =	47	min.	*(Eqn. 4, DCM-2)*
	2827	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	2827	sec.	*(see Step 5)*

Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}

For t ≤ 3,600: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For 3,600 < t < 36,000: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	47	min.	*(see Step 5)*
100-Yr, 1-Hr Wind Speed Over Water, $U_{100\text{-}yr,1\text{-}hr,water}$ =	160.8	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.003		*(see Step 6)*
PMW, t-min Wind Speed Over Water = $U_{PMW,1\text{-}hr,water} \times U_t/U_{3600}$ =	161	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.62	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	° C	

Stability Correction Factor, R_T

For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{PMW,fetch\text{-}min,water}$ =	161	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U_{PMW,fetch\text{-}min,water} \times R_T$ =	161	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{PMW,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	161	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	306	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	449	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input
The cells with analysis output

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.62	miles	*(see Step 5)*
Fetch Length, F =	19,097	ft	
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW,Fetch,Lim}$ =	161	mph	*(see Step 7)*
Wind Stress Factor, U_s (ft/s) =	446	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep Water Significant Wave Height, $H_{mo} = (0.000282)U_s F^{1/2}$ = 17.46 feet *(Eqn. 3-33c, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_s F)^{1/3}$ = 5.76 sec *(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12 T_o^2$ = 171 feet *(Eqn. 2-8b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-6, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water *(pg 2-6, SPM)*

	17.06	feet
Relative Depth = d/L_o =	0.1	*(pg 2-6, SPM)*
Wave Classification =	Transitional/Shallow-Water	*(pg 2-6, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C) U_s/g$ *(Eqn. 3-40, SPM)*
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_s^2)^{3/8}$ =	0.0910	
$B = 0.0379(gF/U_s^2)^{1/3}$ =	0.0550	
$C = \tanh(0.833(gd/U_s^2)^{3/8})$ =	0.0908	
Shallow-Water Wave Period, $T = 7.54 \tanh(A) \tanh(B/C) U_s/g$ =	5.16 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C) U_s^2/g$ *(Eqn. 3-39, SPM)*
where: F = Fetch Length (ft) (step 5) U_s = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_s^2)^{3/4}$ =	0.0063	
$B = 0.00565(gF/U_s^2)^{1/2}$ =	0.0099	
$C = \tanh(0.530(gd/U_s^2)^{3/4})$ =	0.0063	
Shallow-Water Significant Wave Height, $H = 0.283 \tanh(A) \tanh(B/C) U_s^2/g$ =	19.25 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height
Depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	19.25	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{-1/2} H_s$ =	7.25	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms} [-\ln(n/N)]^{1/2}$ =	14.18	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup.
Zeidler Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth< 16 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeidler Zee & Sibul: Recommended for shallow impoundments (ave. depth< 16 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	3.62	miles	*(see Step 5)*
Fetch Length, F =	19,097	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{PMW,Fetch,Lim}$ =	161	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	17.06	feet	*(see Step 14)*
Zeidler Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2 F/(1400D)$ =	3.94	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0002444(F/g)^{1/3}(U^2/g)^{2(F/g)^{-0.0375}}$ =	1.16	feet	*(Eqn. 7, DCM-2)*
Average of Zeidler Zee & Sibul: Wind Setup, $S = (S_{Zeidler\ Zee} + S_{Sibul})/2$ =	2.55	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \frac{3}{4}[(kU^2/gx)(gF/g)$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeidler Zee, Sibul, Average, Bretschneider)* =	Zeidler Zee		
Computed Wind Set-Up, S =	3.94	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_t = Effective Depth + Wind Set-Up = d + S = 21.00 feet *(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 1B-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_x = d_t$ =	21.00	feet *(see Step 19)*
Wave Breaking Height, H_b (for depth d_x) = $(d_x/1.28)$ =	16.41	feet *(Eqn. 2-91 & 3-50, SPM)*
Is max. wave height limited by breaking? (If H_s (step 20) $\leq H^*$ (step 17) than yes, else no) =	No	
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_s (step 20))		
Maximum Wave Height =	14.18 feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	17.06	feet *(see Step 14)*
Deep-Water Wave Length, L_o =	171	feet *(see Step 13)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.1	
H/H'_o =	0.9327	*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17)
then Equivalent Deep-Water Wave Height is Wave Breaking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	16.41	feet	*(see Step 20)*
Significant Wave Height, H_s =	14.18	feet	*(see Step 17)*
H/H'_o =	0.9327		*(see Step 21)*
If Shallow-Water, Equivalent Deep-Water Wave Height, $H'o = H/(H/Ho)$ =	15.20	feet	
If Deep Water, Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking, Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	15.20	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_t/H'_o

Water Depth at Toe of Structure, d_t =	21.00	feet *(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	15.20	feet *(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_t/H'_o =	1.38	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum, DCM-2, Revision 001.00g*, October 26, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.62	miles	*(see Step 5)*
Fetch Length, F =	19,097	feet	
PMW, Fetch Limited Wind Speed Over Water = $U_{PMW,fetch-min}$ =	161	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	449	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	3.94	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	15.20	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	5.78	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.38		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	15.20	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	5.78	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.014		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.38		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.014		*(see Step 24)*
Face Slope Material =	Stop-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.38

$H'_o/(g*T_o^2)$ =	0.014		*(see Step 24)*
ds/H'o <=1.38 from Fig. 7-10 =	0.8		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.82		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.38

$H'_o/(g*T_o^2)$ =	0.014		*(see Step 24)*
ds/H'o >=1.38 from Fig. 7-11 =	2.0		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.96		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.38		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.014		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.89		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.89		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	15.20		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	13.50	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-16 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	13.50	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	15.12	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Stop-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	15.12	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	10.58	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	45	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	10.58		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	9.5	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*. U.S. Department of Interior.

3/12/2007

Case 3: Probable Maximum Wind Speed Combined with Normal Full Storage Level (Uncontrolled Spillway Level)
Site C-43: Cell 2 (Fetch 2B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	0.00	ft	*(no surcharge, normal full storage level elevation assumed)*
Wind Setup =	3.94	ft	*(see Step 18)*
Wave Height & Runup =	9.53	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	13.47	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.06	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	13.47	ft	*(see Step 33)*
Embankment Height (not including camber) =	30.53	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	13.47	ft	*(see Step 33)*
Embankment Settlement =	0.98	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	31.51	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	14.45	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Site C-43: Cell 2 (Fetch 2B)

Step 1-2: Select EASY, 3-Sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$

Project Location =	C-43 Cell No. 2		
EASY, 3-sec Gust Wind Speed, $U_{EASY,3\text{-}sec}$ =	125.0	mph	*(pg. 14, DCM-2)*

The Hurricane Easy, 125 mph, 3-sec gust wind speed is a storm specific case. Therefore, it is assumed that the Step 2 conversion factor adjustment is not relevant for this case.

Step 3: Determine EASY, 1-Hr Wind Speed, $U_{EASY,\ 1\text{-}hr}$

Initial wind speed duration, t =	3	sec.	*(based on Step 1 Data)*
Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}			
For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
U_t/U_{3600} =	1.51		*(Eqn. 1, DCM-2)*
$U_t = U_{EASY,3\text{-}sec}$ =	125.00	mph	*(see Step 2)*
$U_{100\text{-}yr,\ 3600\text{-}sec} = U_{100\text{-}yr,\ 1\text{-}hr} = U_t/(U_t/U_{3600})$ =	82.8	mph	

Step 4: Determine EASY, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$

Fetch Length (in miles), X =	3.62	miles	
Wind Speed Over Water to Wind Speed Over Land Ratio, U_{Water}/U_{Land}:			
If initial data from Step 1 is over water wind speed, no conversion (Ratio = 1.0)	does not apply		*(Fig. II-2-20, CEM)*
For Fetch Length < 10 miles: U_{Water}/U_{Land} = 1.2 or 1.0	applies		*(Fig. II-2-20, CEM)*
For Fetch Length > 10 miles: See Figure II-2-7, CEM	does not apply		*(Fig. II-2-7, CEM)*
U_{water}/U_{land} =	1.2		*(Fig. II-2-20, CEM)*
$U_{Easy,1\text{-}hr,land}$ =	82.8		*(see Step 3)*
$U_{EASY,1\text{-}hr,water} = U_{EASY,1\text{-}hr,land} \times (U_{water}/U_{land})$ =	99.4	mph	

Step 5: Estimate Fetch-Limited Wind Duration Time

Fetch Length (in miles), X =	3.62	miles	*(see Step 4)*
Wind Velocity (in mph), U =	99.4	mph	*(see Step 4)*
Fetch Limited Wind Duration Time, $t = 112(X^{0.57}/U^{0.34})$ =	55	min.	*(Eqn. 4, DCM-2)*
	3329	sec.	

Step 6: Estimate Ratio of Fetch Limited Duration Wind Speed and 1-Hour Wind Speed

Fetch Limited Wind Duration Time (in seconds), t =	3329	sec.	*(see Step 5)*
Equations for ratio of wind speeds to 1-hour average wind speeds, U_t/U_{3600}			
For $t \leq 3{,}600$: $U_t/U_{3600} = 1.277 + 0.296\tanh(0.9\log_{10}(45/t))$ =	applies		*(Eqn. 1, DCM-2)*
For $3{,}600 < t < 36{,}000$: $U_t/U_{3600} = -0.15\log_{10}(t)+1.5334$ =	does not apply		*(Eqn. 2, DCM-2)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(Eqn. 1, DCM-2)*

Step 7: Adjust 1-Hr Wind Speed (over water) to Equivalent Fetch Limited Duration Wind Speed

Fetch Limited Wind Duration (in minutes), t =	55	min.	*(see Step 5)*
EASY, 1-Hr Wind Speed Over Water, $U_{EASY,1\text{-}hr,water}$ =	99.4	mph	*(see Step 4)*
Ratio of Fetch Limited Duration Wind Speed to 1-Hour Wind Speed, U_t/U_{3600} =	1.001		*(see Step 6)*
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,1\text{-}hr,water} \times U_t/U_{3600}$ =	99	mph	

Step 8: Stability Correction, Adjust Wind Speed for Boundary Layer Stability

Fetch Length (in miles), X =	3.62	miles	*(see Step 4)*
(If Fetch Length > 10 miles, else enter 0) Temperature of Air, T_a =	0	o C	
(If Fetch Length > 10 miles, else enter 0) Temperature of Sea, T_s =	0	o C	
Air-Sea Temperature Difference, ΔT_{as} $T_a - T_s$ =	0	°C	
Stability Correction Factor, R_T			
For Fetch Length < 10 miles: R_T = 1.0	applies		*(pg. II-2-36, CEM)*
For Fetch Length > 10 miles: Based on ΔT_{as}, See Figure 3-14, SPM or in absence of temperature information, assume RT = 1.1	does not apply		*(Fig.3-14, SPM)* *(pg 3-30, SPM)*
$U_{EASY,fetch\text{-}min,water}$ =	99	mph	*(see Step 7)*
Stability Correction Factor, R_T =	1		*(pg. II-2-36, CEM)*
$U_{EASY,fetch\text{-}min,water,\ stability\ adjusted} = U_{EASY,fetch\text{-}min,water} \times R_T$ =	99	mph	*(Eqn. 3-27 SPM)*

Step 9. Compute Wind Stress Factor, U_A

$U_{EASY,fetch\text{-}min,water,\ stability\ adjusted} = U$ =	99	mph	*(see Step 8)*
Wind Stress Factor, $U_A = 0.589U^{1.23}$ =	169	mph	*(Eqn. 3-28b SPM)*

Step 10. Wind Stress Factor in ft/s

Wind Stress Factor, U_A (ft/s) = $1.467U_A$ (mph) =	247	ft/sec	*(see Step 9)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (36.7") & 72-hr (46.2") Rainfall Durations)
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,097	ft	
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY(fetch-ltd)}$ =	99	mph	*(see Step 7)*
Wind Stress Factor, U_* (ft/s) =	247	ft/s	*(see Step 10)*

Step 11. Compute Deep-Water Significant Wave Height, H_{mo}

Deep-Water Significant Wave Height, $H_{mo} = (0.000282)U_*F^{1/2}$ =	9.64	feet	*(Eqn. 3-33a, SPM)*

Step 12. Compute Deep-Water Wave Period, T_o

Deep-Water Wave Period, $T_o = 0.02825(U_*F)^{1/2}$ =	4.74	sec	*(Eqn. 3-34c, SPM)*

Step 13. Compute Deep-Water Wave Length, L_o

Deep-Water Wave Length, $L_o = 5.12T_o^2$ =	115	feet	*(Eqn. 3-4b, SPM)*

Step 14. Compute Relative Depth, d/L_o

If $d/L_o \leq 0.5$, waves are classified as transitional or shallow water waves. *(pg 2-9, SPM)*
If $d/L_o > 0.5$, waves are classified as deep water. *(pg 2-9, SPM)*

	20.83	feet	
Relative Depth = d/L_o =	0.181		*(pg 2-9, SPM)*
Wave Classification =	Transitional/Shallow-Water		*(pg 2-9, SPM)*

Step 15. Compute Shallow-Water Wave Period, T

Shallow-Water Wave Period, $T = 7.54\tanh(A)\tanh(B/C)\,U_*/g$ *(Eqn. 3-40, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.833(gd/U_*^2)^{3/4}$ =	0.1533	
$B = 0.0379(gF/U_*^2)^{1/3}$ =	0.0818	
$C = \tanh(0.833(gd/U_*^2)^{3/8})$ =	0.1521	
Shallow-Water Wave Period, $T = 7.54\tanh(A)\tanh(B/C)\,U_*/g$ =	4.33 sec	*(Eqn. 3-40, SPM)*

Step 16. Compute Shallow-Water Significant Wave Height, H

Shallow-Water Significant Wave Height, $H = 0.283\tanh(A)\tanh(B/C)\,U_*^2/g$ *(Eqn. 3-39, SPM)*

where: F = Fetch Length (ft) (step 5) U_* = Wind Stress Factor (step 10) g = 32.2 ft/s²

$A = 0.530(gd/U_*^2)^{3/4}$ =	0.0179	
$B = 0.00565(gF/U_*^2)^{1/2}$ =	0.0179	
$C = \tanh(0.530(gd/U_*^2)^{3/8})$ =	0.0179	
Shallow-Water Significant Wave Height, $H = 0.283\tanh(A)\tanh(B/C)\,U_*^2/g$ =	7.35 feet	*(Eqn. 3-39, SPM)*

Step 17. Compute Shallow-Water Wave Height for Zero Overwash

DCM-2 requires zero over wash as a design criteria for high and significant hazard dams. For purposes of the DCM-2, zero-overwash wave height is defined as the wave height with a 2% occurrence frequency.

Significant Wave Height is either the Deep-Water or Shallow-Water Significant wave height depending upon the Wave Classification (Step 14).

Significant Wave Height, H_s =	7.35	feet	*(see Step 11 or 16)*
Required probability of wave height being exceeded, n/N =	0.02		*(see Step 17 discussion)*
Root Mean Square Wave Height, $H_{rms} = 2^{1/2}H_s$ =	5.19	feet	*(Eqn. 3-10, SPM)*
Wave Height which is exceeded at given probability, $H^* = H_{rms}[-Ln(n/N)]^{1/2}$ =	10.16	feet	*(Eqn. 3-7, SPM)*

Step 18. Compute Wind Set-Up

Four different methods are calculated and considered in estimating wind setup
Zeidler Zee Eqn: Widely used as applied to reservoirs but tends to overestimate wind setup for shallow impoundments (ave. depth<15 ft).
Sibul Eqn: Typically yields the lowest wind setup.
Ave. of Zeidler Zee & Sibul: Recommended for shallow impoundments (ave. depth<15 ft) when Bretschneider has no numeric solution.
Bretschneider Eqn: Recommend for shallow impoundments (average depth <15 ft).

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,097	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{EASY(fetch-ltd)}$ =	99	mph	*(pg A6, DCM-2)(see Step 7)*
Average Depth of Water along Fetch Line, D = Effective Depth =	20.82666667	feet	*(see Step 14)*
Zeidler Zee Eqn (Note: F=miles): Wind Set-Up, $S = U^2F/(1400D)$ =	1.23	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn (Note: F=feet, g=32.2 ft/s²): $S = 0.0000144d(Fd)^{1.65}(U^2/Fg)^{(1/2)(0.57d_{0.25}-0.57d_0)}$ =	0.30	feet	*(Eqn. 7, DCM-2)*
Average of Zeidler Zee & Sibul: Wind Setup, $S = (S_{Zeidler\ Zee} + S_{Sibul})/2$ =	0.76	feet	
Bretschneider Eqn (Note: Calcs provided separately in Step 18a): $S = \Box[(kU^2\Box x)/(gd^2)]$ =	n/a	feet	*(Eqn. 6, DCM-2)(Step 18a)*
Equation Used for Wind Setup *(Enter Zeidler Zee, Sibul, Average, Bretschneider)* =	Zeidler Zee		
Computed Wind Set-Up, S =	1.23	feet	*(Eqn. 5, DCM-2)*

Step 19. Compute Water Depth at Toe of Structure

Water Depth at Toe of Structure, d_o = Effective Depth + Wind Set-Up = d + S =	22.05	feet	*(pg. 6, DCM-2)*

Step 20. Check for Depth Limited Wave Breaking

See if wave height is limited due to breaking. After breaking, waves will tend to reform with lower heights within a few wave lengths. *(pg. 15-4, EM-1110-2-1420)*

Depth of interest is at Toe of Structure, $d_x = d_o$ =	22.05	feet	*(see Step 19)*
Wave Breaking Height, H_b *(for depth d_b)* = $(d_b/1.28)$ =	17.23	feet	*(Eqn. 2-91 & 2-92, SPM)*
Is max. wave height limited by breaking? *(If H_s [step 20] $\leq H^*$ [step 17] then yes, else no)* =	No		
(If no, wave height = H^* (step 17). If yes, conservatively assume wave height = H_b (step 20)) Maximum Wave Height =	10.16	feet	

Step 21. Estimate Ratio Between Deep-Water Wave Ht & Equivalent Deep-Water Ht

The value of H/Ho (shallow-water wave height/equivalent deep-water wave height) is estimated based on the value of d/L_o (effective depth / deep-water wave length) from Table C-1, SPM Vol II, Appendix C.

Effective Depth, d =	20.82666667	feet	*(see Step 14)*
Deep-Water Wave Length, L_o =	115	feet	*(see Step 12)*
Ratio of effective depth to deep-water wave length, d/L_o =	0.181		
H/H'_o =	0.9146		*(Table C-1, SPM Vol 2)*

Step 22. Compute Equivalent Deep-Water Wave Height, H'_o

If wave classification is Deep-Water (Step 14), Significant Deep-Water Height is the Equivalent Deep-Water Height.
If wave classification is Transitional/Shallow-Water an adjustment is necessary.
If Wave Breaking Height (Step 20) is less than the Zero Overwash for Significant Wave Height (Step 17) then Equivalent Deep-Water Wave Height is Wave Braking Height (irregardless of wave classification).

Wave Breaking Height, H_b =	17.23	feet	*(see Step 20)*
Significant Wave Height, H_s =	10.16	feet	*(see Step 17)*
H/H'_o =	0.9146		*(see Step 21)*
If Shallow-Water: Equivalent Deep-Water Wave Height, $H'o = H(H/H'o)$ =	11.11	feet	
If Deep Water: Equivalent Deep-Water Wave Height = Significant Deep-Water Height =	n/a	feet	
If Height Limited by Wave Breaking: Equiv. Deep-Water Wave Ht. = Wave Breaking Ht. =	n/a	feet	
Equivalent Deep-Water Wave Height =	11.11	feet	

Step 23. Compute Depth at Toe of Structure to Equiv. Deep-Water Wave Ht, d_o/H'_o

Water Depth at Toe of Structure, d_o =	22.05	feet	*(see Step 19)*
Equivalent Deep-Water Wave Height, H'_o =	11.11	feet	*(see Step 22)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_o/H'_o =	1.98		

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Site C-43: Cell 2 (Fetch 2B)

Design Wind Analysis - Summary Data

Fetch Length, F =	3.62	miles	*(see Step 4)*
Fetch Length, F =	19,097	feet	
EASY, Fetch Limited Wind Speed Over Water = $U_{EASY,fetch-ltd}$ =	99	mph	*(see Step 7)*
Wind Stress Factor, U_A (ft/s) =	247	ft/s	*(see Step 10)*

Wind Setup and Wave Properties Analysis - Summary Data

Wind Set-Up , S =	1.23	feet	*(see Step 18)*
Equivalent Deep-Water Wave Height, H'_o =	11.11	feet	*(see Step 22)*
Deep-Water Wave Period, T_o =	4.74	sec	*(see Step 12)*
Ratio of Water Depth at Toe of Structure to Equivalent Deep-Water Wave Height, d_s/H'_o =	1.99		*(see Step 23)*

Step 24. Compute Ratio of $H'_o/(g*T_o^2)$

Equivalent Deep-Water Wave Height, H'_o =	11.11	feet	*(see Step 22)*
Gravitational constant, g =	32.2	ft/s^2	*(constant variable)*
Deep Water Wave Period, T_o =	4.74	sec	*(see Step 12)*
$H'_o/(g*T_o^2)$ =	0.015		

Steps 25 - 27. Estimate R/H'o *(Fig. 7-8 thru 7-20, SPM Vol. 2)*

Steps 25-27 are directed towards deriving the ratio of Wave Runup to the Equivalent Deep-Water Wave Height (R/H'_o) from graphs found in SPM Volume 2 (Fig. 7-8 thru 7-20). The graphs are based upon various designs of the runup face slope including the material, roughness, slope, and geometry the face slope. In addition the value of R/H'_o depends upon the values of d_s/H'_o and $H'_o/(gT^2)$. Determination of values will typically require an interpolation of values between graphs.

d_s/H'_o =	1.99		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
Face Slope Material =	Step-Faced Slope		*Embankment Design*
Runup Face Slope (H:1V) =	3		*Embankment Design*
Runup Face Slope (Θ) =	18.4	degrees	
Figure used for Interpolation (Lower Interpolation Number) =	Fig. 7-10		*(SPM Vol. 2)*
Figure to used for Interpolation (Higher Interpolation Number) =	Fig. 7-11		*(SPM Vol. 2)*

Step 25. R/H'o from Fig. 7-10 with ds/H'o <= 1.99

$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
ds/H'o <=1.99 from Fig. 7-10 =	0.6		*(Fig. 7-10, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-10 =	0.75		*(Fig. 7-10, SPM Vol. 2)*

Step 26. R/H'o from Fig. 7-11 with ds/H'o >= 1.99

$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
ds/H'o >=1.99 from Fig. 7-11 =	2		*(Fig. 7-11, SPM Vol. 2)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o from Fig. 7-11 =	0.89		*(Fig. 7-11, SPM Vol. 2)*

Step 27. Estimated Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o

d_s/H'_o =	1.99		*(see Step 23)*
$H'_o/(g*T_o^2)$ =	0.015		*(see Step 24)*
Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'o =	0.89		*(Interpolated from Steps 25 & 26)*

Step 28. Compute Smooth Surface Wave Runup

Ratio of Wave Runup to Equivalent Deep-Water Wave Height, R/H'_o =	0.89		*(see Step 27)*
Equivalent Deep-Water Wave Height, H'_o =	11.11		*(see Step 22)*
Smooth Surface Wave Runup = R/H'_o x H'_o =	9.90	feet	

Step 29. If Applicable, Determine and Apply Wave Runup Correction Factor due to Scale Effects

This step applies if Figures 7-8 thru 7-12 or Figures 7-14 thru 7-18 were used to estimate R/H'_o in Steps 25-27. These figures summarize results for small-scale lab tests. Due to the inability to scale roughness effects in small-scale lab tests, the results are probably smaller than the runup on prototype structures. Figure 7-13 is used to adjust for this scale effect.

Smooth Surface Wave Runup = R/H'_o x H'_o =	9.90	feet	*(see Step 28)*
Scale Wave Runup Correction due to Scale Effects *(If Fig. 7-19 or 7-20 used, enter 1)* =	1.12		*(Fig. 7-13, SPM Vol. 2)*
Scale Corrected Wave Runup Height = (Smooth Surface Wave Runup)(Runup Correction) =	11.09	feet	

Step 30. Determine and Apply Correction Factor due to Dam Surface Roughness

Face Slope Material =	Step-Faced Slope		*(see Step 25)*
Surface Roughness Correction =	0.7		*(Table 7-2, SPM Vol 2) or (Table 2-2 EM1110-2-1614)*
Scale Corrected Wave Runup Height =	11.09	feet	*(see Step 29)*
Corrected Wave Runup = (Scale Corrected Wave Runup)(Surface Roughness Correction) =	7.76	feet	

Step 31. Correction Due to to Fetch Axis Not Being Normal to the Dam Axis

Angle Between Fetch Axis and Embankment Axis =	45	degrees	
Angle Correction Factor =	0.90		*(Fig. 8, ACER TM No. 11)*

Step 32. Adjusted Wave Runup

Corrected Wave Runup =	7.76		*(see Step 30)*
Angle Correction Factor =	0.90		*(see Step 31)*
Final Adjusted Wave Runup = (Corrected Wave Runup)(Angle Correction Factor) =	7.0	feet	

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

The cells that required input.
The cells with analysis output.

Referencos:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003*.
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

3/12/2007

Case 4: Hurricane Easy (125 mph, 3-sec Gust Wind Speed Combined With Both 24-hr (38.7") & 72 hr (45.2") Rainfall Durations)
Site C-43: Cell 2 (Fetch 2B)

Step 33. Minimum Required Design Freeboard

Design Precipitation **or** Flood Surge Depth (Routed Flood Event) =	3.77	ft	*(conservatively assumed to be total EASY precipitation of 45.2")*
Wind Setup =	1.23	ft	*(see Step 16)*
Wave Height & Runup =	6.99	ft	*(see Step 32)*
Waves Induced by Potential Landslides =	0.00	ft	*(not considered)*
Provision for Malfunction of the Spillway or Discharge Structure =	0.00	ft	*(not considered)*
Summation of all above Freeboard Components is Minimum Required Freeboard =	11.98	ft	*(rounded up to the next 0.01 foot)*

Step 34. Minimum Required Design Freeboard with Camber

Average Normal Full Storage Depth =	17.06	ft	*(Average Depth along Fetch based on NFSL = 42 ft El.)*
Minimum Required Freeboard =	11.98	ft	*(see Step 33)*
Embankment Height (not including camber) =	29.04	ft	*(summation of average normal full storage depth and freeboard)*
Minimum Required Freeboard =	11.98	ft	*(see Step 33)*
Embankment Settlement =	0.78	ft	*(see Technical Memorandum Table 3 or BODR Section 8E)*
Minimum Embankment Height (with camber) =	29.82	ft	*(minimum embankment height plus settlement)*
Minimum Required Design Freeboard with Camber =	12.76	ft	*(rounded up to the next 0.01 foot)*

Note: The analyses based upon methodologies presented in the SFWMD Design Criteria Manual DCM-2.

References:

1. South Florida Water Management District, *Design Criteria Memorandum: DCM-2, Revision 001.00g*, October 28, 2005.
2. U.S. Army Corps of Engineers, *Coastal Engineering Manual, EM-1110-2-110, July 31, 2003.*
3. U.S. Army Corps of Engineers, *Hydrologic Engineering Requirements for Reservoirs, EM-1110-2-1420*, October 31, 1997.
4. U.S. Army Corps of Engineers, *Shore Protection Manual: Volume I & Volume II*, 1984.
5. U.S. Army Corps of Engineers, *Design of Coastal Revetments, Seawalls and Bulkheads*, EM 1110-2-1614, 1995.
6. U.S. Bureau of Reclamation, *Downstream Hazard Classification Guidelines, ACER Tech. Memorandum No. 11*, U.S. Department of Interior.

The cells that required input.
The cells with analysis output.

Appendix D: Step-By-Step Manual Freeboard Calculation References

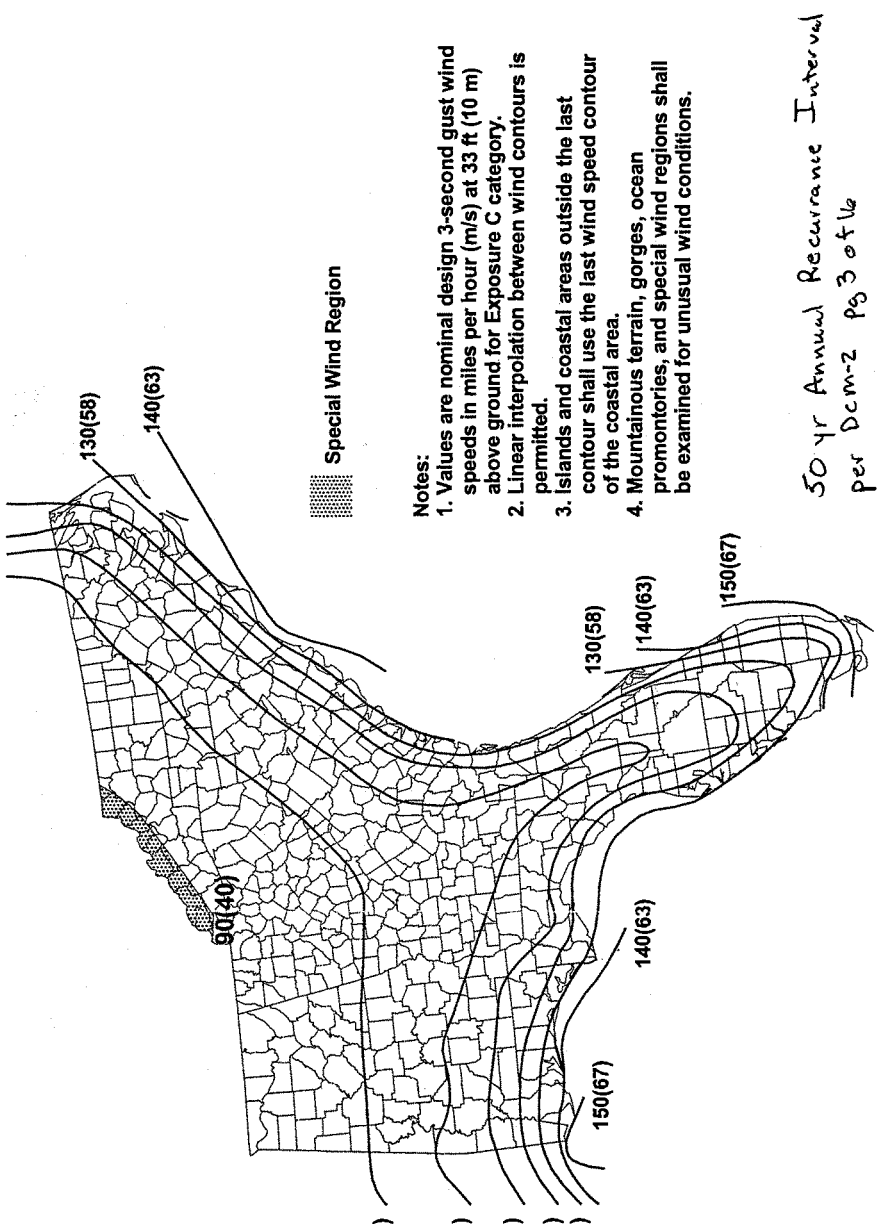


FIGURE 6-1b
BASIC WIND SPEED – EASTERN GULF OF MEXICO AND SOUTHEASTERN US HURRICANE COASTLINE

Step 1

Minimum Design Loads for Buildings and Other Structures

Reference:
ASCE Standard
Minimum Design Loads for
Buildings and Other
Structures. SEI/ASCE 7-02

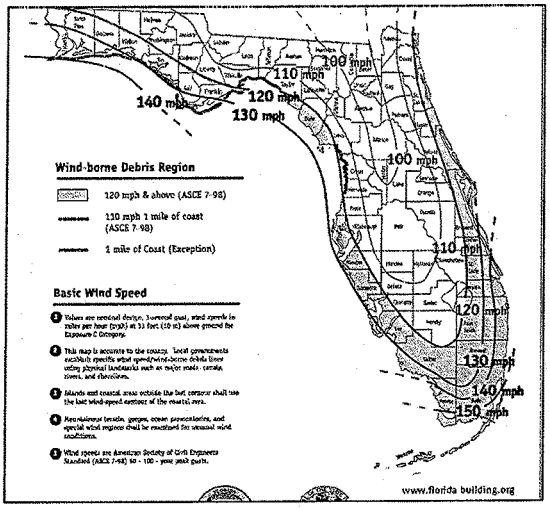


Figure DCM 2-2: Florida 50-Year to 100-Year Gust Wind Speeds (mph) (ref. ASCE 7-02, Figure 6-1b; Florida Building Code, Figure 1606)

The conservative assumption is to assume that the wind speeds on **Figure DCM 2-2** represent 50-year wind speeds and convert the values to 100-year wind speeds, as shown below. The equivalent 100-year wind speeds listed in **Table DCM 2-2**, use a factor of 1.07 to convert hurricane wind speeds from a 50-year to a 100-year return (from the standard structural design reference of the American Society of Civil Engineers (ASCE) Table C 6-3, ASCE 2003). For example, if an area with a 125-mph wind speed is selected from **Figure DCM 2-2**, the corresponding 3-second gust 100-year wind speed would be 134 mph.

Table DCM 2-2: Wind Speed Conversion Factors by Return Period

Return Period (years)	Conversion Factor
500	1.23
200	1.14
100	1.07
50	1.00
25	0.88

The 3-second gust wind speeds shown on **Figure DCM 2-2** are of an insufficient duration to fully develop significant waves. Specifically, the wind speed duration of 3 seconds is insufficient to develop the wave height, which would occur due to the traction of a constant wind at this speed and propagate the wave across the reservoir. Therefore, wind speed adjustments appropriate for developing significant reservoir waves are to be developed as shown below.

ASCE Figure 6-1b (ASCE, 2003) shows the same wind speeds as Figure 1606 in the Florida Building Code. Figures 6-1a, 6-1b, and 6-1c (ASCE, 2003) cover the Gulf and Atlantic coasts from southern Texas to Florida to North Carolina and to Maine. The figures provide "smoothed" contours of wind speed and are based on a substantial amount of data and analysis. It would be impractical for CERP dam design consultants to duplicate the scope of data analysis used in developing the ASCE figures and is generally not necessary. Use of these figures provides reliable and consistent data from location to location. The analysis of local wind speed gage data, even from first-order stations, would provide unreliable and inconsistent results from location to location because of routine gage malfunctions at extreme wind speeds and the "hit and miss" nature of hurricanes relative to data recording stations. Freeboard criteria for CERP reservoirs, therefore, will be based on Figure 1606 of the Florida Building Code for wind speed data, rather than developing wind speeds based on local gage data, with the appropriate adjustments described below. Figure 1606, which is identified as being based on 50-year to 100-year wind speeds, will be conservatively interpreted as representing 50-year wind speeds for application to freeboard determination.

2.1.1.2 Duration Adjustment of Wind Speeds

When evaluating wave generation in water bodies of different sizes, different wind speed averaging intervals are appropriate. The current Coastal Engineering Manual notes that if extreme wind speeds are being considered, wind speed should be adjusted from the averaging time of the observation (3-second on **Figure DCM 2-2**) to an averaging time appropriate for wave prediction (USACE, 2003, pg. II-2-34). To adjust the wind speeds for duration, the Coastal Engineering Manual references a figure on page II-2-4, which also includes the defining equations? The following equations (USACE, 2003, pg. II-2-4) show the calculation adjustments for the ratio of wind speeds by various durations, to 1-hour average wind speeds.

For $t \le 3{,}600$: $$\frac{U_t}{U_{3,600}} = 1.277 + 0.296 \tanh\left(0.9 \log_{10}\left(\frac{45}{t}\right)\right)$$ Eqn. 1

For $3{,}600 < t < 36{,}000$: $$\frac{U_t}{U_{3,600}} = -0.15 \log_{10} t + 1.5334$$ Eqn. 2

where:

t = time (seconds)

U_t = wind speed (mph) at time t (seconds)

$U_{3,600}$ = 1-hour average wind speed (mph)

This document provides working level guidance to assist in the implementation of projects and project features under the Comprehensive Everglades Restoration Plan (CERP) program implemented by the South Florida Water Management District, the Florida Department of Environmental Protection, and the U.S. Army Corps of Engineers. The guidance does not supersede existing or future federal or state regulation, does not constitute policy for any of these agencies, and does not create authority beyond that granted to any agency member carrying out their duties.

Step 3 [redacted]

Reference: DCM-2

Necessary only if Fetch length, F > 10 miles

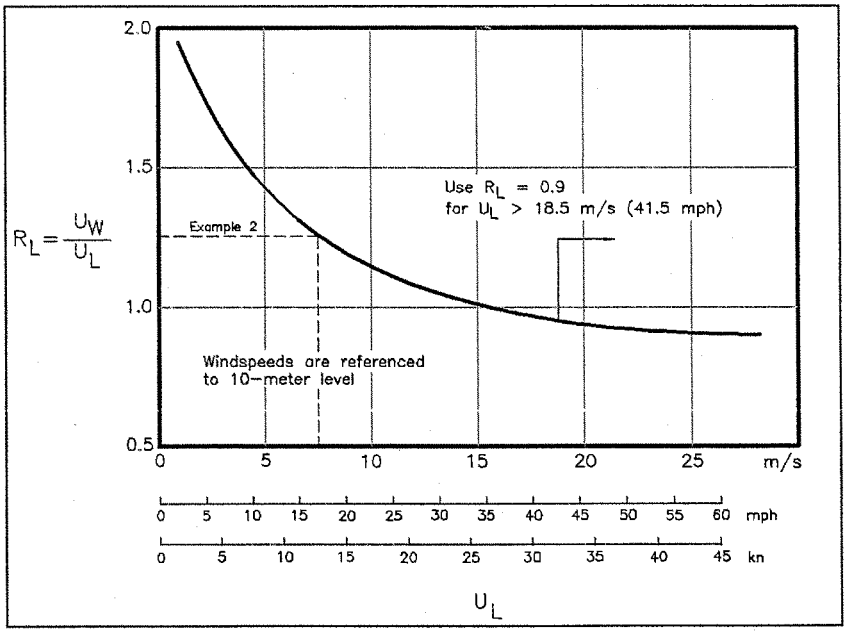


Figure II-2-7. Ratio R_L of windspeed over water U_W to windspeed over land U_L as a function of windspeed over land U_L (after Resio and Vincent (1977))

marine boundary layer and winds from other directions fall within a land boundary layer. In areas such as this, a land-to-sea transform (similar to that shown in Figures II-2-7 and II-2-8) can be used for all angles coming from the land. Depending on the distance to the water and the elevation of the measurement site, winds coming from the direction of open water may or may not still be representative of a marine boundary layer. Guidance for determining the effects of fetch on wind speed modifications can be found in Resio and Vincent (1977) and Smith (1983). These studies indicate that fetch effects wind speeds significantly only at locations within about 16 km (10 miles) of shore.

(e) Wind speed transition from land to water. The net effect of wind speed variation with fetch is to provide a smooth transition from the (generally lower) wind speed over land to the (generally higher) wind speed over water. Thus, wind speeds tend to increase with fetch over the first 10 miles or so after a transition from a land surface. The exact magnitude and characteristics of this transition depend on the roughness characteristics of the terrain and vegetation and on the stability of the air flow. A very simplistic approximation to this wind speed variation for the Resio and Vincent curves used here could be obtained by fitting a logarithmic curve to the asymptotic overland and overwater wind speed values. However, for most design and engineering purposes, it is probably adequate to simply use the long-fetch values with the recognition that they are somewhat conservative. The one situation that should cause some concern would be if overwater wind speed measurements are taken near the upwind end of a fetch. These winds could be considerably lower than wind speeds at the end of the fetch and underconservative values for wave conditions could result from the use of such (uncorrected) winds in a predictive scheme.

Step 4

Reference:
CEM, USACE
EM 1110-2-1100

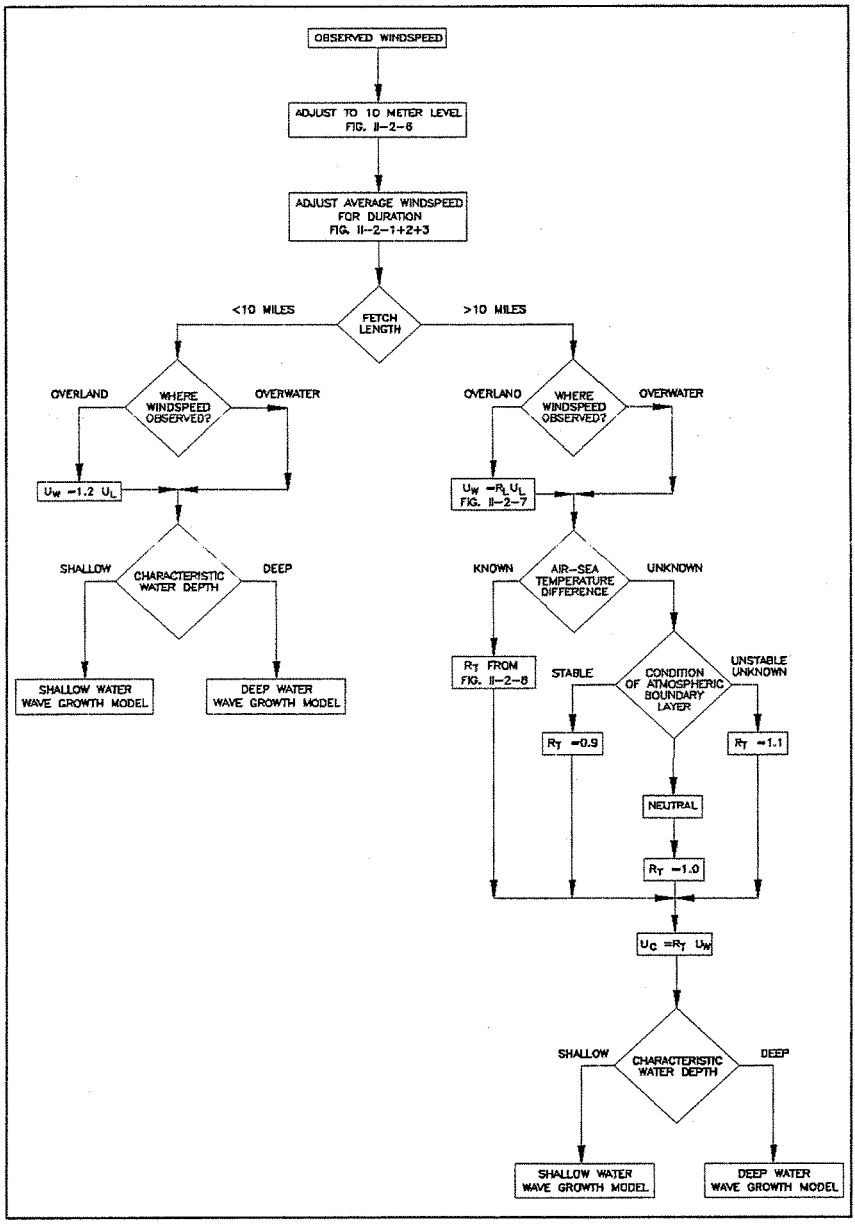


Figure II-2-20. Logic diagram for determining wind speed for use in wave hindcasting and forecasting models

Reference: CEM, USACE EM 1110-2-1100

Step 4.

For a given wind speed and fetch, there is an associated wind duration that, if exceeded, cannot increase the wave size because of the limiting effects of the fetch and depth. The following equation (USACE, 2003, Eqn. II-2-35) can be used to determine whether or not waves in a particular situation can be categorized as fetch limited.

$$t_{x,u} = 77.23\frac{X^{0.67}}{u^{0.34} g^{0.33}} \qquad \text{Eqn. 3}$$

where:

t = wind duration time (seconds)

X = fetch length (meters)

u = wind velocity (meters/sec)

g = gravitational constant (meters/sec^2)

In English units, the above equation would be:

$$t = 112\frac{X^{0.67}}{u^{0.34}} \qquad \text{Eqn. 4}$$

where:

t = wind duration time (minutes)

X = fetch length (miles)

u = wind velocity (mph)

The above Eqn. 4 is also presented in a current publication on freeboard analysis (Holler, 2004). An example can clarify the procedure for determining the 100-year wind speed that would be coincident with the PMP.

2.1.1.3 Example Wind Speed Adjustments

The following wind speed determination generally follows the example procedure for estimating winds for wave prediction provided in the Coastal Engineering Manual beginning on page II-2-34 (USACE, 2003).

1. Assume the reservoir is in an area where the gust-wind is 125 mph based on the Florida Building Code (**Figure DCM 2-2**).

2. Adjust the 50-year, 3-second wind speed to an equivalent 100-year wind speed:

   (125 mph) * 1.07 = 134 mph

This document provides working level guidance to assist in the implementation of projects and project features under the Comprehensive Everglades Restoration Plan (CERP) program implemented by the South Florida Water Management District, the Florida Department of Environmental Protection, and the U.S. Army Corps of Engineers. The guidance does not supersede existing or future federal or state regulation, does not constitute policy for any of these agencies, and does not create authority beyond that granted to any agency member carrying out their duties.

Step 5

Reference: DCM-2

The 3-second gust wind speeds shown on **Figure DCM 2-2** are of an insufficient duration to fully develop significant waves. Specifically, the wind speed duration of 3 seconds is insufficient to develop the wave height, which would occur due to the traction of a constant wind at this speed and propagate the wave across the reservoir. Therefore, wind speed adjustments appropriate for developing significant reservoir waves are to be developed as shown below.

ASCE Figure 6-1b (ASCE, 2003) shows the same wind speeds as Figure 1606 in the Florida Building Code. Figures 6-1a, 6-1b, and 6-1c (ASCE, 2003) cover the Gulf and Atlantic coasts from southern Texas to Florida to North Carolina and to Maine. The figures provide "smoothed" contours of wind speed and are based on a substantial amount of data and analysis. It would be impractical for CERP dam design consultants to duplicate the scope of data analysis used in developing the ASCE figures and is generally not necessary. Use of these figures provides reliable and consistent data from location to location. The analysis of local wind speed gage data, even from first-order stations, would provide unreliable and inconsistent results from location to location because of routine gage malfunctions at extreme wind speeds and the "hit and miss" nature of hurricanes relative to data recording stations. Freeboard criteria for CERP reservoirs, therefore, will be based on Figure 1606 of the Florida Building Code for wind speed data, rather than developing wind speeds based on local gage data, with the appropriate adjustments described below. Figure 1606, which is identified as being based on 50-year to 100-year wind speeds, will be conservatively interpreted as representing 50-year wind speeds for application to freeboard determination.

2.1.1.2 Duration Adjustment of Wind Speeds

When evaluating wave generation in water bodies of different sizes, different wind speed averaging intervals are appropriate. The current Coastal Engineering Manual notes that if extreme wind speeds are being considered, wind speed should be adjusted from the averaging time of the observation (3-second on **Figure DCM 2-2**) to an averaging time appropriate for wave prediction (USACE, 2003, pg. II-2-34). To adjust the wind speeds for duration, the Coastal Engineering Manual references a figure on page II-2-4, which also includes the defining equations? The following equations (USACE, 2003, pg. II-2-4) show the calculation adjustments for the ratio of wind speeds by various durations, to 1-hour average wind speeds.

For $t \le 3{,}600$: $$\frac{U_t}{U_{3,600}} = 1.277 + 0.296 \tanh\left(0.9 \log_{10}\left(\frac{45}{t}\right)\right)$$ Eqn. 1

For $3{,}600 < t < 36{,}000$: $$\frac{U_t}{U_{3,600}} = -0.15 \log_{10} t + 1.5334$$ Eqn. 2

where:

t = time (seconds)

U_t = wind speed (mph) at time t (seconds)

$U_{3,600}$ = 1-hour average wind speed (mph)

Step [redacted] 6

Reference: DCM-2

be considered. When the observed wind is given in terms of the fastest mile, Figure II-2-2 can be used to convert to an equivalent averaging time.

(c) Overland or overwater. When the observation was collected overwater (within the marine boundary layer), this adjustment is not needed. When the observation was collected overland and the fetch is long enough for full development of a marine boundary layer (longer than about 16 km or 10 miles), the observed wind speed should be adjusted to an overwater wind speed using Figure II-2-7 (see Example Problem II-2-4). Otherwise (for overland winds and fetches less than 16 km), wave growth occurs in a transitional atmospheric boundary layer, which has not fully adjusted to the overwater regime. In this case, wind speeds observed overland must be increased to better represent overwater wind speeds. A factor of 1.2 is suggested here, but no simple method can accurately represent this complex case. In relation to all of these adjustments, the term overland implies a measurement site that is predominantly characterized as inland. If a measurement site is directly adjacent to the water body, it may, for some wind directions, be equivalent to overwater.

(d) Stability. For fetches longer than 16 km, an adjustment for stability of the boundary layer may also be needed. If the air-sea temperature difference is known, Figure II-2-8 can be used to make the adjustment. When only general knowledge of the condition of the atmospheric boundary layer is available, it should be categorized as stable, neutral, or unstable according to the following:

Stable - when the air is warmer than the water, the water cools air just above it and decreases mixing in the air column ($R_T = 0.9$).

Neutral - when the air and water have the same temperature, the water temperature does not affect mixing in the air column ($R_T = 1.0$).

Unstable - when the air is colder than the water, the water warms the air, causing air near the water surface to rise, increasing mixing in the air column ($R_T = 1.1$).

When the boundary layer condition is unknown, an unstable condition, $R_T = 1.1$, should be assumed.

(4) Procedure for adjusting winds from synoptic weather charts. As discussed earlier, synoptic weather charts are maps depicting isobars at sea level. The free air, or geostrophic, wind speed is estimated from these sea level pressure charts. Adjustments or corrections are then made to the geostrophic wind speed. Pressure chart estimations should be used only for large areas, and the estimated values should be compared with observations, if possible, to verify their accuracy.

(a) Geostrophic wind speed. To estimate geostrophic wind speed, Equation II-2-10 or Figure II-2-12 should be used (see Example Problem II-2-5).

(b) Level and stability. Wind speed at the 10-m level should be estimated from the geostrophic wind speed using Figure II-2-13. The resulting speed should then be adjusted for stability effects as needed using Figure II-2-8.

(c) Duration. Wind duration estimates are also needed. Since synoptic weather charts are prepared only at 6-hr intervals, it may be necessary to use interpolation to determine duration. Linear interpolation is adequate for most cases. Interpolation should not be used if short-duration phenomena, such as frontal passages or thunderstorms, are present.

(5) Procedure for estimating fetch. Fetch is defined as a region in which the wind speed and direction are reasonably constant. Fetch should be defined so that wind direction variations do not exceed 15 deg and wind speed variations do not exceed 2.5 m/s (5 knots) from the mean. A coastline upwind from the point of interest always limits the fetch. An upwind limit to the fetch may also be provided by curvature, or spreading,

 Step 8

Reference:
CEM, USACE
EM 1110-2-1100

method may be applied to obtain a 3-hour average; however, the assumption of constant wind again may not be valid.

If thunderstorms or other brief, severe winds are included in the data, the method may overestimate results; but often there are no other data available.

c. Stability Correction. If the air-sea temperature difference $\Delta T_{as} = T_a - T_s$ is zero, the boundary layer has neutral stability and no windspeed correction is necessary. If ΔT_{as} is negative, the boundary layer is unstable and the windspeed is more effective in causing wave growth. If ΔT_{as} is positive, the boundary layer is stable and the windspeed is less effective. The correction factor, R_T, is a function of ΔT_{as} and was defined by Resio and Vincent (1977b) to account for this effect. An effective windspeed is obtained by

$$U = R_T \, U(10) \tag{3-27}$$

where R_T is read from Figure 3-14. This correction can be substantial. For example, if the winds are estimated for a ΔT_{as} of $+10^{o}$ C and ΔT_{as} is actually -10^{o} C, the error in $U*$ is 50 percent. ΔT_{as} may vary seasonally. In the fall a lake's water may still be warm, but cold winds may blow across it; in the spring, the reverse may be true. Investigation of the values of T_{as} is usually warranted, and the a priori assumption of a neutrally stable boundary layer should be questioned. In the absence of temperature information, $R_T = 1.1$ should be assumed.

d. Location Effects. Often overwater wind data are not available, but data from nearby land sites are. It is possible to translate overland winds to overwater winds if they are the result of the same pressure gradient and the only major difference is the surface roughness (Resio and Vincent, 1977b). For first-order airport weather stations around the Great Lakes, the relationship between overwater winds to nearby overland winds is given for neutral stability by R_L in Figure 3-15; this can be used as an approximation for other areas unless the landscape roughness characteristics are markedly different. The land anemometer site should be close enough to the body of water so that the winds are caused by the same atmospheric pressure gradient. Thunderstorms and squall lines are small-scale phenomena and violate the assumption that overland winds and overwater winds are from the same pressure gradient. If the anemometer site is adjacent to shore, winds blowing off the water require no adjustment for location effects; i.e., $R_L = 1$. A stability adjustment R_T should be used, however.

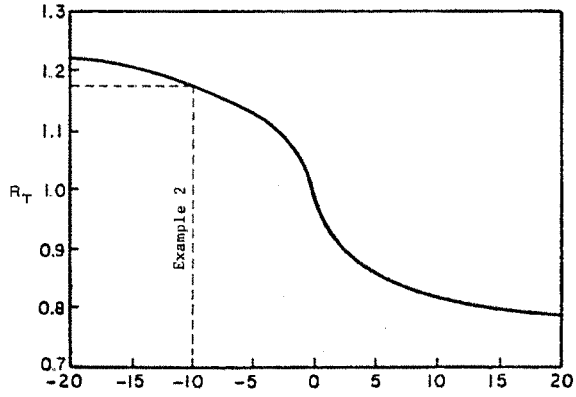
e. Coefficient of Drag. The wave growth formulas and nomograms are expressed in terms of wind-stress factor U_A (adjusted windspeed). After the appropriate windspeed conversions are made, the windspeed is converted to a wind-stress factor by either of the following formulas:

$$U_A = 0.71 \, U^{1.23} \quad (U \text{ in m/s}) \tag{3-28a}$$

$$U_A = 0.589 \, U^{1.23} \quad (U \text{ in mph}) \tag{3-28b}$$

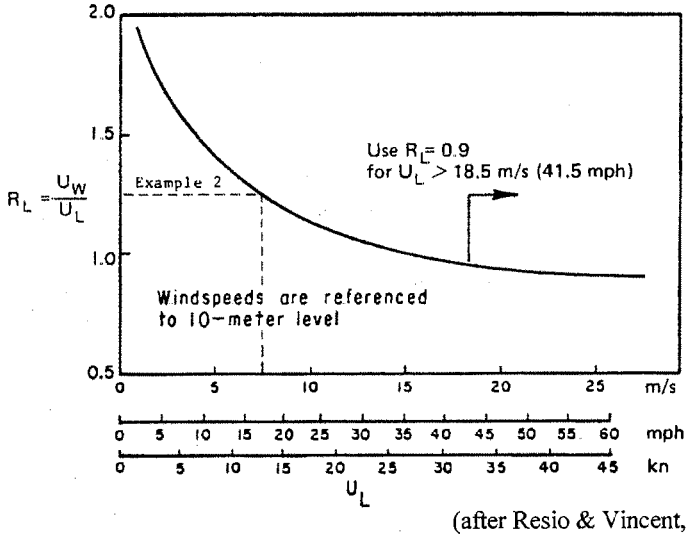
Reference:
SPM Vol I

Step 8



(Resio & Vincent, 1977b)

Figure 3-14. Amplification ratio, R_T, accounting for effects of air-sea temperature difference.



(after Resio & Vincent, 1977b)

Figure 3-15. Ratio, R_L, of windspeed over water, U_W, to windspeed over land, U_L, as a function of windspeed over land, U_L.

Reference:
SPM Vol I

Step 8

method may be applied to obtain a 3-hour average; however, the assumption of constant wind again may not be valid.

If thunderstorms or other brief, severe winds are included in the data, the method may overestimate results; but often there are no other data available.

c. Stability Correction. If the air-sea temperature difference $\Delta T_{as} = T_a - T_s$ is zero, the boundary layer has neutral stability and no windspeed correction is necessary. If ΔT_{as} is negative, the boundary layer is unstable and the windspeed is more effective in causing wave growth. If ΔT_{as} is positive, the boundary layer is stable and the windspeed is less effective. The correction factor, R_T, is a function of ΔT_{as} and was defined by Resio and Vincent (1977b) to account for this effect. An effective windspeed is obtained by

$$U = R_T\, U(10) \tag{3-27}$$

where R_T is read from Figure 3-14. This correction can be substantial. For example, if the winds are estimated for a ΔT_{as} of $+10^{\circ}$ C and ΔT_{as} is actually -10° C, the error in $U*$ is 50 percent. ΔT_{as} may vary seasonally. In the fall a lake's water may still be warm, but cold winds may blow across it; in the spring, the reverse may be true. Investigation of the values of T_{as} is usually warranted, and the a priori assumption of a neutrally stable boundary layer should be questioned. In the absence of temperature information, $R_T = 1.1$ should be assumed.

d. Location Effects. Often overwater wind data are not available, but data from nearby land sites are. It is possible to translate overland winds to overwater winds if they are the result of the same pressure gradient and the only major difference is the surface roughness (Resio and Vincent, 1977b). For first-order airport weather stations around the Great Lakes, the relationship between overwater winds to nearby overland winds is given for neutral stability by R_L in Figure 3-15; this can be used as an approximation for other areas unless the landscape roughness characteristics are markedly different. The land anemometer site should be close enough to the body of water so that the winds are caused by the same atmospheric pressure gradient. Thunderstorms and squall lines are small-scale phenomena and violate the assumption that overland winds and overwater winds are from the same pressure gradient. If the anemometer site is adjacent to shore, winds blowing off the water require no adjustment for location effects; i.e., $R_L = 1$. A stability adjustment R_T should be used, however.

e. Coefficient of Drag. The wave growth formulas and nomograms are expressed in terms of wind-stress factor U_A (adjusted windspeed). After the appropriate windspeed conversions are made, the windspeed is converted to a wind-stress factor by either of the following formulas:

$$U_A = 0.71\, U^{1.23} \quad (U \text{ in m/s}) \tag{3-28a}$$

$$U_A = 0.589\, U^{1.23} \quad (U \text{ in mph}) \tag{3-28b}$$

Reference: SPM Vol I

Step 8, 9

Table 3-2. Deepwater wave forecasting equation.

Dimensionless	Metric Units	
	H(m), T(s), U_A(m/s), F(m), t(s)	H(m), T(s), U_A(m/s), F(km), t(hr)
FETCH LIMITED, (F, U)		
$\frac{gH_{m_o}}{U_A^2} = 1.6\times10^{-3}\left(\frac{gF}{U_A^2}\right)^{1/2}$ (3-33)	$H_{m_o} = 5.112\times10^{-4}\, U_A F^{1/2}$ (3-33a)	$H_{m_o} = 1.616\times10^{-2}\, U_A F^{1/2}$ (3-33b)
$\frac{gT_m}{U_A} = 2.857\times10^{-1}\left(\frac{gF}{U_A^2}\right)^{1/3}$ (3-34)	$T_m = 6.238\times10^{-2}\left(U_A F\right)^{1/3}$ (3-34a)	$T_m = 6.238\times10^{-1}\left(U_A F\right)^{1/3}$ (3-34b)
$\frac{gt}{U_A} = 6.88\times10^{1}\left(\frac{gF}{U_A^2}\right)^{2/3}$ (3-35)	$t = 3.215\times10^{1}\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35a)	$t = 8.93\times10^{-1}\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35b)
FULLY DEVELOPED		
$\frac{gH_{m_o}}{U_A^2} = 2.433\times10^{-1}$ (3-36)	$H_{m_o} = 2.482\times20^{-2}\, U_A^2$ (3-36a)	$H_{m_o} = 2.4821\times10^{-2}\, U_A^2$ (3-36b)
$\frac{gT_m}{U_A} = 8.134$ (3-37)	$T_m = 8.30\times10^{-1}\, U_A$ (3-37a)	$T_m = 8.30\times10^{-1}\, U_A$ (3-37b)
$\frac{gt}{U_A} = 7.15\times10^{4}$ (3-38)	$t = 7.296\times10^{3}\, U_A$ (3-38a)	$t = 2.027\, U_A$ (3-38b)
NOTATIONS	$g = 9.8$ m/s^2	$g = 9.8$ m/s^2 1 kilometer = 1000 m 1 hour = 3600 s

	English Units	
H(ft), T(s), U_A(ft/s), F(ft), t(s)	H(ft), T(s), U_A(mi/hr) F(m), t(hr)	H(ft), T(s), U_A (kn), F(nmi), t(hr)
FETCH LIMITED (F, U)		
$H_{m_o} = 2.82\times10^{-4}\, U_A F^{1/2}$ (3-33c)	$H_{m_o} = 3.01\times10^{-2}\, U_A F^{1/2}$ (3-33d)	$H_{m_o} = 3.714\times10^{-2}\, U_A F^{1/2}$ (3-33e)
$T_m = 2.825\times10^{-2}\left(U_A F\right)^{1/3}$ (3-34c)	$T_m = 5.59\times10^{-1}\left(U_A F\right)^{1/3}$ (3-34d)	$T_m = 6.14\times10^{-1}\left(U_A F\right)^{1/3}$ (3-34e)
$t = 2.16\times10^{1}\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35c)	$t = 1.603\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35d)	$t = 1.680\left(\frac{F^2}{U_A}\right)^{1/3}$ (3-35e)
FULLY DEVELOPED		
$H_{m_o} = 7.553\times10^{-3}\, U_A^2$ (3-36c)	$H_{m_o} = 1.625\times10^{-2}\, U_A^2$ (3-36d)	$H_{m_o} = 2.154\times10^{-2}\, U_A^2$ (3-36e)
$T_m = 2.53\times10^{-1}\, U_A$ (3-37c)	$T_m = 3.706\times10^{-1}\, U_A$ (3-37d)	$T_m = 4.244\times10^{-1}\, U_A$ (3-37e)
$t = 2.220\times10^{3}\, U_A$ (3-38c)	$t = 9.045\times10^{-1}\, U_A$ (3-38d)	$t = 1.04\, U_A$ (3-38e)
NOTATIONS g = 32.2 ft/s^2	g = 32.2 ft/s^2 1 mile = 5280 ft miles per hour = 1.467 ft/s 1 hour = 3600 s	g = 32.2 ft/s^2 1 nautical mile = 6080 ft 1 knot = 1.689 ft/s 1 hour = 3600 s

Reference
SPM Vol I

Step 11, 12

and

$$L_o = \frac{gT^2}{2\pi} = 5.12T^2 \text{ ft} \tag{2-8b}$$

If equations (2-7a) and (2-7b) are used to compute wave celerity when the relative depth is d/L = 0.25, the resulting error will be about 9 percent. It is evident that a relative depth of 0.5 is a satisfactory boundary separating deepwater waves from waves in water of transitional depth. If a wave is traveling in *transitional* depths, equations (2-2) and (2-3) must be used without simplification. Care should be taken to use equations (2-2) and (2-3) when necessary; i.e., when the relative depth is between one-half and one-twenty-fifth.

When the relative water depth becomes shallow, i.e., $2\pi d/L < 1/4$ or $d/L < 1/25$, equation (2-2) can be simplified to

$$C = \sqrt{gd} \tag{2-9}$$

This relation, attributed to Lagrange, is of importance when dealing with long-period waves, often referred to as long waves. Thus, when a wave travels in shallow water, wave celerity depends only on water depth.

b. The Sinusoidal Wave Profile. The equation describing the free surface as a function of time t and horizontal distance x for a simple sinusoidal wave can be shown to be

$$\eta = a \cos\left(\frac{2\pi x}{L} - \frac{2\pi t}{T}\right) = \frac{H}{2} \cos\left(\frac{2\pi x}{L} - \frac{2\pi t}{T}\right) \tag{2-10}$$

where η is the elevation of the water surface relative to the SWL, and H/2 is one-half the wave height equal to the wave amplitude a. This expression represents a periodic, sinusoidal, progressive wave traveling in the positive x-direction. For a wave moving in the negative x-direction, the minus sign before $2\pi t/T$ is replaced with a plus sign. When $(2\pi x/L - 2\pi t/T)$ equals $0, \pi/2, \pi, 3\pi/2$, the corresponding values of η are H/2, 0, -H/2, and 0, respectively.

c. Some Useful Functions. It can be shown by dividing equation (2-3) by equation (2-6), and equation (2-4) by equation (2-8) that

$$\frac{C}{C_o} = \frac{L}{L_o} = \tanh\left(\frac{2\pi d}{L}\right) \tag{2-11}$$

If both sides of equation (2-11) are multiplied by d/L, it becomes

$$\frac{d}{L_o} = \frac{d}{L} \tanh\left(\frac{2\pi d}{L}\right) \tag{2-12}$$

The term d/L_o has been tabulated by Wiegel (1954) as a function of d/L and is presented in Appendix C, Table C-1. Table C-2 includes d/L as a function

Step 13

Reference:
SPM Vol I

Equation (2-4b) explicitly gives L in terms of wave period T and is sufficiently accurate for many engineering calculations. The maximum error of 5 percent occurs when $2\pi d/L \approx 1$.

Gravity waves may also be classified by the water depth in which they travel. The following classifications are made according to the magnitude of d/L and the resulting limiting values taken by the function tanh $(2\pi d/L)$:

Classification	d/L	$2\pi d/L$	tanh $(2\pi d/L)$
Deep water	$> 1/2$	$> \pi$	≈ 1
Transitional	1/25 to 1/2	1/4 to π	tanh $(2\pi d/L)$
Shallow water	$< 1/25$	$< 1/4$	$\approx 2\pi d/L$

In deep water, tanh $(2\pi d/L)$ approaches unity and equations (2-2) and (2-3) reduce to

$$C_o = \sqrt{\frac{gL_o}{2\pi}} = \frac{L_o}{T} \tag{2-5}$$

and

$$C_o = \frac{gT}{2\pi} \tag{2-6}$$

Although *deep water* actually occurs at an infinite depth, tanh $(2\pi d/L)$, for most practical purposes, approaches unity at a much smaller d/L. For a relative depth of one-half (i.e., when the depth is one-half the wavelength), tanh $(2\pi d/L) = 0.9964$.

Thus, when the relative depth d/L is greater than one-half, the wave characteristics are virtually independent of depth. Deepwater conditions are indicated by the subscript o as in L_o and C_o. The period T remains constant and independent of depth for oscillatory waves; hence, the subscript is omitted (Ippen, 1966b, pp. 21-24). If units of meters and seconds are specified, the constant $g/2\pi$ is equal to 1.56 meters per second squared and

$$C_o = \frac{gT}{2\pi} = \frac{9.8}{2\pi} T = 1.56T \text{ m/s} \tag{2-7a}$$

and

$$L_o = \frac{gT^2}{2\pi} = \frac{9.8}{2\pi} T^2 = 1.56T^2 \text{ m} \tag{2-8a}$$

If units of feet and seconds are specified, the constant $g/2\pi$ is equal to 5.12 feet per second squared and

$$C_o = \frac{gT}{2\pi} = 5.12T \text{ ft/s} \tag{2-7b}$$

Step 14

Reference:
SPM Vol I

VI. WAVE FORECASTING FOR SHALLOW WATER

1. Forecasting Curves.

Water depth affects wave generation. For a given set of wind and fetch conditions, wave heights will be smaller and wave periods shorter if generation takes place in transitional or shallow water rather than in deep water. Several forecasting approaches have been made, including the method given by Bretschneider as modified using the results of Ijima and Tang (1966). Bretschneider and Reid (1953) consider bottom friction and percolation in the permeable sea bottom.

There is no single theoretical development for determining the actual growth of waves generated by winds blowing over relatively shallow water. The method presented here is based on successive approximations in which wave energy is added due to wind stress and subtracted due to bottom friction and percolation. This method uses deepwater forecasting relationships (Chapter 3, Section V) to determine the energy added due to wind stress. Wave energy lost due to bottom friction and percolation is determined from the relationships developed by Bretschneider and Reid (1953). Resultant wave heights and periods are obtained by combining the above relationships by numerical methods. The basic assumptions applicable to development of deepwater wave generation relationships as well as development of relationships for bottom friction loss (Putnam and Johnson, 1949) and percolation loss (Putnam, 1949) apply. The duration should be considered approximate.

These shallow-water forecasting curves (Fig. 3-27 through 3-36) represent an interim method for wave forecasting in shallow water. Modifications to the shallow-water forecasting equations were made to provide a transition between the revised deepwater forecasting equations and the shallow-water forecasting model. Research is underway that may revise the shallow-water forecasting model. Until the results of this new research are available, the curves should be used. The curves are plotted from the following equations:

$$\frac{gH}{U_A^2} = 0.283 \tanh\left[0.530\left(\frac{gd}{U_A^2}\right)^{3/4}\right] \tanh\left\{\frac{0.00565\left(\frac{gF}{U_A^2}\right)^{1/2}}{\tanh\left[0.530\left(\frac{gd}{U_A^2}\right)^{3/4}\right]}\right\} \qquad (3\text{-}39)$$

$$\frac{gT}{U_A} = 7.54 \tanh\left[0.833\left(\frac{gd}{U_A^2}\right)^{3/8}\right] \tanh\left\{\frac{0.0379\left(\frac{gF}{U_A^2}\right)^{1/3}}{\tanh\left[0.833\left(\frac{gd}{U_A^2}\right)^{3/8}\right]}\right\} \qquad (3\text{-}40)$$

Reference: SPM Vol I

Step 15, 16

i.e., made dimensionless by dividing each observed height by H_{rms} data from all observations may be combined into a single plot. Points from scaled 15-minute samples are superimposed on Figure 3-3 to show the scatter to be expected from analyzing individual observations in this manner.

Data from 72 scaled 15-minute samples representing 11,678 observed waves have been combined in this manner to produce Figure 3-4. The theoretical height appears to be about 5 percent greater than the observed height for a probability of 0.01 and 15 percent greater at a probability of 0.0001. It is possible that the difference between the actual and the theoretical heights of highest waves is due to breaking of the highest waves before they reach the coastal wave gages. Hence the Rayleigh distribution may be taken as an approximate distribution in shallow water, but is probably conservative.

Equation (3-1) can be established rigorously for restrictive conditions and empirically for a much wider range of conditions. If equation (3-1) is used, the probability density function can be obtained in the form

$$f[(\hat{H} - \Delta H) \leq H \leq (\hat{H} + \Delta H)] = \left(\frac{2}{H_{rms}^2}\right) H\, e^{-\left(\frac{\hat{H}}{H_{rms}}\right)^2} \tag{3-6}$$

The height of the wave with any given probability n/N of being exceeded may be determined approximately from curve a in Figure 3-5 or from the equation

$$\frac{\hat{H}}{H_{rms}} = \left[-\mathrm{Ln}\left(\frac{n}{N}\right)\right]^{1/2} \tag{3-7}$$

The average height of all waves with heights greater than $\hat{H}$, denoted $\overline{H}(\hat{H})$ can be obtained from the equation

$$\overline{H}(\hat{H}) = \frac{\int_{\hat{H}}^{\infty} H^2\, e^{-\left(\frac{H}{H_{rms}}\right)^2} dH}{\int_{\hat{H}}^{\infty} H\, e^{-\left(\frac{H}{H_{rms}}\right)^2} dH} \tag{3-8}$$

Alternatively, the ratio $\overline{H}(\hat{H})/H_{rms}$ can be estimated from curve b in Figure 3-5, where P is the probability of $\hat{H}$ being exceeded. By setting $\hat{H} = 0$, all waves are considered and it is found that the average wave height is given by

$$\overline{H} = 0.886\, H_{rms} \tag{3-9}$$

and the significant wave height is given by

$$H_s = 1.416 H_{rms} \approx \sqrt{2}\, H_{rms} \tag{3-10}$$

In the analysis system used by CERC from 1960 to 1970, and whenever digital recordings cannot be used, the average period of a few of the best formed waves is selected as the significant wave period. An estimated number of

Army Engineer Research and Development Center. An example of the fetch length radials used for wind-wave generation calculations in the ACES program is shown on **Figure DCM 2-2.**

Wave fields include monochromatic (regular) waves and irregular waves. The irregular waves are to be used to evaluate wave fields to determine wave height for freeboard determination. Thorough understanding of the freeboard design process and the basis of the various factors to be applied is critical to effective use of these computer programs. Adequate training and access to technical support is recommended. The programs should not be used for specific project circumstances that are beyond the limitations of the programs.

The traditional spreadsheet/hand calculations using primarily the Coastal Engineering Manual – CEM (USACE, 2003) and the Shore Protection Manual - SPM (USACE, 1984) can be used for analysis of various alternatives. Although the Coastal Engineering Manual is the most current document, the Shore Protection Manual is referenced for wave runup calculations since that portion of the Coastal Engineering Manual is in Draft form at this time. Wave heights from the CEM/SPM utilize Rayleigh Distribution to evaluate wave fields for structures (e.g. significant wave, 2 percent frequency wave, 5 percent frequency wave etc.). Irregular waves in STWAVE and ACES are similarly used to evaluate wave fields for structures.

The results of final computer-generated parameters are also to be compared with the traditional hand calculation methods for the final selected configuration. A direct one-to-one comparison may not result in an exact match. However, order of magnitude agreement should result. An example of the hand calculation method for developing wind speed, wave height and runup for freeboard determination is presented in **Attachment A.** The example computation is presented for **Case 1** condition, and would be repeated in a similar manner for **Cases 2, 3 and 4** in the determination of the controlling freeboard condition and the required dam crest level.

2.5 Wind Setup

Wind setup is one of the required components in the determination of freeboard. On the shallowest CERP impoundments, wind setup is a particularly important component of freeboard, and may even exceed the wave runup component in magnitude. Three methods are available for determining wind setup. The most widely used wind setup equation as applied to reservoirs is probably the Zeider Zee equation, which normally results in the highest wind setup determination of the three methods. The Zeider Zee equation (USACE, 1997, pg. 15-3) is expressed as:

$$S = \frac{U^2 F}{1400d} \qquad \text{Eqn. 5}$$

Where:

S = wind setup (feet) above the stillwater level

U = average wind velocity (miles per hour) over the fetch

F = fetch length (miles)

Step 18

Reference: DCM-2

d = average depth (feet) of water generally along the fetch line

Although the Zeider Zee equation is commonly suggested for determining wind setup in reservoirs, typical reservoirs in the U.S. are substantially deeper than the typical CERP impoundments. Because the Zeider Zee equation may yield results that excessively over-estimate wind setup at average reservoir water depths that are more typical of CERP impoundments, guidance is provided in this section to recommended alternative wind setup methods.

The recommended alternative to the Zeider Zee equation at lower impoundment depths (average stillwater depth less than 16 feet including surcharge depth), is the Bretschneider method (Bretschneider, 1966). The Bretschneider method normally results in wind setup heights that approach the mean value of results for the Zeider Zee and Sibul equations. For an enclosed reservoir of regular or somewhat irregular shape, an effective stress parameter in the Bretschneider method is presented in an integrated form as follows:

$$\frac{\kappa U^2 F}{g d^2} = \sum_{i=1}^{i=M} \left(\frac{\kappa U^2 \Delta x}{g (d_i)^2} \right) \qquad \text{Eqn. 6}$$

where:

κ = a constant equal to 3.3 x 10^{-6} (dimensionless)

U = average wind velocity (feet per second) over the fetch

F = fetch length (feet)

g = the gravitational constant (32.17 ft/sec^2)

d = average depth (feet) of water generally along the fetch line

i = section number

x = horizontal distance (feet)

The effective stress parameter is used for determining the wind setup (S in feet) as a function of S/d with Tables 5.2 and 5.3 as provided by Bretschneider (1966). The method accounts for wind conditions that may create a partially exposed reservoir bottom along the fetch line.

The Sibul equation (Brater and King, 1976) generally yields the lowest wind setup values of the three wind setup equations. The Sibul equation is expressed as:

$$\frac{S}{d} = 2.44 \times 10^{-5} \left(\frac{F}{d} \right)^{1.66} \left(\frac{U^2}{Fg} \right)^{2.02 \left(\frac{F}{d} \right)^{-0.0768}} \qquad \text{Eqn. 7}$$

where:

Step 18

Reference: DCM-2

S = wind setup (feet) above the stillwater level

d = average depth (feet) of water generally along the fetch line

F = fetch length (feet)

U = average wind velocity (feet per second) over the fetch

g = the gravitational constant (32.17 ft/sec^2)

The Bretschneider method is recommended for shallow impoundments with average depths less than 16 feet. Under conditions where the Bretschneider method does not have a numerical solution, the wind setup for the more shallow reservoirs can be computed as the average of the wind setup results for the Zeider Zee and the Sibul equations. For the deeper impoundments, with average depths greater or equal to 16 feet, the Zeider Zee equation is recommended because the equation provides a continuous solution without excessive over-estimation of wind setup.

3. Summary

The state-of-the-practice for freeboard determination includes consideration of combinations of reservoir level/precipitation and wind conditions that are reasonably expected to occur simultaneously. Additional considerations include: settlement, waves induced by landslides or malfunction of the spillway and/or outlet works. At a minimum, freeboard determination for design of high and significant hazard potential impoundments will include the precipitation and wind combinations for **Cases 1** through **4** described in this memorandum, as well as settlement, and malfunction of the spillway and/or outlet works for freeboard determination. Freeboard determination will be based on zero over-wash or over-wash that is not of such magnitude and duration as to threaten the safety of the dam. The Rayleigh Distribution (irregular wave field) will be used for the wave analysis. The recommended method for assessing the over-wash potential is an evaluation of the over-wash rate versus embankment height, in conjunction with an analysis of the probability of exceedance of the precipitation plus wind condition (residual risk based on hydrologic conditions) versus a selected embankment height. A methodology for analysis of mixed populations (e.g. precipitation and wind conditions) is included in USACE EM 1110-2-1415.

Considering information in standard references for freeboard and discussions at the Acceler8 Design Criteria Workshop (Dec. 2004), it is most appropriate to determine freeboard for each impoundment for the four cases of combined precipitation and wind events, at a minimum. The most likely controlling case for freeboard would be for a reservoir level resulting from the PMP for the critical condition, combined with a 100-year wind speed – **Case 1**. The 100-year wind speed will be developed for the specific site location using the Florida Building Code and **Table DCM 2-2** (ASCE, 2003), and with the fetch length of the reservoir. The figures, which are identified as being based on 50-year to 100-year wind speeds, will be conservatively interpreted as representing 50-year wind speeds. Calculation of wind set-up and wave run-up will be in accordance with the applicable portions of the USACE Coastal Engineering Manual, with the adjustments shown above. Bretschneider's and Zeider-Zee equations will be used for wind setup analysis. **Cases 2, 3** and **4** will also be evaluated for each impoundment

This document provides working level guidance to assist in the implementation of projects and project features under the Comprehensive Everglades Restoration Plan (CERP) program implemented by the South Florida Water Management District, the Florida Department of Environmental Protection, and the U.S. Army Corps of Engineers. The guidance does not supersede existing or future federal or state regulation, does not constitute policy for any of these agencies, and does not create authority beyond that granted to any agency member carrying out their duties.

Step 1B

Reference: DCM-2

Step 17: Compute shallow-water wave height for zero over-wash
The freeboard height that results in zero over-wash is the design criteria for high and significant hazard dams, for wave runup conditions and freeboard determination due to the erosive nature of embankment material (see **DCM-2**, Section 2 discussion). A wave height with a 2% frequency will be used to analyze a "low probability of over-wash" condition, to evaluate alternative embankment sections. In addition, the 2% frequency wave height will be used for a manual check of the STWAVE generated value.

The shallow-water wave height in Step 16 is the significant wave height. Using Equations 3-7 and 3-10 in the SPM, the 2% wave height ($H_{2\%}$) is calculated as 1.40 times the significant wave height. Therefore, the maximum wave height would be 10.95 ft (7.82 ft. in Step 16 multiplied by 1.40). Note: If deep-water wave length conditions are determined, Steps 15 through 17 would use deep water equations.

Step 18: Compute wind set-up
Based on the effective depth of 16.47 ft, fetch distance of 6.97 miles, and effective wind speed of 104 mph, the wind set-up is then computed using Eqn. 15-1 (USACE EM 1110-2-1420), as 3.31 ft. It should be noted that the effective wind speed (U) in Step 7 is used to compute the wind set-up not the wind stress factor (U_A) in Step 9 (Note, for average stillwater depth less than 16 feet, the Bretschneider method would be used. See Section 2.5, **DCM – 2**).

Step 19: Compute water depth at toe of the structure (dam)
The water depth at the toe of the structure (d_s) would be 19.78 ft, which is the sum of the effective depth of 16.47 ft plus wind set-up of 3.31 ft in Step 18.

Step 20: Check for depth limited wave breaking
Based on SPM Eqn. 2-91 and 3-50, the depth limited wave breaking height is 0.78 times depth. The depth limited wave height is 15.43 feet (0.78 multiplied by 19.78 ft from Step 19). Therefore, the maximum wave height of 10.95 feet from Step 17 is not limited by wave breaking.

Step 21: Estimate ratio between deep-water wave height and equivalent deep water wave height
Runup curves were developed in reference to equivalent deepwater wave heights. The relative depth calculated in Step 14 is less than 0.5. Therefore, an equivalent deep water wave height (H'_o) needs to be computed. The value of H/H'_o (shallow-water wave height / equivalent deep water wave height) is estimated based on the value of d/L_o (effective depth / deep water wave length). The relationship between d/L_o and H/H'_o is listed in Table C-1 of SPM Vol. II, Appendix C. Based on d/L_o of 0.089 in Step 14, the H/H'_o would be 0.9433.

Step 22: Compute equivalent deep-water wave height
The equivalent deep-wave wave height (H'_o) would be 11.61 ft (10.95 ft in Step 17 divided by 0.9433 in Step 18).

This document provides working level guidance to assist in the implementation of the projects and project features under the Comprehensive Everglades Restoration Plan (CERP) program implemented by the South Florida Water Management District, the Florida Department of Environmental Regulation, and the U.S. Army Corps of Engineers. The guidance does not supersede existing or future federal or state regulation, does not constitute policy for any of these agencies, and does not create authority beyond that granted to any agency member carrying out their duties.

Step 18, 19
Reference: DCM-12

becomes shallow enough to initiate breaking; this depth is usually denoted as d_b and termed the breaking depth. Munk (1949) derived several relationships from a modified solitary wave theory relating the breaker height H_b, the breaking depth d_b, the unrefracted deepwater wave height H'_o, and the deepwater wavelength L_o. His expressions are given by

$$\frac{H_b}{H'_o} = \frac{1}{3.3(H'_o/L_o)^{1/3}} \tag{2-90}$$

and

$$\frac{d_b}{H_b} = 1.28 \tag{2-91}$$

The ratio H_b/H'_o is frequently termed the breaker height index. Subsequent observations and investigations by Iversen (1952, 1953) Calvin (1969), and Goda (1970) among others, have established that H_b/H'_o and d_b/H_b depend on beach slope and on incident wave steepness. Figure 2-72 shows Coda's empirically derived relationships between H_b/H'_o and H_o/L_o for several beach slopes. Curves shown on the figure are fitted to widely scattered data; however they illustrate a dependence of H_b/H'_o on the beach slope. Empirical relationships derived by Weggel (1972) between d_b/H_b and H_b/gT^2 for various beach slopes are presented in Figure 2-73. It is recommended that Figures 2-72 and 2-73 be used, rather than equations (2-90) and (2-91), for making estimates of the depth at breaking or the maximum breaker height in a given depth since the figures take into consideration the observed dependence of d_b/H_b and H_b/H'_o on beach slope. The curves in Figure 2-73 are given by

$$\frac{d_b}{H_b} = \frac{1}{b-(aH_b/gT^2)} \tag{2-92}$$

where a and b are functions of the beach slope m, and may be approximated by

$$a = 43.75(1 - e^{-19m}) \tag{2-93}$$

$$b = \frac{1.56}{(1 + e^{-19.5m})} \tag{2-94}$$

Breaking waves have been classified as spilling, plunging, or surging depending on the way in which they break (Patrick and Wiegel, 1955), and (Wiegel, 1964). Spilling breakers break gradually and are characterized by *white water* at the crest (see Fig. 2-74). Plunging breakers curl over at the crest with a plunging forward of the mass of water at the crest (see Fig. 2-75). Surging breakers build up as if to form a plunging breaker but the base of the wave surges up the beach before the crest can plunge forward (see Fig. 2-76). Further subdivision of breaker types has also been proposed. The term collapsing breaker is sometimes used (Calvin, 1968) to describe breakers in the transition from plunging to surging (see Fig. 2-77). In actuality, the

Step 20

Reference:
CEM, USACE
EM 1110-2-1100

$$\alpha_r = \frac{1 - K_{fa}}{1 - K_{f.01}} \tag{3-47}$$

and, for a decaying wave,

$$F_a = \alpha_r \, \Delta x \tag{3-48}$$

b. Wave Growth. For any given water depth, windspeed, and fetch length, a maximum significant wave height H_{sm} which is generated can be defined from Figure 3-21. If the initial wave height H_i at the seaward or beginning edge of the fetch segment is less than H_{sm}, it is assumed that the wave will increase in height.

To find the wave growth, first determine an equivalent fetch length F_e for the initial wave (obtained directly from Figure 3-21 using the given wave height, windspeed, and water depth). Secondly, the adjusted fetch F_a as discussed in Chapter 3, Section IV,2,a is determined using equations (3-45) and (3-46) and Figure 3-38. The total fetch is then given as

$$F = F_e + F_a \tag{3-49}$$

Reentering Figures 3-21 and 3-22 with the fetch length F and the adjusted windspeed factor U_A and water depth d the wave height and period at the end of the fetch segment, H_f and T, are determined.

c. Wave Decay. If the initial significant wave height H_i at the seaward or beginning edge of a segment of fetch exceeds the maximum significant wave height H_{sm} for the given water depth of the segment of fetch and the given windspeed, it may be assumed that the effects of the bottom friction will exceed the effects of the wind stress. Therefore, the wave will decay, will lose height, and over a long distance will approach a wave height equal to the maximum significant wave height.

The following steps are used to predict the decay of a wave:

(a) At the seaward end of fetch segment determine the maximum significant wave height Hem that would be generated for a given wind speed and water depth, assuming an unlimited fetch and using Figure 3-21.

(b) Determine the maximum stable wave height H_m at the seaward edge of the fetch segment, where

$$H_m = 0.78 \, d \tag{3-50}$$

(c) Determine the fractional reduction R_i at the seaward edge of the segment of fetch under consideration. This is given by

$$R_i = \frac{H_m - H_i}{H_m - H_{sm}} \tag{3-51}$$

(d) Determine an equivalent initial wave height H_{ie}, assuming that fractional wave growth is proportional to fractional wave decay, by

Reference: SPM Vol I

Step 20

Table C-1. Functions of d/L for even increments of d/L_o (from 0.0001 to 1.000).

d/L_o	d/L	2π d/L	TANH 2π d/L	SINH 2π d/L	COSH 2π d/L	H/H'_o	K	4π d/L	SINH 4π d/L	COSH 4π d/L	n	C_g/C_o	M
0	0	0	0	0	1	∞	1	0	0	1	1	0	∞
.000100	.003990	.02507	.02506	.02507	1.0003	4.467	.9997	.05014	.05016	1.001	.9998	.02506	7,855
.000200	.005643	.03546	.03544	.03547	1.0006	3.757	.9994	.07091	.07097	1.003	.9996	.03543	3,928
.000300	.006912	.04343	.04340	.04344	1.0009	3.395	.9991	.08686	.08697	1.004	.9994	.04336	2,620
.000400	.007982	.05015	.05011	.05018	1.0013	3.160	.9987	.1003	.1005	1.005	.9992	.05007	1,965
.000500	.008925	.05608	.05602	.05611	1.0016	2.989	.9984	.1122	.1124	1.006	.9990	.05596	1,572
.000600	.009778	.06144	.06136	.06148	1.0019	2.856	.9981	.1229	.1232	1.008	.9988	.06128	1,311
.000700	.01056	.06637	.06627	.06642	1.0022	2.749	.9978	.1327	.1331	1.009	.9985	.06617	1,124
.000800	.01129	.07096	.07084	.07102	1.0025	2.659	.9975	.1419	.1424	1.010	.9983	.07072	983.5
.000900	.01198	.07527	.07513	.07534	1.0028	2.582	.9972	.1505	.1511	1.011	.9981	.07499	874.3
.001000	.01263	.07935	.07918	.07943	1.0032	2.515	.9969	.1587	.1594	1.013	.9979	.07902	787.0
.001100	.01325	.08323	.08304	.08333	1.0035	2.456	.9966	.1665	.1672	1.014	.9977	.08285	715.6
.001200	.01384	.08694	.08672	.08705	1.0038	2.404	.9962	.1739	.1748	1.015	.9975	.08651	656.1
.001300	.01440	.09050	.09026	.09063	1.0041	2.357	.9959	.1810	.1820	1.016	.9973	.09001	605.8
.001400	.01495	.09393	.09365	.09407	1.0044	2.314	.9956	.1879	.1890	1.018	.9971	.09338	562.6
.001500	.01548	.09723	.09693	.09739	1.0047	2.275	.9953	.1945	.1957	1.019	.9969	.09663	525
.001600	.01598	.1004	.1001	.1006	1.0051	2.239	.9949	.2009	.2022	1.020	.9967	.09977	493
.001700	.01648	.1035	.1032	.1037	1.0054	2.205	.9946	.2071	.2086	1.022	.9965	.1028	463
.001800	.01696	.1066	.1062	.1068	1.0057	2.174	.9943	.2131	.2147	1.023	.9962	.1058	438
.001900	.01743	.1095	.1091	.1097	1.0060	2.145	.9940	.2190	.2207	1.024	.9960	.1087	415
.002000	.01788	.1123	.1119	.1125	1.0063	2.119	.9937	.2247	.2266	1.025	.9958	.1114	394
.002100	.01832	.1151	.1146	.1154	1.0066	2.094	.9934	.2303	.2323	1.027	.9956	.1141	376
.002200	.01876	.1178	.1173	.1181	1.0069	2.070	.9931	.2357	.2379	1.028	.9954	.1161	359
.002300	.01918	.1205	.1199	.1208	1.0073	2.047	.9928	.2410	.2433	1.029	.9952	.1193	343
.002400	.01959	.1231	.1225	.1234	1.0076	2.025	.9925	.2462	.2487	1.031	.9950	.1219	329
.002500	.02000	.1257	.1250	.1260	1.0079	2.005	.9922	.2513	.2540	1.032	.9948	.1243	316
.002600	.02040	.1282	.1275	.1285	1.0082	1.986	.9919	.2563	.2592	1.033	.9946	.1268	304
.002700	.02079	.1306	.1299	.1310	1.0085	1.967	.9916	.2612	.2642	1.034	.9944	.1292	292
.002800	.02117	.1330	.1323	.1334	1.0089	1.950	.9912	.2661	.2692	1.036	.9942	.1315	282
.002900	.02155	.1354	.1346	.1358	1.0092	1.933	.9909	.2708	.2741	1.037	.9939	.1338	272
.003000	.02192	.1377	.1369	.1382	1.0095	1.917	.9906	.2755	.2790	1.038	.9937	.1360	263
.003100	.02228	.1400	.1391	.1405	1.0098	1.902	.9903	.2800	.2837	1.040	.9935	.1382	255
.003200	.02264	.1423	.1413	.1427	1.0101	1.887	.9900	.2845	.2884	1.041	.9933	.1404	247
.003300	.02300	.1445	.1435	.1449	1.0104	1.873	.9897	.2890	.2930	1.042	.9931	.1425	240
.003400	.02335	.1467	.1456	.1472	1.0108	1.860	.9893	.2934	.2976	1.043	.9929	.1446	233
.003500	.02369	.1488	.1477	.1494	1.0111	1.847	.9890	.2977	.3021	1.045	.9927	.1466	226
.003600	.02403	.1510	.1498	.1515	1.0114	1.834	.9887	.3020	.3065	1.046	.9925	.1487	220
.003700	.02436	.1531	.1519	.1537	1.0117	1.822	.9884	.3061	.3109	1.047	.9923	.1507	214
.003800	.02469	.1551	.1539	.1558	1.0121	1.810	.9881	.3103	.3153	1.049	.9921	.1527	208
.003900	.02502	.1572	.1559	.1579	1.0124	1.799	.9878	.3144	.3196	1.050	.9919	.1546	203
.004000	.02534	.1592	.1579	.1599	1.0127	1.788	.9875	.3184	.3238	1.051	.9917	.1565	198
.004100	.02566	.1612	.1598	.1619	1.0130	1.777	.9872	.3224	.3280	1.052	.9915	.1584	193
.004200	.02597	.1632	.1617	.1639	1.0133	1.767	.9869	.3263	.3322	1.054	.9912	.1602	189
.004300	.02628	.1651	.1636	.1659	1.0137	1.756	.9865	.3302	.3362	1.055	.9910	.1621	184
.004400	.02659	.1671	.1655	.1678	1.0140	1.746	.9862	.3341	.3403	1.056	.9908	.1640	180
.004500	.02689	.1690	.1674	.1698	1.0143	1.737	.9859	.3380	.3444	1.058	.9906	.1658	176
.004600	.02719	.1708	.1692	.1717	1.0146	1.727	.9856	.3417	.3483	1.059	.9904	.1676	172
.004700	.02749	.1727	.1710	.1736	1.0149	1.718	.9853	.3454	.3523	1.060	.9902	.1693	169
.004800	.02778	.1745	.1728	.1754	1.0153	1.709	.9849	.3491	.3562	1.062	.9900	.1711	165
.004900	.02807	.1764	.1746	.1773	1.0156	1.701	.9846	.3527	.3601	1.063	.9898	.1728	162
.005000	.02836	.1782	.1764	.1791	1.0159	1.692	.9843	.3564	.3640	1.064	.9896	.1746	159
.005100	.02864	.1800	.1781	.1809	1.0162	1.684	.9840	.3599	.3678	1.066	.9894	.1762	156
.005200	.02893	.1818	.1798	.1827	1.0166	1.676	.9837	.3635	.3715	1.067	.9892	.1779	153
.005300	.02921	.1835	.1815	.1845	1.0169	1.669	.9834	.3670	.3753	1.068	.9889	.1795	150
.005400	.02948	.1852	.1832	.1863	1.0172	1.662	.9831	.3705	.3790	1.069	.9887	.1811	147
.005500	.02976	.1870	.1848	.1880	1.0175	1.654	.9828	.3739	.3827	1.071	.9885	.1827	145
.005600	.03003	.1887	.1865	.1898	1.0178	1.647	.9825	.3774	.3864	1.072	.9883	.1843	142
.005700	.03030	.1904	.1881	.1915	1.0182	1.640	.9822	.3808	.3900	1.073	.9881	.1859	140
.005800	.03057	.1921	.1897	.1932	1.0185	1.633	.9818	.3841	.3937	1.075	.9879	.1874	137
.005900	.03083	.1937	.1913	.1949	1.0188	1.626	.9815	.3875	.3972	1.076	.9877	.1890	135

*Also: b_s/a_s, C/C_o, L/L_o

Step 24

Reference: SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi\, d/L$	TANH $2\pi\, d/L$	SINH $2\pi\, d/L$	COSH $2\pi\, d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi\, d/L$	COSH $4\pi\, d/L$	n	C_g/C_o	M
.006000	.03110	.1954	.1929	.1967	1.0192	1.620	.9812	.3908	.4008	1.077	.9875	.1905	133
.006100	.03136	.1970	.1945	.1983	1.0195	1.614	.9809	.3941	.4044	1.079	.9873	.1920	130
.006200	.03162	.1987	.1961	.2000	1.0198	1.607	.9806	.3973	.4079	1.080	.9871	.1935	128
.006300	.03188	.2003	.1976	.2016	1.0201	1.601	.9803	.4006	.4114	1.081	.9869	.1950	126
.006400	.03213	.2019	.1992	.2033	1.0205	1.595	.9799	.4038	.4148	1.083	.9867	.1965	124
.006500	.03238	.2035	.2007	.2049	1.0208	1.589	.9796	.4070	.4183	1.084	.9865	.1980	123
.006600	.03264	.2051	.2022	.2065	1.0211	1.583	.9793	.4101	.4217	1.085	.9863	.1994	121
.006700	.03289	.2066	.2037	.2081	1.0214	1.578	.9790	.4133	.4251	1.087	.9860	.2009	119
.006800	.03313	.2082	.2052	.2097	1.0217	1.572	.9787	.4164	.4285	1.088	.9858	.2023	117
.006900	.03338	.2097	.2067	.2113	1.0221	1.567	.9784	.4195	.4319	1.089	.9856	.2037	116
.007000	.03362	.2113	.2082	.2128	1.0224	1.561	.9781	.4225	.4352	1.091	.9854	.2051	114
.007100	.03387	.2128	.2096	.2144	1.0227	1.556	.9778	.4256	.4386	1.092	.9852	.2065	112
.007200	.03411	.2143	.2111	.2160	1.0231	1.551	.9774	.4286	.4419	1.093	.9850	.2079	111
.007300	.03435	.2158	.2125	.2175	1.0234	1.546	.9771	.4316	.4452	1.095	.9848	.2093	109
.007400	.03459	.2173	.2139	.2190	1.0237	1.541	.9768	.4346	.4484	1.096	.9846	.2106	108
.007500	.03482	.2188	.2154	.2205	1.0240	1.536	.9765	.4376	.4517	1.097	.9844	.2120	106
.007600	.03506	.2203	.2168	.2221	1.0244	1.531	.9762	.4406	.4549	1.099	.9842	.2134	105
.007700	.03529	.2218	.2182	.2236	1.0247	1.526	.9759	.4435	.4582	1.100	.9840	.2147	104
.007800	.03552	.2232	.2196	.2251	1.0250	1.521	.9756	.4464	.4614	1.101	.9838	.2160	102
.007900	.03576	.2247	.2209	.2265	1.0253	1.517	.9753	.4493	.4646	1.103	.9836	.2173	101
.008000	.03598	.2261	.2223	.2280	1.0257	1.512	.9750	.4522	.4678	1.104	.9834	.2186	100
.008100	.03621	.2275	.2237	.2295	1.0260	1.508	.9747	.4551	.4709	1.105	.9832	.2199	98.6
.008200	.03644	.2290	.2250	.2310	1.0263	1.503	.9744	.4579	.4741	1.107	.9830	.2212	97.5
.008300	.03666	.2304	.2264	.2324	1.0266	1.499	.9741	.4607	.4772	1.108	.9827	.2225	96.3
.008400	.03689	.2318	.2277	.2338	1.0270	1.495	.9737	.4636	.4803	1.109	.9825	.2237	95.2
.008500	.03711	.2332	.2290	.2353	1.0273	1.491	.9734	.4664	.4834	1.111	.9823	.2250	94.1
.008600	.03733	.2346	.2303	.2367	1.0276	1.487	.9731	.4691	.4865	1.112	.9821	.2262	93.0
.008700	.03755	.2360	.2317	.2381	1.0280	1.482	.9728	.4719	.4896	1.113	.9819	.2275	91.9
.008800	.03777	.2373	.2330	.2396	1.0283	1.478	.9725	.4747	.4927	1.115	.9817	.2287	90.9
.008900	.03799	.2387	.2343	.2410	1.0286	1.474	.9722	.4774	.4957	1.116	.9815	.2300	89.9
.009000	.03821	.2401	.2356	.2424	1.0290	1.471	.9718	.4801	.4988	1.118	.9813	.2312	88.9
.009100	.03842	.2414	.2368	.2438	1.0293	1.467	.9715	.4828	.5018	1.119	.9811	.2324	88.0
.009200	.03864	.2428	.2381	.2452	1.0296	1.463	.9712	.4855	.5049	1.120	.9809	.2336	87.1
.009300	.03885	.2441	.2394	.2465	1.0299	1.459	.9709	.4882	.5079	1.122	.9807	.2348	86.1
.009400	.03906	.2455	.2407	.2479	1.0303	1.456	.9706	.4909	.5109	1.123	.9805	.2360	85.2
.009500	.03928	.2468	.2419	.2493	1.0306	1.452	.9703	.4936	.5138	1.124	.9803	.2371	84.3
.009600	.03949	.2481	.2431	.2507	1.0309	1.448	.9700	.4962	.5168	1.126	.9801	.2383	83.5
.009700	.03970	.2494	.2443	.2520	1.0313	1.445	.9697	.4988	.5198	1.127	.9799	.2394	82.7
.009800	.03990	.2507	.2456	.2534	1.0316	1.442	.9694	.5014	.5227	1.128	.9797	.2406	81.8
.009900	.04011	.2520	.2468	.2547	1.0319	1.438	.9691	.5040	.5257	1.130	.9794	.2417	81.0
.01000	.04032	.2533	.2480	.2560	1.0322	1.435	.9688	.5066	.5286	1.131	.9792	.2429	80.2
.01100	.04233	.2660	.2598	.2691	1.0356	1.403	.9656	.5319	.5574	1.145	.9772	.2539	73.1
.01200	.04426	.2781	.2711	.2817	1.0389	1.375	.9625	.5562	.5853	1.159	.9751	.2643	67.1
.01300	.04612	.2898	.2820	.2938	1.0423	1.350	.9594	.5795	.6125	1.173	.9731	.2743	62.1
.01400	.04791	.3010	.2924	.3056	1.0456	1.327	.9564	.6020	.6391	1.187	.9710	.2838	57.8
.01500	.04964	.3119	.3022	.3170	1.0490	1.307	.9533	.6238	.6651	1.201	.9690	.2928	54.0
.01600	.05132	.3225	.3117	.3281	1.0524	1.288	.9502	.6450	.6906	1.215	.9670	.3014	50.8
.01700	.05296	.3328	.3209	.3389	1.0559	1.271	.9471	.6655	.7158	1.230	.9649	.3096	47.9
.01800	.05455	.3428	.3298	.3495	1.0593	1.255	.9440	.6856	.7405	1.244	.9629	.3176	45.3
.01900	.05611	.3525	.3386	.3599	1.0628	1.240	.9409	.7051	.7650	1.259	.9609	.3253	43.0
.02000	.05763	.3621	.3470	.3701	1.0663	1.226	.9378	.7242	.7891	1.274	.9588	.3327	41.0
.02100	.05912	.3714	.3552	.3800	1.0698	1.213	.9348	.7429	.8131	1.289	.9568	.3399	39.1
.02200	.06057	.3806	.3632	.3898	1.0733	1.201	.9317	.7612	.8368	1.304	.9548	.3468	37.4
.02300	.06200	.3896	.3710	.3995	1.0768	1.189	.9287	.7791	.8603	1.319	.9528	.3535	35.9
.02400	.06340	.3984	.3786	.4090	1.0804	1.178	.9256	.7967	.8837	1.335	.9508	.3600	34.4
.02500	.06478	.4070	.3860	.4184	1.0840	1.168	.9225	.8140	.9069	1.350	.9488	.3662	33.1
.02600	.06613	.4155	.3932	.4276	1.0876	1.159	.9195	.8310	.9310	1.366	.9468	.3722	31.9
.02700	.06747	.4239	.4002	.4367	1.0912	1.150	.9164	.8478	.9530	1.381	.9448	.3781	30.8
.02800	.06878	.4322	.4071	.4457	1.0949	1.141	.9133	.8643	.9760	1.397	.9428	.3838	29.8
.02900	.07007	.4403	.4138	.4546	1.0985	1.133	.9103	.8805	.9988	1.413	.9408	.3893	28.8

Step 21

Reference:
SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi\, d/L$	TANH $2\pi\, d/L$	SINH $2\pi\, d/L$	COSH $2\pi\, d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_G/C_o	M
.03000	.07135	.4483	.4205	.4634	1.1021	1.125	.9073	.8966	1.022	1.430	.9388	.3947	27.9
.03100	.07260	.4562	.4269	.4721	1.1059	1.118	.9042	.9124	1.044	1.446	.9369	.4000	27.1
.03200	.07385	.4640	.4333	.4808	1.1096	1.111	.9012	.9280	1.067	1.462	.9349	.4051	26.3
.03300	.07507	.4717	.4395	.4894	1.1133	1.104	.8982	.9434	1.090	1.479	.9329	.4100	25.6
.03400	.07630	.4794	.4457	.4980	1.1171	1.098	.8952	.9588	1.113	1.496	.9309	.4149	24.8
.03500	.07748	.4868	.4517	.5064	1.1209	1.092	.8921	.9737	1.135	1.513	.9289	.4196	24.19
.03600	.07867	.4943	.4577	.5147	1.1247	1.086	.8891	.9886	1.158	1.530	.9270	.4242	23.56
.03700	.07984	.5017	.4635	.5230	1.1285	1.080	.8861	1.003	1.180	1.547	.9250	.4287	22.97
.03800	.08100	.5090	.4691	.5312	1.1324	1.075	.8831	1.018	1.203	1.564	.9230	.4330	22.42
.03900	.08215	.5162	.4747	.5394	1.1362	1.069	.8801	1.032	1.226	1.582	.9211	.4372	21.90
.04000	.08329	.5233	.4802	.5475	1.1401	1.064	.8771	1.047	1.248	1.600	.9192	.4414	21.40
.04100	.08442	.5304	.4857	.5556	1.1440	1.059	.8741	1.061	1.271	1.617	.9172	.4455	20.92
.04200	.08553	.5374	.4911	.5637	1.1479	1.055	.8711	1.075	1.294	1.636	.9153	.4495	20.46
.04300	.08664	.5444	.4964	.5717	1.1518	1.050	.8688	1.089	1.317	1.654	.9133	.4534	20.03
.04400	.08774	.5513	.5015	.5796	1.1558	1.046	.8652	1.103	1.340	1.672	.9114	.4571	19.62
.04500	.08883	.5581	.5066	.5876	1.1599	1.042	.8621	1.116	1.363	1.691	.9095	.4607	19.23
.04600	.08991	.5649	.5116	.5954	1.1639	1.038	.8592	1.130	1.386	1.709	.9076	.4643	18.85
.04700	.09098	.5717	.5166	.6033	1.1679	1.034	.8562	1.143	1.409	1.728	.9057	.4679	18.49
.04800	.09205	.5784	.5215	.6111	1.1720	1.030	.8532	1.157	1.433	1.747	.9037	.4713	18.15
.04900	.09311	.5850	.5263	.6189	1.1760	1.026	.8503	1.170	1.456	1.766	.9018	.4746	17.82
.05000	.09416	.5916	.5310	.6267	1.1802	1.023	.8473	1.183	1.479	1.786	.8999	.4779	17.50
.05100	.09520	.5981	.5357	.6344	1.1843	1.019	.8444	1.196	1.503	1.805	.8980	.4811	17.19
.05200	.09623	.6046	.5403	.6421	1.1884	1.016	.8415	1.209	1.526	1.825	.8961	.4842	16.90
.05300	.09726	.6111	.5449	.6499	1.1926	1.013	.8385	1.222	1.550	1.845	.8943	.4873	16.62
.05400	.09829	.6176	.5494	.6575	1.1968	1.010	.8356	1.235	1.574	1.865	.8924	.4903	16.35
.05500	.09930	.6239	.5538	.6652	1.2011	1.007	.8326	1.248	1.598	1.885	.8905	.4932	16.09
.05600	.1003	.6303	.5582	.6729	1.2053	1.004	.8297	1.261	1.622	1.906	.8886	.4960	15.84
.05700	.1013	.6366	.5626	.6805	1.2096	1.001	.8267	1.273	1.646	1.926	.8867	.4988	15.60
.05800	.1023	.6428	.5668	.6880	1.2138	.9985	.8239	1.286	1.670	1.947	.8849	.5015	15.36
.05900	.1033	.6491	.5711	.6956	1.2181	.9958	.8209	1.298	1.695	1.968	.8830	.5042	15.13
.06000	.1043	.6553	.5753	.7033	1.2225	.9932	.8180	1.311	1.719	1.989	.8811	.5068	14.91
.06100	.1053	.6616	.5794	.7110	1.2270	.9907	.8150	1.323	1.744	2.011	.8792	.5094	14.70
.06200	.1063	.6678	.5834	.7187	1.2315	.9883	.8121	1.336	1.770	2.033	.8773	.5119	14.50
.06300	.1073	.6739	.5874	.7256	1.2355	.9860	.8093	1.348	1.795	2.055	.8755	.5143	14.30
.06400	.1082	.6799	.5914	.7335	1.2402	.9837	.8063	1.360	1.819	2.076	.8737	.5167	14.11
.06500	.1092	.6860	.5954	.7411	1.2447	.9815	.8035	1.372	1.845	2.098	.8719	.5191	13.92
.06600	.1101	.6920	.5993	.7486	1.2492	.9793	.8005	1.384	1.870	2.121	.8700	.5214	13.74
.06700	.1111	.6981	.6031	.7561	1.2537	.9772	.7977	1.396	1.896	2.144	.8682	.5236	13.57
.06800	.1120	.7037	.6069	.7633	1.2580	.9752	.7948	1.408	1.921	2.166	.8664	.5258	13.40
.06900	.1130	.7099	.6106	.7711	1.2628	.9732	.7919	1.420	1.948	2.189	.8646	.5279	13.24
.07000	.1139	.7157	.6144	.7783	1.2672	.9713	.7890	1.432	1.974	2.213	.8627	.5300	13.08
.07100	.1149	.7219	.6181	.7863	1.2721	.9694	.7861	1.444	2.000	2.236	.8609	.5321	12.92
.07200	.1158	.7277	.6217	.7937	1.2767	.9676	.7833	1.455	2.026	2.260	.8591	.5341	12.77
.07300	.1168	.7336	.6252	.8011	1.2813	.9658	.7804	1.467	2.053	2.284	.8572	.5360	12.62
.07400	.1177	.7395	.6289	.8088	1.2861	.9641	.7775	1.479	2.080	2.308	.8554	.5380	12.48
.07500	.1186	.7453	.6324	.8162	1.2908	.9624	.7747	1.490	2.107	2.332	.8537	.5399	12.34
.07600	.1195	.7511	.6359	.8237	1.2956	.9607	.7719	1.502	2.135	2.357	.8519	.5417	12.21
.07700	.1205	.7569	.6392	.8312	1.3004	.9591	.7690	1.514	2.162	2.382	.8501	.5435	12.08
.07800	.1214	.7625	.6427	.8386	1.3051	.9576	.7662	1.525	2.189	2.407	.8483	.5452	11.95
.07900	.1223	.7683	.6460	.8462	1.3100	.9562	.7634	1.537	2.217	2.432	.8465	.5469	11.83
.08000	.1232	.7741	.6493	.8538	1.3149	.9548	.7605	1.548	2.245	2.458	.8448	.5485	11.71
.08100	.1241	.7799	.6526	.8614	1.3198	.9534	.7577	1.560	2.274	2.484	.8430	.5501	11.59
.08200	.1251	.7854	.6558	.8687	1.3246	.9520	.7549	1.571	2.303	2.511	.8413	.5517	11.47
.08300	.1259	.7911	.6590	.8762	1.3295	.9506	.7522	1.583	2.331	2.537	.8395	.5533	11.36
.08400	.1268	.7967	.6622	.8837	1.3345	.9493	.7494	1.594	2.360	2.563	.8378	.5548	11.25
.08500	.1277	.8026	.6655	.8915	1.3397	.9481	.7464	1.605	2.389	2.590	.8360	.5563	11.14
.08600	.1286	.8080	.6685	.8989	1.3446	.9469	.7437	1.616	2.418	2.617	.8342	.5577	11.04
.08700	.1295	.8137	.6716	.9064	1.3497	.9457	.7409	1.628	2.448	2.644	.8325	.5591	10.94
.08800	.1304	.8193	.6747	.9141	1.3548	.9445	.7381	1.639	2.478	2.672	.8308	.5605	10.84
.08900	.1313	.8250	.6778	.9218	1.3600	.9433	.7353	1.650	2.508	2.700	.8290	.5619	10.74

Reference:
SPM Vol II

Step 21

Table C-1. Continued.

d/L_o	d/L	$2\pi d/L$	TANH $2\pi d/L$	SINH $2\pi d/L$	COSH $2\pi d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_G/C_o	%
.09000	.1322	.8306	.6808	.9295	1.3653	.9422	.7324	1.661	2.538	2.728	.8273	.5632	10.65
.09100	.1331	.8363	.6838	.9372	1.3706	.9411	.7296	1.672	2.568	2.756	.8255	.5645	10.55
.09200	.1340	.8420	.6868	.9450	1.3759	.9401	.7268	1.684	2.599	2.785	.8238	.5658	10.46
.09300	.1349	.8474	.6897	.9525	1.3810	.9391	.7241	1.695	2.630	2.814	.8221	.5670	10.37
.09400	.1357	.8528	.6925	.9600	1.3862	.9381	.7214	1.706	2.662	2.843	.8204	.5682	10.29
.09500	.1366	.8583	.6953	.9677	1.3917	.9371	.7186	1.717	2.693	2.873	.8187	.5693	10.21
.09600	.1375	.8639	.6982	.9755	1.3970	.9362	.7158	1.728	2.726	2.903	.8170	.5704	10.12
.09700	.1384	.8694	.7011	.9832	1.4023	.9353	.7131	1.739	2.757	2.933	.8153	.5716	10.04
.09800	.1392	.8749	.7039	.9908	1.4077	.9344	.7104	1.750	2.790	2.963	.8136	.5727	9.962
.09900	.1401	.8803	.7066	.9985	1.4131	.9335	.7076	1.761	2.822	2.994	.8120	.5737	9.884
.1000	.1410	.8858	.7093	1.006	1.4187	.9327	.7049	1.772	2.855	3.025	.8103	.5747	9.808
.1010	.1419	.8913	.7120	1.014	1.4242	.9319	.7022	1.783	2.888	3.057	.8086	.5757	9.734
.1020	.1427	.8967	.7147	1.022	1.4297	.9311	.6994	1.793	2.922	3.088	.8069	.5766	9.661
.1030	.1436	.9023	.7173	1.030	1.4354	.9304	.6967	1.805	2.956	3.121	.8052	.5776	9.590
.1040	.1445	.9076	.7200	1.037	1.4410	.9297	.6940	1.815	2.990	3.153	.8036	.5785	9.519
.1050	.1453	.9130	.7226	1.045	1.4465	.9290	.6913	1.826	3.024	3.185	.8019	.5794	9.451
.1060	.1462	.9184	.7252	1.053	1.4523	.9282	.6886	1.837	3.059	3.218	.8003	.5803	9.384
.1070	.1470	.9239	.7277	1.061	1.4580	.9276	.6859	1.848	3.094	3.251	.7986	.5812	9.318
.1080	.1479	.9293	.7303	1.069	1.4638	.9269	.6833	1.858	3.128	3.284	.7970	.5820	9.254
.1090	.1488	.9343	.7327	1.076	1.4692	.9263	.6806	1.869	3.164	3.319	.7954	.5828	9.191
.1100	.1496	.9400	.7352	1.085	1.4752	.9257	.6779	1.880	3.201	3.353	.7937	.5836	9.129
.1110	.1505	.9456	.7377	1.093	1.4814	.9251	.6752	1.891	3.237	3.388	.7920	.5843	9.068
.1120	.1513	.9508	.7402	1.101	1.4871	.9245	.6725	1.902	3.274	3.423	.7904	.5850	9.009
.1130	.1522	.9563	.7426	1.109	1.4932	.9239	.6697	1.913	3.312	3.459	.7888	.5857	8.950
.1140	.1530	.9616	.7450	1.117	1.4990	.9234	.6671	1.923	3.348	3.494	.7872	.5864	8.891
.1150	.1539	.9670	.7474	1.125	1.5051	.9228	.6645	1.934	3.385	3.530	.7856	.5871	8.835
.1160	.1547	.9720	.7497	1.133	1.5108	.9223	.6619	1.944	3.423	3.566	.7840	.5878	8.780
.1170	.1556	.9775	.7520	1.141	1.5171	.9218	.6592	1.955	3.462	3.603	.7824	.5884	8.726
.1180	.1564	.9827	.7543	1.149	1.5230	.9214	.6566	1.966	3.501	3.641	.7808	.5890	8.673
.1190	.1573	.9882	.7566	1.157	1.5293	.9209	.6539	1.977	3.540	3.678	.7792	.5896	8.621
.1200	.1581	.9936	.7589	1.165	1.5356	.9204	.6512	1.987	3.579	3.716	.7776	.5902	8.569
.1210	.1590	.9989	.7612	1.174	1.5418	.9200	.6486	1.998	3.620	3.755	.7760	.5907	8.518
.1220	.1598	1.004	.7634	1.182	1.5479	.9196	.6460	2.008	3.659	3.793	.7745	.5913	8.468
.1230	.1607	1.010	.7656	1.190	1.5546	.9192	.6433	2.019	3.699	3.832	.7729	.5918	8.419
.1240	.1615	1.015	.7678	1.198	1.5605	.9189	.6407	2.030	3.740	3.871	.7713	.5922	8.371
.1250	.1624	1.020	.7700	1.207	1.5674	.9186	.6381	2.041	3.782	3.912	.7698	.5926	8.324
.1260	.1632	1.025	.7721	1.215	1.5734	.9182	.6356	2.051	3.824	3.952	.7682	.5931	8.278
.1270	.1640	1.030	.7742	1.223	1.5795	.9178	.6331	2.061	3.865	3.992	.7667	.5936	8.233
.1280	.1649	1.036	.7763	1.231	1.5862	.9175	.6305	2.072	3.907	4.033	.7652	.5940	8.189
.1290	.1657	1.041	.7783	1.240	1.5927	.9172	.6279	2.082	3.950	4.074	.7637	.5944	8.146
.1300	.1665	1.046	.7804	1.248	1.5990	.9169	.6254	2.093	3.992	4.115	.7621	.5948	8.103
.1310	.1674	1.052	.7824	1.257	1.6060	.9166	.6228	2.104	4.036	4.158	.7606	.5951	8.061
.1320	.1682	1.057	.7844	1.265	1.6124	.9164	.6202	2.114	4.080	4.201	.7591	.5954	8.020
.1330	.1691	1.062	.7865	1.273	1.6191	.9161	.6176	2.125	4.125	4.245	.7575	.5958	7.978
.1340	.1699	1.068	.7885	1.282	1.6260	.9158	.6150	2.135	4.169	4.288	.7560	.5961	7.937
.1350	.1708	1.073	.7905	1.291	1.633	.9156	.6123	2.146	4.217	4.334	.7545	.5964	7.897
.1360	.1716	1.078	.7925	1.300	1.640	.9154	.6098	2.156	4.262	4.378	.7530	.5967	7.857
.1370	.1724	1.084	.7945	1.308	1.647	.9152	.6073	2.167	4.309	4.423	.7515	.5969	7.819
.1380	.1733	1.089	.7964	1.317	1.654	.9150	.6047	2.177	4.355	4.468	.7500	.5972	7.781
.1390	.1741	1.094	.7983	1.326	1.660	.9148	.6022	2.188	4.402	4.514	.7485	.5975	7.744
.1400	.1749	1.099	.8002	1.334	1.667	.9146	.5998	2.198	4.450	4.561	.7471	.5978	7.707
.1410	.1758	1.105	.8021	1.343	1.675	.9144	.5972	2.209	4.498	4.607	.7456	.5980	7.671
.1420	.1766	1.110	.8039	1.352	1.681	.9142	.5947	2.219	4.546	4.654	.7441	.5982	7.636
.1430	.1774	1.115	.8057	1.360	1.688	.9141	.5923	2.230	4.595	4.663	.7426	.5984	7.602
.1440	.1783	1.120	.8076	1.369	1.696	.9140	.5898	2.240	4.644	4.751	.7412	.5986	7.567
.1450	.1791	1.125	.8094	1.378	1.703	.9139	.5873	2.251	4.695	4.800	.7397	.5987	7.533
.1460	.1800	1.131	.8112	1.388	1.710	.9137	.5847	2.261	4.746	4.850	.7382	.5989	7.499
.1470	.1808	1.136	.8131	1.397	1.718	.9136	.5822	2.272	4.798	4.901	.7368	.5990	7.465
.1480	.1816	1.141	.8149	1.405	1.725	.9135	.5798	2.282	4.847	4.951	.7354	.5992	7.432
.1490	.1825	1.146	.8166	1.415	1.732	.9134	.5773	2.293	4.901	5.001	.7339	.5993	7.400

Step 21

Reference:
SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi\, d/L$	TANH $2\pi\, d/L$	SINH $2\pi\, d/L$	COSH $2\pi\, d/L$	H/H'_o	K	$4\pi\, d/L$	SINH $4\pi\, d/L$	COSH $4\pi\, d/L$	n	C_G/C_o	M
.1500	.1833	1.152	.8183	1.424	1.740	.9133	.5748	2.303	4.954	5.054	.7325	.5994	7.369
.1510	.1841	1.157	.8200	1.433	1.747	.9133	.5723	2.314	5.007	5.106	.7311	.5994	7.339
.1520	.1850	1.162	.8217	1.442	1.755	.9132	.5699	2.324	5.061	5.159	.7296	.5995	7.309
.1530	.1858	1.167	.8234	1.451	1.762	.9132	.5675	2.335	5.115	5.212	.7282	.5996	7.279
.1540	.1866	1.173	.8250	1.460	1.770	.9132	.5651	2.345	5.169	5.265	.7268	.5996	7.250
.1550	.1875	1.178	.8267	1.469	1.777	.9131	.5627	2.356	5.225	5.320	.7254	.5997	7.221
.1560	.1883	1.183	.8284	1.479	1.785	.9130	.5602	2.366	5.283	5.376	.7240	.5998	7.191
.1570	.1891	1.188	.8301	1.488	1.793	.9129	.5577	2.377	5.339	5.432	.7226	.5999	7.162
.1580	.1900	1.194	.8317	1.498	1.801	.9130	.5552	2.387	5.398	5.490	.7212	.5998	7.134
.1590	.1908	1.199	.8333	1.507	1.809	.9130	.5528	2.398	5.454	5.544	.7198	.5998	7.107
.1600	.1917	1.204	.8349	1.517	1.817	.9130	.5504	2.408	5.513	5.603	.7184	.5998	7.079
.1610	.1925	1.209	.8365	1.527	1.825	.9130	.5480	2.419	5.571	5.660	.7171	.5998	7.052
.1620	.1933	1.215	.8381	1.536	1.833	.9130	.5456	2.429	5.630	5.718	.7157	.5998	7.026
.1630	.1941	1.220	.8396	1.546	1.841	.9130	.5432	2.440	5.690	5.777	.7144	.5998	7.000
.1640	.1950	1.225	.8411	1.555	1.849	.9130	.5409	2.450	5.751	5.837	.7130	.5998	6.975
.1650	.1958	1.230	.8427	1.565	1.857	.9131	.5385	2.461	5.813	5.898	.7117	.5997	6.949
.1660	.1966	1.235	.8442	1.574	1.865	.9132	.5362	2.471	5.874	5.959	.7103	.5996	6.924
.1670	.1975	1.240	.8457	1.584	1.873	.9132	.5339	2.482	5.938	6.021	.7090	.5996	6.900
.1680	.1983	1.246	.8472	1.594	1.882	.9133	.5315	2.492	6.003	6.085	.7076	.5995	6.876
.1690	.1992	1.251	.8486	1.604	1.890	.9133	.5291	2.503	6.066	6.148	.7063	.5994	6.853
.1700	.2000	1.257	.8501	1.614	1.899	.9134	.5267	2.513	6.130	6.212	.7050	.5993	6.830
.1710	.2008	1.262	.8515	1.624	1.907	.9135	.5243	2.523	6.197	6.275	.7036	.5992	6.807
.1720	.2017	1.267	.8529	1.634	1.915	.9136	.5220	2.534	6.262	6.342	.7023	.5991	6.784
.1730	.2025	1.272	.8544	1.644	1.924	.9137	.5197	2.544	6.329	6.407	.7010	.5989	6.761
.1740	.2033	1.277	.8558	1.654	1.933	.9138	.5174	2.555	6.395	6.473	.6997	.5988	6.738
.1750	.2042	1.282	.8572	1.664	1.941	.9139	.5151	2.565	6.465	6.541	.6984	.5987	6.716
.1760	.2050	1.288	.8586	1.675	1.951	.9140	.5127	2.576	6.534	6.610	.6971	.5985	6.694
.1770	.2058	1.293	.8600	1.685	1.959	.9141	.5104	2.586	6.603	6.679	.6958	.5984	6.672
.1780	.2066	1.298	.8614	1.695	1.968	.9142	.5081	2.597	6.672	6.747	.6946	.5982	6.651
.1790	.2075	1.304	.8627	1.706	1.977	.9144	.5058	2.607	6.744	6.818	.6933	.5980	6.631
.1800	.2083	1.309	.8640	1.716	1.986	.9145	.5036	2.618	6.818	6.891	.6920	.5979	6.611
.1810	.2092	1.314	.8653	1.727	1.995	.9146	.5013	2.629	6.890	6.963	.6907	.5977	6.591
.1820	.2100	1.320	.8666	1.737	2.004	.9148	.4990	2.639	6.963	7.035	.6895	.5975	6.571
.1830	.2108	1.325	.8680	1.748	2.013	.9149	.4967	2.650	7.038	7.109	.6882	.5974	6.550
.1840	.2117	1.330	.8693	1.758	2.022	.9150	.4945	2.660	7.113	7.183	.6870	.5972	6.530
.1850	.2125	1.335	.8706	1.769	2.032	.9152	.4922	2.671	7.191	7.260	.6857	.5969	6.511
.1860	.2134	1.341	.8718	1.780	2.041	.9154	.4899	2.681	7.267	7.336	.6845	.5967	6.492
.1870	.2142	1.346	.8731	1.791	2.051	.9155	.4876	2.692	7.345	7.412	.6832	.5965	6.474
.1880	.2150	1.351	.8743	1.801	2.060	.9157	.4854	2.702	7.421	7.488	.6820	.5963	6.456
.1890	.2159	1.356	.8755	1.812	2.070	.9159	.4832	2.712	7.500	7.566	.6808	.5961	6.438
.1900	.2167	1.362	.8767	1.823	2.079	.9161	.4809	2.723	7.581	7.647	.6796	.5958	6.421
.1910	.2176	1.367	.8779	1.834	2.089	.9163	.4787	2.734	7.663	7.728	.6784	.5955	6.403
.1920	.2184	1.372	.8791	1.845	2.099	.9165	.4765	2.744	7.746	7.810	.6772	.5952	6.385
.1930	.2192	1.377	.8803	1.856	2.108	.9167	.4743	2.755	7.827	7.891	.6760	.5950	6.368
.1940	.2201	1.383	.8815	1.867	2.118	.9169	.4721	2.765	7.911	7.974	.6748	.5948	6.351
.1950	.2209	1.388	.8827	1.879	2.128	.9170	.4699	2.776	7.996	8.059	.6736	.5946	6.334
.1960	.2218	1.393	.8839	1.890	2.138	.9172	.4677	2.787	8.083	8.145	.6724	.5944	6.317
.1970	.2226	1.399	.8850	1.901	2.148	.9174	.4655	2.797	8.167	8.228	.6712	.5941	6.300
.1980	.2234	1.404	.8862	1.913	2.158	.9176	.4633	2.808	8.256	8.316	.6700	.5938	6.284
.1990	.2243	1.409	.8873	1.924	2.169	.9179	.4611	2.819	8.346	8.406	.6689	.5935	6.268
.2000	.2251	1.414	.8884	1.935	2.178	.9181	.4590	2.829	8.436	8.495	.6677	.5932	6.253
.2010	.2260	1.420	.8895	1.947	2.189	.9183	.4569	2.840	8.524	8.583	.6666	.5929	6.237
.2020	.2268	1.425	.8906	1.959	2.199	.9186	.4547	2.850	8.616	8.674	.6654	.5926	6.222
.2030	.2277	1.430	.8917	1.970	2.210	.9188	.4526	2.861	8.708	8.766	.6642	.5923	6.206
.2040	.2285	1.436	.8928	1.982	2.220	.9190	.4504	2.872	8.803	8.860	.6631	.5920	6.191
.2050	.2293	1.441	.8939	1.994	2.231	.9193	.4483	2.882	8.897	8.953	.6620	.5917	6.176
.2060	.2302	1.446	.8950	2.006	2.242	.9195	.4462	2.893	8.994	9.050	.6608	.5914	6.161
.2070	.2310	1.451	.8960	2.017	2.252	.9197	.4441	2.903	9.090	9.144	.6597	.5911	6.147
.2080	.2319	1.457	.8971	2.030	2.263	.9200	.4419	2.914	9.187	9.240	.6586	.5908	6.133
.2090	.2328	1.462	.8981	2.042	2.274	.9202	.4398	2.925	9.288	9.342	.6574	.5905	6.119

Step 21

Reference:
SPM Vol II

Table C-1. Continued

d/L_o	d/L	$2\pi d/L$	TANH $2\pi d/L$	SINH $2\pi d/L$	COSH $2\pi d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_G/C_o	M
.2100	.2336	1.468	.8991	2.055	2.285	.9205	.4377	2.936	9.389	9.442	.6563	.5901	6.105
.2110	.2344	1.473	.9001	2.066	2.295	.9207	.4357	2.946	9.490	9.542	.6552	.5898	6.091
.2120	.2353	1.479	.9011	2.079	2.307	.9210	.4336	2.957	9.590	9.642	.6541	.5894	6.077
.2130	.2361	1.484	.9021	2.091	2.318	.9213	.4315	2.967	9.693	9.744	.6531	.5891	6.064
.2140	.2370	1.489	.9031	2.103	2.329	.9215	.4294	2.978	9.796	9.847	.6520	.5888	6.051
.2150	.2378	1.494	.9041	2.115	2.340	.9218	.4274	2.989	9.902	9.952	.6509	.5884	6.037
.2160	.2387	1.500	.9051	2.128	2.351	.9221	.4253	2.999	10.01	10.06	.6498	.5881	6.024
.2170	.2395	1.506	.9061	2.142	2.364	.9223	.4232	3.010	10.12	10.17	.6488	.5878	6.011
.2180	.2404	1.511	.9070	2.154	2.375	.9226	.4211	3.021	10.23	10.28	.6477	.5874	5.999
.2190	.2412	1.516	.9079	2.166	2.386	.9228	.4191	3.031	10.34	10.38	.6467	.5871	5.987
.2200	.2421	1.521	.9088	2.178	2.397	.9231	.4171	3.042	10.45	10.50	.6456	.5868	5.975
.2210	.2429	1.526	.9097	2.192	2.409	.9234	.4151	3.052	10.56	10.61	.6446	.5864	5.963
.2220	.2438	1.532	.9107	2.204	2.421	.9236	.4131	3.063	10.68	10.72	.6436	.5861	5.951
.2230	.2446	1.537	.9116	2.218	2.433	.9239	.4111	3.074	10.79	10.84	.6425	.5857	5.939
.2240	.2455	1.542	.9125	2.230	2.444	.9242	.4091	3.085	10.91	10.95	.6414	.5854	5.927
.2250	.2463	1.548	.9134	2.244	2.457	.9245	.4071	3.095	11.02	11.07	.6404	.5850	5.915
.2260	.2472	1.553	.9143	2.257	2.469	.9248	.4051	3.106	11.15	11.19	.6394	.5846	5.903
.2270	.2481	1.559	.9152	2.271	2.481	.9251	.4031	3.117	11.27	11.31	.6383	.5842	5.891
.2280	.2489	1.564	.9161	2.284	2.493	.9254	.4011	3.128	11.39	11.44	.6373	.5838	5.880
.2290	.2498	1.569	.9170	2.297	2.506	.9258	.3991	3.138	11.51	11.56	.6363	.5834	5.869
.2300	.2506	1.575	.9178	2.311	2.518	.9261	.3971	3.149	11.64	11.68	.6353	.5830	5.858
.2310	.2515	1.580	.9186	2.325	2.531	.9264	.3952	3.160	11.77	11.81	.6343	.5826	5.848
.2320	.2523	1.585	.9194	2.338	2.543	.9267	.3932	3.171	11.90	11.93	.6333	.5823	5.838
.2330	.2532	1.591	.9203	2.352	2.556	.9270	.3912	3.182	12.03	12.07	.6323	.5819	5.827
.2340	.2540	1.596	.9211	2.366	2.569	.9273	.3893	3.192	12.15	12.19	.6313	.5815	5.816
.2350	.2549	1.602	.9219	2.380	2.581	.9276	.3874	3.203	12.29	12.33	.6304	.5811	5.806
.2360	.2558	1.607	.9227	2.393	2.594	.9279	.3855	3.214	12.43	12.47	.6294	.5807	5.796
.2370	.2566	1.612	.9235	2.408	2.607	.9282	.3836	3.225	12.55	12.59	.6284	.5804	5.786
.2380	.2575	1.618	.9243	2.422	2.620	.9285	.3816	3.236	12.69	12.73	.6275	.5800	5.776
.2390	.2584	1.623	.9251	2.436	2.634	.9288	.3797	3.247	12.83	12.87	.6265	.5796	5.766
.2400	.2592	1.629	.9259	2.450	2.647	.9291	.3779	3.257	12.97	13.01	.6256	.5792	5.756
.2410	.2601	1.634	.9267	2.464	2.660	.9294	.3760	3.268	13.11	13.15	.6246	.5788	5.746
.2420	.2610	1.640	.9275	2.480	2.674	.9298	.3741	3.279	13.26	13.30	.6237	.5784	5.736
.2430	.2618	1.645	.9282	2.494	2.687	.9301	.3722	3.290	13.40	13.44	.6228	.5780	5.727
.2440	.2627	1.650	.9289	2.508	2.700	.9304	.3704	3.301	13.55	13.59	.6218	.5776	5.718
.2450	.2635	1.656	.9296	2.523	2.714	.9307	.3685	3.312	13.70	13.73	.6209	.5272	5.710
.2460	.2644	1.661	.9304	2.538	2.728	.9310	.3666	3.323	13.85	13.88	.6200	.5768	5.701
.2470	.2653	1.667	.9311	2.553	2.742	.9314	.3648	3.334	14.00	14.04	.6191	.5764	5.692
.2480	.2661	1.672	.9318	2.568	2.755	.9317	.3629	3.344	14.15	14.19	.6182	.5760	5.684
.2490	.2670	1.678	.9325	2.583	2.770	.9320	.3610	3.355	14.31	14.35	.6173	.5756	5.675
.2500	.2679	1.683	.9332	2.599	2.784	.9323	.3592	3.367	14.47	14.51	.6164	.5752	5.667
.2510	.2687	1.689	.9339	2.614	2.798	.9327	.3574	3.377	14.62	14.66	.6155	.5748	5.658
.2520	.2696	1.694	.9346	2.629	2.813	.9330	.3556	3.388	14.79	14.82	.6146	.5744	5.650
.2530	.2705	1.700	.9353	2.645	2.828	.9333	.3537	3.399	14.95	14.99	.6137	.5740	5.641
.2540	.2714	1.705	.9360	2.660	2.842	.9336	.3519	3.410	15.12	15.15	.6128	.5736	5.633
.2550	.2722	1.711	.9367	2.676	2.856	.9340	.3501	3.421	15.29	15.32	.6120	.5732	5.624
.2560	.2731	1.716	.9374	2.691	2.871	.9343	.3483	3.432	15.45	15.49	.6111	.5728	5.616
.2570	.2740	1.722	.9381	2.707	2.886	.9346	.3465	3.443	15.63	15.66	.6102	.5724	5.608
.2580	.2749	1.727	.9388	2.723	2.901	.9349	.3447	3.454	15.80	15.83	.6093	.5720	5.600
.2590	.2757	1.732	.9394	2.739	2.916	.9353	.3430	3.465	15.97	16.00	.6085	.5716	5.592
.2600	.2766	1.738	.9400	2.755	2.931	.9356	.3412	3.476	16.15	16.18	.6076	.5712	5.585
.2610	.2775	1.744	.9406	2.772	2.946	.9360	.3394	3.487	16.33	16.36	.6068	.5707	5.578
.2620	.2784	1.749	.9412	2.788	2.962	.9363	.3376	3.498	16.51	16.54	.6060	.5703	5.571
.2630	.2792	1.755	.9418	2.804	2.977	.9367	.3359	3.509	16.69	16.73	.6052	.5699	5.563
.2640	.2801	1.760	.9425	2.820	2.992	.9370	.3342	3.520	16.88	16.91	.6043	.5695	5.556
.2650	.2810	1.766	.9431	2.837	3.008	.9373	.3325	3.531	17.07	17.10	.6035	.5691	5.548
.2660	.2819	1.771	.9437	2.853	3.023	.9377	.3308	3.542	17.26	17.28	.6027	.5687	5.541
.2670	.2827	1.776	.9443	2.870	3.039	.9380	.3291	3.553	17.45	17.45	.6018	.5683	5.534
.2680	.2836	1.782	.9449	2.886	3.055	.9383	.3274	3.564	17.64	17.67	.6010	.5679	5.527
.2690	.2845	1.788	.9455	2.904	3.071	.9386	.3256	3.575	17.84	17.87	.6002	.5675	5.520

Step 21

Reference: SPM Vol II

Table C-1. Continued

d/L_o	d/L	$2\pi d/L$	TANH $2\pi d/L$	SINH $2\pi d/L$	COSH $2\pi d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_G/C_o	M
.2700	.2854	1.793	.9461	2.921	3.088	.9390	.3239	3.587	18.04	18.07	.5994	.5671	5.513
.2710	.2863	1.799	.9467	2.938	3.104	.9393	.3222	3.598	18.24	18.27	.5986	.5667	5.506
.2720	.2872	1.804	.9473	2.956	3.120	.9396	.3205	3.610	18.46	18.49	.5978	.5663	5.499
.2730	.2880	1.810	.9478	2.973	3.136	.9400	.3189	3.620	18.65	18.67	.5971	.5659	5.493
.2740	.2889	1.815	.9484	2.990	3.153	.9403	.3172	3.631	18.86	18.89	.5963	.5655	5.486
.2750	.2898	1.821	.9490	3.008	3.170	.9406	.3155	3.642	19.07	19.10	.5955	.5651	5.480
.2760	.2907	1.826	.9495	3.025	3.186	.9410	.3139	3.653	19.28	19.30	.5947	.5647	5.474
.2770	.2916	1.832	.9500	3.043	3.203	.9413	.3122	3.664	19.49	19.51	.5940	.5643	5.468
.2780	.2924	1.837	.9505	3.061	3.220	.9416	.3106	3.675	19.71	19.74	.5932	.5639	5.462
.2790	.2933	1.843	.9511	3.079	3.237	.9420	.3089	3.686	19.93	19.96	.5925	.5635	5.456
.2800	.2942	1.849	.9516	3.097	3.254	.9423	.3073	3.697	20.16	20.18	.5917	.5631	5.450
.2810	.2951	1.854	.9521	3.115	3.272	.9426	.3057	3.709	20.39	20.41	.5910	.5627	5.444
.2820	.2960	1.860	.9526	3.133	3.289	.9430	.3040	3.720	20.62	20.64	.5902	.5623	5.438
.2830	.2969	1.866	.9532	3.152	3.307	.9433	.3024	3.731	20.85	20.87	.5895	.5619	5.432
.2840	.2978	1.871	.9537	3.171	3.325	.9436	.3008	3.742	21.09	21.11	.5887	.5615	5.426
.2850	.2987	1.877	.9542	3.190	3.343	.9440	.2992	3.754	21.33	21.35	.5880	.5611	5.420
.2860	.2996	1.882	.9547	3.209	3.361	.9443	.2976	3.765	21.57	21.59	.5873	.5607	5.414
.2870	.3005	1.888	.9552	3.228	3.379	.9446	.2959	3.776	21.82	21.84	.5866	.5603	5.409
.2880	.3014	1.893	.9557	3.246	3.396	.9449	.2944	3.787	22.05	22.07	.5859	.5600	5.403
.2890	.3022	1.899	.9562	3.264	3.414	.9452	.2929	3.798	22.30	22.32	.5852	.5596	5.397
.2900	.3031	1.905	.9567	3.284	3.433	.9456	.2913	3.809	22.54	22.57	.5845	.5592	5.392
.2910	.3040	1.910	.9572	3.303	3.451	.9459	.2898	3.821	22.81	22.83	.5838	.5588	5.386
.2920	.3049	1.916	.9577	3.323	3.471	.9463	.2882	3.832	23.07	23.09	.5831	.5584	5.380
.2930	.3058	1.922	.9581	3.343	3.490	.9466	.2866	3.843	23.33	23.35	.5824	.5580	5.375
.2940	.3067	1.927	.9585	3.362	3.508	.9469	.2851	3.855	23.60	23.62	.5817	.5576	5.371
.2950	.3076	1.933	.9590	3.382	3.527	.9473	.2835	3.866	23.86	23.88	.5810	.5572	5.366
.2960	.3085	1.938	.9594	3.402	3.546	.9476	.2820	3.877	24.12	24.15	.5804	.5568	5.361
.2970	.3094	1.944	.9599	3.422	3.565	.9480	.2805	3.888	24.40	24.42	.5797	.5564	5.356
.2980	.3103	1.950	.9603	3.442	3.585	.9483	.2790	3.900	24.68	24.70	.5790	.5560	5.351
.2990	.3112	1.955	.9607	3.462	3.604	.9486	.2775	3.911	24.96	24.98	.5784	.5556	5.347
.3000	.3121	1.961	.9611	3.483	3.624	.9490	.2760	3.922	25.24	25.26	.5777	.5552	5.342
.3010	.3130	1.967	.9616	3.503	3.643	.9493	.2745	3.933	25.53	25.55	.5771	.5549	5.337
.3020	.3139	1.972	.9620	3.524	3.663	.9496	.2730	3.945	25.82	25.83	.5764	.5545	5.332
.3030	.3148	1.978	.9624	3.545	3.683	.9499	.2715	3.956	26.12	26.14	.5758	.5541	5.328
.3040	.3157	1.984	.9629	3.566	3.703	.9502	.2700	3.968	26.42	26.44	.5751	.5538	5.323
.3050	.3166	1.989	.9633	3.587	3.724	.9505	.2685	3.979	26.72	26.74	.5745	.5534	5.318
.3060	.3175	1.995	.9637	3.609	3.745	.9509	.2670	3.990	27.02	27.04	.5739	.5530	5.314
.3070	.3184	2.001	.9641	3.630	3.765	.9512	.2656	4.002	27.33	27.35	.5732	.5527	5.309
.3080	.3193	2.007	.9645	3.651	3.786	.9515	.2641	4.013	27.65	27.66	.5726	.5523	5.305
.3090	.3202	2.012	.9649	3.673	3.806	.9518	.2627	4.024	27.96	27.98	.5720	.5519	5.300
.3100	.3211	2.018	.9653	3.694	3.827	.9522	.2613	4.036	28.28	28.30	.5714	.5515	5.296
.3110	.3220	2.023	.9656	3.716	3.848	.9525	.2599	4.047	28.60	28.62	.5708	.5511	5.292
.3120	.3230	2.029	.9660	3.738	3.870	.9528	.2584	4.058	28.93	28.95	.5701	.5507	5.288
.3130	.3239	2.035	.9664	3.760	3.891	.9531	.2570	4.070	29.27	29.28	.5695	.5504	5.284
.3140	.3248	2.041	.9668	3.782	3.912	.9535	.2556	4.081	29.60	29.62	.5689	.5500	5.280
.3150	.3257	2.046	.9672	3.805	3.934	.9538	.2542	4.093	29.94	29.96	.5683	.5497	5.276
.3160	.3266	2.052	.9676	3.828	3.956	.9541	.2528	4.104	30.29	30.31	.5678	.5494	5.272
.3170	.3275	2.058	.9679	3.851	3.978	.9544	.2514	4.116	30.64	30.65	.5672	.5490	5.268
.3180	.3284	2.063	.9682	3.873	4.000	.9547	.2500	4.127	30.99	31.00	.5666	.5486	5.264
.3190	.3294	2.069	.9686	3.896	4.022	.9550	.2486	4.139	31.35	31.37	.5660	.5483	5.260
.3200	.3302	2.075	.9690	3.919	4.045	.9553	.2472	4.150	31.71	31.72	.5655	.5479	5.256
.3210	.3311	2.081	.9693	3.943	4.068	.9556	.2459	4.161	32.07	32.08	.5649	.5476	5.252
.3220	.3321	2.086	.9696	3.966	4.090	.9559	.2445	4.173	32.44	32.46	.5643	.5472	5.249
.3230	.3330	2.092	.9700	3.990	4.114	.9562	.2431	4.185	32.83	32.84	.5637	.5468	5.245
.3240	.3339	2.098	.9703	4.014	4.136	.9565	.2418	4.196	33.20	33.22	.5632	.5465	5.241
.3250	.3349	2.104	.9707	4.038	4.160	.9568	.2404	4.208	33.60	33.61	.5627	.5462	5.237
.3260	.3357	2.110	.9710	4.061	4.183	.9571	.2391	4.219	33.97	33.99	.5621	.5458	5.234
.3270	.3367	2.115	.9713	4.085	4.206	.9574	.2378	4.231	34.37	34.38	.5616	.5455	5.231
.3280	.3376	2.121	.9717	4.110	4.230	.9577	.2364	4.242	34.77	34.79	.5610	.5451	5.227
.3290	.3385	2.127	.9720	4.135	4.254	.9580	.2351	4.254	35.18	35.19	.5605	.5448	5.223

Step 21

Reference:
SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi\, d/L$	TANH $2\pi\, d/L$	SINH $2\pi\, d/L$	COSH $2\pi\, d/L$	H/H'_o	K	$4\pi\, d/L$	SINH $4\pi\, d/L$	COSH $4\pi\, d/L$	n	C_g/C_o	M
.3300	.3394	2.133	.9723	4.159	4.277	.9583	.2338	4.265	35.58	35.59	.5599	.5444	5.220
.3310	.3403	2.138	.9726	4.184	4.301	.9586	.2325	4.277	35.99	36.00	.5594	.5441	5.217
.3320	.3413	2.144	.9729	4.209	4.326	.9589	.2312	4.288	36.42	36.43	.5589	.5438	5.214
.3330	.3422	2.150	.9732	4.234	4.359	.9592	.2299	4.300	36.84	36.85	.5584	.5434	5.210
.3340	.3431	2.156	.9735	4.259	4.375	.9595	.2286	4.311	37.25	37.27	.5578	.5431	5.207
.3350	.3440	2.161	.9738	4.284	4.399	.9598	.2273	4.323	37.70	37.72	.5573	.5427	5.204
.3360	.3449	2.167	.9741	4.310	4.424	.9601	.2260	4.335	38.14	38.15	.5568	.5424	5.201
.3370	.3459	2.173	.9744	4.336	4.450	.9604	.2247	4.346	38.59	38.60	.5563	.5421	5.198
.3380	.3468	2.179	.9747	4.361	4.474	.9607	.2235	4.358	39.02	39.04	.5558	.5417	5.194
.3390	.3477	2.185	.9750	4.388	4.500	.9610	.2222	4.369	39.48	39.49	.5553	.5414	5.191
.3400	.3468	2.190	.9753	4.413	4.525	.9613	.2210	4.381	39.95	39.96	.5548	.5411	5.188
.3410	.3495	2.196	.9756	4.439	4.550	.9615	.2198	4.392	40.40	40.41	.5544	.5408	5.185
.3420	.3504	2.202	.9758	4.466	4.576	.9618	.2185	4.404	40.87	40.89	.5539	.5405	5.182
.3430	.3514	2.208	.9761	4.492	4.602	.9621	.2173	4.416	41.36	41.37	.5534	.5402	5.179
.3440	.3523	2.214	.9764	4.521	4.630	.9623	.2160	4.427	41.85	41.84	.5529	.5399	5.176
.3450	.3532	2.220	.9767	4.547	4.656	.9626	.2148	4.439	42.33	42.34	.5524	.5396	5.173
.3460	.3542	2.225	.9769	4.575	4.682	.9629	.2136	4.451	42.83	42.84	.5519	.5392	5.171
.3470	.3551	2.231	.9772	4.602	4.709	.9632	.2124	4.462	43.34	43.35	.5515	.5389	5.168
.3480	.3560	2.237	.9775	4.629	4.736	.9635	.2111	4.474	43.85	43.86	.5510	.5386	5.165
.3490	.3570	2.243	.9777	4.657	4.763	.9638	.2099	4.486	44.37	44.40	.5505	.5383	5.162
.3500	.3579	2.249	.9780	4.685	4.791	.9640	.2087	4.498	44.89	44.80	.5501	.5380	5.159
.3510	.3588	2.255	.9782	4.713	4.818	.9643	.2076	4.509	45.42	45.43	.5496	.5377	5.157
.3520	.3598	2.260	.9785	4.741	4.845	.9646	.2064	4.521	45.95	45.96	.5492	.5374	5.154
.3530	.3607	2.266	.9787	4.770	4.873	.9648	.2052	4.533	46.50	46.51	.5487	.5371	5.152
.3540	.3616	2.272	.9790	4.798	4.901	.9651	.2040	4.544	47.03	47.04	.5483	.5368	5.149
.3550	.3625	2.278	.9792	4.827	4.929	.9654	.2029	4.556	47.59	47.60	.5479	.5365	5.147
.3560	.3635	2.284	.9795	4.856	4.957	.9657	.2017	4.568	48.15	48.16	.5474	.5362	5.144
.3570	.3644	2.290	.9797	4.885	4.987	.9659	.2005	4.579	48.72	48.73	.5470	.5359	5.141
.3580	.3653	2.296	.9799	4.914	5.015	.9662	.1994	4.591	49.29	49.30	.5466	.5356	5.139
.3590	.3663	2.301	.9801	4.944	5.044	.9665	.1983	4.603	49.88	49.89	.5461	.5353	5.137
.3600	.3672	2.307	.9804	4.974	5.072	.9667	.1972	4.615	50.47	50.48	.5457	.5350	5.134
.3610	.3682	2.313	.9806	5.004	5.103	.9670	.1960	4.627	51.08	51.09	.5453	.5347	5.132
.3620	.3691	2.319	.9808	5.034	5.132	.9673	.1949	4.638	51.67	51.67	.5449	.5344	5.130
.3630	.3700	2.325	.9811	5.063	5.161	.9675	.1938	4.650	52.27	52.28	.5445	.5342	5.127
.3640	.3709	2.331	.9813	5.094	5.191	.9677	.1926	4.661	52.89	52.90	.5441	.5339	5.125
.3650	.3719	2.337	.9815	5.124	5.221	.9680	.1915	4.673	53.52	53.53	.5437	.5336	5.123
.3660	.3728	2.342	.9817	5.155	5.251	.9683	.1904	4.685	54.15	54.16	.5433	.5333	5.121
.3670	.3737	2.348	.9819	5.186	5.281	.9686	.1894	4.697	54.78	54.79	.5429	.5330	5.118
.3680	.3747	2.354	.9821	5.217	5.312	.9688	.1883	4.708	55.42	55.43	.5425	.5327	5.116
.3690	.3756	2.360	.9823	5.248	5.343	.9690	.1872	4.720	56.09	56.10	.5421	.5325	5.114
.3700	.3766	2.366	.9825	5.280	5.374	.9693	.1861	4.732	56.76	56.77	.5417	.5322	5.112
.3710	.3775	2.372	.9827	5.312	5.406	.9696	.1850	4.744	57.43	57.44	.5413	.5319	5.110
.3720	.3785	2.378	.9830	5.345	5.438	.9698	.1839	4.756	58.13	58.14	.5409	.5317	5.107
.3730	.3794	2.384	.9832	5.377	5.469	.9700	.1828	4.768	58.82	58.83	.5405	.5314	5.105
.3740	.3804	2.390	.9834	5.410	5.502	.9702	.1818	4.780	59.52	59.53	.5402	.5312	5.103
.3750	.3813	2.396	.9835	5.443	5.534	.9705	.1807	4.792	60.24	60.25	.5398	.5309	5.101
.3760	.3822	2.402	.9837	5.475	5.566	.9707	.1797	4.803	60.95	60.95	.5394	.5306	5.099
.3770	.3832	2.408	.9839	5.508	5.598	.9709	.1786	4.815	61.68	61.68	.5390	.5304	5.097
.3780	.3841	2.413	.9841	5.541	5.631	.9712	.1776	4.827	62.41	62.42	.5387	.5301	5.095
.3790	.3850	2.419	.9843	5.572	5.661	.9714	.1766	4.838	63.13	63.14	.5383	.5299	5.093
.3800	.3860	2.425	.9845	5.609	5.697	.9717	.1756	4.851	63.91	63.91	.5380	.5296	5.091
.3810	.3869	2.431	.9847	5.643	5.731	.9719	.1745	4.862	64.67	64.67	.5376	.5294	5.090
.3820	.3879	2.437	.9848	5.677	5.765	.9721	.1735	4.875	65.45	65.46	.5372	.5291	5.088
.3830	.3888	2.443	.9850	5.712	5.798	.9724	.1725	4.885	66.16	66.17	.5369	.5288	5.086
.3840	.3898	2.449	.9852	5.746	5.833	.9726	.1715	4.898	67.02	67.03	.5365	.5286	5.084
.3850	.3907	2.455	.9854	5.780	5.866	.9728	.1705	4.910	67.80	67.81	.5362	.5284	5.082
.3860	.3917	2.461	.9855	5.814	5.900	.9730	.1695	4.922	68.61	68.62	.5359	.5281	5.081
.3870	.3926	2.467	.9857	5.850	5.935	.9732	.1685	4.934	69.45	69.46	.5355	.5279	5.079
.3880	.3936	2.473	.9859	5.886	5.970	.9735	.1675	4.946	70.28	70.29	.5352	.5276	5.077
.3890	.3945	2.479	.9860	5.921	6.005	.9737	.1665	4.958	71.12	71.13	.5349	.5274	5.076

Step 21

Reference:
SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi d/L$	TANH $2\pi d/L$	SINH $2\pi d/L$	COSH $2\pi d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_g/C_o	M
.3900	.3955	2.485	.9862	5.957	6.040	.9739	.1656	4.970	71.97	71.98	.5345	.5271	5.074
.3910	.3964	2.491	.9864	5.993	6.076	.9741	.1646	4.982	72.85	72.86	.5342	.5269	5.072
.3920	.3974	2.497	.9865	6.029	6.112	.9743	.1636	4.993	73.72	73.72	.5339	.5267	5.071
.3930	.3983	2.503	.9867	6.066	6.148	.9745	.1627	5.005	74.58	74.59	.5336	.5265	5.069
.3940	.3993	2.509	.9869	6.103	6.185	.9748	.1617	5.017	75.48	75.49	.5332	.5262	5.067
.3950	.4002	2.515	.9870	6.140	6.221	.9750	.1608	5.029	76.40	76.40	.5329	.5260	5.066
.3960	.4012	2.521	.9872	6.177	6.258	.9752	.1598	5.041	77.31	77.32	.5326	.5258	5.064
.3970	.4021	2.527	.9873	6.215	6.295	.9754	.1589	5.053	78.24	78.24	.5323	.5255	5.063
.3980	.4031	2.532	.9874	6.252	6.332	.9756	.1579	5.065	79.19	79.19	.5320	.5253	5.062
.3990	.4040	2.538	.9876	6.290	6.369	.9758	.1570	5.077	80.13	80.13	.5317	.5251	5.060
.4000	.4050	2.544	.9877	6.329	6.407	.9761	.1561	5.089	81.12	81.12	.5314	.5248	5.058
.4010	.4059	2.550	.9879	6.367	6.445	.9763	.1552	5.101	82.07	82.08	.5311	.5246	5.056
.4020	.4069	2.556	.9880	6.406	6.483	.9765	.1542	5.113	83.06	83.06	.5308	.5244	5.055
.4030	.4078	2.562	.9882	6.444	6.521	.9766	.1533	5.125	84.07	84.07	.5305	.5242	5.053
.4040	.4088	2.568	.9883	6.484	6.561	.9768	.1524	5.137	85.11	85.12	.5302	.5240	5.052
.4050	.4098	2.575	.9885	6.525	6.601	.9770	.1515	5.149	86.14	86.14	.5299	.5238	5.050
.4060	.4107	2.581	.9886	6.564	6.640	.9772	.1506	5.161	87.17	87.17	.5296	.5236	5.049
.4070	.4116	2.586	.9887	6.603	6.679	.9774	.1497	5.173	88.19	88.20	.5293	.5234	5.048
.4080	.4126	2.592	.9889	6.644	6.718	.9776	.1488	5.185	89.28	89.28	.5290	.5232	5.046
.4090	.4136	2.598	.9890	6.684	6.758	.9778	.1480	5.197	90.38	90.39	.5287	.5229	5.045
.4100	.4145	2.604	.9891	6.725	6.799	.9780	.1471	5.209	91.44	91.44	.5285	.5227	5.044
.4110	.4155	2.610	.9892	6.766	6.839	.9782	.1462	5.221	92.54	92.55	.5282	.5225	5.043
.4120	.4164	2.616	.9894	6.806	6.879	.9784	.1454	5.233	93.67	93.67	.5279	.5223	5.041
.4130	.4174	2.623	.9895	6.849	6.921	.9786	.1445	5.245	94.83	94.83	.5277	.5221	5.040
.4140	.4183	2.629	.9896	6.890	6.963	.9788	.1436	5.257	95.95	95.96	.5274	.5219	5.039
.4150	.4193	2.635	.9898	6.932	7.004	.9790	.1428	5.269	97.13	97.13	.5271	.5217	5.037
.4160	.4203	2.641	.9899	6.974	7.046	.9792	.1419	5.281	98.29	98.30	.5269	.5215	5.036
.4170	.4212	2.647	.9900	7.018	7.088	.9794	.1411	5.294	99.52	99.52	.5266	.5213	5.035
.4180	.4222	2.653	.9901	7.060	7.130	.9795	.1403	5.305	100.7	100.7	.5263	.5211	5.034
.4190	.4231	2.659	.9902	7.102	7.173	.9797	.1394	5.317	101.9	101.9	.5261	.5209	5.033
.4200	.4241	2.665	.9904	7.146	7.215	.9798	.1386	5.329	103.1	103.1	.5258	.5208	5.031
.4210	.4251	2.671	.9905	7.190	7.259	.9800	.1378	5.341	104.4	104.4	.5256	.5206	5.030
.4220	.4260	2.677	.9906	7.234	7.303	.9802	.1369	5.353	105.7	105.7	.5253	.5204	5.029
.4230	.4270	2.683	.9907	7.279	7.349	.9804	.1361	5.366	107.0	107.0	.5251	.5202	5.028
.4240	.4280	2.689	.9908	7.325	7.392	.9806	.1353	5.378	108.3	108.3	.5248	.5200	5.027
.4250	.4289	2.695	.9909	7.371	7.438	.9808	.1345	5.390	109.7	109.7	.5246	.5198	5.026
.4260	.4298	2.701	.9910	7.412	7.479	.9810	.1337	5.402	110.9	110.9	.5244	.5196	5.025
.4270	.4308	2.707	.9911	7.457	7.524	.9811	.1329	5.414	112.2	112.2	.5241	.5195	5.024
.4280	.4318	2.713	.9912	7.503	7.570	.9812	.1321	5.426	113.6	113.6	.5239	.5193	5.023
.4290	.4328	2.719	.9913	7.550	7.616	.9814	.1313	5.438	115.0	115.0	.5237	.5191	5.022
.4300	.4337	2.725	.9914	7.595	7.661	.9816	.1305	5.450	116.4	116.4	.5234	.5189	5.021
.4310	.4347	2.731	.9915	7.642	7.707	.9818	.1298	5.462	117.8	117.8	.5232	.5187	5.020
.4320	.4356	2.737	.9916	7.688	7.753	.9819	.1290	5.474	119.2	119.3	.5230	.5186	5.019
.4330	.4366	2.743	.9917	7.735	7.800	.9821	.1282	5.486	120.7	120.7	.5227	.5184	5.018
.4340	.4376	2.749	.9918	7.783	7.847	.9823	.1274	5.499	122.2	122.2	.5225	.5182	5.017
.4350	.4385	2.755	.9919	7.831	7.895	.9824	.1267	5.511	123.7	123.7	.5223	.5181	5.016
.4360	.4395	2.762	.9920	7.880	7.943	.9826	.1259	5.523	125.2	125.2	.5221	.5179	5.015
.4370	.4405	2.768	.9921	7.922	7.991	.9828	.1251	5.535	126.7	126.7	.5218	.5177	5.014
.4380	.4414	2.774	.9922	7.975	8.035	.9829	.1244	5.547	128.3	128.3	.5216	.5176	5.013
.4390	.4424	2.780	.9923	8.026	8.088	.9830	.1236	5.560	129.9	129.9	.5214	.5174	5.012
.4400	.4434	2.786	.9924	8.075	8.136	.9832	.1229	5.572	131.4	131.4	.5212	.5172	5.011
.4410	.4443	2.792	.9925	8.124	8.185	.9833	.1222	5.584	133.0	133.0	.5210	.5171	5.010
.4420	.4453	2.798	.9926	8.175	8.236	.9835	.1214	5.596	134.7	134.7	.5208	.5169	5.009
.4430	.4463	2.804	.9927	8.228	8.285	.9836	.1207	5.608	136.3	136.3	.5206	.5168	5.008
.4440	.4472	2.810	.9928	8.274	8.334	.9838	.1200	5.620	137.9	137.9	.5204	.5166	5.007
.4450	.4482	2.816	.9929	8.326	8.387	.9839	.1192	5.632	139.6	139.7	.5202	.5165	5.006
.4460	.4492	2.822	.9930	8.379	8.438	.9841	.1185	5.644	141.4	141.4	.5200	.5163	5.005
.4470	.4501	2.828	.9930	8.427	8.486	.9843	.1178	5.657	143.1	143.1	.5198	.5161	5.005
.4480	.4511	2.834	.9931	8.481	8.540	.9844	.1171	5.669	144.8	144.8	.5196	.5160	5.004
.4490	.4521	2.840	.9932	8.532	8.590	.9846	.1164	5.681	146.6	146.6	.5194	.5158	5.003

Step 21

Reference: SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi\, d/L$	TANH $2\pi\, d/L$	SINH $2\pi\, d/L$	COSH $2\pi\, d/L$	H/H'_o	K	$4\pi\, d/L$	SINH $4\pi\, d/L$	COSH $4\pi\, d/L$	n	C_g/C_o	M
.4500	.4531	2.847	.9933	8.585	8.643	.9847	.1157	5.693	148.4	148.4	.5192	.5157	5.002
.4510	.4540	2.853	.9934	8.638	8.695	.9848	.1150	5.705	150.2	150.2	.5190	.5156	5.001
.4520	.4550	2.859	.9935	8.693	8.750	.9849	.1143	5.717	152.1	152.1	.5188	.5154	5.000
.4530	.4560	2.865	.9935	8.747	8.804	.9851	.1136	5.730	154.0	154.0	.5186	.5152	5.000
.4540	.4569	2.871	.9936	8.797	8.854	.9852	.1129	5.742	155.9	155.9	.5184	.5151	4.999
.4550	.4579	2.877	.9937	8.853	8.910	.9853	.1122	5.754	157.7	157.7	.5182	.5150	4.998
.4560	.4589	2.883	.9938	8.910	8.965	.9855	.1115	5.766	159.7	159.7	.5181	.5148	4.997
.4570	.4599	2.890	.9938	8.965	9.021	.9857	.1109	5.779	161.7	161.7	.5179	.5146	4.997
.4580	.4608	2.896	.9939	9.016	9.072	.9858	.1102	5.791	163.6	163.6	.5177	.5145	4.996
.4590	.4618	2.902	.9940	9.074	9.129	.9859	.1095	5.803	165.6	165.6	.5175	.5144	4.995
.4600	.4628	2.908	.9941	9.132	9.186	.9860	.1089	5.815	167.7	167.7	.5173	.5143	4.994
.4610	.4637	2.914	.9941	9.183	9.238	.9862	.1083	5.827	169.7	169.7	.5172	.5141	4.994
.4620	.4647	2.920	.9942	9.242	9.296	.9863	.1076	5.840	171.8	171.8	.5170	.5140	4.993
.4630	.4657	2.926	.9943	9.301	9.354	.9864	.1069	5.852	173.9	173.9	.5168	.5139	4.992
.4640	.4666	2.932	.9944	9.353	9.406	.9865	.1063	5.864	176.0	176.0	.5167	.5138	4.991
.4650	.4676	2.938	.9944	9.413	9.466	.9867	.1056	5.876	178.2	178.2	.5165	.5136	4.991
.4660	.4686	2.944	.9945	9.472	9.525	.9868	.1050	5.888	180.4	180.4	.5163	.5135	4.990
.4670	.4695	2.951	.9946	9.533	9.585	.9869	.1043	5.900	182.6	182.6	.5162	.5134	4.989
.4680	.4705	2.957	.9946	9.586	9.638	.9871	.1037	5.912	184.8	184.8	.5160	.5132	4.989
.4690	.4715	2.963	.9947	9.647	9.699	.9872	.1031	5.925	187.2	187.2	.5158	.5131	4.988
.4700	.4725	2.969	.9947	9.709	9.760	.9873	.1025	5.937	189.5	189.5	.5157	.5129	4.988
.4710	.4735	2.975	.9948	9.770	9.821	.9874	.1018	5.949	191.8	191.8	.5155	.5128	4.987
.4720	.4744	2.981	.9949	9.826	9.877	.9875	.1012	5.962	194.2	194.2	.5154	.5127	4.986
.4730	.4754	2.987	.9949	9.888	9.938	.9876	.1006	5.974	196.5	196.5	.5152	.5126	4.986
.4740	.4764	2.993	.9950	9.951	10.00	.9877	.1000	5.986	199.0	199.0	.5150	.5125	4.985
.4750	.4774	2.999	.9951	10.01	10.07	.9878	.09942	5.999	201.4	201.4	.5149	.5124	4.984
.4760	.4783	3.005	.9951	10.07	10.12	.9880	.09882	6.011	203.9	203.9	.5147	.5122	4.984
.4770	.4793	3.012	.9952	10.13	10.18	.9881	.09820	6.023	206.5	206.5	.5146	.5121	4.983
.4780	.4803	3.018	.9952	10.20	10.25	.9882	.09759	6.036	209.0	209.0	.5144	.5120	4.983
.4790	.4813	3.024	.9953	10.26	10.31	.9883	.09698	6.048	211.7	211.7	.5143	.5119	4.982
.4800	.4822	3.030	.9953	10.32	10.37	.9885	.09641	6.060	214.2	214.2	.5142	.5117	4.982
.4810	.4832	3.036	.9954	10.39	10.43	.9886	.09583	6.072	216.8	216.8	.5140	.5116	4.981
.4820	.4842	3.042	.9955	10.45	10.50	.9887	.09523	6.085	219.5	219.5	.5139	.5115	4.980
.4830	.4852	3.049	.9955	10.52	10.57	.9888	.09464	6.097	222.2	222.2	.5137	.5114	4.980
.4840	.4862	3.055	.9956	10.59	10.63	.9889	.09405	6.109	225.0	225.0	.5136	.5113	4.979
.4850	.4871	3.061	.9956	10.65	10.69	.9890	.09352	6.121	228.3	228.3	.5134	.5112	4.979
.4860	.4881	3.067	.9957	10.71	10.76	.9891	.09294	6.134	230.6	230.6	.5133	.5111	4.978
.4870	.4891	3.073	.9957	10.78	10.83	.9892	.09236	6.146	233.5	233.5	.5132	.5110	4.978
.4880	.4901	3.079	.9958	10.85	10.90	.9893	.09178	6.159	236.4	236.4	.5130	.5109	4.977
.4890	.4911	3.086	.9958	10.92	10.96	.9895	.09121	6.171	239.6	239.6	.5129	.5107	4.977
.4900	.4920	3.092	.9959	10.99	11.03	.9896	.09064	6.183	242.3	242.3	.5128	.5106	4.976
.4910	.4930	3.098	.9959	11.05	11.09	.9897	.09010	6.195	245.2	245.2	.5126	.5105	4.976
.4920	.4940	3.104	.9960	11.12	11.16	.9898	.08956	6.208	248.3	248.3	.5125	.5104	4.975
.4930	.4950	3.110	.9960	11.19	11.24	.9899	.08901	6.220	251.3	251.3	.5124	.5103	4.975
.4940	.4960	3.117	.9961	11.26	11.31	.9899	.08845	6.232	254.5	254.5	.5122	.5102	4.974
.4950	.4969	3.122	.9961	11.32	11.37	.9900	.08793	6.245	257.6	257.6	.5121	.5101	4.974
.4960	.4979	3.128	.9962	11.40	11.44	.9901	.08741	6.257	260.8	260.8	.5120	.5100	4.973
.4970	.4989	3.135	.9962	11.47	11.51	.9902	.08691	6.269	264.0	264.0	.5119	.5099	4.973
.4980	.4999	3.141	.9963	11.54	11.59	.9903	.08637	6.282	267.3	267.3	.5118	.5098	4.972
.4990	.5009	3.147	.9963	11.61	11.65	.9904	.08584	6.294	270.6	270.6	.5116	.5097	4.972
.5000	.5018	3.153	.9964	11.68	11.72	.9905	.08530	6.306	274.0	274.0	.5115	.5096	4.971
.5010	.5028	3.159	.9964	11.75	11.80	.9906	.08477	6.319	277.5	277.5	.5114	.5095	4.971
.5020	.5038	3.166	.9964	11.83	11.87	.9907	.08424	6.331	280.8	280.8	.5113	.5094	4.971
.5030	.5048	3.172	.9965	11.91	11.95	.9908	.08371	6.343	284.3	284.3	.5112	.5093	4.970
.5040	.5058	3.178	.9965	11.98	12.02	.9909	.08320	6.356	287.9	287.9	.5110	.5092	4.970
.5050	.5067	3.184	.9966	12.05	12.09	.9909	.08270	6.368	291.4	291.4	.5109	.5092	4.969
.5060	.5077	3.190	.9966	12.12	12.16	.9910	.08220	6.380	295.0	295.0	.5108	.5091	4.969
.5070	.5087	3.196	.9967	12.20	12.24	.9911	.08169	6.393	298.7	298.7	.5107	.5090	4.968
.5080	.5097	3.203	.9967	12.28	12.32	.9912	.08119	6.405	302.4	302.4	.5106	.5089	4.968
.5090	.5107	3.209	.9968	12.35	12.39	.9913	.08068	6.417	306.2	306.2	.5105	.5088	4.967

Step 21

Reference:
SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi\, d/L$	TANH $2\pi\, d/L$	SINH $2\pi\, d/L$	COSH $2\pi\, d/L$	H/H'_o	K	$4\pi\, d/L$	SINH $4\pi\, d/L$	COSH $4\pi\, d/L$	n	C_G/C_o	M
.5100	.5117	3.215	.9968	12.43	12.47	.9914	.08022	6.430	310.0	310.0	.5104	.5087	4.967
.5110	.5126	3.221	.9968	12.50	12.54	.9915	.07972	6.442	313.8	313.8	.5103	.5086	4.967
.5120	.5136	3.227	.9969	12.58	12.62	.9915	.07922	6.454	317.7	317.7	.5102	.5086	4.966
.5130	.5146	3.233	.9969	12.66	12.70	.9916	.07873	6.467	321.7	321.7	.5101	.5085	4.966
.5140	.5156	3.240	.9970	12.74	12.78	.9917	.07824	6.479	325.7	325.7	.5100	.5084	4.965
.5150	.5166	3.246	.9970	12.82	12.86	.9918	.07776	6.491	329.7	329.7	.5098	.5083	4.965
.5160	.5176	3.252	.9970	12.90	12.94	.9919	.07729	6.504	333.8	333.8	.5097	.5082	4.965
.5170	.5185	3.258	.9971	12.98	13.02	.9919	.07682	6.516	337.9	337.9	.5096	.5082	4.964
.5180	.5195	3.264	.9971	13.06	13.10	.9920	.07634	6.529	342.2	342.2	.5095	.5081	4.964
.5190	.5205	3.270	.9971	13.14	13.18	.9921	.07587	6.541	346.4	346.4	.5094	.5080	4.964
.5200	.5215	3.277	.9972	13.22	13.26	.9922	.07540	6.553	350.7	350.7	.5093	.5079	4.963
.5210	.5225	3.283	.9972	13.31	13.35	.9923	.07494	6.566	355.1	355.1	.5092	.5078	4.963
.5220	.5235	3.289	.9972	13.39	13.43	.9924	.07449	6.578	359.6	359.6	.5092	.5077	4.963
.5230	.5244	3.295	.9973	13.47	13.51	.9924	.07404	6.590	364.0	364.0	.5091	.5077	4.962
.5240	.5254	3.301	.9973	13.55	13.59	.9925	.07358	6.603	368.5	368.5	.5090	.5076	4.962
.5250	.5264	3.308	.9973	13.64	13.68	.9926	.07312	6.615	373.1	373.1	.5089	.5075	4.962
.5260	.5274	3.314	.9974	13.73	13.76	.9927	.07266	6.628	377.8	377.8	.5088	.5074	4.961
.5270	.5284	3.320	.9974	13.81	13.85	.9927	.07221	6.640	382.5	382.5	.5087	.5074	4.961
.5280	.5294	3.326	.9974	13.90	13.94	.9928	.07177	6.652	387.3	387.3	.5086	.5073	4.961
.5290	.5304	3.333	.9975	13.99	14.02	.9929	.07134	6.665	392.2	392.2	.5085	.5072	4.960
.5300	.5314	3.339	.9975	14.07	14.10	.9930	.07091	6.677	397.0	397.0	.5084	.5071	4.960
.5310	.5323	3.345	.9975	14.16	14.19	.9931	.07047	6.690	402.0	402.0	.5083	.5070	4.960
.5320	.5333	3.351	.9976	14.25	14.28	.9931	.07003	6.702	406.9	406.9	.5082	.5070	4.959
.5330	.5343	3.357	.9976	14.34	14.37	.9932	.06959	6.714	412.0	412.0	.5082	.5069	4.959
.5340	.5353	3.363	.9976	14.43	14.46	.9933	.06915	6.727	417.2	417.2	.5081	.5068	4.959
.5350	.5363	3.370	.9976	14.52	14.55	.9933	.06872	6.739	422.4	422.4	.5080	.5068	4.959
.5360	.5373	3.376	.9977	14.61	14.64	.9934	.06829	6.752	427.7	427.7	.5079	.5067	4.958
.5370	.5383	3.382	.9977	14.70	14.73	.9935	.06787	6.764	433.1	433.1	.5078	.5066	4.958
.5380	.5393	3.388	.9977	14.79	14.82	.9935	.06746	6.776	438.5	438.5	.5077	.5066	4.958
.5390	.5402	3.394	.9977	14.88	14.91	.9936	.06705	6.789	444.0	444.0	.5077	.5065	4.958
.5400	.5412	3.401	.9978	14.97	15.01	.9936	.06664	6.801	449.5	449.5	.5076	.5065	4.957
.5410	.5422	3.407	.9978	15.07	15.10	.9937	.06623	6.814	455.1	455.1	.5075	.5064	4.957
.5420	.5432	3.413	.9978	15.16	15.19	.9938	.06582	6.826	460.7	460.7	.5074	.5063	4.957
.5430	.5442	3.419	.9979	15.25	15.29	.9938	.06542	6.838	466.4	466.4	.5073	.5063	4.956
.5440	.5452	3.426	.9979	15.35	15.38	.9939	.06501	6.851	472.2	472.2	.5073	.5062	4.956
.5450	.5461	3.432	.9979	15.45	15.48	.9940	.06461	6.863	478.1	478.1	.5072	.5061	4.956
.5460	.5471	3.438	.9979	15.54	15.58	.9941	.06420	6.876	484.3	484.3	.5071	.5060	4.956
.5470	.5481	3.444	.9980	15.64	15.67	.9941	.06380	6.888	490.3	490.3	.5070	.5060	4.955
.5480	.5491	3.450	.9980	15.74	15.77	.9942	.06341	6.901	496.4	496.4	.5070	.5059	4.955
.5490	.5501	3.456	.9980	15.84	15.87	.9942	.06302	6.913	502.5	502.5	.5069	.5059	4.955
.5500	.5511	3.463	.9980	15.94	15.97	.9942	.06263	6.925	508.7	508.7	.5068	.5058	4.955
.5510	.5521	3.469	.9981	16.04	16.07	.9942	.06224	6.937	515.0	515.0	.5067	.5058	4.954
.5520	.5531	3.475	.9981	16.14	16.17	.9943	.06186	6.950	521.6	521.6	.5067	.5057	4.954
.5530	.5541	3.481	.9981	16.24	16.27	.9944	.06148	6.962	528.1	528.1	.5066	.5056	4.954
.5540	.5551	3.488	.9981	16.34	16.37	.9944	.06110	6.975	534.8	534.8	.5065	.5056	4.954
.5550	.5560	3.494	.9982	16.44	16.47	.9945	.06073	6.987	541.4	541.4	.5065	.5056	4.953
.5560	.5570	3.500	.9982	16.54	16.57	.9945	.06035	7.000	548.1	548.1	.5064	.5055	4.953
.5570	.5580	3.506	.9982	16.65	16.68	.9946	.05997	7.012	554.9	554.9	.5063	.5054	4.953
.5580	.5590	3.512	.9982	16.75	16.78	.9947	.05960	7.025	562.0	562.0	.5063	.5053	4.953
.5590	.5600	3.519	.9982	16.85	16.88	.9947	.05923	7.037	569.1	569.1	.5062	.5053	4.953
.5600	.5610	3.525	.9983	16.96	16.99	.9947	.05887	7.050	576.1	576.1	.5061	.5053	4.952
.5610	.5620	3.531	.9983	17.06	17.09	.9948	.05850	7.062	583.3	583.3	.5061	.5052	4.952
.5620	.5630	3.537	.9983	17.17	17.20	.9949	.05814	7.074	590.7	590.7	.5060	.5051	4.952
.5630	.5640	3.543	.9983	17.28	17.31	.9949	.05778	7.087	598.0	598.0	.5059	.5051	4.952
.5640	.5649	3.550	.9984	17.38	17.41	.9950	.05743	7.099	605.0	605.0	.5059	.5050	4.951
.5650	.5659	3.556	.9984	17.49	17.52	.9950	.05707	7.112	613.2	613.2	.5058	.5050	4.951
.5660	.5669	3.562	.9984	17.60	17.63	.9951	.05672	7.124	620.8	620.8	.5057	.5049	4.951
.5670	.5679	3.568	.9984	17.71	17.74	.9951	.05637	7.136	628.5	628.5	.5057	.5049	4.951
.5680	.5689	3.575	.9984	17.82	17.85	.9952	.05602	7.149	636.4	636.4	.5056	.5048	4.951
.5690	.5699	3.581	.9985	17.94	17.97	.9952	.05567	7.161	644.3	644.3	.5056	.5048	4.950

Step 21

Reference
SPM Vol II

Table C-1. Continued.

d/L_o	d/L	$2\pi d/L$	TANH $2\pi d/L$	SINH $2\pi d/L$	COSH $2\pi d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_G/C_o	M
.5700	.5709	3.587	.9985	18.05	18.08	.9953	.05532	7.174	652.4	652.4	.5055	.5047	4.950
.5710	.5719	3.593	.9985	18.16	18.19	.9953	.05497	7.186	660.5	660.5	.5054	.5047	4.950
.5720	.5729	3.600	.9985	18.28	18.31	.9954	.05463	7.199	668.8	668.8	.5054	.5046	4.950
.5730	.5738	3.606	.9985	18.39	18.42	.9954	.05430	7.211	677.2	677.2	.5053	.5046	4.950
.5740	.5748	3.612	.9985	18.50	18.53	.9955	.05396	7.224	685.6	685.6	.5053	.5045	4.950
.5750	.5758	3.618	.9986	18.62	18.64	.9955	.05363	7.236	694.3	694.3	.5052	.5045	4.949
.5760	.5768	3.624	.9986	18.73	18.76	.9956	.05330	7.249	703.2	703.2	.5052	.5044	4.949
.5770	.5778	3.630	.9986	18.85	18.88	.9956	.05297	7.261	711.9	711.9	.5051	.5044	4.949
.5780	.5788	3.637	.9986	18.97	19.00	.9957	.05264	7.274	720.8	720.8	.5051	.5043	4.949
.5790	.5798	3.643	.9986	19.09	19.12	.9957	.05231	7.286	729.9	729.9	.5050	.5043	4.949
.5800	.5808	3.649	.9987	19.21	19.24	.9957	.05198	7.298	739.0	739.0	.5049	.5043	4.948
.5810	.5818	3.656	.9987	19.33	19.36	.9958	.05166	7.311	748.1	748.1	.5049	.5042	4.948
.5820	.5828	3.662	.9987	19.45	19.48	.9958	.05134	7.323	757.5	757.5	.5048	.5042	4.948
.5830	.5838	3.668	.9987	19.58	19.60	.9959	.05102	7.336	767.0	767.0	.5048	.5041	4.948
.5840	.5848	3.674	.9987	19.70	19.73	.9959	.05070	7.348	776.7	776.7	.5047	.5041	4.948
.5850	.5858	3.680	.9987	19.81	19.84	.9960	.05040	7.361	786.5	786.5	.5047	.5040	4.948
.5860	.5867	3.686	.9987	19.94	19.96	.9960	.05009	7.373	796.4	796.4	.5046	.5040	4.948
.5870	.5877	3.693	.9988	20.06	20.09	.9960	.04978	7.386	806.5	806.5	.5046	.5040	4.947
.5880	.5887	3.699	.9988	20.19	20.21	.9961	.04947	7.398	816.5	816.5	.5045	.5039	4.947
.5890	.5897	3.705	.9988	20.32	20.34	.9961	.04916	7.411	826.7	826.7	.5045	.5039	4.947
.5900	.5907	3.712	.9988	20.45	20.47	.9962	.04885	7.423	837.1	837.1	.5044	.5038	4.947
.5910	.5917	3.718	.9988	20.57	20.60	.9962	.04855	7.436	847.6	847.6	.5044	.5038	4.947
.5920	.5927	3.724	.9988	20.70	20.73	.9963	.04824	7.448	858.2	858.2	.5043	.5037	4.947
.5930	.5937	3.730	.9989	20.83	20.86	.9963	.04794	7.460	868.9	868.9	.5043	.5037	4.946
.5940	.5947	3.737	.9989	20.97	20.99	.9963	.04764	7.473	879.8	879.8	.5043	.5037	4.946
.5950	.5957	3.743	.9989	21.10	21.12	.9964	.04735	7.485	890.8	890.8	.5042	.5036	4.946
.5960	.5967	3.749	.9989	21.23	21.25	.9964	.04706	7.498	901.9	901.9	.5042	.5036	4.946
.5970	.5977	3.755	.9989	21.35	21.37	.9964	.04677	7.510	913.4	913.4	.5041	.5036	4.946
.5980	.5987	3.761	.9989	21.49	21.51	.9965	.04648	7.523	925.0	925.0	.5041	.5035	4.946
.5990	.5996	3.767	.9989	21.62	21.64	.9965	.04619	7.535	936.5	936.5	.5040	.5035	4.946
.6000	.6006	3.774	.9990	21.76	21.78	.9965	.04591	7.548	948.1	948.1	.5040	.5035	4.945
.6100	.6106	3.836	.9991	23.17	23.19	.9969	.04313	7.673	1,074	1,074	.5036	.5031	4.944
.6200	.6205	3.899	.9992	24.66	24.68	.9972	.04052	7.798	1,217	1,217	.5032	.5028	4.943
.6300	.6305	3.961	.9993	26.25	26.27	.9975	.03806	7.923	1,379	1,379	.5029	.5025	4.942
.6400	.6404	4.024	.9994	27.95	27.97	.9977	.03576	8.048	1,527	1,527	.5026	.5023	4.941
.6500	.6504	4.086	.9994	29.75	29.77	.9980	.03359	8.173	1,771	1,771	.5023	.5020	4.940
.6600	.6603	4.149	.9995	31.68	31.69	.9982	.03155	8.298	2,008	2,008	.5021	.5018	4.940
.6700	.6703	4.212	.9996	33.73	33.74	.9983	.02964	8.423	2,275	2,275	.5019	.5017	4.939
.6800	.6803	4.274	.9996	35.90	35.92	.9985	.02784	8.548	2,579	2,579	.5017	.5015	4.939
.6900	.6902	4.337	.9997	38.23	38.24	.9987	.02615	8.674	2,923	2,923	.5015	.5013	4.938
.7000	.7002	4.400	.9997	40.71	40.72	.9988	.02456	8.799	3,314	3,314	.5013	.5012	4.938
.7100	.7102	4.462	.9997	43.34	43.35	.9989	.02307	8.925	3,757	3,757	.5012	.5011	4.937
.7200	.7202	4.525	.9998	46.14	46.15	.9990	.02167	9.050	4,258	4,258	.5011	.5010	4.937
.7300	.7302	4.588	.9998	49.13	49.14	.9991	.02035	9.175	4,828	4,828	.5010	.5009	4.937
.7400	.7401	4.650	.9998	52.31	52.32	.9992	.01911	9.301	5,473	5,473	.5009	.5008	4.937
.7500	.7501	4.713	.9998	55.70	55.71	.9993	.01795	9.426	6,204	6,204	.5008	.5007	4.936
.7600	.7601	4.776	.9999	59.31	59.31	.9994	.01686	9.552	7,034	7,034	.5007	.5006	4.936
.7700	.7701	4.839	.9999	63.15	63.16	.9995	.01583	9.677	7,976	7,976	.5006	.5005	4.936
.7800	.7801	4.902	.9999	67.24	67.25	.9996	.01487	9.803	9,042	9,042	.5005	.5004	4.936
.7900	.7901	4.964	.9999	71.60	71.60	.9996	.01397	9.929	10,250	10,250	.5005	.5004	4.936
.8000	.8001	5.027	.9999	76.24	76.24	.9996	.01312	10.05	11,620	11,620	.5004	.5004	4.936
.8100	.8101	5.090	.9999	81.18	81.19	.9996	.01232	10.18	13,180	13,180	.5004	.5004	4.936
.8200	.8201	5.153	.9999	86.44	86.44	.9997	.01157	10.31	14,940	14,940	.5003	.5003	4.935
.8300	.8301	5.215	.9999	92.04	92.05	.9997	.01086	10.43	17,340	17,340	.5003	.5003	4.935
.8400	.8400	5.278	1.000	98.00	98.01	.9997	.01020	10.56	19,210	19,210	.5003	.5003	4.935
.8500	.8500	5.341	1.000	104.4	104.4	.9998	.009582	10.68	21,780	21,780	.5002	.5002	4.935
.8600	.8600	5.404	1.000	111.1	111.1	.9998	.009000	10.81	24,690	24,690	.5002	.5002	4.935
.8700	.8700	5.467	1.000	118.3	118.3	.9998	.008451	10.93	28,000	28,000	.5002	.5002	4.935
.8800	.8800	5.529	1.000	126.0	126.0	.9998	.007934	11.06	31,750	31,750	.5002	.5002	4.935
.8900	.8900	5.592	1.000	134.2	134.2	.9998	.007454	11.18	36,000	36,000	.5002	.5002	4.935

Step 21

Reference
SPM Vol II

Table C-1. Concluded.

d/L_o	d/L	$2\pi d/L$	TANH $2\pi d/L$	SINH $2\pi d/L$	COSH $2\pi d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_G/C_o	M
.9000	.9000	5.655	1.000	142.9	142.9	.9999	.007000	11.31	40,810	40,810	.5001	.5001	4.935
.9100	.9100	5.718	1.000	152.1	152.1	.9999	.006574	11.44	46,280	46,280	.5001	.5001	4.935
.9200	.9200	5.781	1.000	162.0	162.0	.9999	.006173	11.56	52,470	52,470	.5001	.5001	4.935
.9300	.9300	5.844	1.000	172.5	172.5	.9999	.005797	11.69	59,500	59,500	.5001	.5001	4.935
.9400	.9400	5.906	1.000	183.7	183.7	.9999	.005445	11.81	67,470	67,470	.5001	.5001	4.935
.9500	.9500	5.969	1.000	195.6	195.6	.9999	.005114	11.94	76,490	76,490	.5001	.5001	4.935
.9600	.9600	6.032	1.000	208.2	208.2	.9999	.004802	12.06	86,740	86,740	.5001	.5001	4.935
.9700	.9700	6.095	1.000	221.7	221.7	.9999	.004510	12.19	98,340	98,340	.5001	.5001	4.935
.9800	.9800	6.158	1.000	236.1	236.1	.9999	.004235	12.32	111,500	111,500	.5001	.5001	4.935
.9900	.9900	6.220	1.000	251.4	251.4	1.000	.003977	12.44	126,500	126,500	.5000	.5000	4.935
1.000	1.000	6.283	1.000	267.7	267.7	1.000	.003735	12.57	143,400	143,400	.5000	.5000	4.935

after Wiegel, R. L., "Oscillatory Waves," U.S. Army, Beach Erosion Board, Bulletin, Special Issue No. 1, July 1948.

Table C-2. Functions of d/L for even increments of d/L (from 0.0001 to 1.000).

d/L	d/L_o	$2\pi d/L$	TANH $2\pi d/L$	SINH $2\pi d/L$	COSH $2\pi d/L$	H/H'_o	K	$4\pi d/L$	SINH $4\pi d/L$	COSH $4\pi d/L$	n	C_G/C_o	M
0	0	0	0	0	1.0000	∞	1.000	0	0	1.000	1.000	0	∞
.000100	6.283×10^{-8}	.0006283	.0006283	.0006283	1.0000	28.21	1.000	.001257	.001257	1.000	1.000	.0006283	12,500,000
.000200	2.514×10^{-7}	.001257	.001257	.001257	1.0000	19.95	1.000	.002513	.002513	1.000	1.000	.001257	3,125,000
.000300	5.655×10^{-7}	.001885	.001885	.001885	1.0000	16.29	1.000	.003770	.003770	1.000	1.000	.001885	1,389,000
.000400	1.005×10^{-6}	.002513	.002513	.002513	1.0000	14.10	1.000	.005027	.005027	1.000	1.000	.002513	781,300
.000500	1.571×10^{-6}	.003142	.003142	.003142	1.0000	12.62	1.000	.006283	.006283	1.000	1.000	.003142	500,000
.000600	2.226×10^{-6}	.003770	.003770	.003770	1.0000	11.52	1.000	.007540	.007540	1.000	1.000	.003770	347,200
.000700	3.079×10^{-6}	.004398	.004398	.004398	1.0000	10.66	1.000	.008796	.008797	1.000	1.000	.004398	255,100
.000800	4.022×10^{-6}	.005027	.005027	.005027	1.0000	9.974	1.000	.01005	.01005	1.000	1.000	.005026	195,300
.000900	5.090×1	.005655	.005655	.005655	1.0000	9.403	1.000	.01131	.01131	1.000	1.000	.005655	154,300
.001000	6.283×10^{-6}	.006283	.006283	.006283	1.0000	8.921	1.000	.01257	.01257	1.000	1.000	.006283	125,000
.001100	7.603×10^{-6}	.006912	.006911	.006912	1.0000	8.506	1.000	.01382	.01382	1.000	1.000	.006911	103,300
.001200	9.048×10^{-6}	.007540	.007540	.007540	1.0000	8.144	1.000	.01508	.01508	1.000	1.000	.007540	86,810
.001300	.00001062	.008168	.008168	.008168	1.0000	7.824	1.000	.01634	.01634	1.000	1.000	.008168	73,970
.001400	.00001231	.008796	.008796	.008797	1.0000	7.539	1.000	.01759	.01759	1.000	1.000	.008796	63,780
.001500	.00001414	.009425	.009425	.009425	1.0000	7.284	1.000	.01885	.01885	1.000	1.000	.009424	55,560
.001600	.00001608	.01005	.01005	.01005	1.0001	7.052	.9999	.02011	.02011	1.000	1.000	.01005	48,830
.001700	.00001816	.01068	.01068	.01068	1.0001	6.842	.9999	.02136	.02136	1.000	1.000	.01068	43,260
.001800	.00002036	.01131	.01131	.01131	1.0001	6.649	.9999	.02262	.02262	1.000	1.000	.01131	38,580
.001900	.00002269	.01194	.01194	.01194	1.0001	6.472	.9999	.02388	.02388	1.000	1.000	.01194	34,630

Step 21

Reference: SPM Vol II

SHORE PROTECTION MANUAL



VOLUME II

(Chapters 6 Through 8; Appendices A Through D)

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
COASTAL ENGINEERING RESEARCH CENTER

1984

Fourth Edition

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 (2-part set; sold in sets only)

354-897 (Vol. 2) O - 93 - 1 QL 3

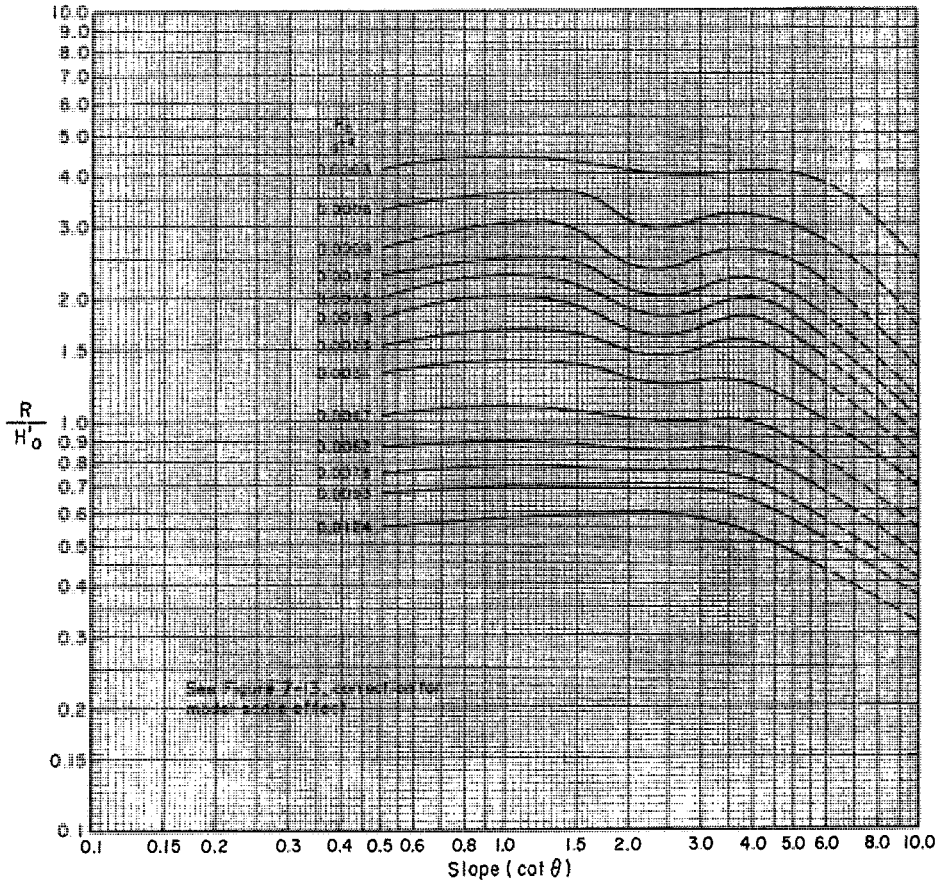


Figure 7-8. Wave runup on smooth, impermeable slopes when $d_s/H_o' = 0$ (structures fronted by a 1:10 slope).

Steps 25, 26

Reference
SPM Vol II

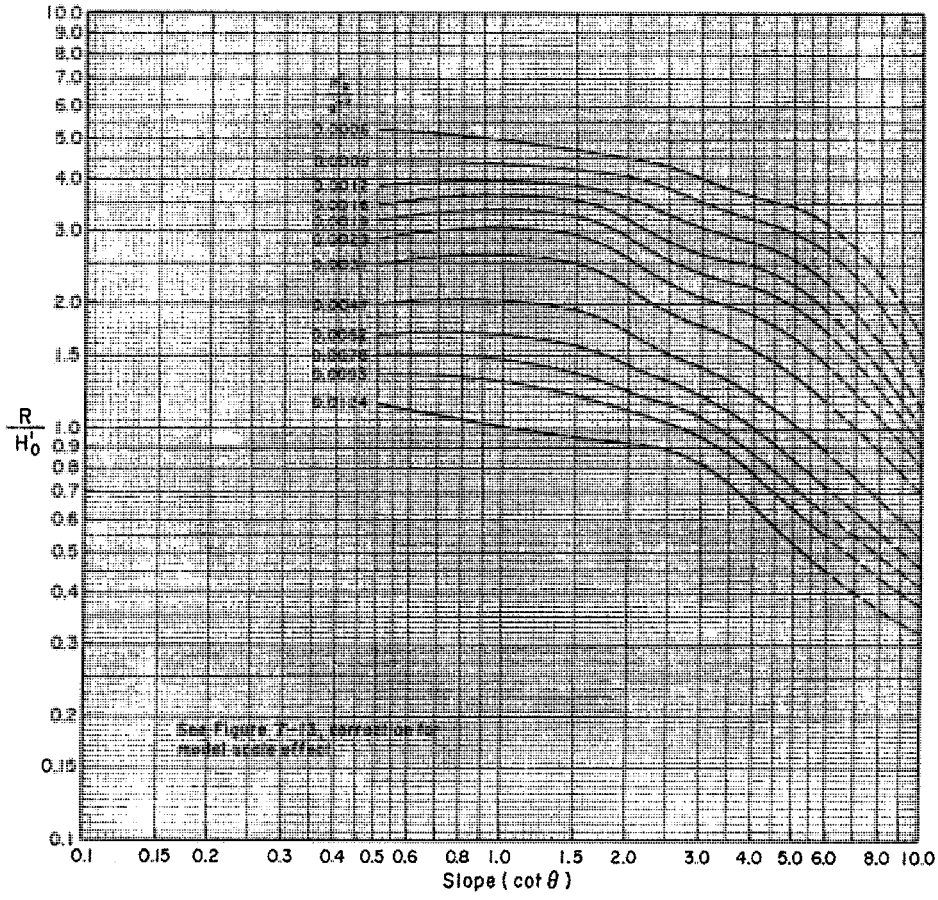


Figure 7-9. Wave runup on smooth, impermeable slopes when $d_s / H'_o \approx 0.45$ (structures fronted by a 1:10 slope).

Steps 25, 26

Reference: SPM Vol II

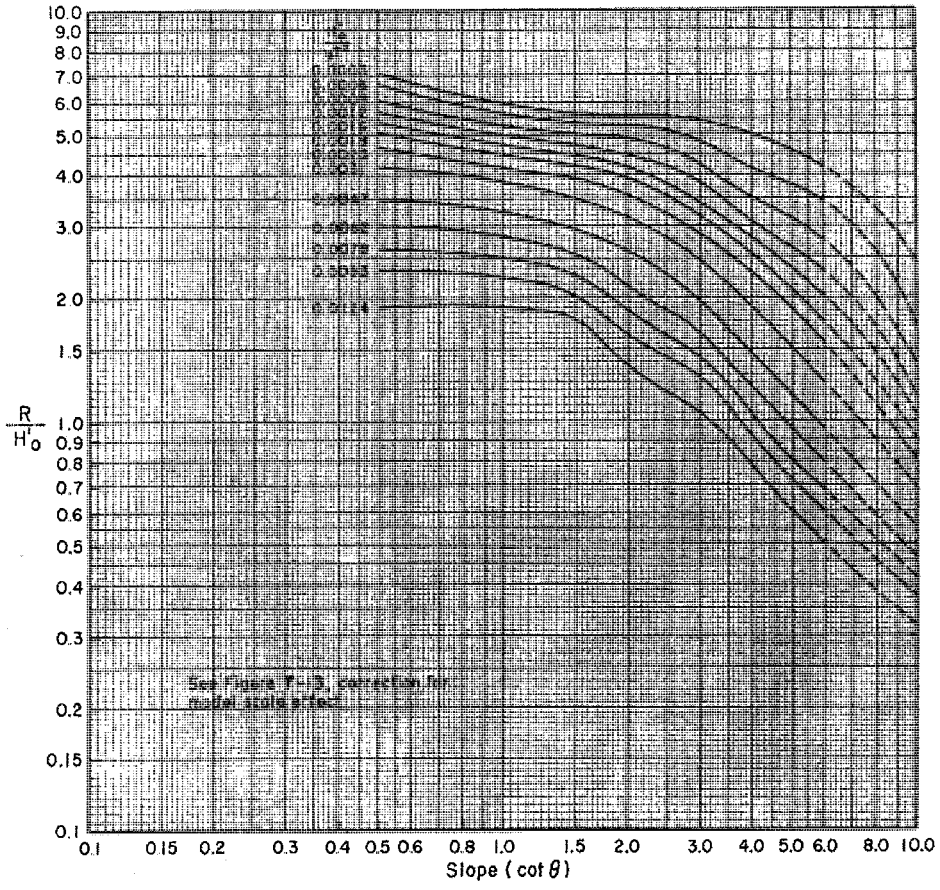


Figure 7-10. Wave runup on smooth, impermeable slopes when $d_s/H'_o \approx 0.80$ (structures fronted by a 1:10 slope).

Steps 25,26

Reference:
SPM Vol II

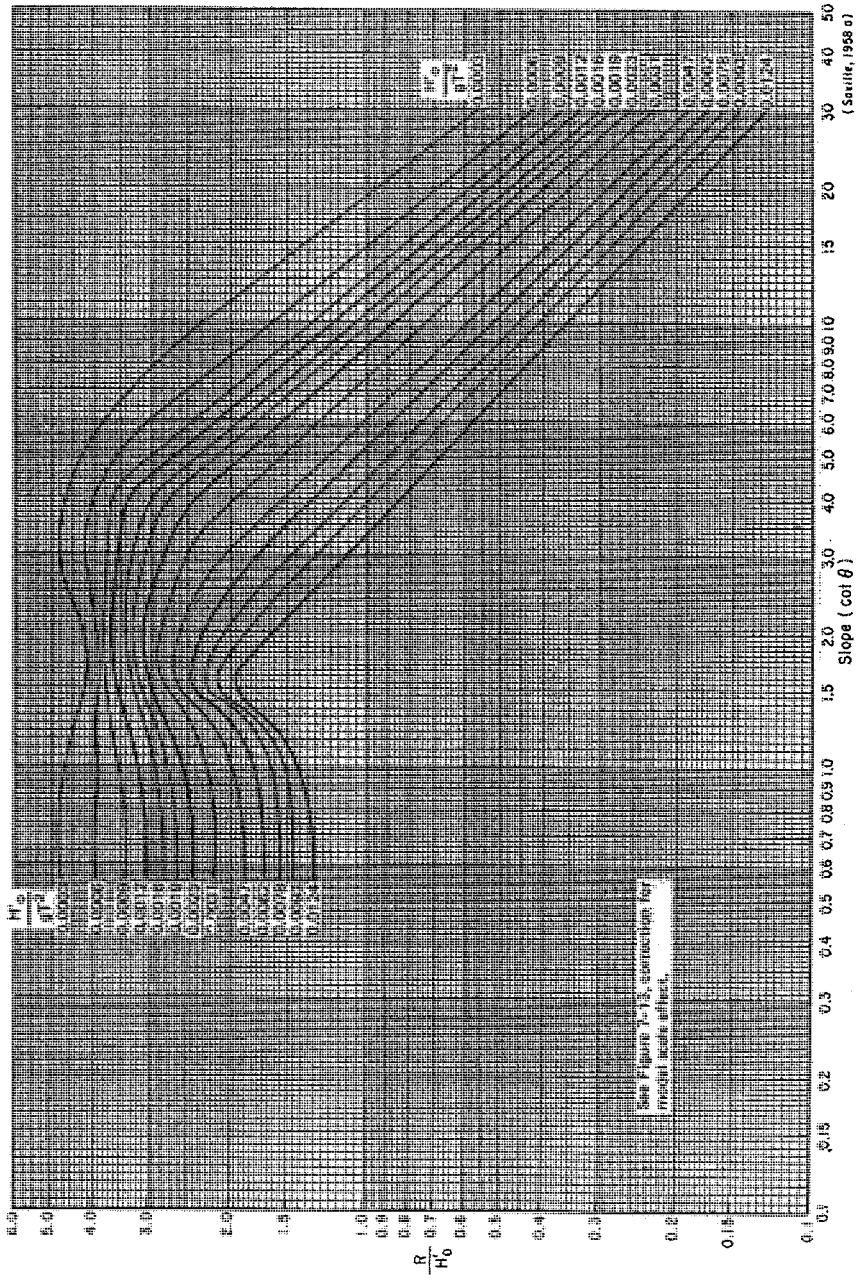


Figure 7-11. Wave runup on smooth, impermeable slopes when $d_s/H'_o \geq 2.0$.

Steps 25,26

Reference:
SPM Vol II

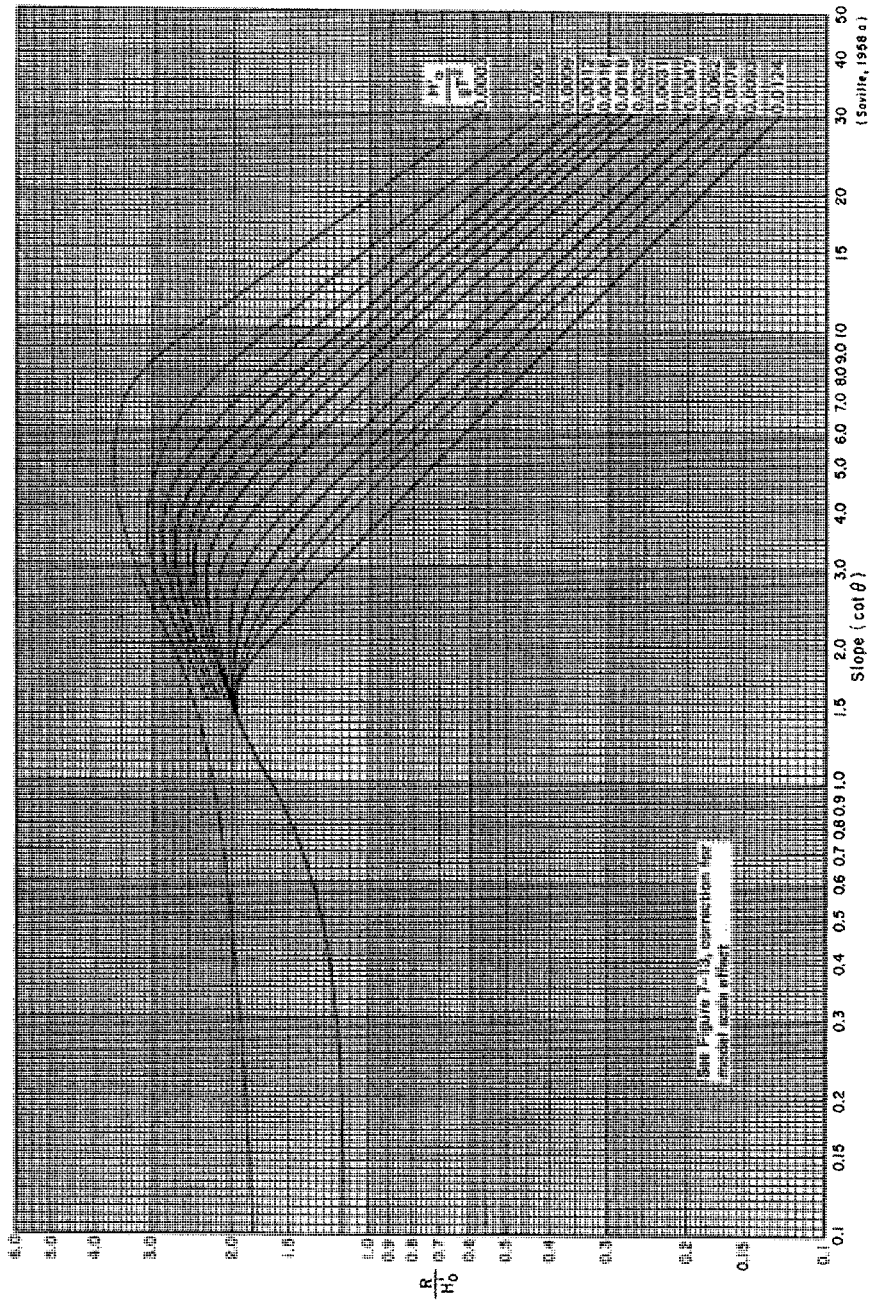


Figure 7-12. Wave runup on smooth, impermeable slopes when $d_s/H'_o \geq 3.0$.

Steps 25,26

Reference:
SPM Vol II

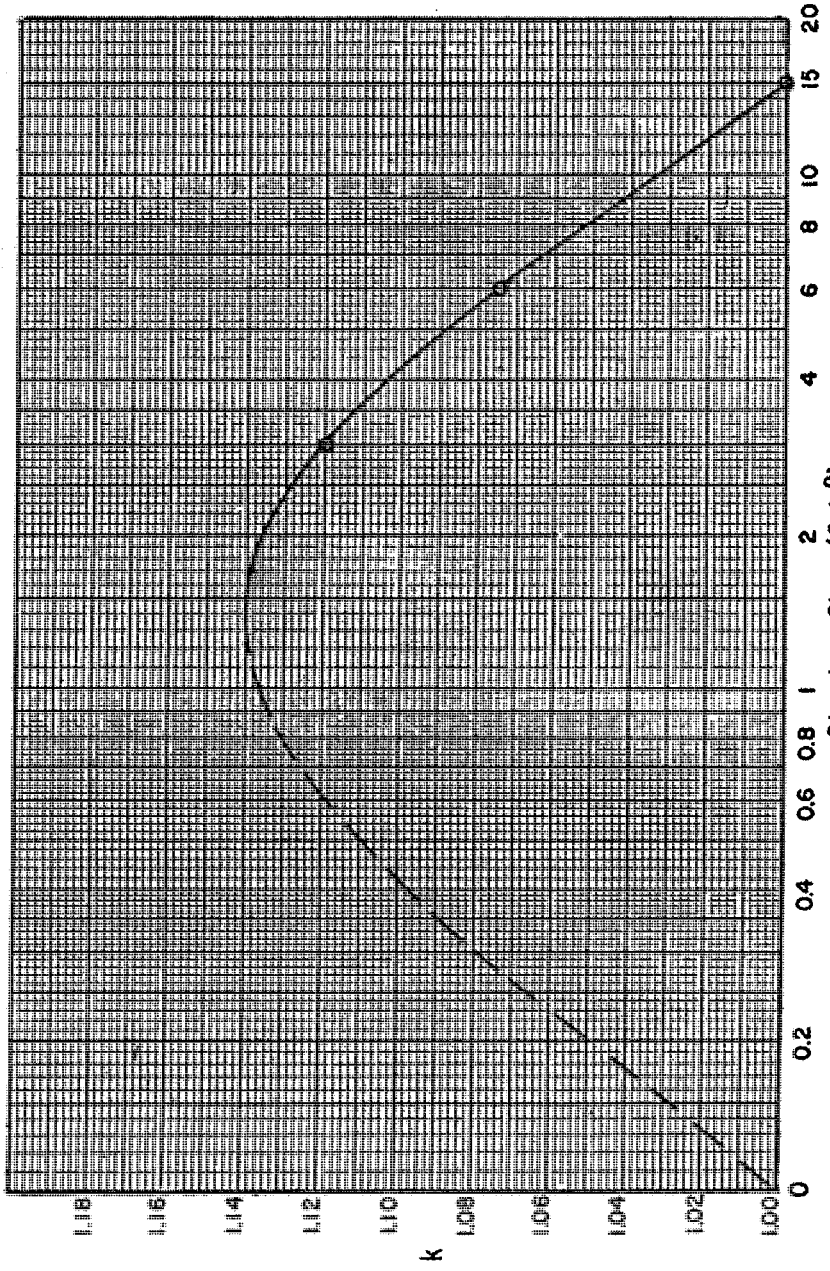


Figure 7-13. Runup correction for scale effects.

Reference
SPM Vol II

Step 29

$$r = \frac{R \text{ (rough slope)}}{R \text{ (smooth slope)}} = \frac{R/H_o' \text{ (rough slope)}}{R/H_o' \text{ (smooth slope)}} \tag{7-7}$$

Table 7-2 indicated the range of values of r for various slope characteristics.

This roughness and porosity correction factor is also considered applicable) as a first approximation, in the analysis of wave runup on slopes having surface materials with two or more different roughness values, r. Until more detailed guidance is available, it is suggested that the percentage of the total slope length, ℓ , subjected to wave runup of each roughness value be used to develop an adjusted roughness correction value. This is expressed by the equation

$$r \text{ (adjusted)} = \frac{\ell_1}{\ell} r_1 + \frac{\ell_2}{\ell} r_2 + \frac{\ell_3}{\ell} r_3 + \cdots \tag{7-8}$$

where ℓ is the total slope length, ℓ_1 is the length of slope where the roughness value r_2 applies, ℓ_2 is the length of slope where the roughness value r_2 applies, and so on. This procedure has obvious deficiencies as it does not account for location of the roughness on the structure and the varying interaction of slope roughness characteristics to the depth of water jet running up the structure slope.

Table 7-2. Value of r for various slope characteristics (after Battjes, 1974).

Slope Surface Characteristics	Placement	r
Smooth, impermeable	------	1.00
Concrete blocks	Fitted	0.90
Basalt blocks	Fitted	0.85 to 0.90
Gobi blocks	Fitted	0.85 to 0.90
Grass	-------	0.85 to 0.90
One layer of quarrystone (impermeable foundation)	Random	0.80
Quarrystone	Fitted	0.75 to 0.80
Rounded quarrystone	Random	0.60 to 0.65
Three layers of quarrystone (impermeable foundation)	Random	0.60 to 0.65
Quarrystone	Random	0.50 to 0.55
Concrete armor units (~ 50 percent void ratio)	Random	0.45 to 0.50

The use of the figures to estimate wave runup is illustrated by the following example.

STEP 30

REFERENCE: SPM, Vol II

Table 2-2
Rough Slope Runup Correction Factors (Carstea et al. 1975b)

Armor Type	Slope (cot θ)	Relative Size H / K_r[a,b]	Correction Factor r
Quarrystone	1.5	3 to 4	0.60
Quarrystone	2.5	3 to 4	0.63
Quarrystone	3.5	3 to 4	0.60
Quarrystone	5	3	0.60
Quarrystone	5	4	0.68
Quarrystone	5	5	0.72
Concrete Blocks[c]	Any	6[b]	0.93
Stepped slope with vertical risers	1.5	$1 \le H_o'/K_r$[d]	0.75
Stepped slope with vertical risers	2.0	$1 \le H_o'/K_r$[d]	0.75
Stepped slope with vertical risers	3.0	$1 \le H_o'/K_r$[d]	0.70
Stepped slope with rounded edges	3.0	$1 \le H_o'/K_r$[d]	0.86
Concrete Armor Units			
Tetrapods random two layers	1.3 to 3.0	-	0.45
Tetrapods uniform two layers	1.3 to 3.0	-	0.51
Tribars random two layers	1.3 to 3.0	-	0.45
Tribars uniform one layer	1.3 to 3.0	-	0.50

[a] K_r is the characteristic height of the armor unit perpendicular to the slope. For quarrystone, it is the nominal diameter; for armor units, the height above the slope.
[b] Use H_o' for $d_s/H_o' > 3$; and the local wave height, H_s for $d_s/H_o' \le 3$.
[c] Perforated surfaces of Gobi Blocks, Monoslaps, and concrete masonry units placed hollows up.
[d] K_r is the riser height.

Step 30

Reference:
Design of Coastal Revetments, Seawalls & Bulkheads, USACE, EM 1110-2-1614, June 1995

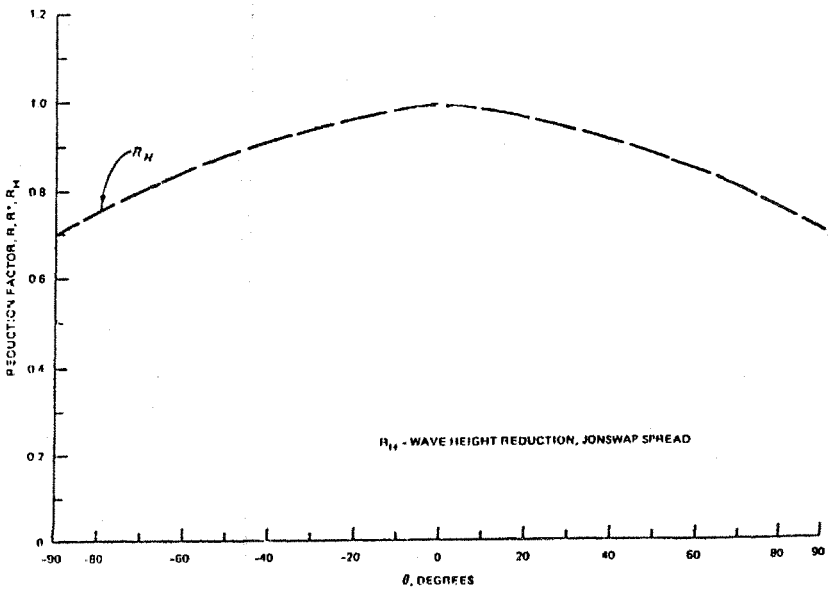


Figure 8. - Wave height reduction due to angular spread.

Step 31

Reference:
USBR, Freeboard Criteria and Guidelines for Computing Freeboard Allowances, for Storage Dams, ACER Tech Memo No. 2, 1992.

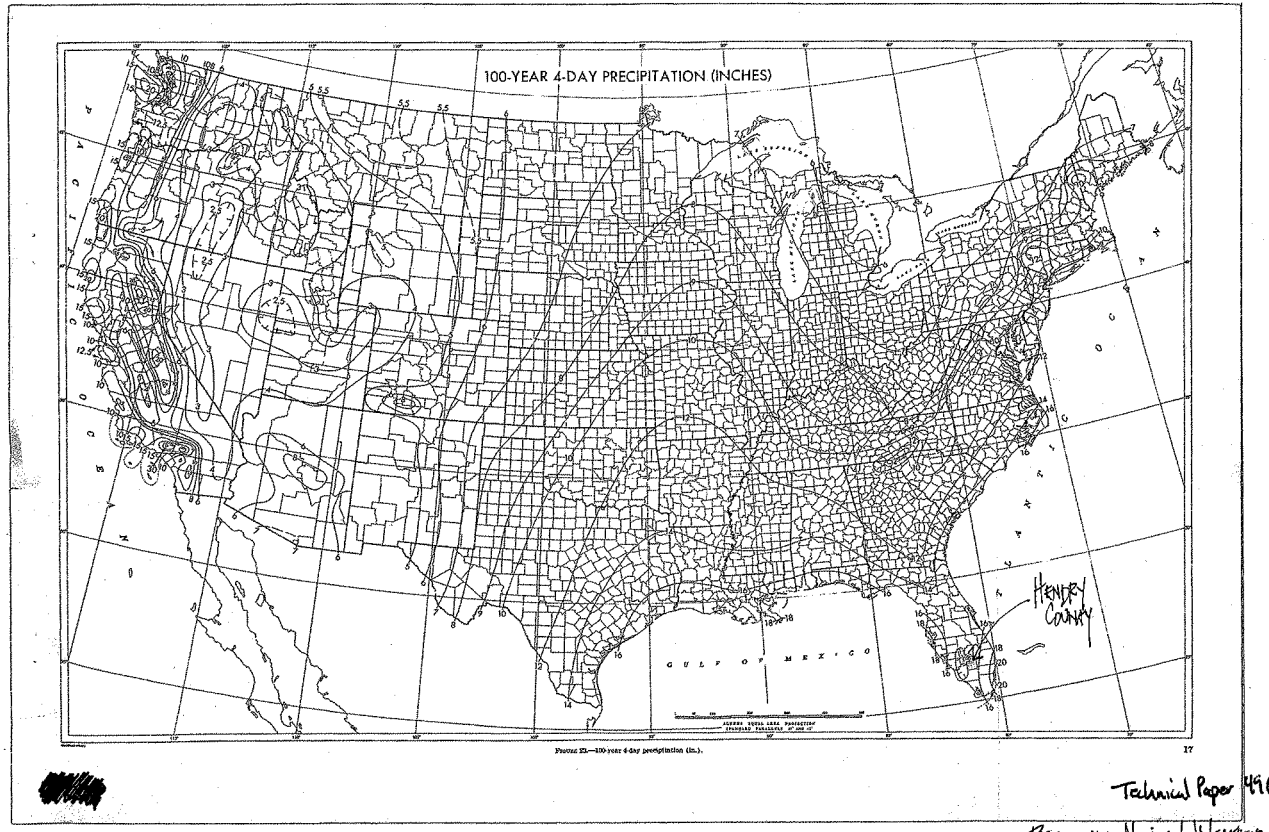


FIGURE 22.—100-year 4-day precipitation (in.).

17

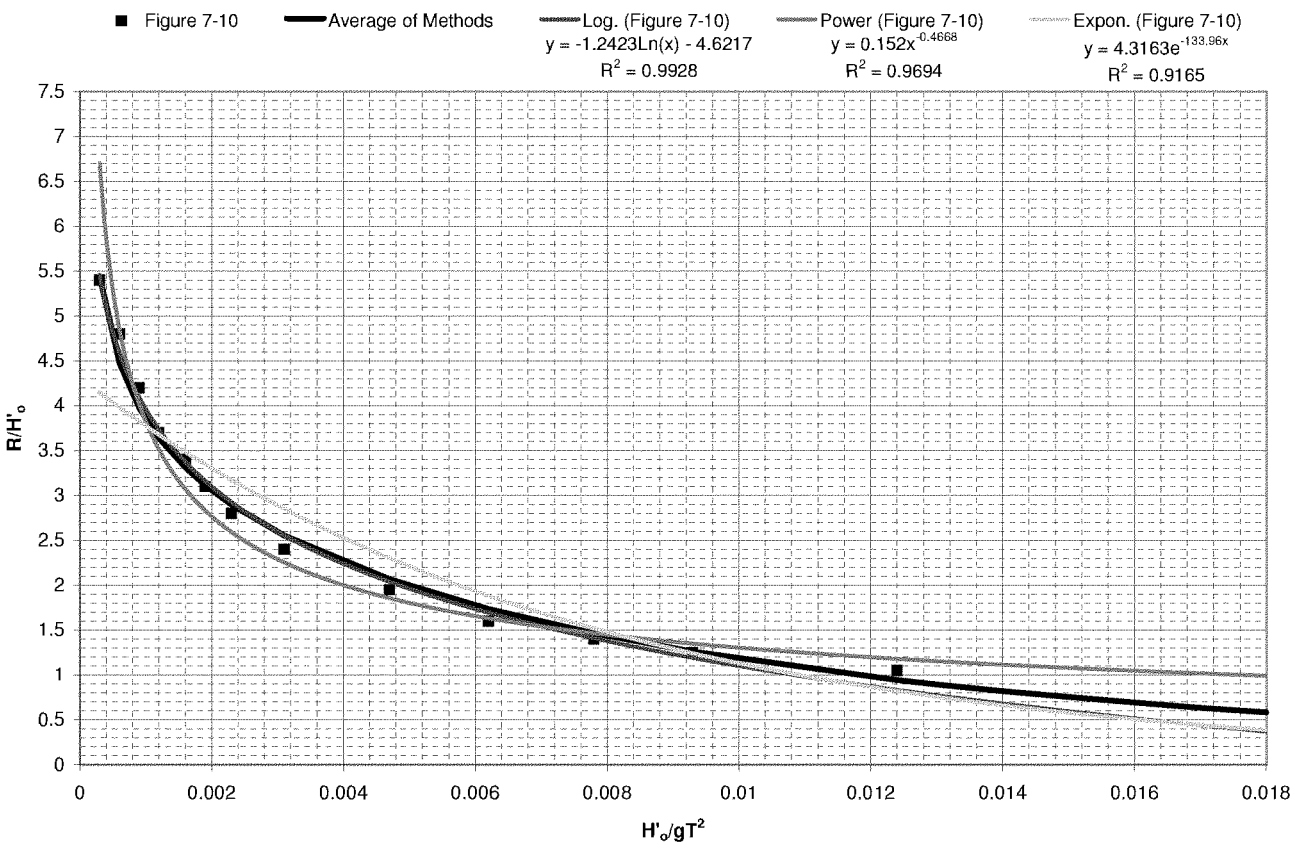
[redacted]

Technical Paper 49 (NWS, 1964)

REFERENCE: National Weather Service

CASE 2, 100-YEAR STORM CONDITION

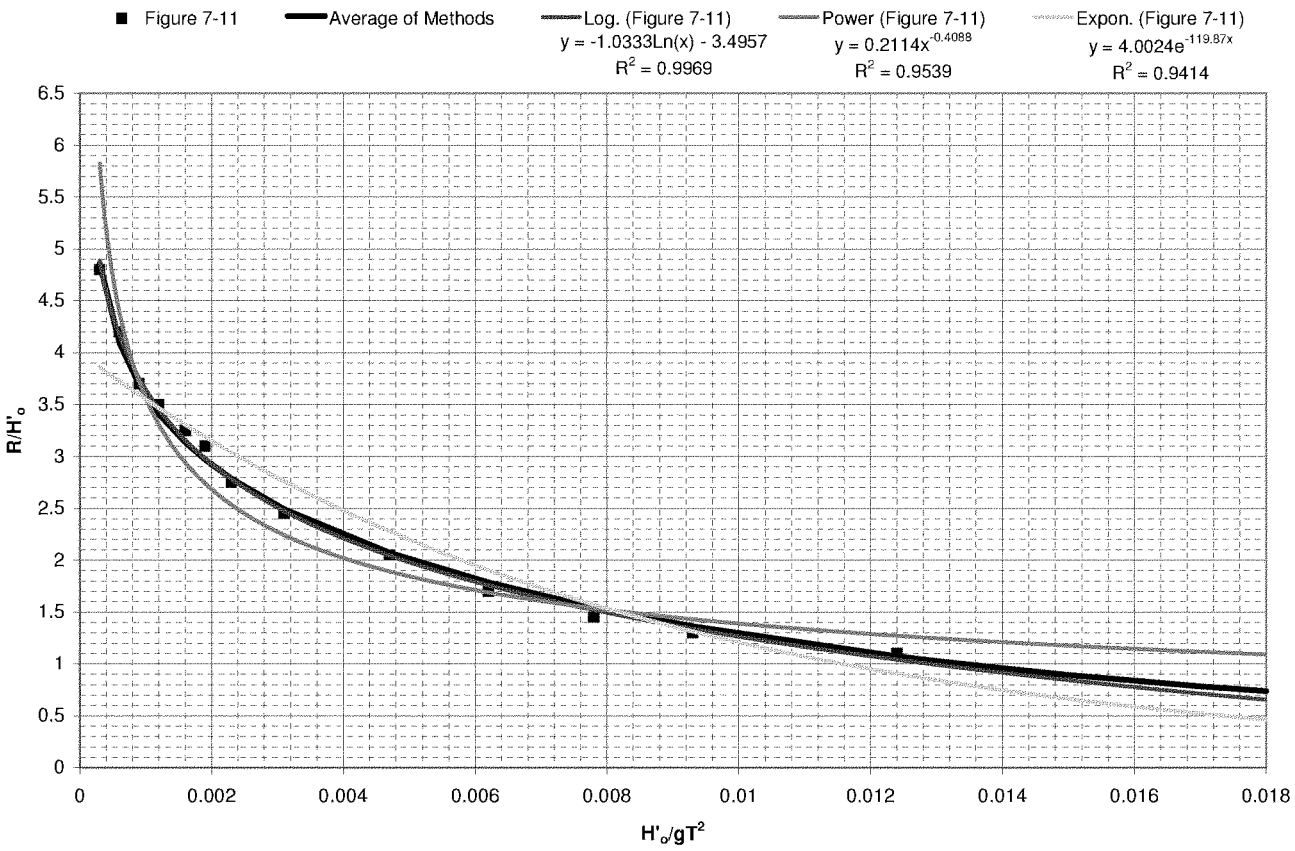
Appendix E: Regression Analyses for Wave Runup Calculations



Regression of Wave Runup Figures.xls

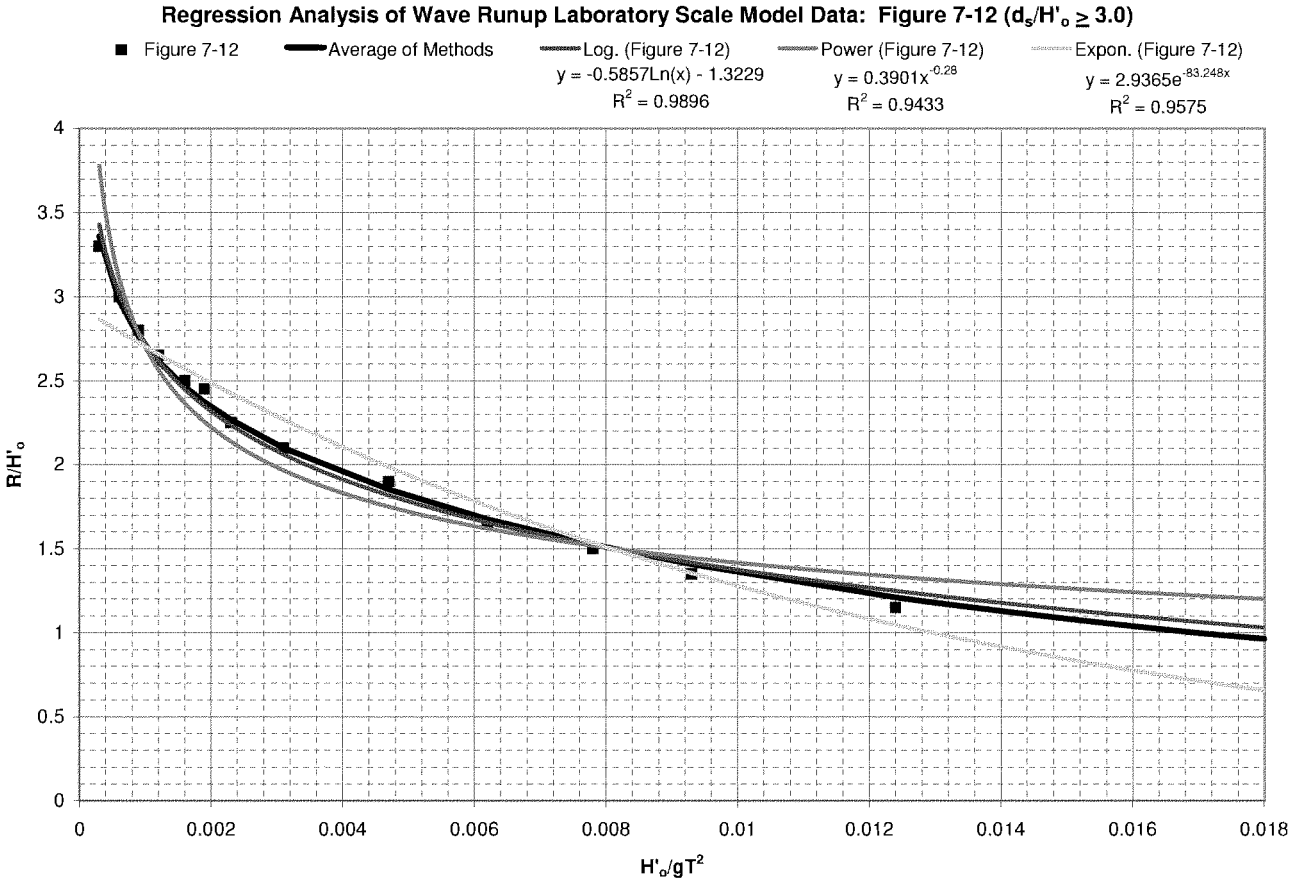
Figure 7-10

2098



Regression of Wave Runup Figures.xls

Figure 7-11



Regression of Wave Runup Figures.xls

Figure 7-12

Regression Analysis of Wave Runup Laboratory Scale Model Data

	Figure 7-10:					Figure 7-11:					Figure 7-12:				
H'_o/gT^2	Log. R/H'_o	Power R/H'_o	Expon. R/H'_o	Average R/H'_o	Figure 7-10 $d_s/H'_o \sim 0.8$ R/H'_o	Log. R/H'_o	Power R/H'_o	Expon. R/H'_o	Average R/H'_o	Figure 7-11 $d_s/H'_o \sim 2.0$	Log. R/H'_o	Power R/H'_o	Expon. R/H'_o	Average R/H'_o	Figure 7-12 $d_s/H'_o \geq 3.0$ R/H'_o
0.0003	5.46	6.70	4.15	5.44	5.4	4.89	5.82	3.86	4.86	4.8	3.43	3.78	2.86	3.36	3.3
0.0006	4.59	4.85	3.98	4.47	4.8	4.17	4.39	3.72	4.09	4.2	3.02	3.11	2.79	2.98	3
0.0009	4.09	4.01	3.83	3.98	4.2	3.75	3.72	3.59	3.69	3.7	2.78	2.78	2.72	2.76	2.8
0.0012	3.73	3.51	3.68	3.64	3.7	3.45	3.30	3.47	3.41	3.5	2.62	2.56	2.66	2.61	2.65
0.0016	3.38	3.07	3.48	3.31	3.4	3.16	2.94	3.30	3.13	3.25	2.45	2.37	2.57	2.46	2.5
0.0019	3.16	2.83	3.35	3.11	3.1	2.98	2.74	3.19	2.97	3.1	2.35	2.25	2.51	2.37	2.45
0.0023	2.93	2.59	3.17	2.90	2.8	2.78	2.53	3.04	2.78	2.75	2.24	2.14	2.42	2.27	2.25
0.0031	2.55	2.25	2.85	2.55	2.4	2.47	2.24	2.76	2.49	2.45	2.06	1.97	2.27	2.10	2.1
0.0047	2.04	1.86	2.30	2.07	1.95	2.04	1.89	2.28	2.07	2.05	1.82	1.75	1.99	1.85	1.9
0.0062	1.69	1.63	1.88	1.73	1.6	1.76	1.69	1.90	1.78	1.7	1.65	1.62	1.75	1.67	1.65
0.0078	1.41	1.46	1.52	1.46	1.4	1.52	1.54	1.57	1.54	1.45	1.52	1.52	1.53	1.52	1.5
0.0093	1.19	1.35	1.24	1.26	1.25	1.34	1.43	1.31	1.36	1.3	1.42	1.45	1.35	1.41	1.35
0.0124	0.83	1.18	0.82	0.94	1.05	1.04	1.27	0.91	1.07	1.1	1.25	1.33	1.05	1.21	1.15
0.013	0.77	1.15	0.76	0.89		0.99	1.25	0.84	1.03		1.22	1.32	1.00	1.18	
0.014	0.68	1.11	0.66	**0.82**		0.92	1.21	0.75	**0.96**		1.18	1.29	0.92	**1.13**	
0.015	0.60	1.08	0.58	**0.75**		0.84	1.18	0.66	**0.89**		1.14	1.26	0.84	**1.08**	
0.016	0.52	1.05	0.51	**0.69**		0.78	1.15	0.59	**0.84**		1.10	1.24	0.78	**1.04**	
0.017	0.44	1.02	0.44	**0.63**		0.71	1.12	0.52	**0.78**		1.06	1.22	0.71	**1.00**	
0.018	0.37	0.99	0.39	0.58		0.66	1.09	0.46	0.74		1.03	1.20	0.66	0.96	

2101

Appendix F: STWAVE and ACES Analyses

STWAVE and ACES Analyses
Summary Tables

Summary of STWAVE and ACES Case 1 Overtopping Rate Analyses (External Embankment)

Cell 1																					
Wind	STWAVE		Wave		Toe	Wind	Depth	Structure at Overtopping Rate of													
Direction	Station[2]		Ht	Period	Elev.	Setup	at El.[1]	0.10			0.01			0.005			0.001				
(0=North)	X	Y	(ft)	(s)	(ft)	(ft)	46.13	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Comments	
45	14600	14110	6.53	4.00	15.81	1.03	31.35	37.17	1.56	54.54	38.73	1.71	56.25	39.12	1.71	56.64	39.86	1.79	57.46	Fetch 1A	
135	14730	800	6.53	4.30	19.63	0.90	27.40	33.51	1.24	54.38	35.15	1.40	56.18	35.56	1.40	56.59	36.33	1.48	57.44	Fetch 1B	

Cell 2																					
Wind	STWAVE		Wave		Toe	Wind	Depth	Structure at Overtopping Rate of													
Direction	Station[2]		Ht	Period	Elev.	Setup	at El.[1]	0.10			0.01			0.005			0.001				
(0=North)	X	Y	(ft)	(s)	(ft)	(ft)	46.13	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Comments	
45	14700	14760	6.66	4.30	20.19	1.12	27.06	33.27	1.25	54.71	34.93	1.39	56.51	35.27	1.26	56.72	36.12	1.47	57.78	Fetch 2A	
315	14710	2390	6.50	4.30	23.76	1.22	23.59	29.69	0.87	54.32	31.33	1.07	56.16	31.73	1.07	56.56	32.50	1.16	57.42	Fetch 2B	

Summary of STWAVE and ACES Case 1 Overtopping Rate Analyses (Internal Embankment)

Internal Embankment																					
Wind	STWAVE		Wave		Toe	Wind	Depth	Structure at Overtopping Rate of													
Direction	Station[2]		Ht	Period	Elev.	Setup	at El.[1]	0.10			0.01			0.005			0.001				
(0=North)	X	Y	(ft)	(s)	(ft)	(ft)	46.13	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Comments	
90	14430	3030	6.27	4.00	21.42	0.87	25.58	31.17	1.07	53.66	32.71	1.16	55.29	33.10	1.25	55.77	33.83	1.25	56.50	Cell 2	
270	14810	11900	6.27	4.00	21.95	0.78	24.96	30.55	0.96	53.46	32.09	1.15	55.19	32.47	1.15	55.57	33.21	1.24	56.40	Cell 1	

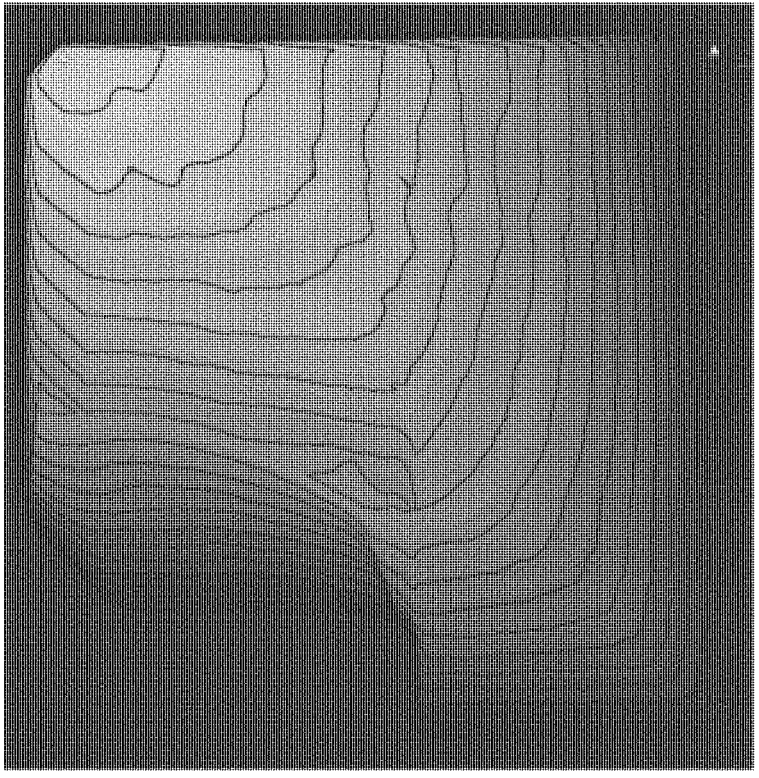
Internal Embankment																					
Wind	STWAVE		Wave		Toe	Wind	Depth	Structure at Overtopping Rate of													
Direction	Station[2]		Ht	Period	Elev.	Setup	at El.[1]	1.00													
(0=North)	X	Y	(ft)	(s)	(ft)	(ft)	46.13	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Ht	Camber	Elev	Comments	
90	14430	3030	6.27	4.00	21.42	0.87	25.58	29.21	0.77	51.40										Cell 2	
270	14810	11900	6.27	4.00	21.95	0.78	24.96	28.59	0.76	51.30										Cell 1	

Note:
1. Depth at Elevation 46.13 is the water depth at the embankment toe with the surcharge elevation of 46.13 plus the wind setup.
2. Due to a software bug, the station (X,Y) coordinates in the graphical output is shown backwards as (Y,X). The results, however, appear OK. The station coordinates in this spreadsheet are the correct coordinates (so they are the reverse of what is shown in the graphical output data).

Case 1: 100 mph (Fetch 1A) (10x10)

Wave Height (ft)

STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 45.00

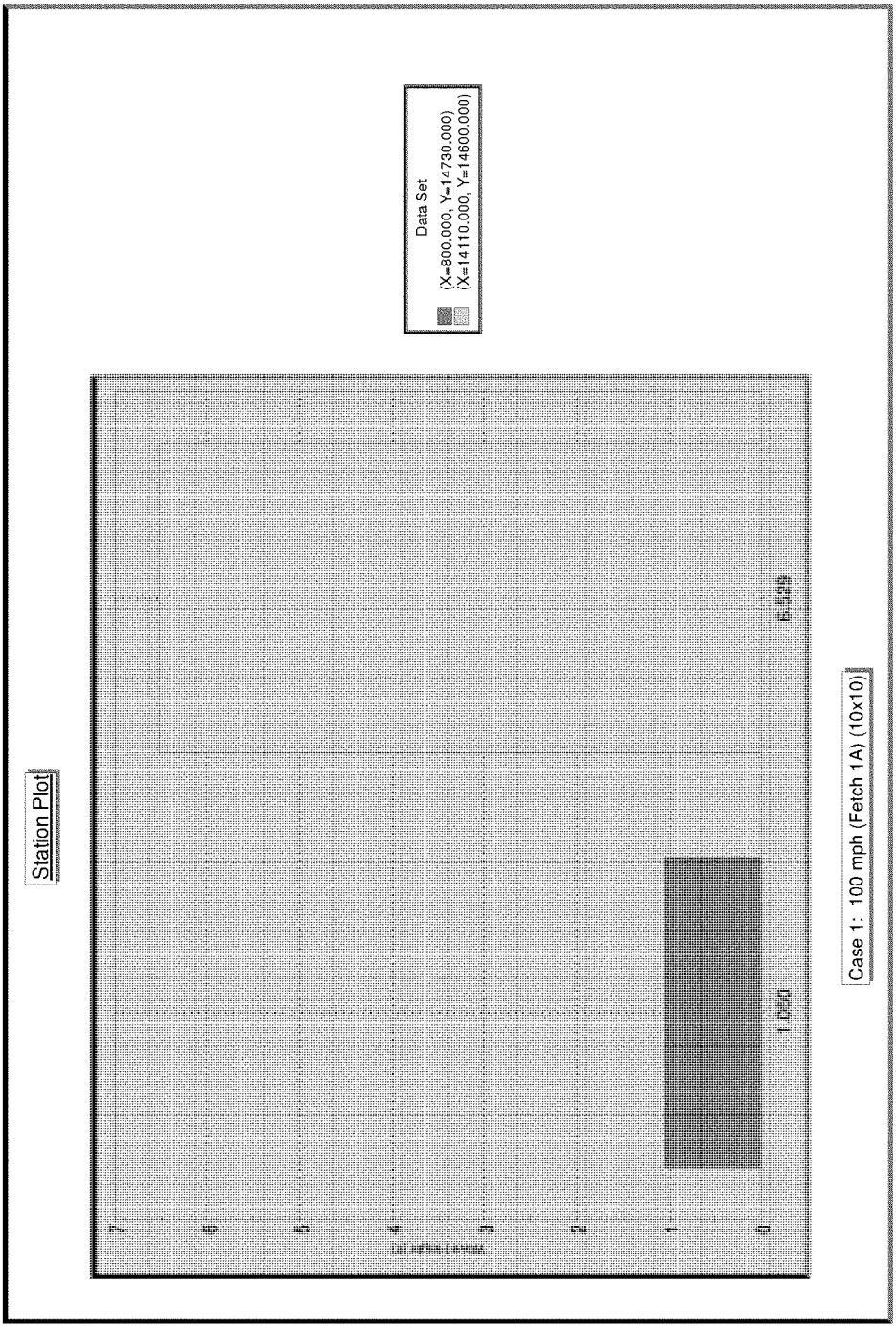


6.53
6.09
5.66
5.22
4.79
4.35
3.92
3.48
3.05
2.61
2.18
1.74
1.31
0.87
0.44
0.00

X

Y

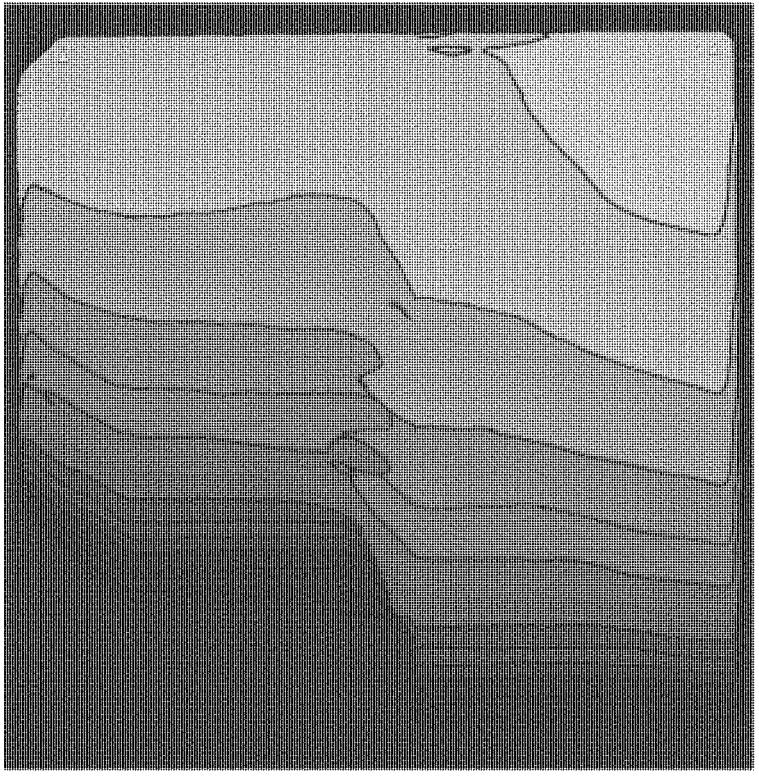
2106


Station Plot
Data Set
(X=800.000, Y=14730.000)
(X=14110.000, Y=14600.000)
Case 1: 100 mph (Fetch 1A) (10x10)

Case 1: 100 mph (Fetch 1A) (10x10)

Wave Period (sec)

STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 45.00

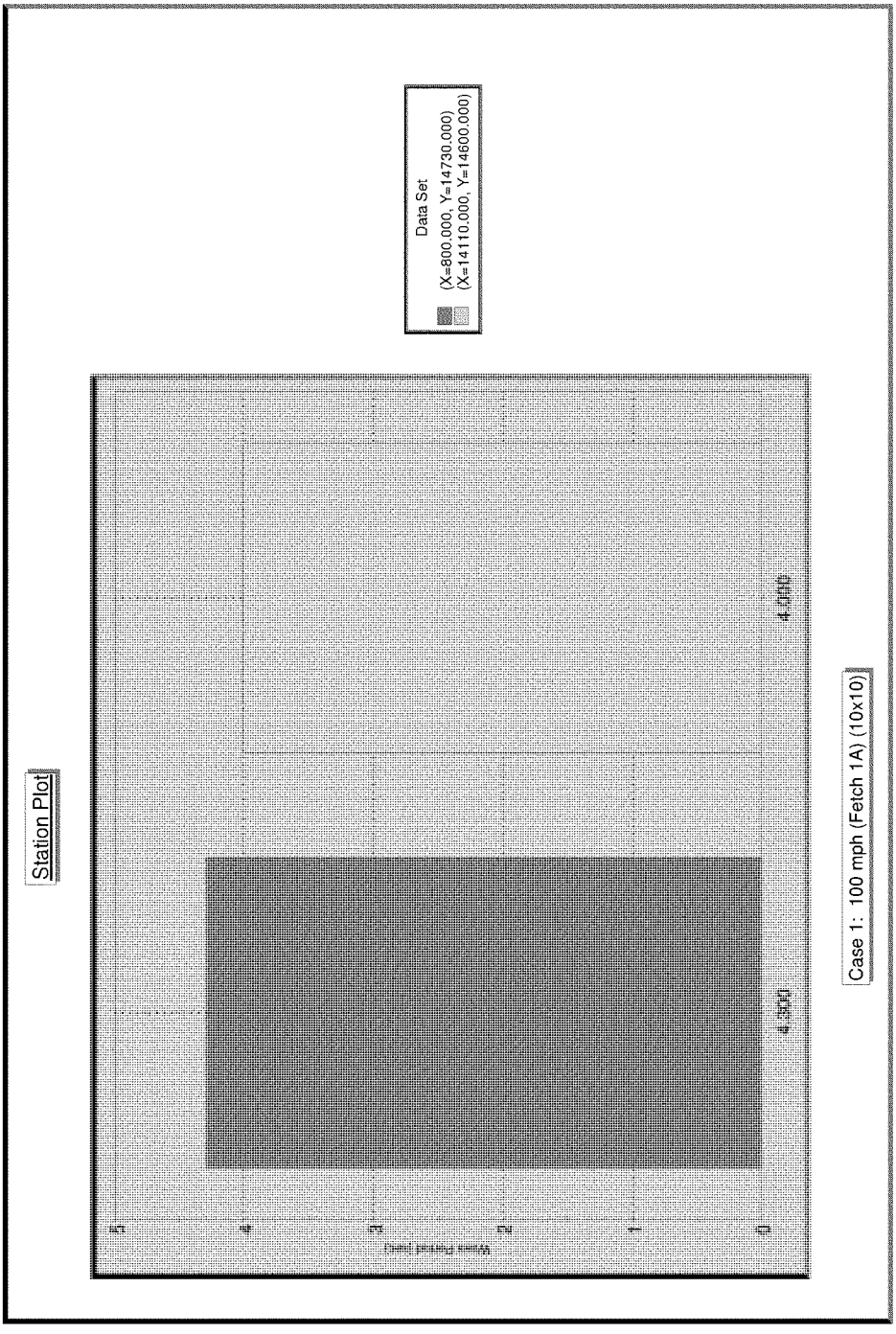


4.30
4.12
3.94
3.76
3.58
3.40
3.22
3.04
2.86
2.68
2.50
2.32
2.14
1.96
1.78
1.60

X

Y

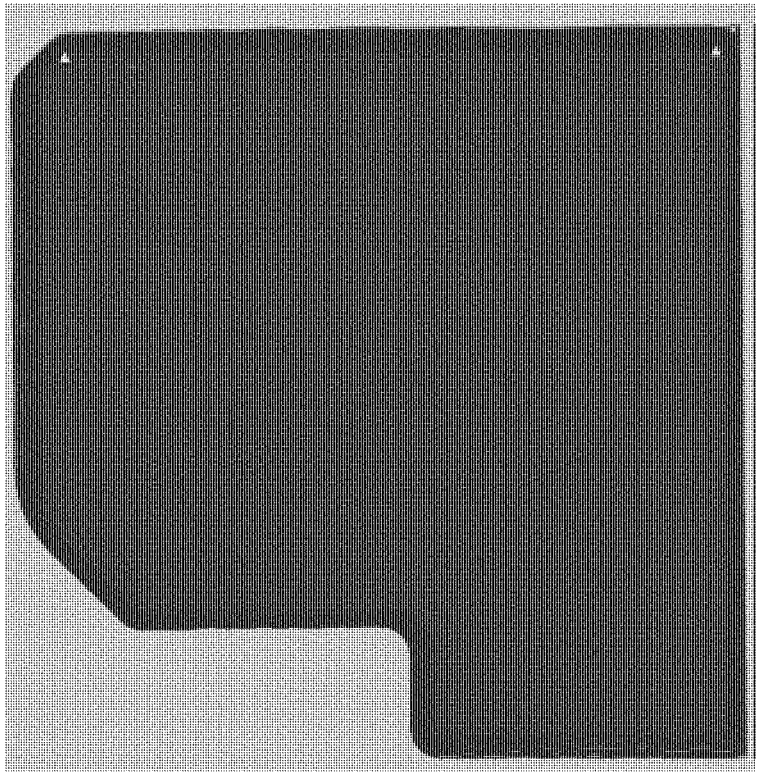
2108


Station Plot
Data Set
(X=800.000, Y=14730.000)
(X=14110.000, Y=14600.000)
Case 1: 100 mph (Fetch 1A) (10x10)

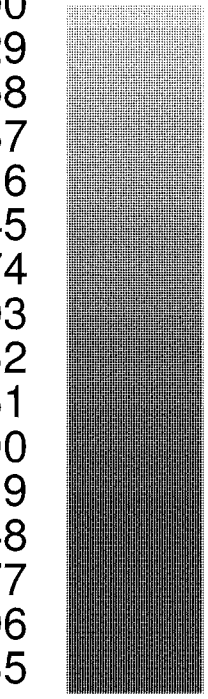
Case 1: 100 mph (Fetch 1A) (10x10)

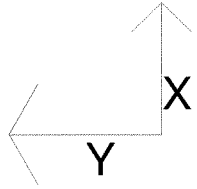
Bathymetry (ft)

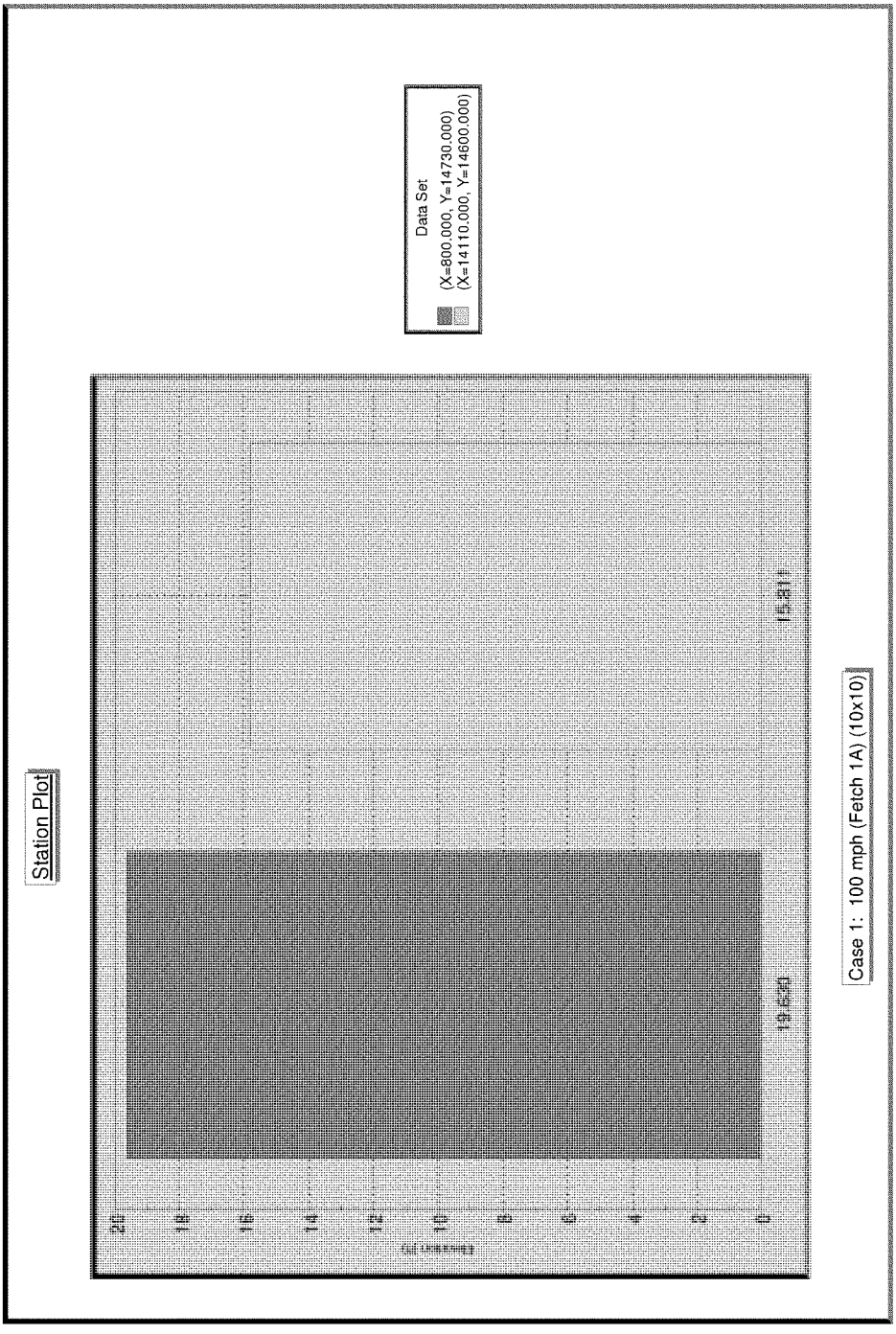
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 45.00



55.00
52.29
49.58
46.87
44.16
41.45
38.74
36.03
33.32
30.61
27.90
25.19
22.48
19.77
17.06
14.35






Station Plot
Data Set
(X=800.000, Y=14730.000)
(X=14110.000, Y=14600.000)
20
18
16
14
12
10
8
6
4
2
0
15.811
10.630
Case 1: 100 mph (Fetch 1A) (10x10)

Project:
Group: 10x10 - 0.001 Overtop WindSetup Incl.

Case: Cell1(Fetch1A)(10x10)(100mph=147ft/s)WS=1.03'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.014	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.716	ft
Water depth at structure toe (ds):	31.350	ft	Relative height (ds/Ho):	4.668	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT²):	0.013	
Structure height above toe (hs):	39.860	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.048	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.001	ft³/s-ft

2112

Project:
Group: 10x10 - 0.005 Overtop WindSetup Incl.

Case: Cell1(Fetch1A)(10x10)(100mph=147ft/s)WS=1.03'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.014	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.716	ft
Water depth at structure toe (ds):	31.350	ft	Relative height (ds/Ho):	4.668	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	39.120	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.048	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.005	ft^3/s-ft

2113

Project:
Group: 10x10 - 0.01 Overtop WindSetup Incl.

Case: Cell1(Fetch1A)(10x10)(100mph=147ft/s)WS=1.03'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.014	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.716	ft
Water depth at structure toe (ds):	31.350	ft	Relative height (ds/Ho):	4.668	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	38.730	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.048	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.010	ft^3/s-ft

2114

Project:
Group: 10x10 - 0.1 Overtop WindSetup Incl.

Case: Cell1(Fetch1A)(10x10)(100mph=147ft/s)WS=1.03'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

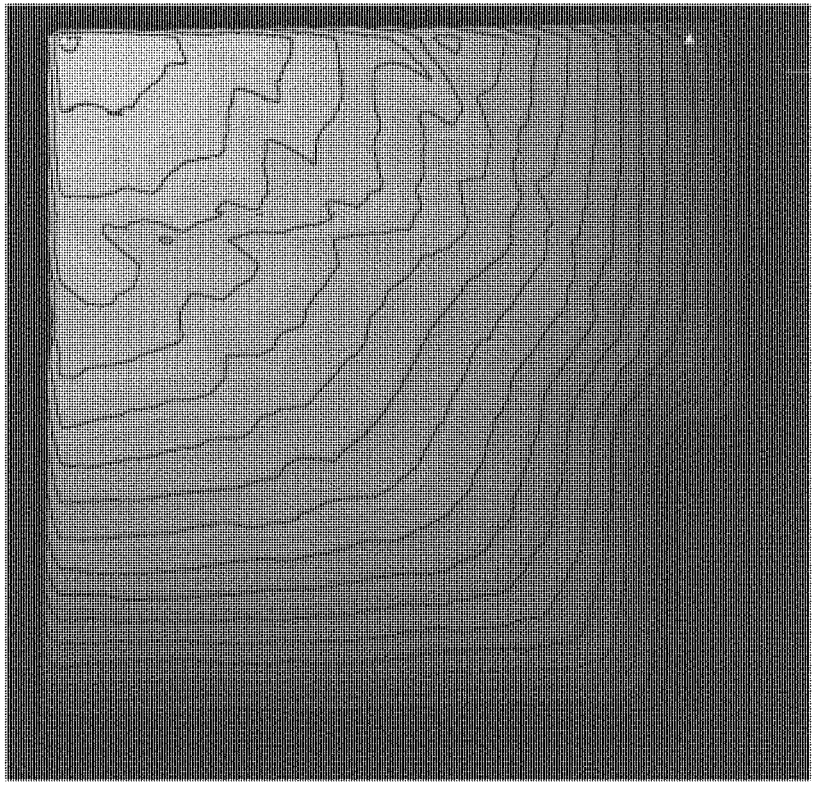
Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.014	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.716	ft
Water depth at structure toe (ds):	31.350	ft	Relative height (ds/Ho):	4.668	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	37.170	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.048	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.099	ft^3/s-ft

2115

Case 1: 100 mph (Fetch 2A) (10x10)

Wave Height (ft)

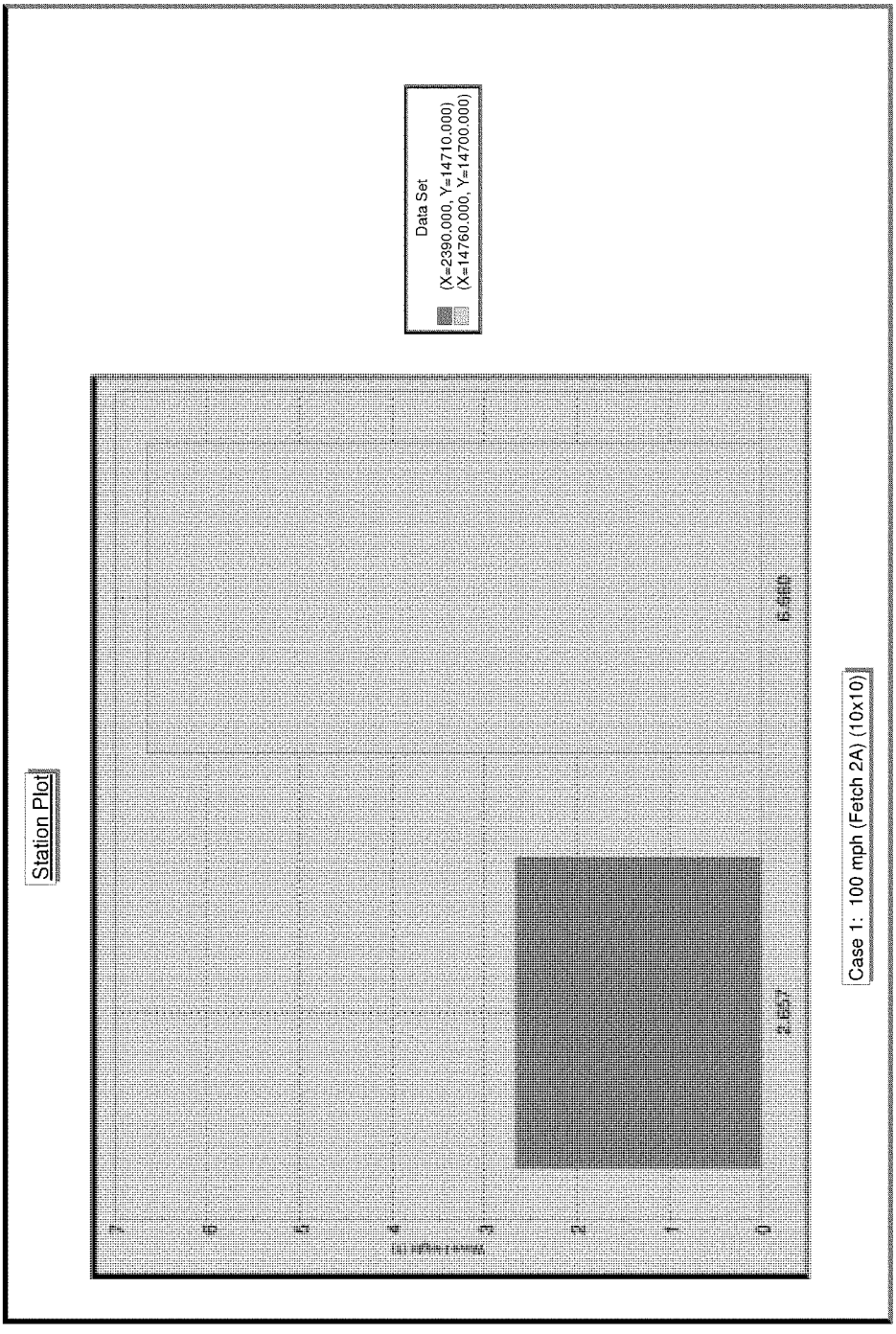
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 45.00



6.66
6.22
5.77
5.33
4.88
4.44
4.00
3.55
3.11
2.66
2.22
1.78
1.33
0.89
0.44
0.00

X

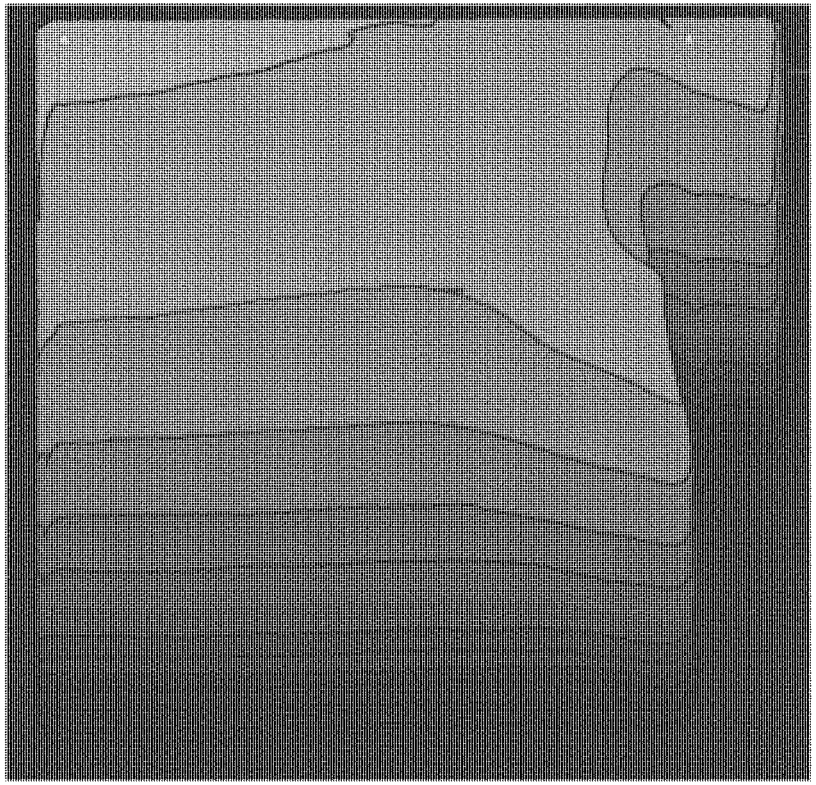
Y

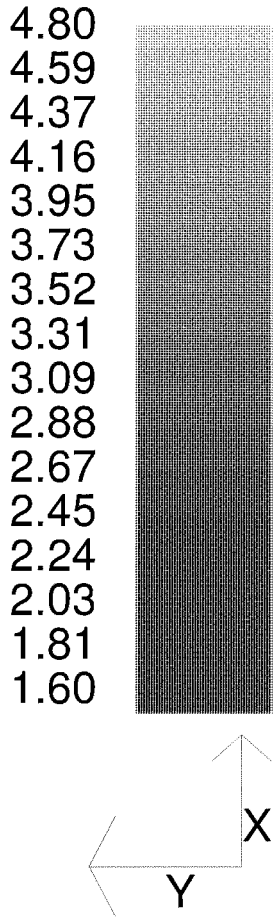

Station Plot
Data Set
(X=2390.000, Y=14710.000)
(X=14760.000, Y=14700.000)
Case 1: 100 mph (Fetch 2A) (10x10)

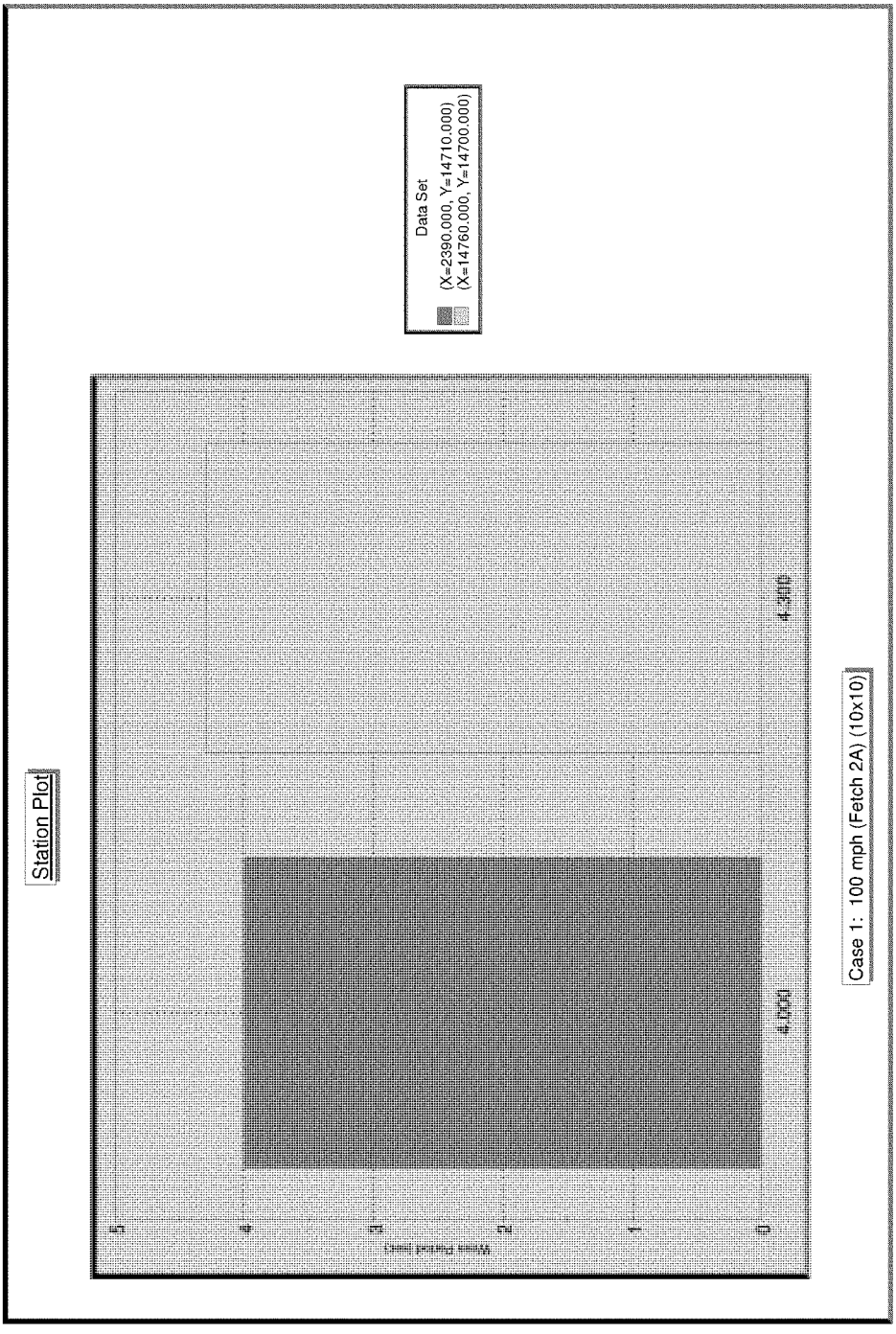
Case 1: 100 mph (Fetch 2A) (10x10)

Wave Period (sec)

STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 45.00



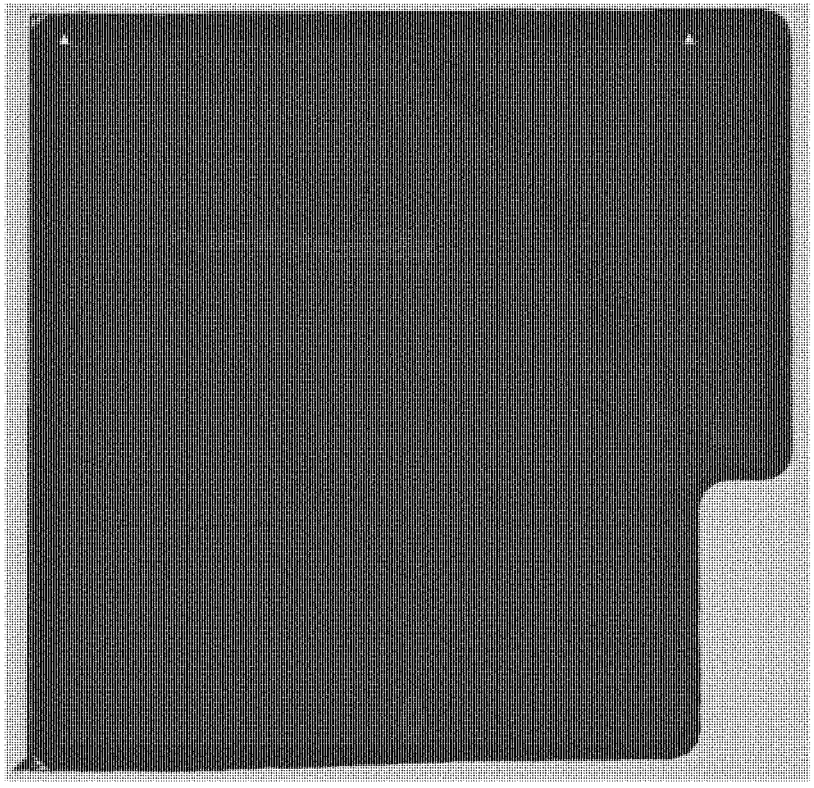



Station Plot
Data Set
(X=2390.000, Y=14710.000)
(X=14760.000, Y=14700.000)
Case 1: 100 mph (Fetch 2A) (10x10)

Case 1: 100 mph (Fetch 2A) (10x10)

Bathymetry (ft)

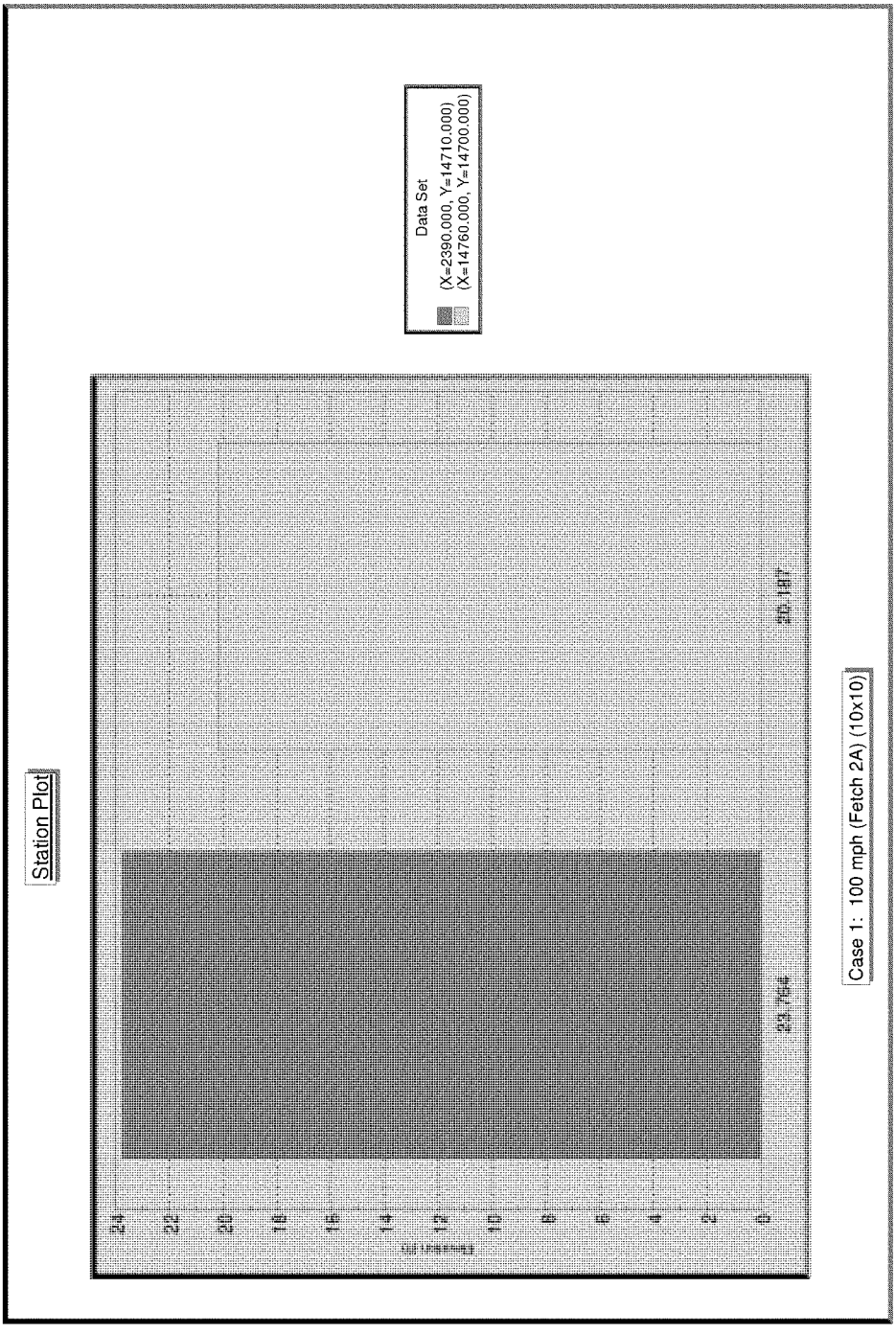
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 45.00



55.00
52.33
49.66
46.98
44.31
41.64
38.97
36.29
33.62
30.95
28.28
25.60
22.93
20.26
17.59
14.91

X

Y


Station Plot
Data Set
(X=2390.000, Y=14710.000)
(X=14760.000, Y=14700.000)
24
22
20
18
16
14
12
10
8
6
4
2
0
20.187
23.764
Case 1: 100 mph (Fetch 2A) (10x10)

Project:
Group: 10x10 - 0.001 Overtop WindSetup Incl.

Case: Cell2(Fetch2A)(10x10)(100mph=147ft/s)WS=1.12'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.660	ft	Runup for significant waves (R):	5.334	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	7.053	ft
Water depth at structure toe (ds):	27.060	ft	Relative height (ds/Ho):	3.837	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	36.120	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q^*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.001	ft^3/s-ft

2123

Project:
Group: 10x10 - 0.005 Overtop WindSetup Incl.

Case: Cell2(Fetch2A)(10x10)(100mph=147ft/s)WS=1.12'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.660	ft	Runup for significant waves (R):	5.334	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	7.053	ft
Water depth at structure toe (ds):	27.060	ft	Relative height (ds/Ho):	3.837	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	35.270	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.040	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.005	ft^3/s-ft

2124

Project:
Group: 10x10 - 0.01 Overtop WindSetup Incl.

Case: Cell2(Fetch2A)(10x10)(100mph=147ft/s)WS=1.12'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.660	ft	Runup for significant waves (R):	5.334	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	7.053	ft
Water depth at structure toe (ds):	27.060	ft	Relative height (ds/Ho):	3.837	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	34.930	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.010	ft^3/s-ft

2125

Project:
Group: 10x10 - 0.1 Overtop WindSetup Incl.

Case: Cell2(Fetch2A)(10x10)(100mph=147ft/s)WS=1.12'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.660	ft	Runup for significant waves (R):	5.334	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	7.053	ft
Water depth at structure toe (ds):	27.060	ft	Relative height (ds/Ho):	3.837	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	33.270	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.100	ft^3/s-ft

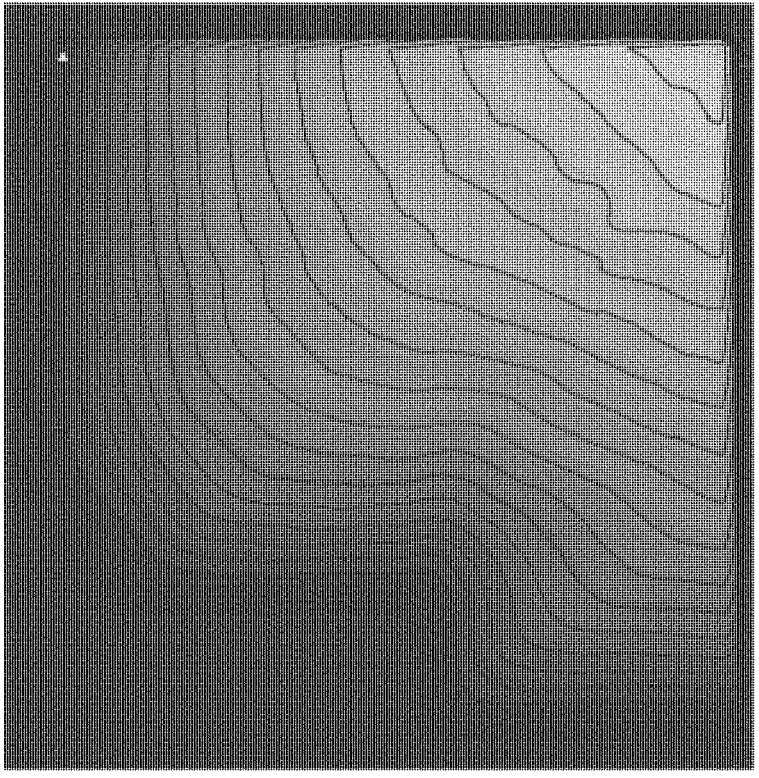
2126

Fetch 1B Analyses

Case 1: 100 mph (Fetch 1B) (10x10)

Wave Height (ft)

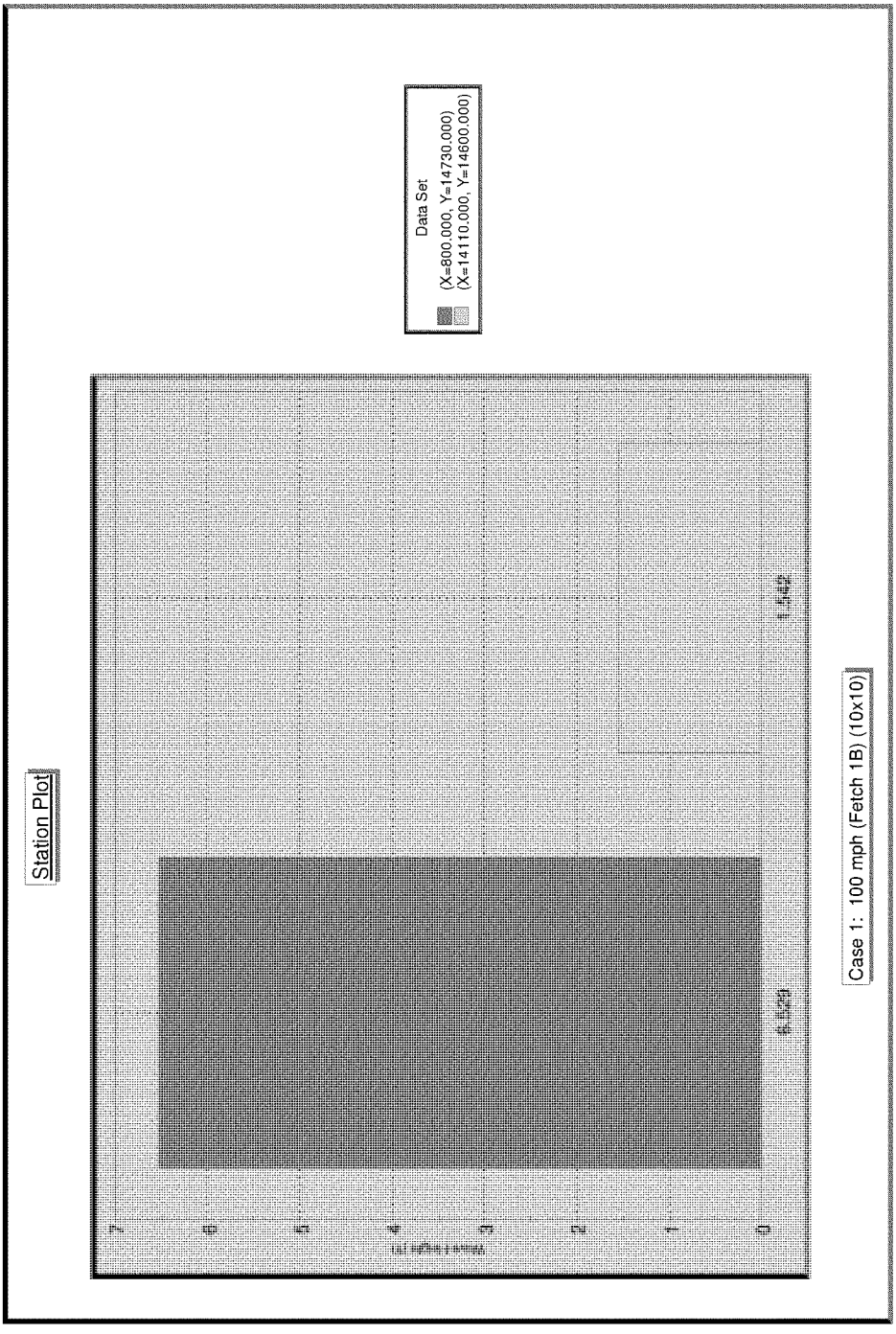
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: -45.00



6.53
6.09
5.66
5.22
4.79
4.35
3.92
3.48
3.05
2.61
2.18
1.74
1.31
0.87
0.44
0.00

X

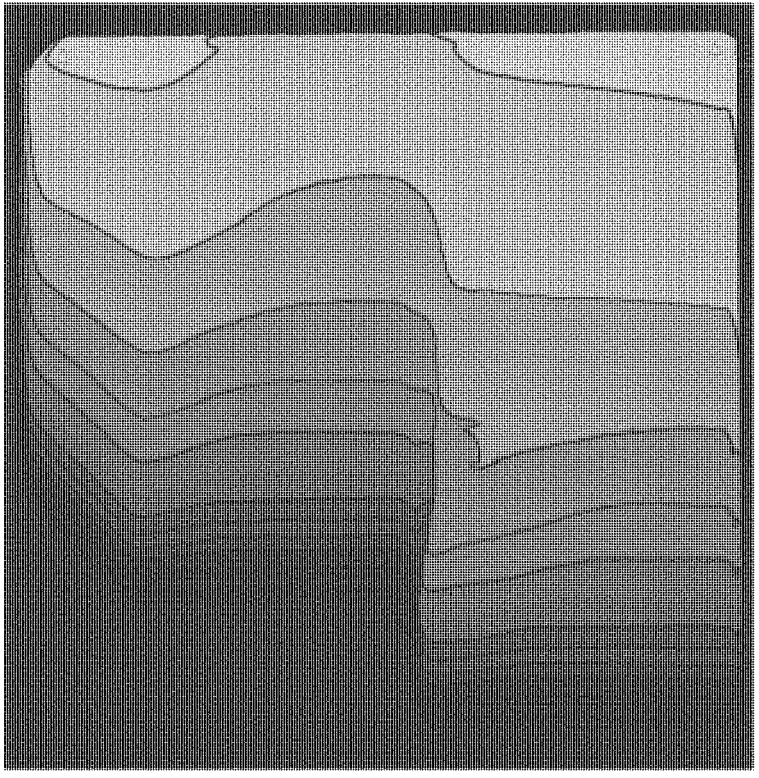
Y

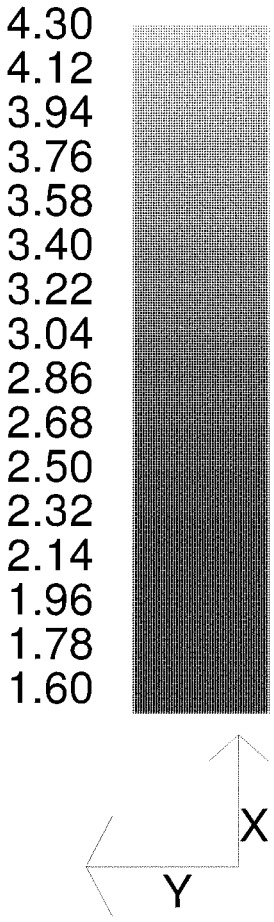

Station Plot
Data Set
(X=800.000, Y=14730.000)
(X=14110.000, Y=14600.000)
Wave Height (ft)
7
6
5
4
3
2
1
0
6.529
1.642
Case 1: 100 mph (Fetch 1B) (10x10)

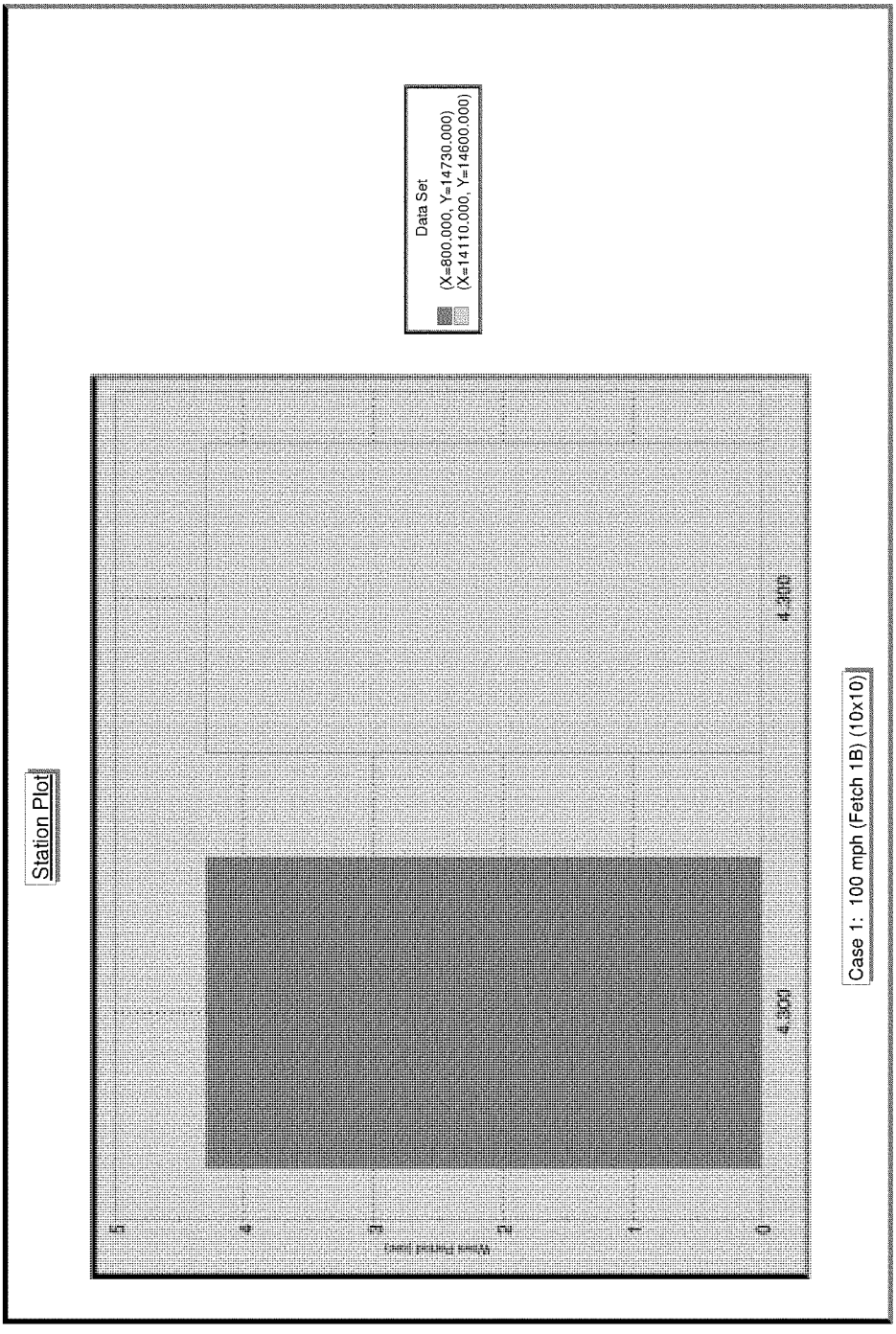
Case 1: 100 mph (Fetch 1B) (10x10)

Wave Period (sec)

STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: -45.00



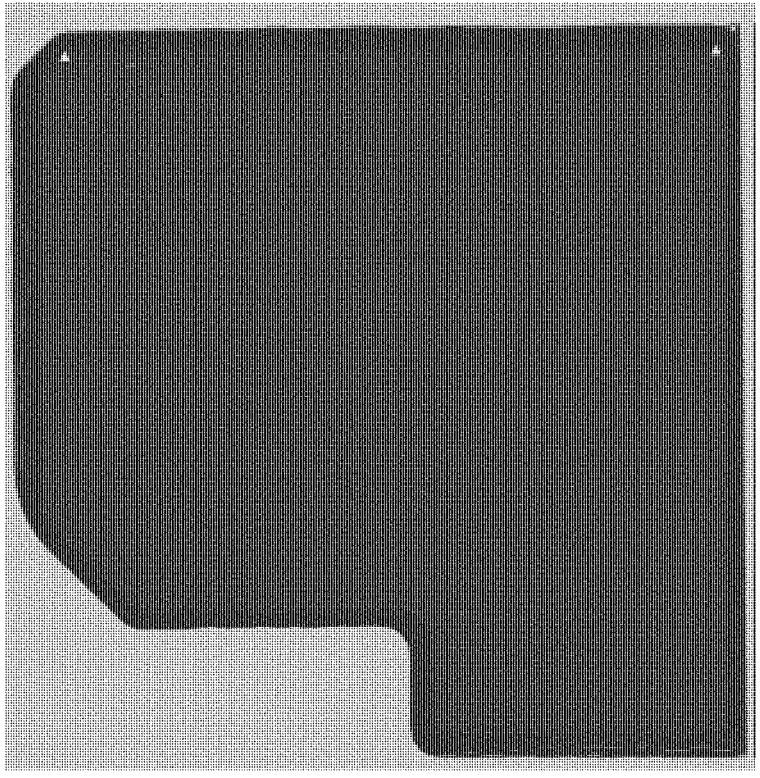



Station Plot
Data Set
(X=800.000, Y=14730.000)
(X=14110.000, Y=14600.000)
Wave Period (sec)
5
4
3
2
1
0
4.300
4.300
Case 1: 100 mph (Fetch 1B) (10x10)

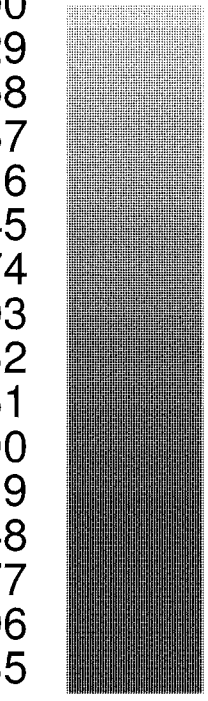
Case 1: 100 mph (Fetch 1B) (10x10)

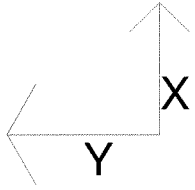
Bathymetry (ft)

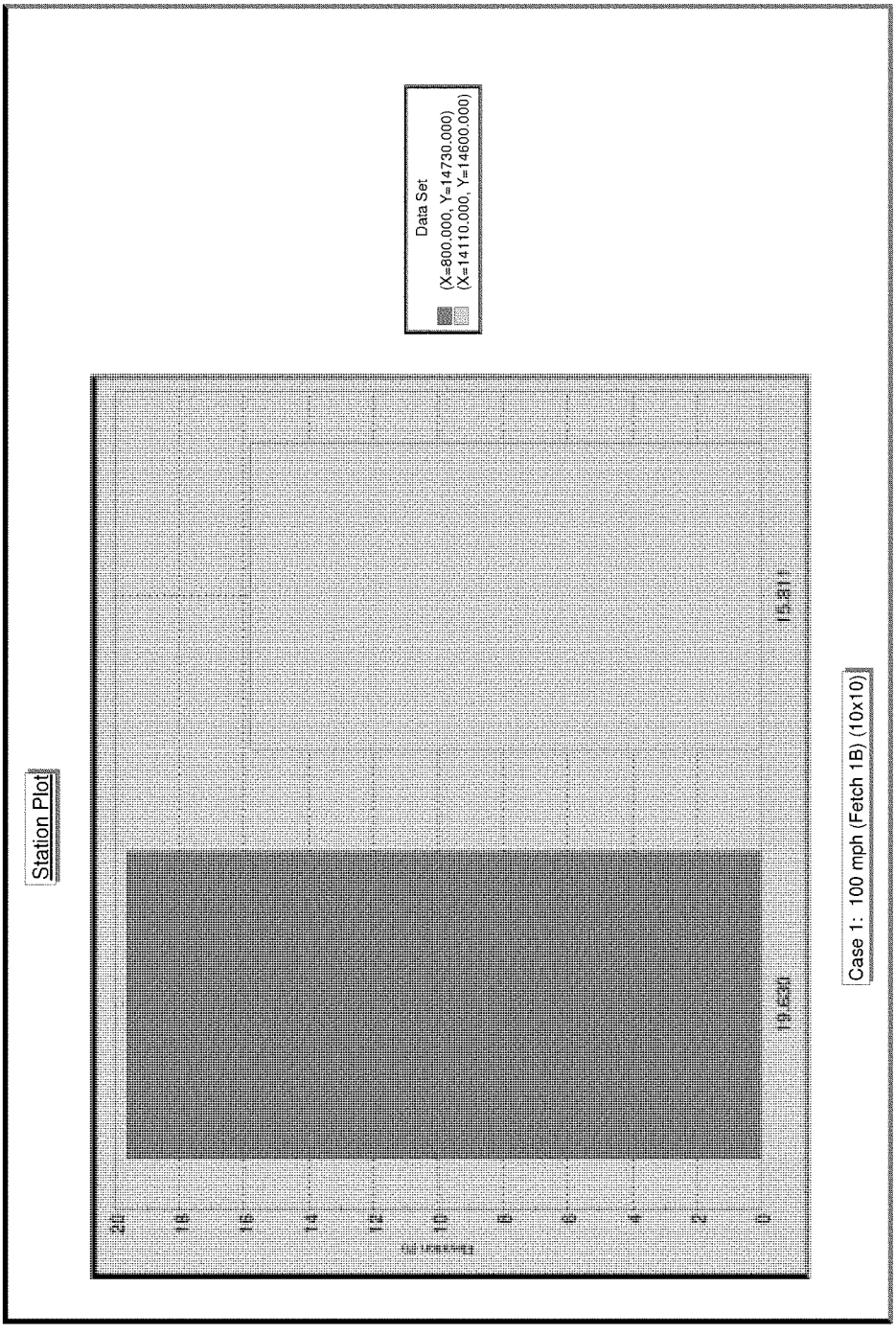
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: -45.00



55.00
52.29
49.58
46.87
44.16
41.45
38.74
36.03
33.32
30.61
27.90
25.19
22.48
19.77
17.06
14.35






Station Plot
Data Set
(X=800.000, Y=14730.000)
(X=14110.000, Y=14600.000)
20
18
16
14
12
10
8
6
4
2
0
15.811
10.630
Case 1: 100 mph (Fetch 1B) (10x10)

Case: Cell1(Fetch1B)(10x10)(100mph=147ft/s)WS=0.9'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.264	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.907	ft
Water depth at structure toe (ds):	27.400	ft	Relative height (ds/Ho):	3.967	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	36.330	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q^*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.001	ft^3/s-ft

Project:
Group: 10x10 - 0.005 Overtop WindSetup Incl.

Case: Cell1(Fetch1B)(10x10)(100mph=147ft/s)WS=0.9'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.264	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.907	ft
Water depth at structure toe (ds):	27.400	ft	Relative height (ds/Ho):	3.967	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	35.560	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*c):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.005	ft^3/s-ft

2135

Case: Cell1(Fetch1B)(10x10)(100mph=147ft/s)WS=0.9'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.264	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.907	ft
Water depth at structure toe (ds):	27.400	ft	Relative height (ds/Ho):	3.967	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	35.150	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*c):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.010	ft^3/s-ft

Project:
Group: 10x10 - 0.1 Overtop WindSetup Incl.

Case: Cell1(Fetch1B)(10x10)(100mph=147ft/s)WS=0.9'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.530	ft	Runup for significant waves (R):	5.264	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.907	ft
Water depth at structure toe (ds):	27.400	ft	Relative height (ds/Ho):	3.967	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	33.510	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.099	ft^3/s-ft

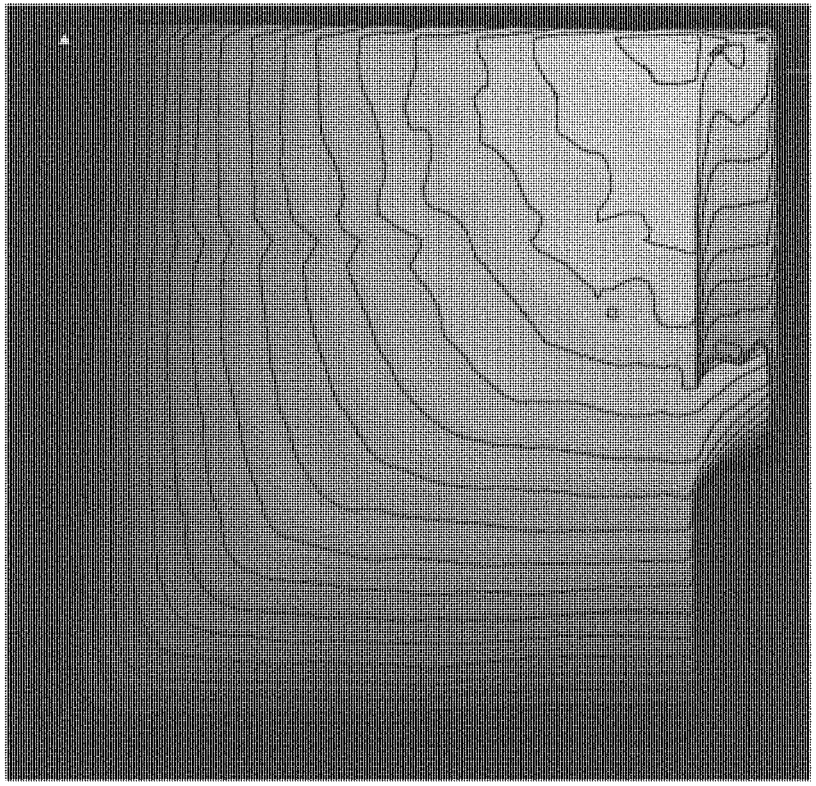
2137

Fetch 2B Analyses

Case 1: 100 mph (Fetch 2B) (10x10)

Wave Height (ft)

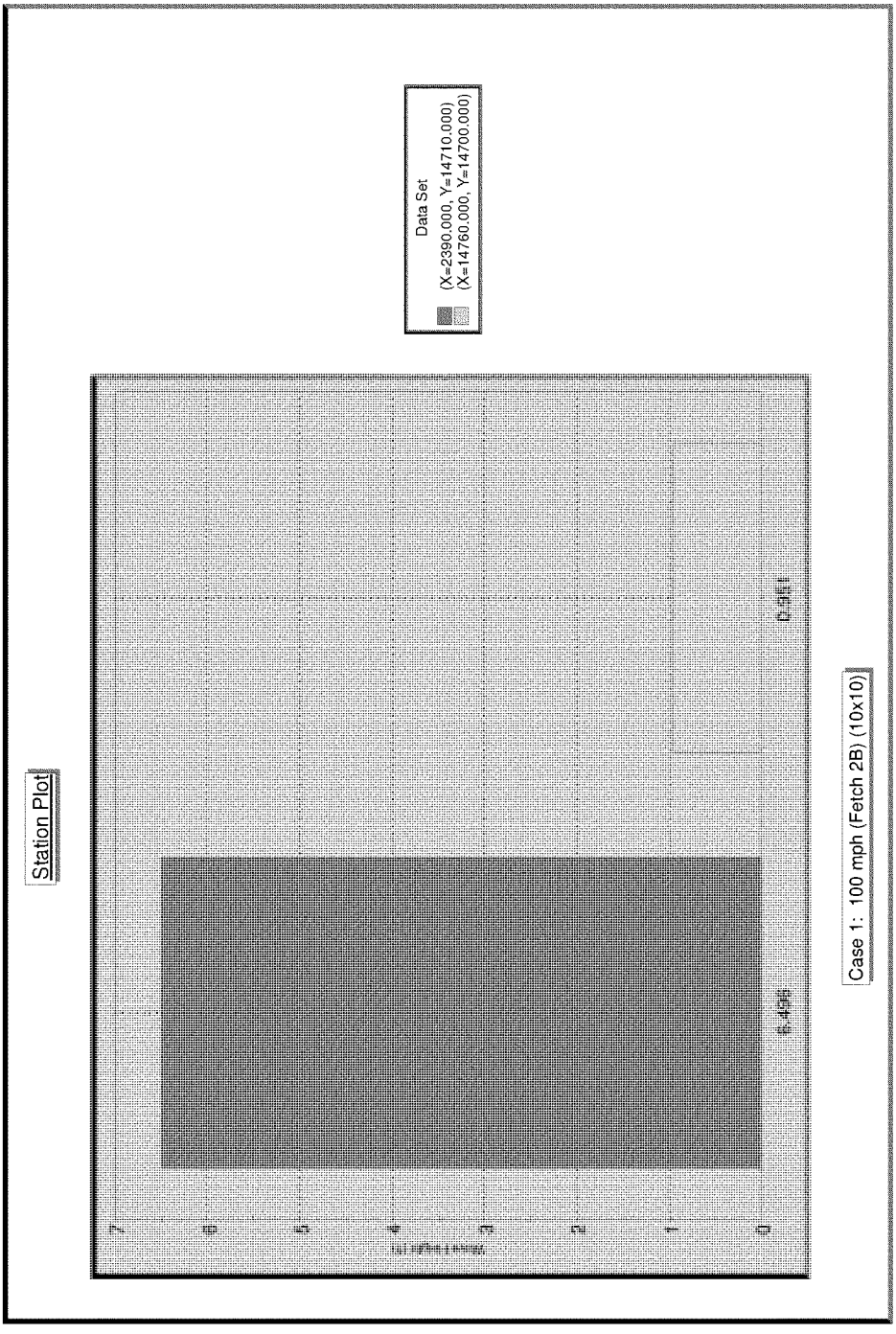
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: -45.00



6.50
6.06
5.63
5.20
4.76
4.33
3.90
3.46
3.03
2.60
2.17
1.73
1.30
0.87
0.43
0.00

X

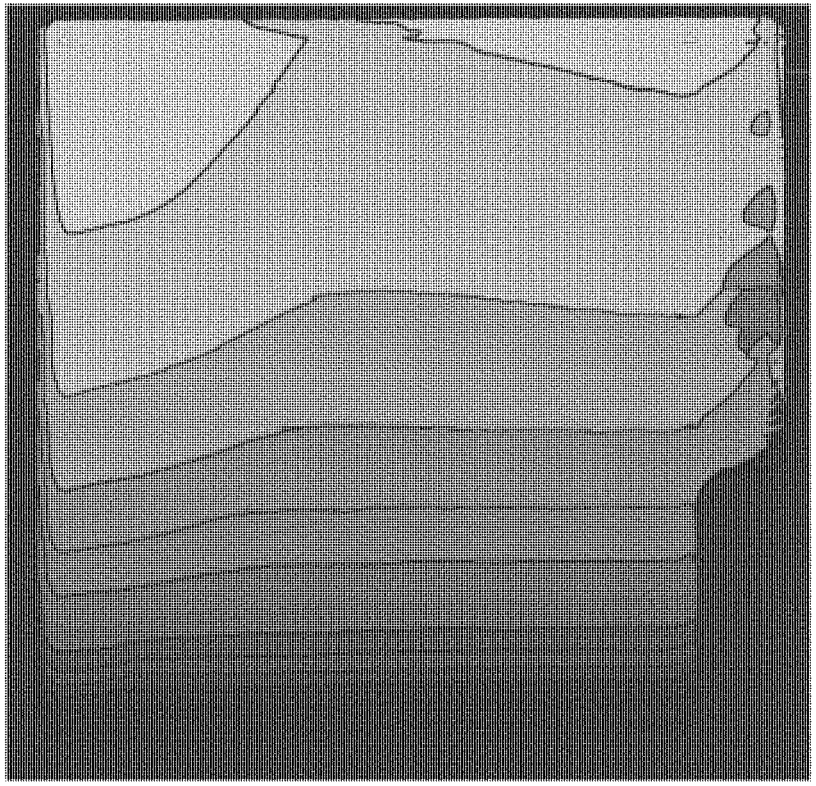
Y


Station Plot
Data Set
(X=2390.000, Y=14710.000)
(X=14760.000, Y=14700.000)
Case 1: 100 mph (Fetch 2B) (10x10)

Case 1: 100 mph (Fetch 2B) (10x10)

Wave Period (sec)

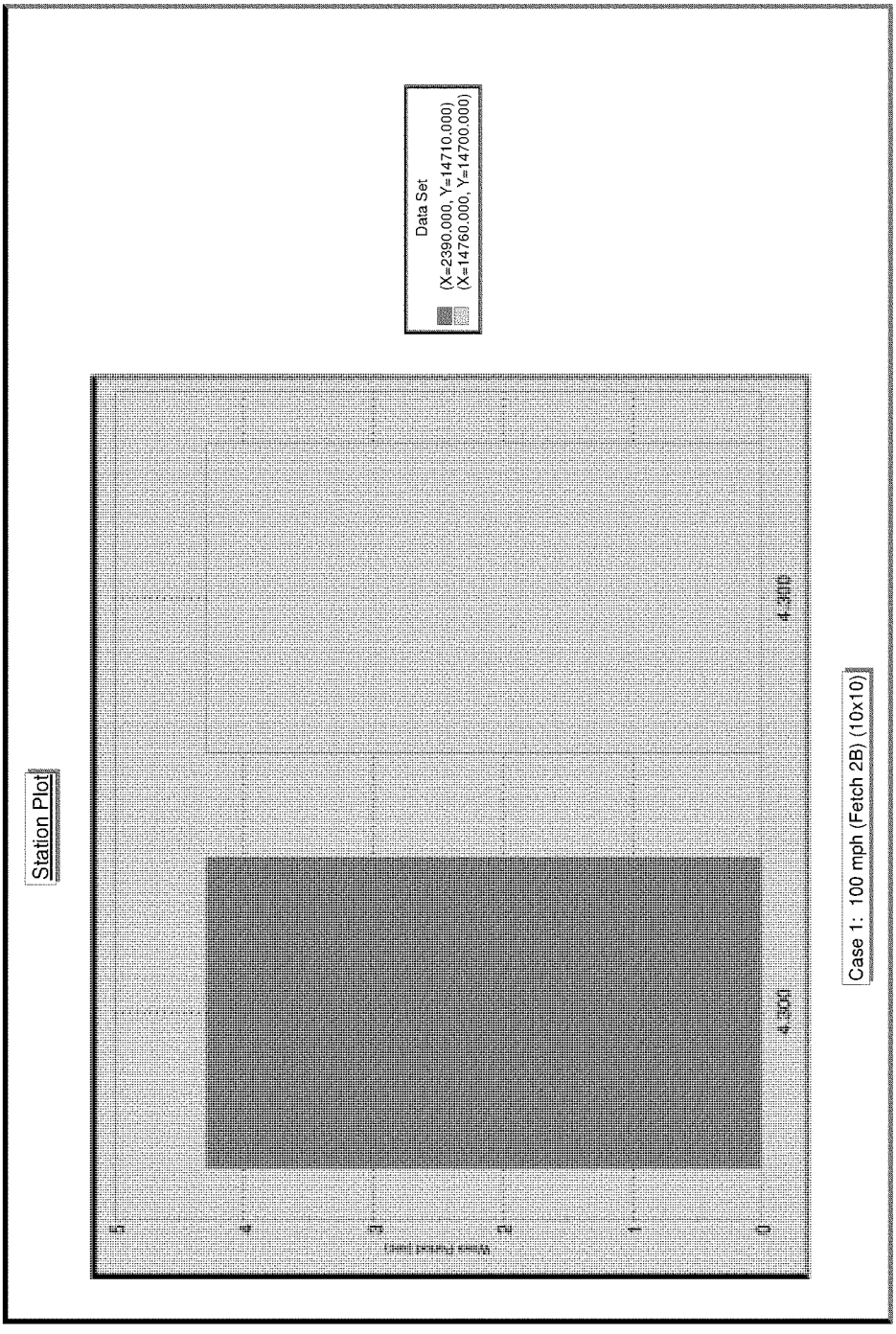
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: -45.00



4.30
4.12
3.94
3.76
3.58
3.40
3.22
3.04
2.86
2.68
2.50
2.32
2.14
1.96
1.78
1.60

X

Y


Station Plot
Data Set
(X=2390.000, Y=14710.000)
(X=14760.000, Y=14700.000)
Wave Period [sec]
5
4
3
2
1
0
4.300
4.300
Case 1: 100 mph (Fetch 2B) (10x10)

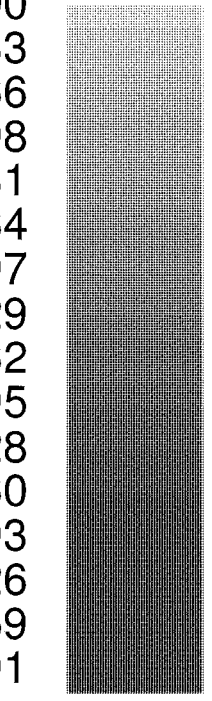
Case 1: 100 mph (Fetch 2B) (10x10)

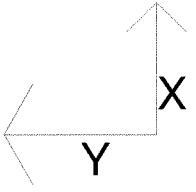
Bathymetry (ft)

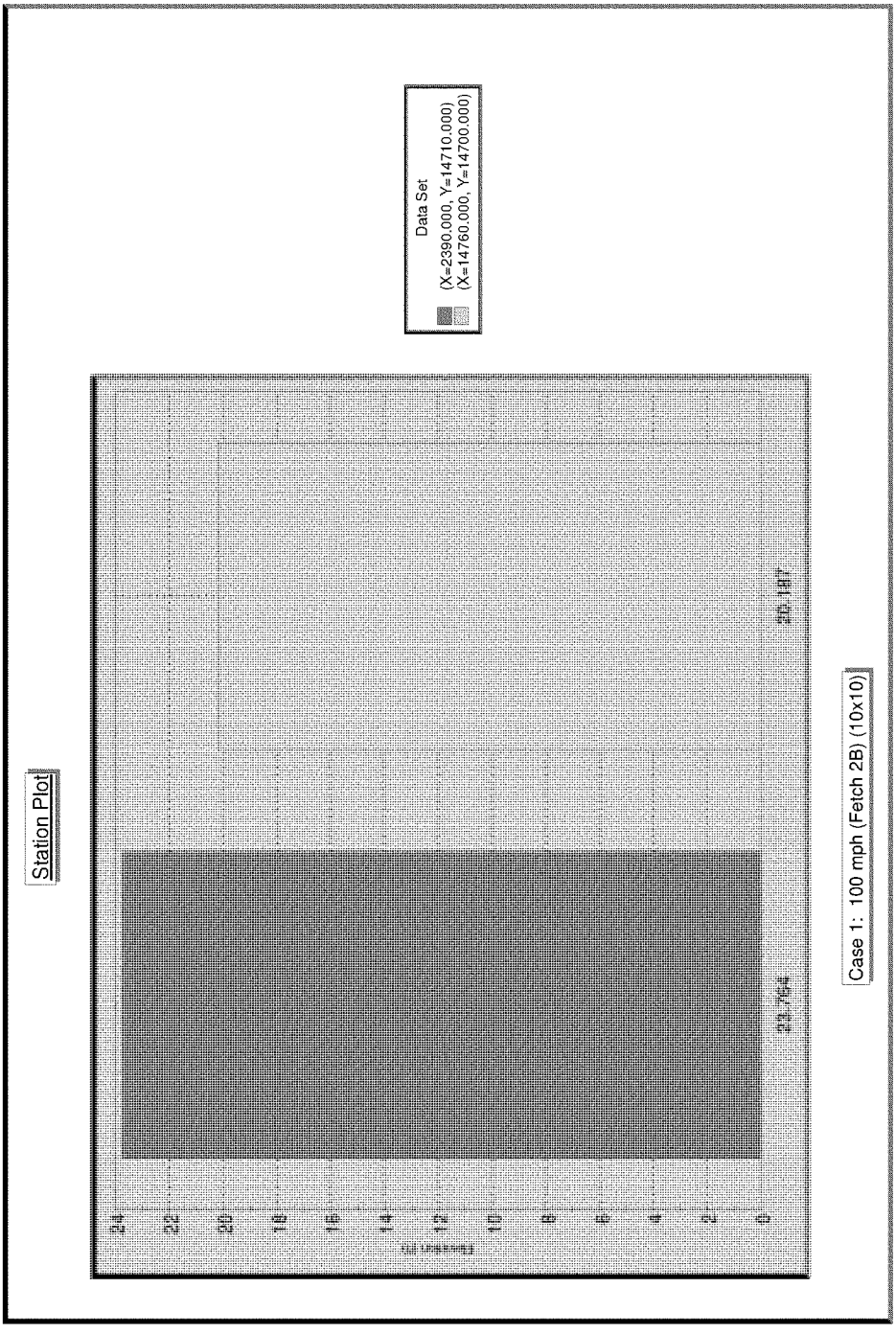
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: -45.00



55.00
52.33
49.66
46.98
44.31
41.64
38.97
36.29
33.62
30.95
28.28
25.60
22.93
20.26
17.59
14.91






Station Plot
Data Set
(X=2390.000, Y=14710.000)
(X=14760.000, Y=14700.000)
Case 1: 100 mph (Fetch 2B) (10x10)

Project:
Group: 10x10 - 0.001 Overtop WindSetup Incl.

Case:

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.500	ft	Runup for significant waves (R):	5.248	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.974	ft
Water depth at structure toe (ds):	23.590	ft	Relative height (ds/Ho):	3.383	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	32.500	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q^*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.001	ft^3/s-ft

2145

Project:
Group: 10x10 - 0.005 Overtop WindSetup Incl.

Case: Cell2(Fetch2B)(10x10)(100mph=147ft/s)WS=1.22'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.500	ft	Runup for significant waves (R):	5.248	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.974	ft
Water depth at structure toe (ds):	23.590	ft	Relative height (ds/Ho):	3.383	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	31.730	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.005	ft^3/s-ft

Project:
Group: 10x10 - 0.01 Overtop WindSetup Incl.

Case: Cell2(Fetch2B)(10x10)(100mph=147ft/s)WS=1.22'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.500	ft	Runup for significant waves (R):	5.248	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.974	ft
Water depth at structure toe (ds):	23.590	ft	Relative height (ds/Ho):	3.383	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	31.330	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*c):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.010	ft^3/s-ft

2147

Project:
Group: 10x10 - 0.1 Overtop WindSetup Incl.

Case: Cell2(Fetch2B)(10x10)(100mph=147ft/s)WS=1.22'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.500	ft	Runup for significant waves (R):	5.248	ft
Peak wave period (T):	4.300		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.974	ft
Water depth at structure toe (ds):	23.590	ft	Relative height (ds/Ho):	3.383	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.012	
Structure height above toe (hs):	29.690	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q^*o):	0.044	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.099	ft^3/s-ft

Internal Embankment

Internal Embankment Wind Setup Calculations

Internal Embankment
Wind Setup Calculations

Compute Wind Set-Up Cell 1

Four different methods are calculated and considered in estimating wind setup

Zeider Zee Eqn: Widely used as applied to reservoirs. Tends to overestimate wind setup for shallow impoundments (depth<16 ft).

Sibul Eqn: Typically yields the lowest wind setup.

Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (depth<16 ft) when Bretschneider has no numeric solution.

Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

Fetch Length, F =	2.65	miles	
Fetch Length, F =	14000	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{100\text{-}yr,t\text{-}min}$ =	100	mph	
NFSL Elevation + Surcharge =	46.13	feet	
Average Fetch Elevation =	21.79	feet	
Average Depth of Water along Fetch Line, D = Effective Depth =	24.34	feet	
Zeider Zee Eqn {Note: F=miles}: Wind Set-Up, $S = U^2F/(1400D)$ =	0.78	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn {Note: F=feet, g=32.2 ft/s²}: $S = 0.0000244d(F/d)^{1.66}(U^2/Fg)^{2.02(F/d)^{\wedge}-0.0768}$ =	0.20	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibel})/2$ =	0.49	feet	
Bretschneider Eqn {Note: Calcs provided separately in Step 18a}: $S = \Sigma\{(kU^2\Delta x)/(gd^2)\}$ =	-	feet	
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	0.78	feet	*(Eqn. 5, DCM-2)*

Compute Wind Set-Up Cell 2

Four different methods are calculated and considered in estimating wind setup

Zeider Zee Eqn: Widely used as applied to reservoirs. Tends to overestimate wind setup for shallow impoundments (depth<16 ft).

Sibul Eqn: Typically yields the lowest wind setup.

Ave. of Zeider Zee & Sibul: Recommended for shallow impoundments (depth<16 ft) when Bretschneider has no numeric solution.

Bretschneider Eqn: Recommend for shallow impoundments (average depth <16 ft).

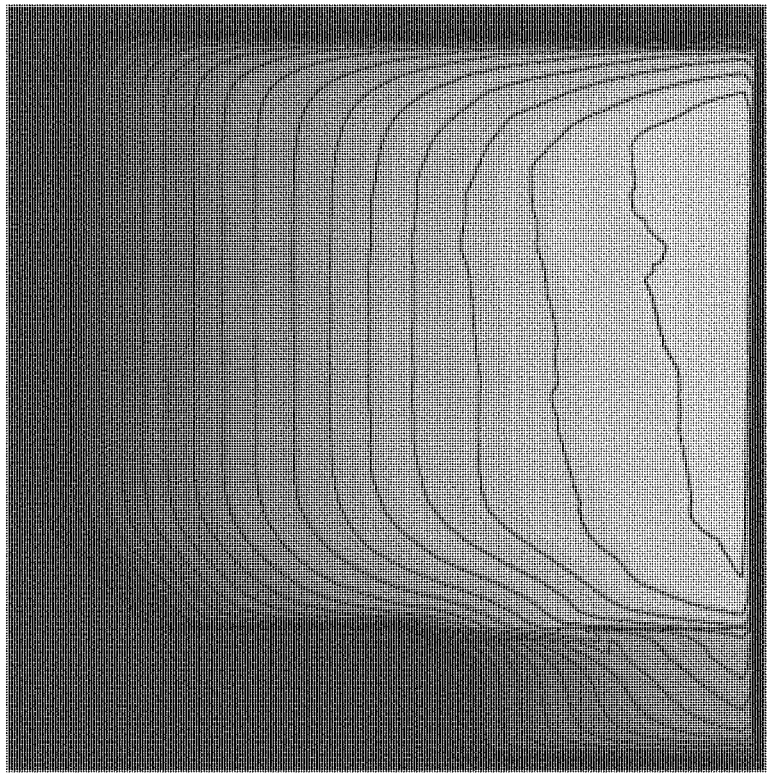
Fetch Length, F =	2.65	miles	
Fetch Length, F =	14000	feet	
Average Wind Velocity, U = Wind Speed per Step 7 = $U_{100\text{-}yr,t\text{-}min}$ =	100	mph	
	46.13	feet	
	24.47	feet	
Average Depth of Water along Fetch Line, D = Effective Depth =	21.66	feet	
Zeider Zee Eqn {Note: F=miles}: Wind Set-Up, $S = U^2F/(1400D)$ =	0.87	feet	*(Eqn. 5, DCM-2)*
Sibul Eqn {Note: F=feet, g=32.2 ft/s²}: $S = 0.0000244d(F/d)^{1.66}(U^2/Fg)^{2.02(F/d)^{\wedge}-0.0768}$ =	0.23	feet	*(Eqn. 7, DCM-2)*
Average of Zeider Zee & Sibul: Wind Setup, $S = (S_{Zeider\ Zee} + S_{Sibel})/2$ =	0.55	feet	
Bretschneider Eqn {Note: Calcs provided separately in Step 18a}: $S = \Sigma\{(kU^2\Delta x)/(gd^2)\}$ =	-	feet	
Equation Used for Wind Setup *(Enter Zeider Zee, Sibul, Average, Bretschneider)* =	Zeider Zee		
Computed Wind Set-Up, S =	0.87	feet	*(Eqn. 5, DCM-2)*

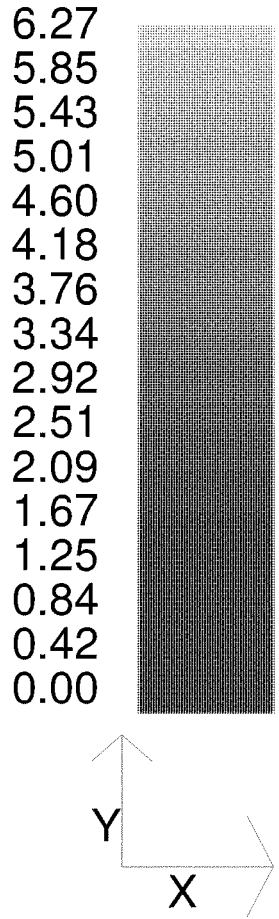
Internal Embankment Cell 1 Analyses

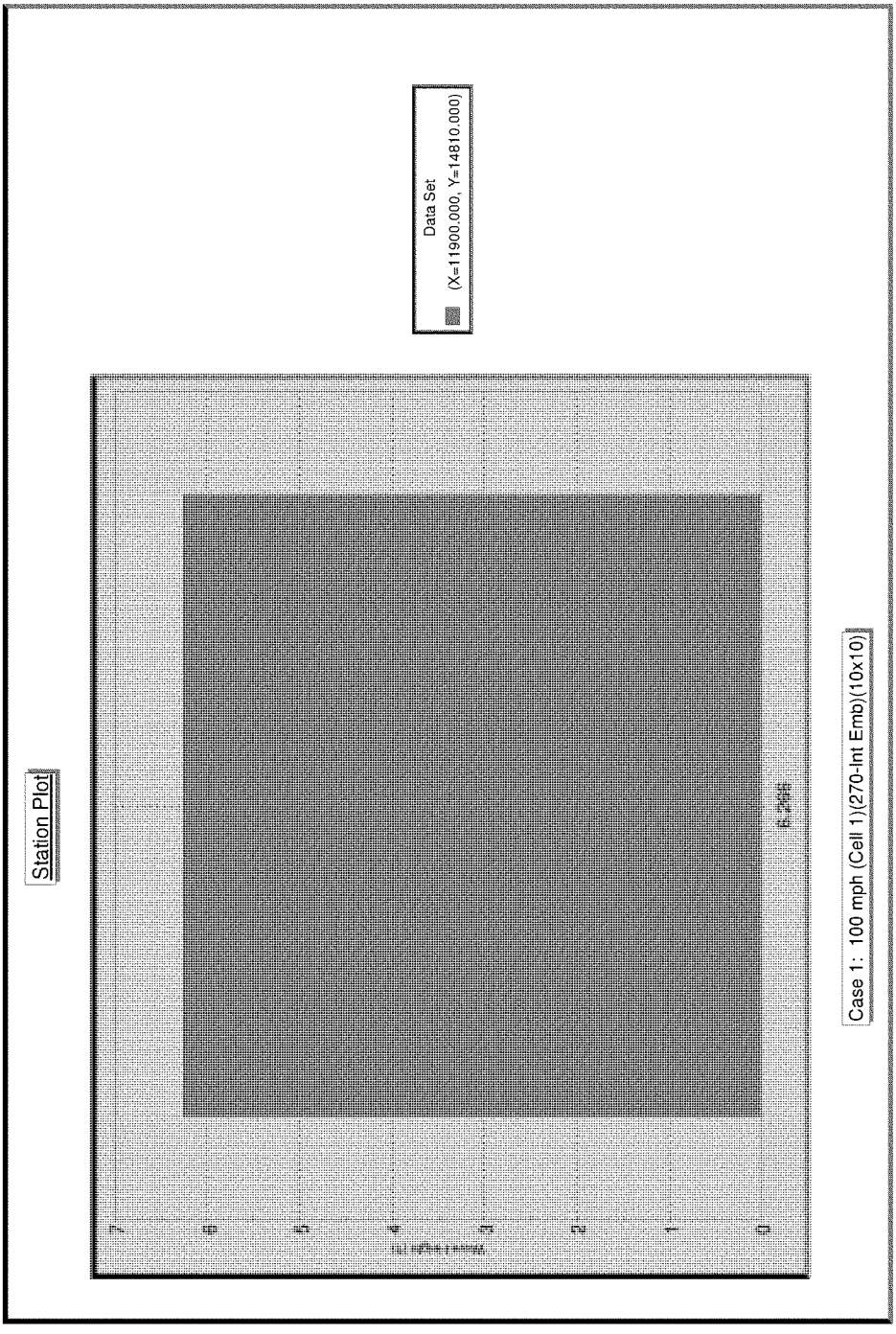
Case 1: 100 mph (Cell 1)(270-Int Emb)(10x10)

Wave Height (ft)

STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 0.00



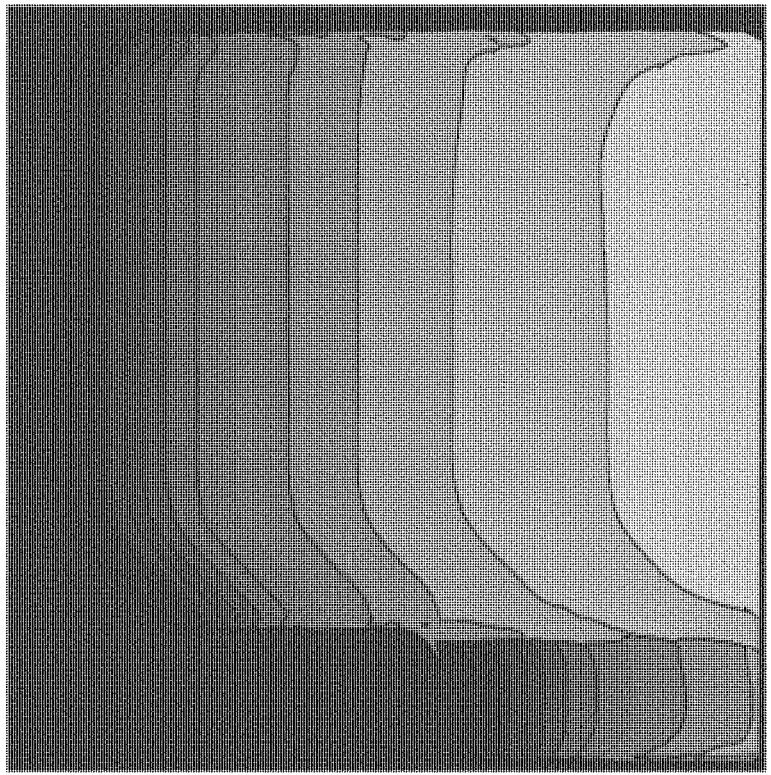



Station Plot
Data Set
(X=11900.000, Y=14810.000)
Case 1: 100 mph (Cell 1)(270-Int Emb)(10x10)

Case 1: 100 mph (Cell 1)(270-Int Emb)(10x10)

Wave Period (sec)

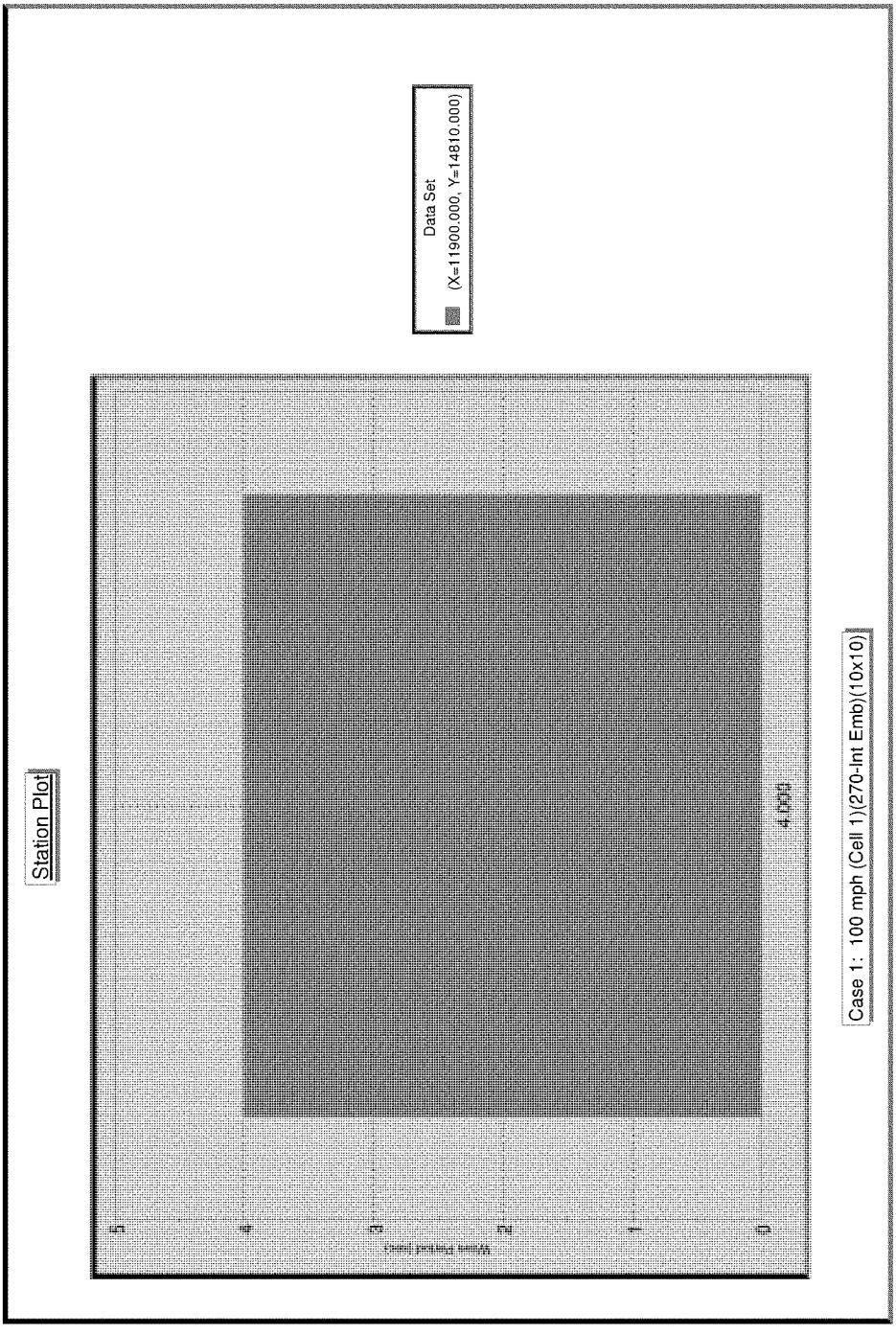
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 0.00



4.00
3.84
3.68
3.52
3.36
3.20
3.04
2.88
2.72
2.56
2.40
2.24
2.08
1.92
1.76
1.60

Y

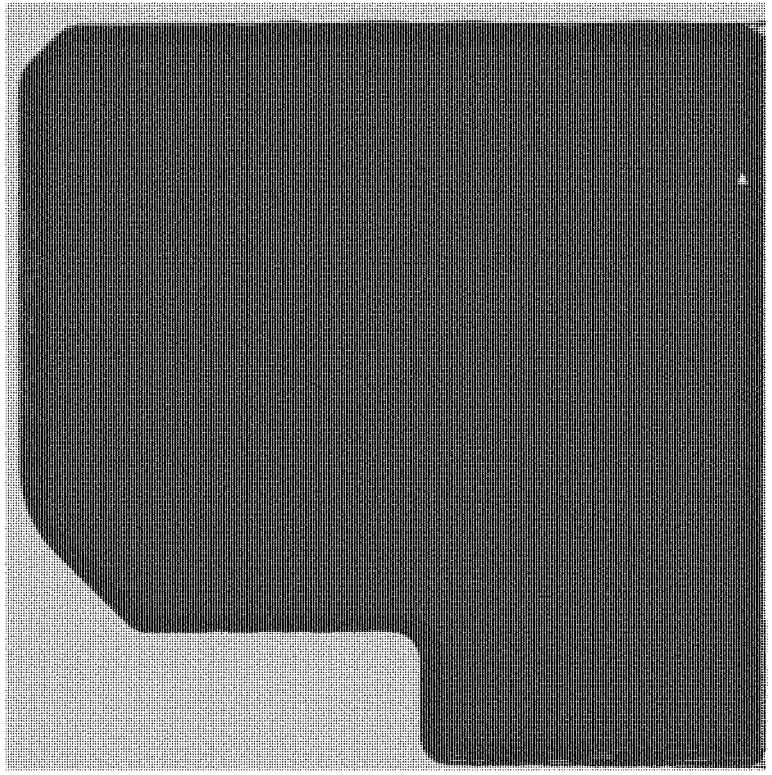
X


Station Plot
Data Set
(X=11900.000, Y=14810.000)
Case 1: 100 mph (Cell 1)(270-Int Emb)(10x10)

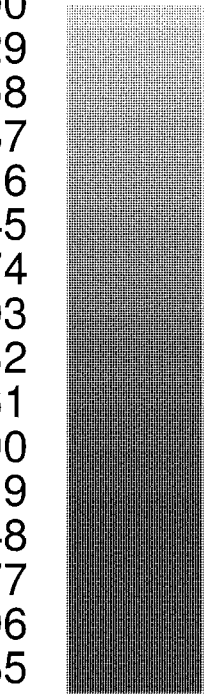
Case 1: 100 mph (Cell 1)(270-Int Emb)(10x10)

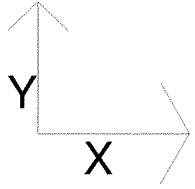
Bathymetry (ft)

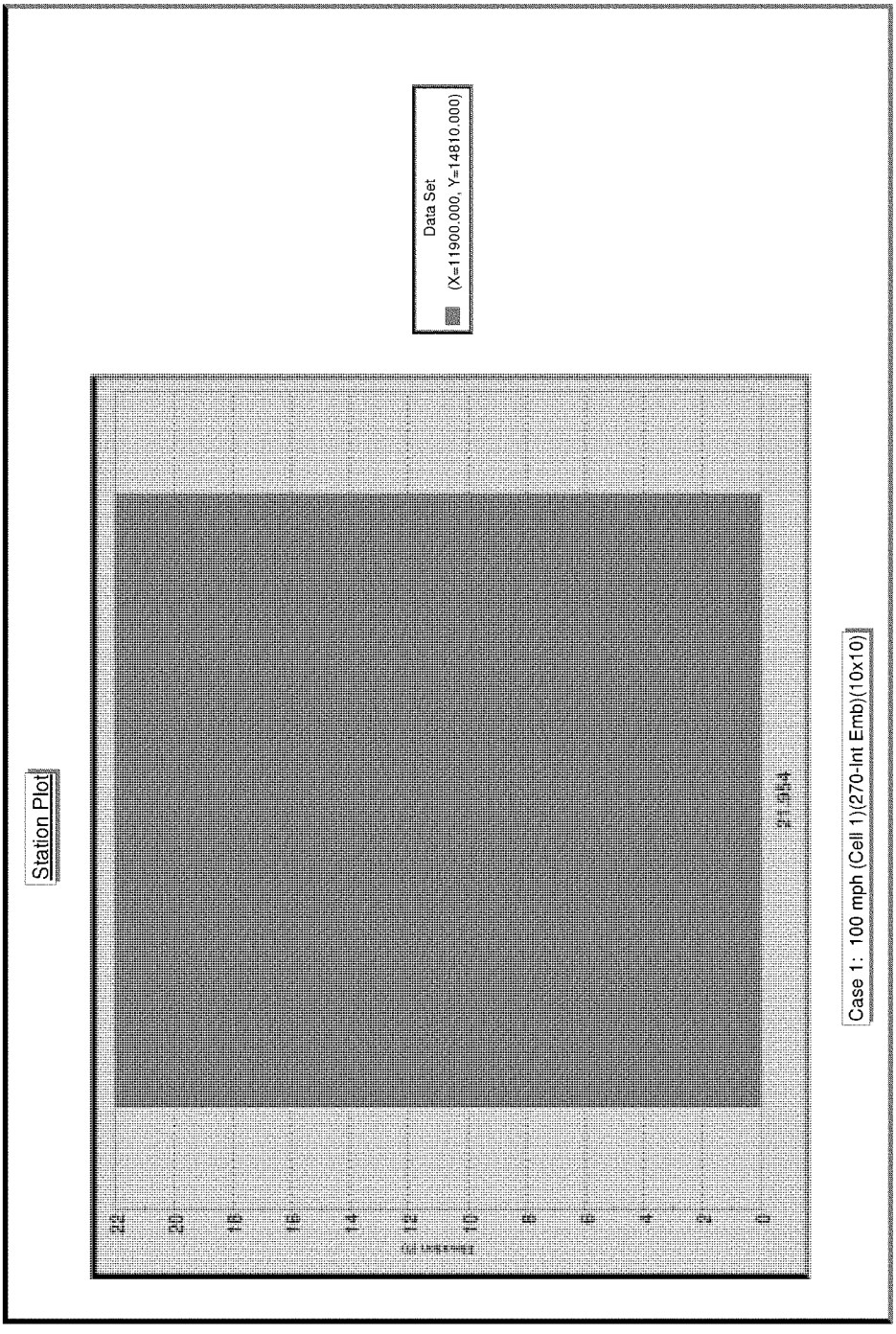
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 0.00



55.00
52.29
49.58
46.87
44.16
41.45
38.74
36.03
33.32
30.61
27.90
25.19
22.48
19.77
17.06
14.35






Station Plot
Data Set
(X=11900.000, Y=14810.000)
Case 1: 100 mph (Cell 1)(270-Int Emb)(10x10)

Project:
Group: 10x10 - 0.001 Overtop WindSetup Incl.

Case: Cell1(270)-(10x10)(100mph=147ft/s)WS=0.78'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.597	ft
Water depth at structure toe (ds):	24.960	ft	Relative height (ds/Ho):	3.784	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	33.210	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.041	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.001	ft^3/s-ft

2159

Project:
Group: 10x10 - 0.005 Overtop WindSetup Incl.

Case: Cell1(270)-(10x10)(100mph=147ft/s)WS=0.78'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.597	ft
Water depth at structure toe (ds):	24.960	ft	Relative height (ds/Ho):	3.784	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	32.470	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.041	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.005	ft^3/s-ft

2160

Project:
Group: 10x10 - 0.01 Overtop WindSetup Incl.

Case: Cell1(270)-(10x10)(100mph=147ft/s)WS=0.78'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.597	ft
Water depth at structure toe (ds):	24.960	ft	Relative height (ds/Ho):	3.784	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	32.090	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.041	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.010	ft^3/s-ft

2161

Project:
Group: 10x10 - 0.1 Overtop WindSetup Incl.

Case: Cell1(270)-(10x10)(100mph=147ft/s)WS=0.78'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.597	ft
Water depth at structure toe (ds):	24.960	ft	Relative height (ds/Ho):	3.784	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	30.550	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.041	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.099	ft^3/s-ft

Project:
Group: 10x10 - 1.0 Overtop WindSetup Incl.

Case: Cell1(270)-(10x10)(100mph=147ft/s)WS=0.78'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.597	ft
Water depth at structure toe (ds):	24.960	ft	Relative height (ds/Ho):	3.784	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT²):	0.013	
Structure height above toe (hs):	28.590	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*c):	0.041	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.990	ft³/s-ft

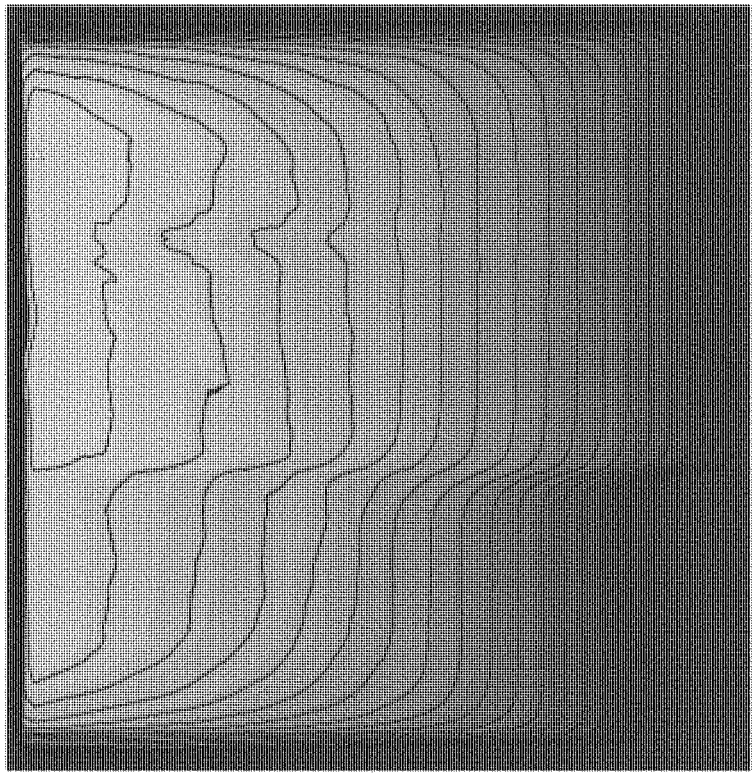
2163

Internal Embankment Cell 2 Analyses

Case 1: 100 mph (Cell 2)(90-Int Emb)(10x10)

Wave Height (ft)

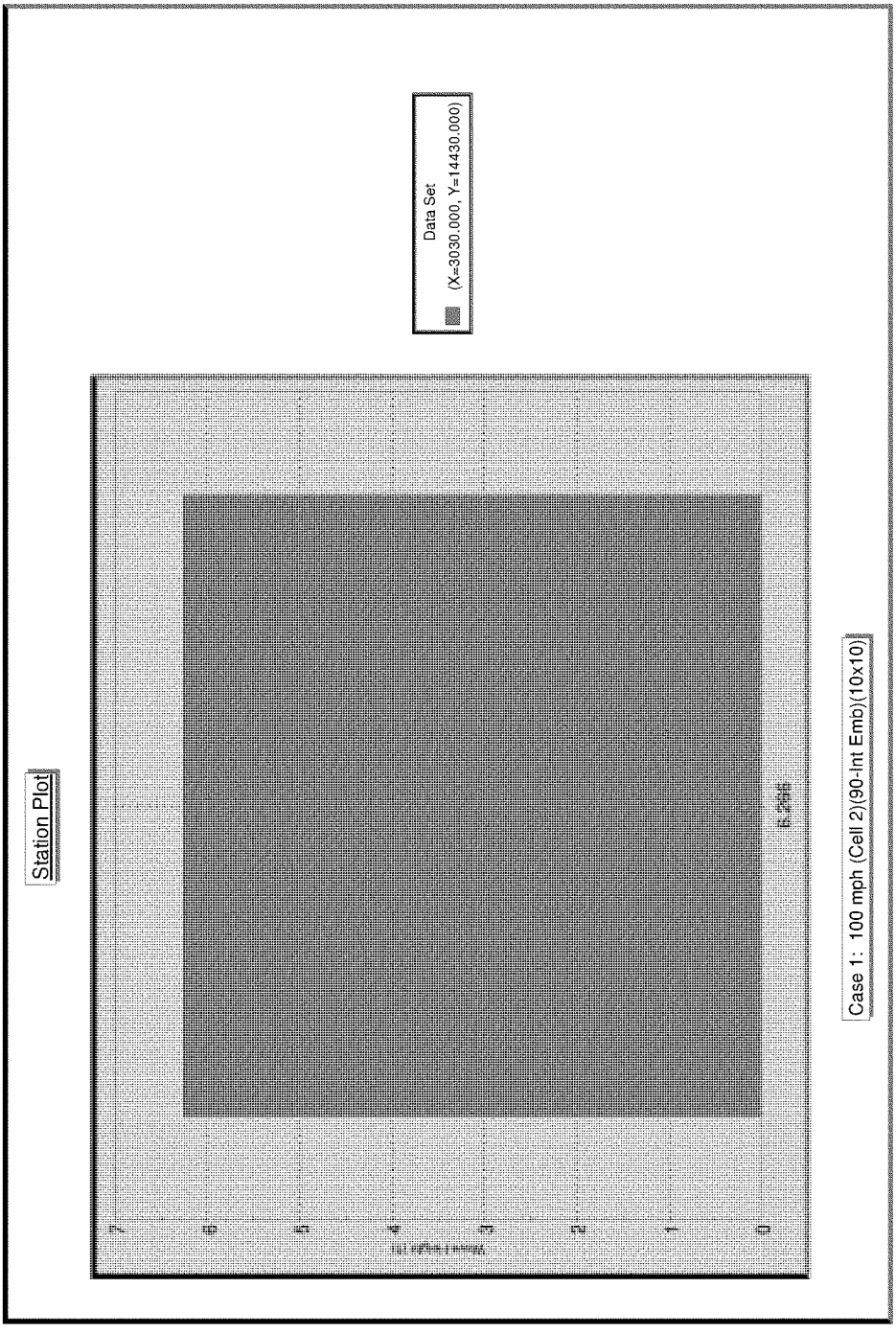
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 0.00



6.27
5.85
5.43
5.01
4.60
4.18
3.76
3.34
2.92
2.51
2.09
1.67
1.25
0.84
0.42
0.00

X

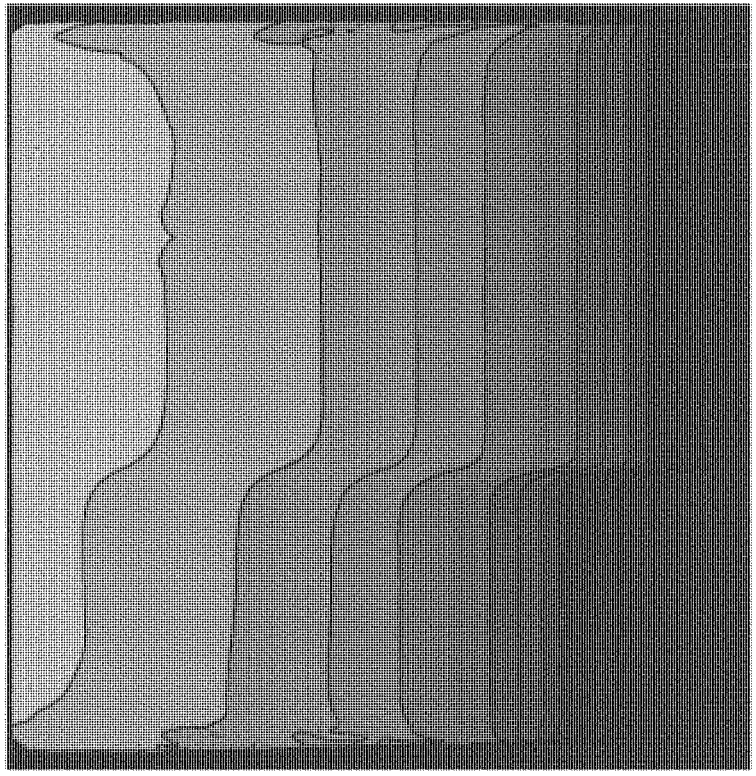
Y

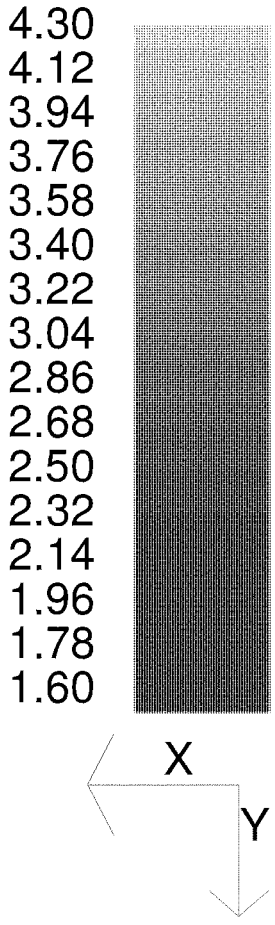

Station Plot
Data Set
(X=3030.000, Y=14430.000)
Case 1: 100 mph (Cell 2)(90-Int Emb)(10x10)

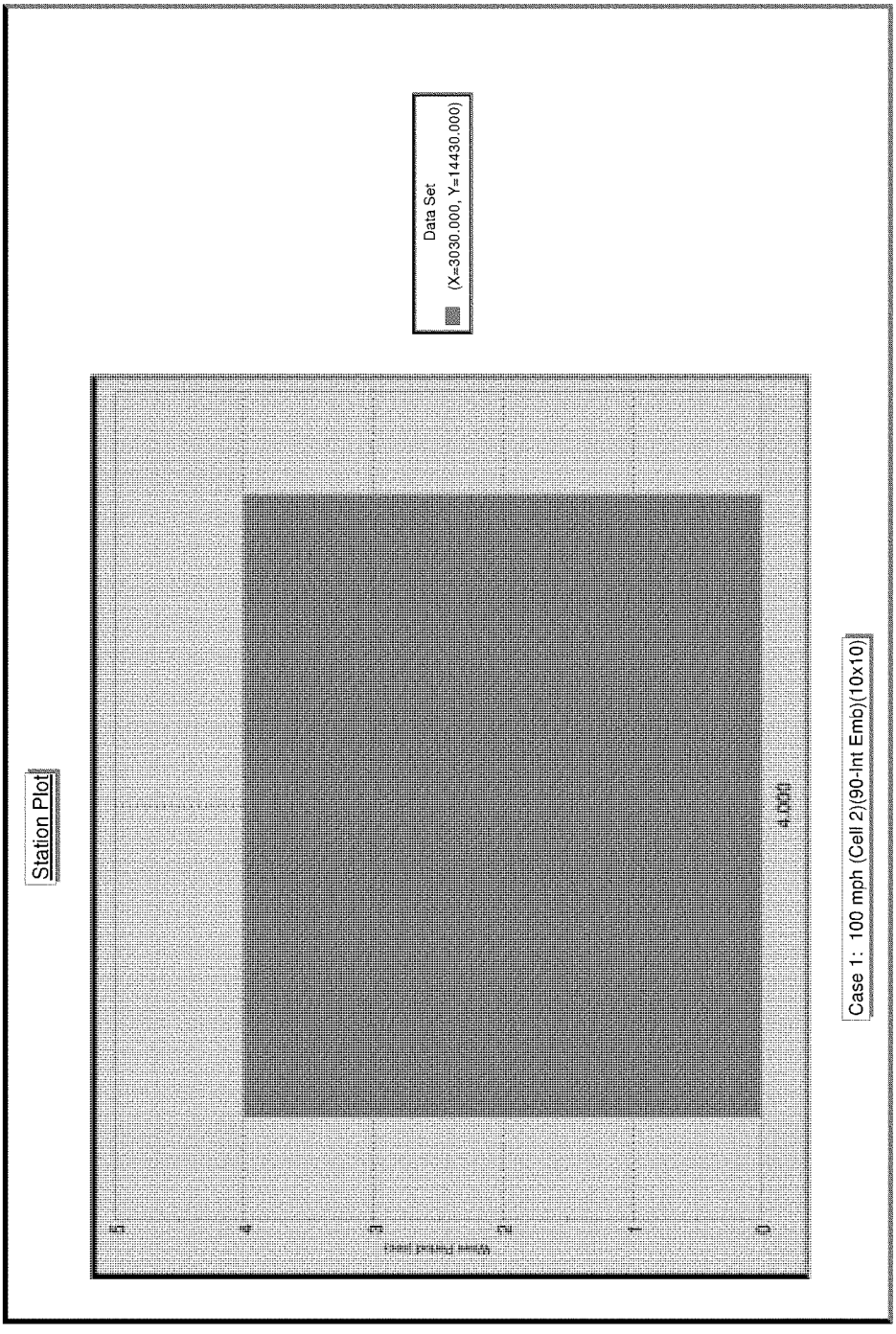
Case 1: 100 mph (Cell 2)(90-Int Emb)(10x10)

Wave Period (sec)

STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 0.00



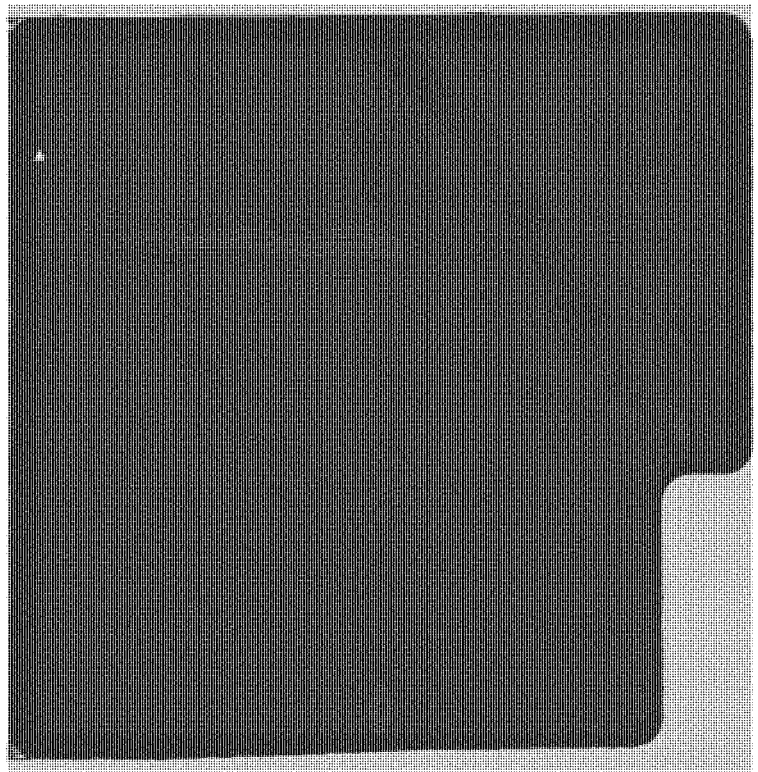



Station Plot
Data Set
(X=3030.000, Y=14430.000)
Case 1: 100 mph (Cell 2)(90-Int Emb)(10x10)

Case 1: 100 mph (Cell 2)(90-Int Emb)(10x10)

Bathymetry (ft)

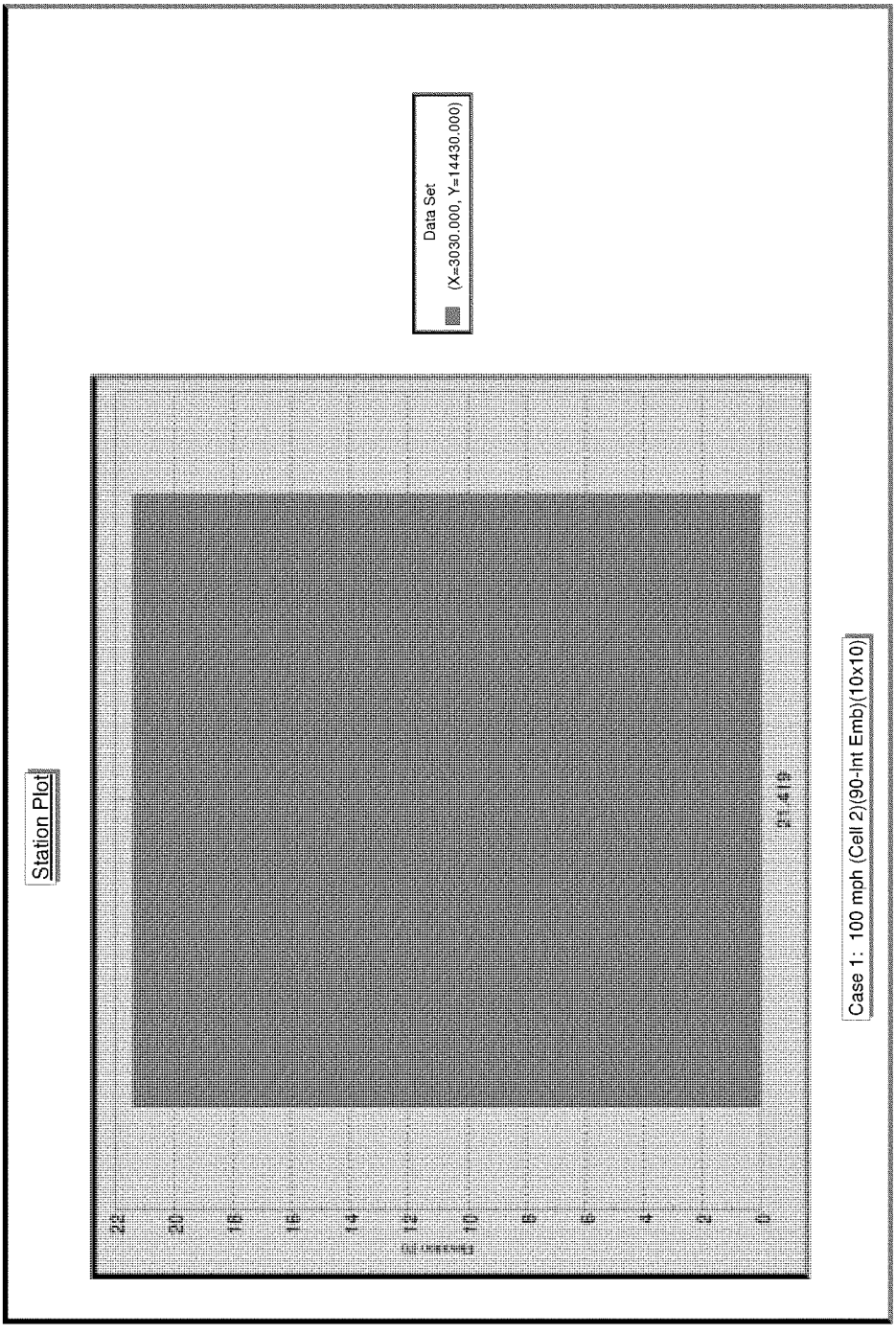
STWAVE: Event 1 H: 0.00 T: 1.59 Theta: 0.00 U: 44.70 Udir: 0.00



55.00
52.32
49.65
46.97
44.30
41.62
38.95
36.28
33.60
30.93
28.25
25.58
22.90
20.23
17.55
14.88

X

Y


Station Plot
Data Set
(X=3030.000, Y=14430.000)
22
20
18
16
14
12
10
8
6
4
2
0
21:419
Case 1: 100 mph (Cell 2)(90-Int Emb)(10x10)

Project:
Group: 10x10 - 0.001 Overtop WindSetup Incl.

Case: Cell2(90)-(10x10)(100mph=147ft/s)WS=0.87'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.580	ft
Water depth at structure toe (ds):	25.580	ft	Relative height (ds/Ho):	3.887	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	33.830	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.042	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.001	ft^3/s-ft

2171

Project:
Group: 10x10 - 0.005 Overtop WindSetup Incl.

Case: Cell2(90)-(10x10)(100mph=147ft/s)WS=0.87'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.580	ft
Water depth at structure toe (ds):	25.580	ft	Relative height (ds/Ho):	3.887	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT²):	0.013	
Structure height above toe (hs):	33.100	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.042	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.005	ft³/s-ft

2172

Project:
Group: 10x10 - 0.01 Overtop WindSetup Incl.

Case: Cell2(90)-(10x10)(100mph=147ft/s)WS=0.87'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.580	ft
Water depth at structure toe (ds):	25.580	ft	Relative height (ds/Ho):	3.887	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT²):	0.013	
Structure height above toe (hs):	32.710	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.042	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.010	ft³/s-ft

2173

Project:
Group: 10x10 - 0.1 Overtop WindSetup Incl.

Case: Cell2(90)-(10x10)(100mph=147ft/s)WS=0.87'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.580	ft
Water depth at structure toe (ds):	25.580	ft	Relative height (ds/Ho):	3.887	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT^2):	0.013	
Structure height above toe (hs):	31.170	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*c):	0.042	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.100	ft^3/s-ft

2174

Project:
Group: 10x10 - 1.0 Overtop WindSetup Incl.

Case: Cell2(90)-(10x10)(100mph=147ft/s)WS=0.87'

Wave Runup and Overtopping on Impermeable Structures

Wave type: Irregular Slope type: Rough
Rate estimate: Overtopping

Breaking criteria:	0.780				
Incident significant wave ht (Hi):	6.270	ft	Runup for significant waves (R):	4.881	ft
Peak wave period (T):	4.000		Onshore wind velocity (U):	147.000	ft/sec
COTAN of nearshore slope (cot phi):	100.000		Deepwater significant wave (Ho):	6.580	ft
Water depth at structure toe (ds):	25.580	ft	Relative height (ds/Ho):	3.887	
COTAN of structure slope (cot theta):	3.000		Wave steepness (Ho/gT²):	0.013	
Structure height above toe (hs):	29.210	ft	Overtopping coef(alpha):	0.076	
Rough slope coefficient(a):	0.956		Overtopping coef(Q*o):	0.042	
Rough slope coefficient(b):	0.398		Overtopping rate (Q):	0.998	ft³/s-ft

2175

Appendix G:
C-43 WSR Overwash Rate Memo

MEMO

TO: LuAnn McVicker, PhD, PE
Project Manager
C-43 West Storage Reservoir

DATE: March 7, 2007

FROM: Dave Grounds

SUBJECT: C-43 WSR Overwash Rate

An overtopping rate of 0.001 cfs/LF of dam was used for the C-43 West Storage Reservoir (C-43 WSR) 30% design submittal before the overwash tests were performed. This overtopping rate was based on DCM-2 and the example analysis contained in DCM-2 as well as discussions with USACE and A8 staff. This overtopping rate was chosen for the C-43 WSR site primarily due to the highly erodible "fine sand and silt" that will be used to construct the dam. In addition, a dam-break analysis was conducted to determine the hazard classification of the C-43 WSR and to determine the potential flooding effects on the adjacent properties. According to the classification system in the SFWMD Design Criteria Manual DCM-1, the proposed C-43 WSR has been classified as a high hazard potential impoundment.

The highly erodible on-site soil conditions were further documented during the construction of the C-43 Test Cell Project. Very minimal project rain events produced deep "gulley" erosion on the dam slope as well as the Perimeter Canal slopes. The erosion potential was greatly increased by the lack of vegetative cover and/or concentrated run-off flows.

As you know, overwash tests were completed on vegetated portions of the test cell embankment during the week of December 18, 2006. On Wednesday December 20, 2006 the overwash test used a flow rate of 0.01 cubic feet per linear foot of embankment (cfs/LF). For the first 3.5 hours, no significant erosion was observed. At 3 hours and 35 minutes into the test, a gully began forming rapidly at the center of the slope. The soil appeared to be saturated and began to quickly erode into the gully. Once the gully began to form, the erosion rate increased to the point where the major gully was incised into the embankment slope to a depth of over four feet.

The "washouts" created by 0.01 cfs/LF at the C-43 Test Cell are not acceptable for the long-term integrity of the dam. These washouts would be even more pronounced with the C-43 WSR dam crest at elevation 56.6 feet, instead of the crest elevation 42.0 feet at the Test Cell Project. At a minimum, this overwash rate would likely require substantial maintenance and repair of the downstream embankment slope and could result in "cutting back" into the filter blanket and toe drain system. If the C-43 WSR embankment is exposed to the 0.01 cfs/LF overwash rate for a sustained amount of time, the erosion would be uncontrolled and could threaten the embankment integrity.

Based on the results of the C-43 Test Cell overwash tests, it was determined that an overwash rate of 0.005 cfs/LF would be acceptable and would be used for final design or the C-43 WSR. However, after construction is completed, it would require that a good maintenance program be implemented and maintained for the life of the C-43 WSR. This long-term maintenance must ensure that the vegetative cover will be maintained in at least the same condition as the C-43 Test Cell Project was at the time it was tested. It is our opinion that this vegetative condition is reasonable to expect in the long-term with a good maintenance program.

The overwash test on the C-44 WSR Project indicated that if the reservoirs were properly sodded and maintained as a sodded "lawn", then an overwash rate of 0.01 cfs/LF could be used. In our meeting of March 1, 2007, it was

the consensus among the Operations and Maintenance staff that this sod condition would not last after 5 to 10 years and from that point forward the exterior of the reservoirs would most likely be represented by the C-43 Overwash Test.

The condition of the C-43 Test Cell turf at the time of the overwash test is comparable to and resembles the current turf condition of the dam around Lake Okeechobee. The Lake Okeechobee dam is representative of what can be expected after 5 to 10 years of maintenance. At some point during a period of drought and long after the results of this overwash test are forgotten, the vegetative cover of the C-43 WSR is expected to be no better than the Lake Okeechobee dam and would be representative of the turf condition during the C-43 Test Cell overwash test. Therefore, the C-43 WSR's safety will be compromised with any overwash rate exceeding 0.005 cfs/LF. It is simply too optimistic to assume that the exterior of the C-43 WSR will be maintained as a lawn for the next 50+ years.

By using an overwash rate of 0.01 cfs/LF when compared to a rate of 0.005 cfs/LF, the project savings for the C-43 WSR is approximately $2.3 million. Although this amount is significant, it is very small (less than 1%) when compared to an overall project cost of $334 million and certainly does not justify using the higher overwash rate.

Other considerations for safety at the C-43 WSR site include its close proximity to existing development and in the future will probably be bordered by development on the north, east and south sides. If any type of failure were to occur, very significant loss of life could result. The C-43 WSR is also within 3,000 feet of SR-80, which is a hurricane evacuation route and can not be compromised.

To follow the design criteria as described in DCM-2, "the designer must apply engineering judgment in analyzing the risk and acceptable over-wash rate that is selected for each embankment." Based on the overwash test results, site investigations, risk analysis and intensive overtopping rate modeling analyses, Stanley is responsible and is in the best position to select an acceptable over-wash rate for the C-43 WSR Project.

In summary, it is Stanley's position that an overwash rate of 0.005 cfs/LF is correct for the C-43 WSR Project for the long-term safety and integrity of the C-43 WSR and this rate will be used for final design.

A.13 TECHNICAL MEMORANDUM – TOWNSEND CANAL IMPACTS FOR VARIOUS PUMPING SCENARIOS AT C43PS-1

TECHNICAL MEMORANDUM

TO: ACCELR8
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

DATE: January 19, 2007

FROM: Stanley Consultants, Inc.
1601 Belvedere Road, Suite 400 East
West Palm beach, Florida 33406

SUBJECT: **Work Order C-C10401P-WO 09, Revision 1: Task 4.3** – Townsend Canal Impacts for Various Pumping Scenarios at C43PS-1

INTRODUCTION:

The following technical memorandum summarizes the evaluation, findings and proposed improvements from HEC-RAS modeling of the Townsend Canal for various pumping scenarios. The evaluation examines impacts to the Townsend Canal, S.R. 80 Bridge and Duda Pump Station, (Duda PS), from the addition and operation of Pump Station No. 1, (C43PS-1) of the proposed C-43 Reservoir. Additionally, the capacity or limitations, from the Townsend Canal Weir and Gated Orifice Structure, (Townsend Canal Structure), was considered in the analysis.

The HEC-RAS simulations of the Townsend Canal consisted of modeling the following pumping scenarios, with indicated conditions, to establish existing parameters and predict proposed water surface profiles:

1. **Existing canal geometry, including Townsend Canal Structure**, for pumping **600 cfs** from the Caloosahatchee River (C-43) to Berry Groves Pump Station (300 cfs) and the Duda PS (300 cfs).
2. **Existing canal geometry** and proposed **1,500 cfs pump** station at C43PS-1 with the **Townsend Canal Structure removed**, and **300 cfs** to the Duda PS
3. **Proposed canal geometry** (e.g. canal cross-section improvements), **1,500 cfs pump** at C43PS-1 with **Townsend Canal Structure in place** and **300 cfs** to Duda PS.
4. **Proposed canal geometry, 1,500 cfs pump** at C43PS-1 with the **Townsend Canal Structure removed** and **300 cfs** to Duda PS.
5. **Proposed canal geometry, 2,000 cfs pump** at C43PS-1 with the **Townsend Canal Structure removed** and **300 cfs** to Duda PS.

6. **Proposed canal geometry, 2,500 cfs pump** at C43PS-1 with the **Townsend Canal Structure removed** and **300 cfs** to Duda PS.
7. **Proposed canal geometry, 3,800 cfs pump** at C43PS-1 with the **Townsend Canal Structure removed** and **300 cfs** to Duda PS.

For reference, it should be noted, under natural flow conditions or when pumps are not "ON", the Townsend Canal flows northerly to the Caloosahatchee River. Therefore the Caloosahatchee River is the downstream receiving water body for the Townsend Canal. For all natural flow conditions, the flow rate is controlled by the weir portion of the Townsend Canal Structure, which is a 70.4 linear-foot broad-crested weir with a crest elevation of 2.37' North American Vertical Datum, (NAVD). For the purposes of discussion and consistency in the memorandum the Caloosahatchee River will always be referred to as "downstream" with respect to the Townsend Canal. However, during pumping operations the direction of flow reverses and the Caloosahatchee River becomes "upstream" with respect the flow within the Townsend Canal.

The Townsend Canal Structure was analyzed for existing conditions with 'Head vs. Discharge' curves to determine the level of influence, on flow conditions at the mouth of the Townsend Canal. When the pumps are on the pump induced flow into the Townsend Canal from the Caloosahatchee River is controlled by 10-6'x6' orifices with flap gates, in the Townsend Canal Structure. The 10 orifices are positioned linearly below the 70.4-foot weir crest and cut directly through the Townsend Canal Structure. Each orifice has a common flow-line elevation of -5.2' NAVD. When the water surface elevation exceeds 2.37' NAVD in the Caloosahatchee River, flow passes over the 70.4-foot weir of the Townsend Canal Structure in addition to the orifice flow. The orifices permit flow, in one direction, from the Caloosahatchee River to the Townsend Canal due to the flap gates positioned on the southern face of the Townsend Canal Structure. The flap gates are closed over the orifice openings during natural flow conditions, but open when the flow direction is reversed from existing pump activation. The orifices with flap gates induce head loss; and the elevation, dimensions and physical configuration of the Townsend Canal Structure with respect to common water surface elevations, in both the Townsend Canal and Caloosahatchee River create limiting flow conditions. This presents one of the main obstacles to overcome for the proposed pumping scenarios.

APPROACH:

The Townsend Canal was modeled using the U.S. Army Corps of Engineers, (USACE), HEC-RAS software, Version 3.1.3. The analysis examines the Canal in two sections, the Northern Section, which is considered to be from the mouth of the Townsend Canal at the Caloosahatchee River to the proposed "Junction" point in the Townsend Canal. The "Junction" branches to the Intake Canal of the C-43 Reservoir and provides conveyance to the primary C-43 Reservoir Pump Station; C43PS-1. The C43PS-1 structure lies approximately 1,050 feet east of the Townsend Canal. The second or Southern Section of the Townsend Canal is from the "Junction" point, south to the Duda PS. Refer to Attachment 'A' for the Townsend Canal Orientation Plan.

All model runs were performed until a constant water surface elevation, (WSEL), of 2.00 NAVD in the Caloosahatchee River was obtained for each scenario. The WSEL of 2.00 NAVD was selected as a baseline elevation for proposed conditions. The benefit of obtaining a constant WSEL in the Caloosahatchee River allows for direct comparisons of the water surface profile conditions, between the various pumping scenarios. The modeled Townsend Canal section from the Caloosahatchee River to the Duda PS is 3.18 miles long, with incremental distances of; 0.41 miles from the Caloosahatchee River to the S.R. 80 Bridge, 0.98 miles from the Caloosahatchee River to the proposed Junction at the Intake Canal to C43PS-1.

The Existing Condition Geometry includes original Townsend Canal cross-sections determined from survey information. The Existing Condition Geometry, HEC-RAS model runs include a 600 cfs flow rate through the Townsend Canal Structure with 300 cfs diverting to the existing Berry Groves Pump station and the remaining 300 cfs continuing to the Duda PS. This run mimics the current pumping scenario and establishes the WSEL at the Duda PS. A second model was run using the Existing Condition Geometry, the Townsend Canal Structure removed and a flow of 1,800 cfs (1,500 cfs for C43PS-1 and 300 cfs for the Duda PS). The result from this run indicated considerable losses in the North Section and demonstrated the need for improvements to the canal to accommodate the proposed flows and to maintain the pre-reservoir WSEL in the canal at the Duda PS.

Both Existing Condition Geometry model runs indicate that the existing cross-sections of the Townsend Canal from the Junction point south to the Duda PS as having sufficient capacity for 300 cfs. As a result, all proposed geometry changes or improvements should occur only in the North Section of the Townsend Canal.

The initial improvements to the North Section Geometry examine 1,800 cfs through the improved Townsend Canal with the Townsend Canal Structure in place. The losses through the structure for 1,800 cfs correlate to 1.1 feet of head, which is directly subtracted from the water surface elevation of 2.00' NAVD at the Caloosahatchee River. This forces the WSEL at the Duda PS to be significantly lower than existing conditions in order to produce a WSEL at the mouth of the Townsend Canal 0.9' NAVD. Therefore, all Proposed Condition model runs are performed with the Townsend Weir Structure removed, varying C43PS-1 pump rates and 300 cfs continuing to the Duda PS.

All proposed improvement HEC-RAS model runs for the various pumping rates include expanding or reshaping only the North Section canal geometry. Proposed improvements at the SR-80 Bridge include reshaping the canal side-slopes, re-armoring (rip-rap) the side-slopes and adding armor to the canal bottom. Based on the surveyed cross-sections, the canal bottom at the SR 80 Bridge has already scoured beyond the scour depth anticipated during the bridge design. For that reason the proposed improvements do not include lowering the canal flow-line within approximately 100-feet north and south of the SR 80 Bridge.

The physical criteria for cross-sectional improvements and design goals for all pumping conditions consisted of the following:

- Provide a water surface elevation at Duda PS of approximately 1.0 NAVD
- Limit flow velocity near the S.R. 80 Bridge to 3.0 fps
- Limit flow velocity in the Townsend canal to less than 2.5 fps
- Avoid over-excavation of the canal bottom to eliminate undermining of the existing side-slopes
- Avoid over-excavating of the canal bottom on either side of the bridges to eliminate significant fluctuations in the canal bottom profile which might create critical velocity conditions.
- Increase cross-sectional area by expanding the canal width
- Limit Townsend Canal improvements to within the existing right-of-way

RESULTS:

Each of the HEC-RAS, water surface profile model run simulations is summarized below:

Existing Canal Geometry, 600 cfs – with Townsend Canal Structure (Table 1)

This HEC-RAS model run examines the existing canal geometry and a total flow rate of 600 cfs through the Townsend Canal Structure which introduces 0.15 feet of head loss. At approximately the midpoint of the canal, 300 cfs diverts to the Berry Groves Pump Station and the remaining 300 cfs continues to the Duda PS. This evaluation establishes a baseline for the WSEL and velocities.

Table 1: HEC-RAS Profile Summary

Townsend Canal Location	Flow Rate (cfs)	Channel Velocity (fps)	Water Surface Elevation (NAVD)
C-43 & Townsend	600	0.74	1.85 (2.00-0.15)
S.R. 80 Bridge	600	1.17	1.70
Junction for C43PS-1	600	0.74	1.63
Duda PS	300	0.65	1.24

Existing Canal Geometry, 1,800 cfs – without Townsend Canal Structure (Table 2)

This HEC-RAS model run examines conditions and impacts from a 1,500 cfs pump flow at C43PS-1 along with the 300 cfs at the Duda PS. The purpose is to examine the impact and determine the capacity or capability of the existing Townsend Canal geometry, without the Townsend Canal Structure, but with respect to proposed pump flow. The results clearly identify considerable losses in the North Section. This indicates that without canal improvements, the WSEL (-3.00) at the Duda PS is not acceptable. The WSEL of 2.10 at the connection between the Townsend Canal and the Caloosahatchee River is the limiting WSEL prior to incurring a critical velocity flow regime. Critical velocities of approximately 10 fps are unacceptable for the Townsend Canal.

Table 2: HEC-RAS Profile Summary

Townsend Canal Station	Flow Rate (cfs)	Channel Velocity (fps)	Water Surface Elevation (NAVD)
C-43 & Townsend	1,800	2.14	2.10
S.R. 80 Bridge	1,800	4.30	0.41
Junction for C43PS-1	1,800	3.74	-0.75
Duda PS	300	1.84	-3.00

North Section Improvements, 1,800 cfs – with Townsend Canal Structure (Table 3)

This HEC-RAS model run simulates improvements to the Townsend Canal cross-sections in the North Section. Additional armoring and bank protection is proposed at the SR 80 Bridge location, which allows for higher velocities through the bridge opening. The purpose of this modeling scenario is to examine the impact the Townsend Canal Structure has on higher flow rates due to pumping conditions, with Townsend Canal improvements for increased capacity. The results indicate a head loss of 1.1 feet through the Townsend Canal Structure. This loss reduces the water surface elevation at the mouth of the Townsend Canal which reduces the cross-sectional flow area, and consequently the water surface at the Duda PS is well below the elevation that was determined for current flow conditions. The results indicate that the Townsend Canal Structure introduces losses that create conditions incapable of conveying the various proposed pumping scenario flow rates.

Table 3: HEC-RAS Profile Summary

Townsend Canal Location	Flow Rate (cfs)	Channel Velocity (fps)	Water Surface Elevation (NAVD)
C-43 & Townsend	1,800	1.92	0.93 (2.00-1.07)
S.R. 80 Bridge	1,800	3.09	0.56
Junction for C43PS-1	1,800	2.84	-0.61
Duda PS	300	1.35	-2.00

North Section Improvements, 1,800 cfs – without Townsend Canal Structure (Table 4)

This HEC-RAS model run proposes cross section improvements along the entire North Section of the Townsend Canal. The improvements consist of streamlining the bottom elevation to reduce obstructions and re-grading the eastern bank side-slope. Additional modifications include configuring the cross-sections at the S.R. 80 Bridge to 1:1 side-slope and armoring the side-slopes and canal bottom. The improvements provide minor increases in the cross-sectional flow area, but primarily eliminate inconsistencies in the bottom elevation of the canal and reduce losses. The final modification consists of removing the Townsend Canal Structure. No modifications are proposed for the Townsend Canal south of the Junction for conveyance of 300 cfs to the Duda PS.

Table 4: HEC-RAS Profile Summary

Townsend Canal Location	Flow Rate (cfs)	Channel Velocity (fps)	Water Surface Elevation (NAVD)
C-43 & Townsend	1,800	2.15	2.01
S.R. 80 Bridge	1,800	2.83	1.64
Junction for C43PS-1	1,800	2.23	1.28
Duda PS	300	0.67	1.00

Refer to Attachment 'B' for cross-sections showing improvements at the SR 80 Bridge corresponding to the 1,500 cfs, 2,000 cfs, 2,800 cfs and 3,800 cfs pumping scenarios.

North Section Improvements, 2,300 cfs – without Townsend Canal Structure (Table 5)

This model run proposes cross section improvements along the entire North Section of the Townsend Canal. The improvements consist of streamlining and excavating the bottom elevation to reduce obstructions and excavating the eastern bank side slope. Additional modifications include configuring the cross-sections at the S.R. 80 Bridge to 1:1 side-slope and armoring the side-slopes and canal bottom. Additionally, the improvements include beginning the 1:1 side-slopes at a higher elevation which effectively increases the bottom width. The improvements provide an increase in the cross-sectional flow area, and eliminate inconsistencies in the bottom elevation of the canal and reduce losses. The final modification consists of removing the Townsend Canal Structure. No modifications are proposed for the Townsend Canal, south of the Junction, for conveyance of 300 cfs to the Duda PS.

Table 5: HEC-RAS Profile Summary

Townsend Canal Location	Flow Rate (cfs)	Channel Velocity (fps)	Water Surface Elevation (NAVD)
C-43 & Townsend	2,300	2.14	2.01
S.R. 80 Bridge	2,300	3.33	1.63
Junction for C43PS-1	2,300	2.35	1.30
Duda PS	300	0.67	1.03

North Section Improvements, 2,800 cfs – without Townsend Canal Structure (Table 6)

This HEC-RAS model run proposes cross section improvements along the entire North Section of the Townsend canal. The improvements consist of excavating the bottom elevation to the same depth as the 2,300 cfs pump scenario with additional expansion or widening to the eastern bank side-slope. Additional modifications include configuring the cross-sections at the S.R. 80 Bridge to 1:1 side-slope, armoring the side-slopes, canal bottom and constructing an additional bridge span to accommodate the wider cross-section. The improvements provide a significant increase in the cross-sectional flow area, and eliminate inconsistencies in the bottom elevation of the canal and reduce losses. The final modification consists of removing the Townsend Canal Structure. No modifications are proposed for the South Section of the Townsend Canal, which conveys the 300 cfs to the Duda PS. The widening of the Townsend Canal North Section requires additional right-of-way to accommodate the required maintenance berm.

Table 6: HEC-RAS Profile Summary

Townsend Canal Location	Flow Rate (cfs)	Channel Velocity (fps)	Water Surface Elevation (NAVD)
C-43 & Townsend	2,800	2.23	2.00
S.R. 80 Bridge	2,800	3.02	1.66
Junction for C43PS-1	2,800	2.40	1.33
Duda PS	300	0.66	1.06

North Section Improvements, 4,100 cfs – without Townsend Canal Structure (Table7)

This HEC-RAS model run proposes cross section improvements along the entire North Section of the Townsend Canal. The improvements consist of further excavating the bottom and additional expansion or widening of the cross-sections. The proposed widening is configured to fit within the extent of the canal right-of-way however; additional right-of-way is required to accommodate the required maintenance berm. Additional modifications include configuring the cross-sections at the S.R. 80 Bridge to 1:1 slope, stabilizing the side slope and canal bottom and constructing two additional bridge spans to accommodate the wider cross-section. The improvements provide a significant increase in the cross-sectional flow area, and eliminate inconsistencies in the bottom elevation of the canal to reduce losses. The final modification consists of removing the Townsend Canal Structure. No modifications are proposed for the Townsend Canal south of the Junction for conveyance of 300 cfs to the Duda PS.

Table 7: HEC-RAS Profile Summary

Townsend Canal Location	Flow Rate (cfs)	Channel Velocity (fps)	Water Surface Elevation (NAVD)
C-43 & Townsend	4,100	2.31	2.00
S.R. 80 Bridge	4,100	3.01	1.68
Junction for C43PS-1	4,100	2.53	1.38
Duda PS	300	0.66	1.12

CONCLUSION:

The model runs determined the following:

- For the existing pumping conditions (600cfs), the WSEL at the Duda PS was determined from the model to be 1.24' NAVD. This established a baseline elevation at the Duda PS for analyzing proposed pump-flow scenarios.
- The proposed pumping scenarios without any canal improvements create erosive velocities and lower the WSEL at the Duda PS significantly below the baseline elevation. Therefore canal improvements are necessary.

The goal was to quantify the impacts to the canal from the proposed pumping scenarios, determine necessary improvements for acceptable flow conditions in the canal and estimate the improvement costs associated with each pumping scenario.

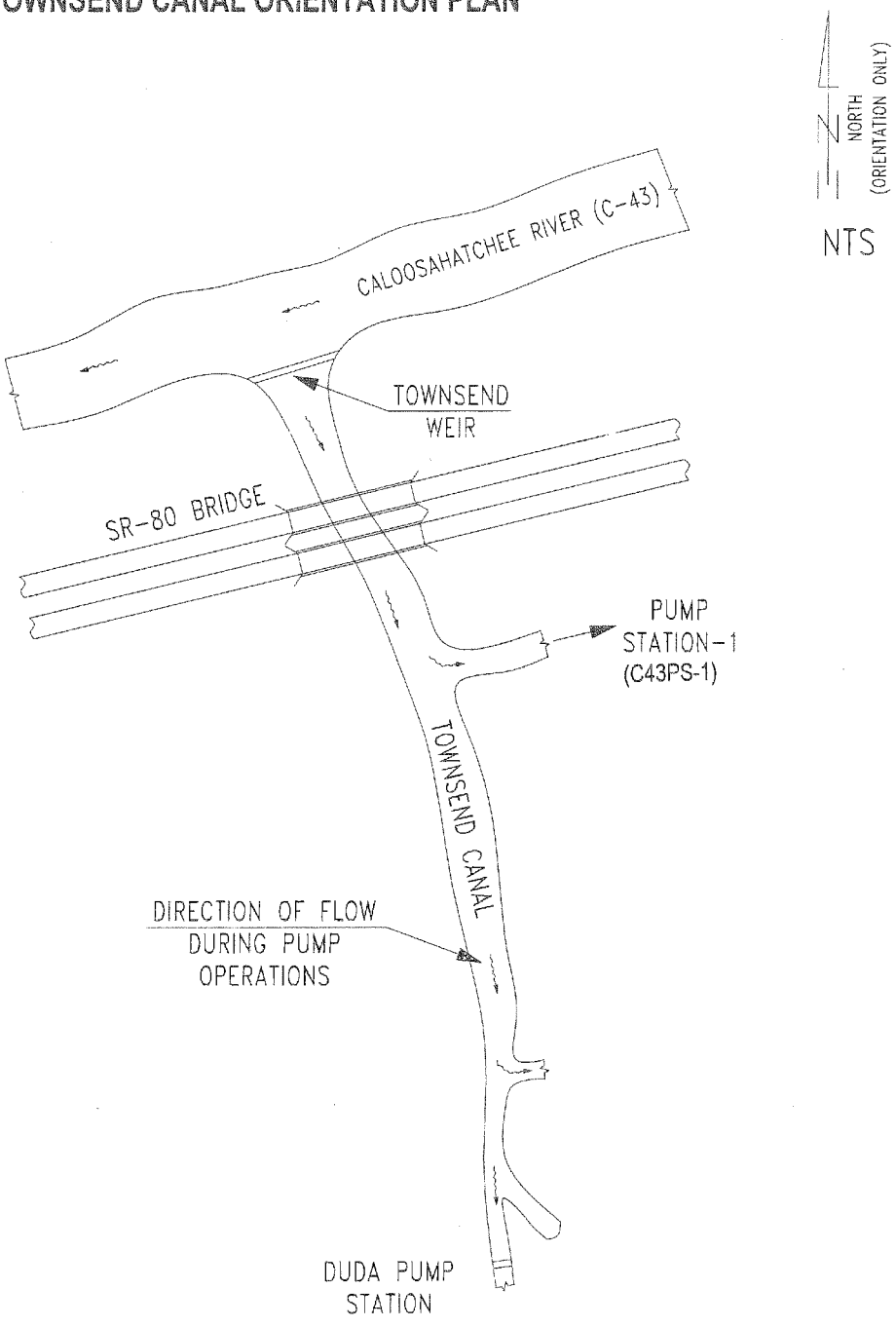
As previously indicated, all improvements are proposed within the North Section of the Townsend Canal. They include removal of the Townsend Canal Structure, providing erosion protection (rip-rap armoring) along the side-slopes and the canal bottom at the S.R. 80 Bridge and re-grading the Townsend Canal cross-section (earthwork increases as the pump flows increase). These improvements are considered the necessary minimum, and are recommended for all proposed pumping scenarios.

Based on the FDOT Bridge Hydraulics Sheet and canal surveys, the Townsend Canal at the S.R. 80 Bridge has exceeded the anticipated scour. Therefore, minimal excavation is proposed in the canal adjacent to the Bridges and erosion protection is proposed for the side slopes and bottom to eliminate further scouring. Velocity rates around the S.R. 80 Bridge have been limited to values around 3.0 fps.

To assist in the selection of a pump station size, costs were assigned to the various pumping scenario improvements. Refer to attachment 'C' for the C43PS-1 Pump Station Capacity Comparison table.

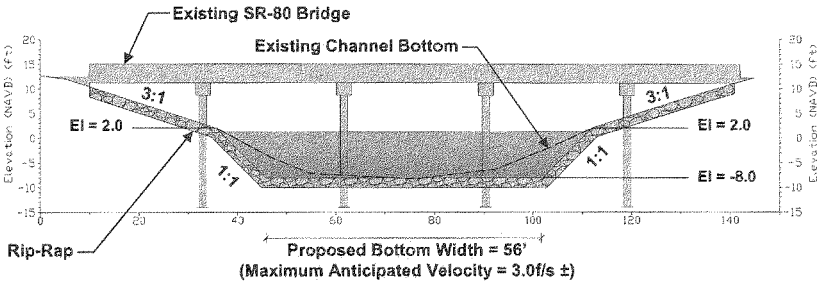
Attachment A
Townsend Canal Orientation Plan

TOWNSEND CANAL ORIENTATION PLAN



Attachment B
Townsend Canal: Channel Improvements at SR-80 Bridge

C-43 WEST STORAGE RESERVOIR
CHANNEL IMPROVEMENTS AT SR-80 BRIDGE

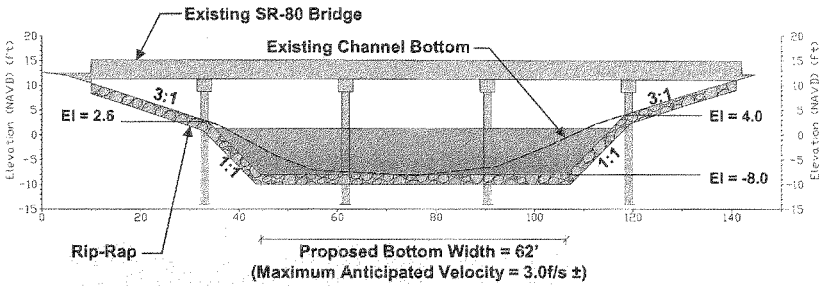


PUMP STATION CAPACITY AT 1500 CFS
LOOKING NORTH (DOWNSTREAM)

ACCELER8
everglades now.org

Stanley Consultants INC.

C-43 WEST STORAGE RESERVOIR
CHANNEL IMPROVEMENTS AT SR-80 BRIDGE

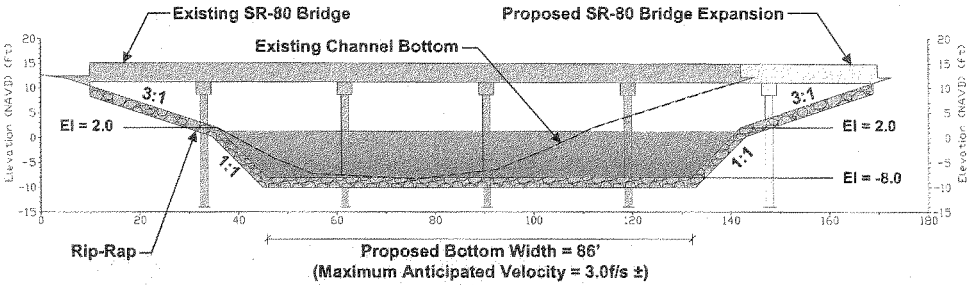


PUMP STATION CAPACITY AT 2000 CFS
LOOKING NORTH (DOWNSTREAM)

ACCELER8 Improvement Now!

Stanley Consultants INC

C-43 WEST STORAGE RESERVOIR
CHANNEL IMPROVEMENTS AT SR-80 BRIDGE

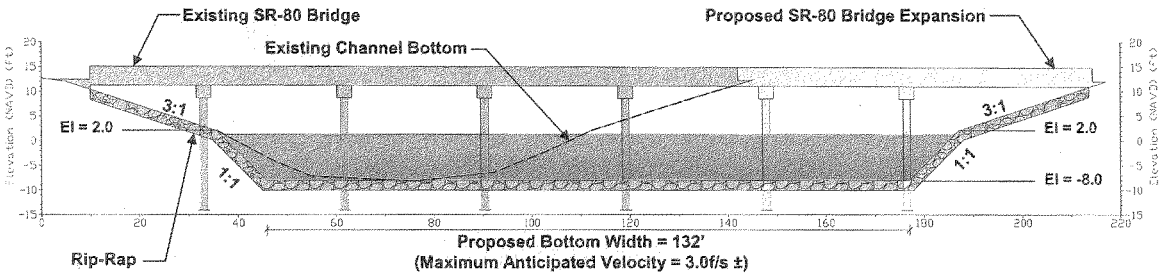


PUMP STATION CAPACITY AT 2500 CFS
LOOKING NORTH (DOWNSTREAM)

Stanley Consultants INC.

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

C-43 WEST STORAGE RESERVOIR
CHANNEL IMPROVEMENTS AT SR-80 BRIDGE



PUMP STATION CAPACITY AT 3800 CFS
LOOKING NORTH (DOWNSTREAM)

ACCELER8 everglades now.org

Stanley Consultants INC.

Attachment C

Proposed Improvements Table: C43PS-1 Pump Station Capacity Comparison

C-43 WSR
C43PS-1 PUMP STATION CAPACITY COMPARISON

Element	Unit	Unit Price	1,500 cfs		2,000 cfs		2,500 cfs		3,800 cfs	
			Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Remove Townsend Weir	LS	$300,000	1	$300,000	1	$300,000	1	$300,000	1	$300,000
Channel Excavation (C-43 to Bridge)	CY	$5.00	36,170	$180,849	58,218	$291,088	78,774	$393,871	125,264	$626,320
SR-80 Rip-Rap (Includes Excavation and Dewatering)	TN	$150.00	4,451	$667,583	4,553	$683,024	5,374	$806,114	6,358	$953,718
Lengthen Bridge (add 1 or 2 spans)(incl demo)	LS	See PS Options		$0		$0	1 Span	$770,000	2 Spans	$1,156,700
Channel Excavation (Bridge to PS-1 Junction)	CY	$5.00	63,801	$319,007	92,253	$461,265	146,553	$732,766	254,250	$1,271,252
Subtotal Canal Improvements				**$1,477,440**		**$1,735,376**		**$3,002,751**		**$4,367,990**
Increase in PS Cost	LS		1	$0	1	$11,000,000	1	$22,000,000	1	$31,000,000
Total Costs				**$1,477,440**		**$12,735,376**		**$25,002,751**		**$35,367,990**

SUMMARY								
Total PDR Cost Estimate:		$334,298,000		$334,298,000		$334,298,000		$334,298,000
Revised Cost Estimate:		**$335,775,440**		**$347,033,376**		**$359,300,751**		**$369,665,990**

NOTES:

1) The cost summary spread sheet indicates the cost impacts to the Townsend Canal, Townsend Canal Weir Structure, and the SR 80 Bridge for the various C43PS-1 capacity runs. The Townsend Canal improvements for all the runs are north of the C43PS-1 Pump Station. There are no Townsend Canal improvements between Duda's pump station and C43PS-1.

2) Only the major items have been included in the estimate. The unit prices used, contingency of 25%, and an escalation of 17.5% were the same as used in the PDR (30%) submittal.

3) The estimated cost for C43PS-1 (1500 cfs capacity) included in the PDR is $59, 817,000.

4) The maximum velocity in the Townsend Canal of 2.5 f/s was used for all the pump capacity runs. A maximum velocity of 3.0 f/s was used at the SR-80 bridge. A bridge typical section for each run will be provided as soon as they are developed. In general, the slopes at each abutment was steepened for the 1500 cfs and the 2000 cfs runs. For the 2500 cfs run the SR-80 bridge was lengthened by 30 ft. (one span). For the 3800 cfs run, the SR-80 bridge was lengthened by 60 ft. (two spans).

5) We have contacted FDOT to discuss the potential improvements to the SR 80 Bridge used in our cost analysis. FDOT will not make any commitment to accept any of the assumed improvements until a formal bridge hydraulics report and designs are submitted for their review

6) It should be noted that the Townsend Canal improvements north or the SR 80 bridge for the 3800 cfs C43PS-1 will not fit within the existing 200 ft. canal easement. This is probably true for the 2500 cfs run also. No additional cost for purchasing a wider canal easement has been included.

7) HACRAS pumping assumptions for the various capacity runs includes: C43PS-4 not pumping; Duda's pump station pumping 300 cfs; all water pumped from the C-43.

2200



US Army Corps
of Engineers®

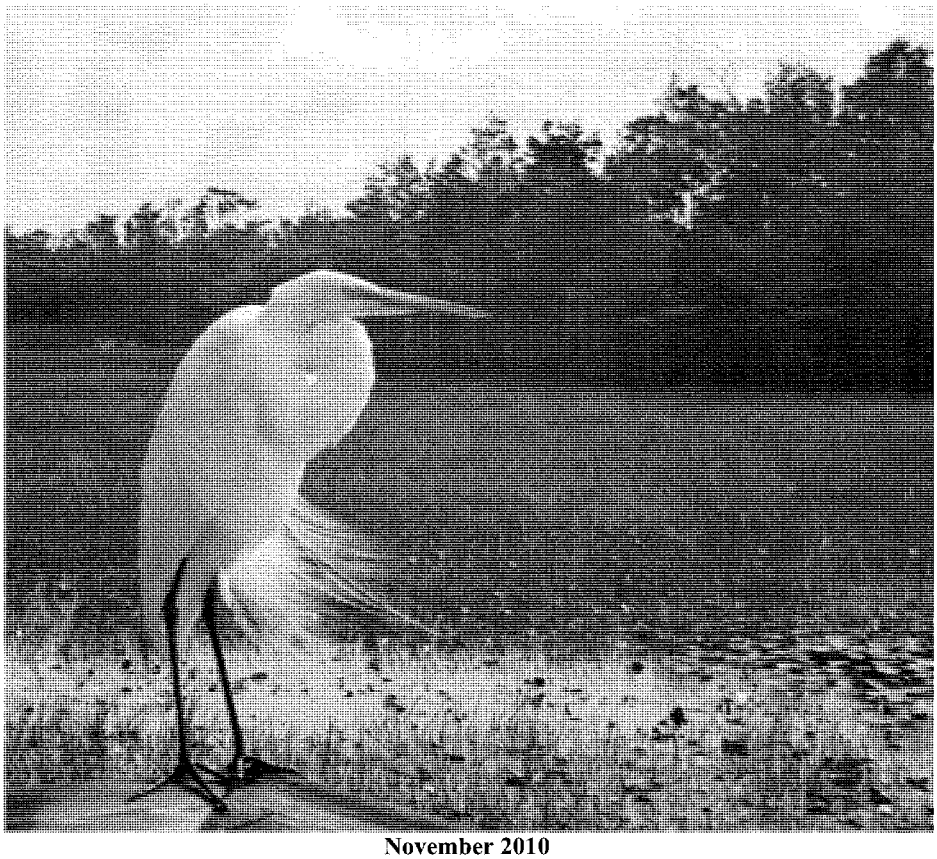
Jacksonville District



South Florida Water
Management District

CENTRAL AND SOUTHERN FLORIDA PROJECT
COMPREHENSIVE EVERGLADES RESTORATION PLAN
FINAL CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT
IMPLEMENTATION REPORT

FINAL APPENDICES
COST ESTIMATES – APPENDIX B
ENVIRONMENTAL INFORMATION – APPENDIX C
REAL ESTATE – APPENDIX D
AGENCY / PUBLIC COORDINATION – APPENDIX E
PLAN FORMULATION – APPENDIX F
ECONOMIC AND SOCIAL CONSIDERATIONS – APPENDIX G
RECREATION – APPENDIX H



November 2010

This Report Contains [5] Volumes

You Are Here

Volume 1 – Main Report – November 2010
- Addendum A
- Addendum B
- Executive Summary
- Section 1 – Introduction
- Section 2 – Existing Conditions/Affected Environment
- Section 3 – Future "Without Project" Condition
- Section 4 – Identification of Problems and Opportunities
- Section 5 – Formulation of Alternative Plans
- Section 6 – Environmental Effects of the Selected Alternative Plan
- Section 7 – The Selected Alternative Plan
- Section 8 – Plan Implementation
- Section 9 – Summary of Coordination, Public Views, and Comments
- Section 10 – Recommendations
- List of Report Preparers
- Index
- Glossary of Terms
- Acronyms
- References

Volume 2- Annex – September 2007
- Annex A – FWCA and Endangered Species Act Compliance

Volume 3 – Annexes – September 2007
- Annex B – NEPA Information
- Annex C – Analyses Required by WRDA 2000 and State Law
- Annex D – Draft Project Operating Manual and Monitoring Plan
- Annex E – Reports Provided by RECOVER to Support the PIR
- Annex F – CZM Consistency and 404(b)(1) Evaluations

Volume 4 – Appendices – November 2010
- Appendix A – Engineering

Volume 5 – Appendices – November 2010
- Appendix B – Cost Estimates
- Appendix C – Environmental Information
- Appendix D – Real Estate
- Appendix E – Agency / Public Coordination
- Appendix F – Plan Formulation
- Appendix G – Economic and Social Considerations
- Appendix H – Recreation

CENTRAL AND SOUTHERN FLORIDA PROJECT
CALOOSAHATCHEE RIVER (C43) WEST BASIN STORAGE RESERVOIR

FINAL APPENDICES

Cost Estimates – Appendix B
Environmental Information – Appendix C
Real Estate – Appendix D
Agency / Public Coordination – Appendix E
Plan Formulation – Appendix F
Economic and Social Considerations – Appendix G
Recreation – Appendix H

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

SOUTH FLORIDA WATER
MANAGEMENT DISTRICT

November 2010

This page intentionally left blank.

APPENDIX B
COST ESTIMATES

This page intentionally left blank

TABLE OF CONTENTS

B.0 COST ESTIMATES B-1
B.1 GENERAL INFORMATION B-1
B.1.1 Selected Alternative Plan B-2
B.1.2 Plan Formulation Cost Estimates B-5
B.2 PLAN FORMULATION COST ESTIMATES B-8
B.3 MCACES COST ESTIMATE B-16
B.4 TOTAL PROJECT COST SUMMARY B-26
B.5 RISK AND UNCERTAINTY ANALYSIS B-30
B.5.1 Risk analysis methods B-30
B.5.2 Qualitative description of risk B-30
B.5.3 Quantitative description of risk B-34
B.5.4 Monte Carlo Simulation Results B-39

LIST OF TABLES

Table 1. Weighted Profit Guidelines Calculation-Prime Contractor B-3
Table 2. Historic Pump Station Data B-6
Table 3. Curve Adjustment Calculation B-7
Table 4: Alternative 2 ..... B-8
Table 5: Alternative 3B B-10
Table 6: Alternative 3C B-12
Table 7: Alternative 4 ..... B-14
Table 8: Input for Monte Carlo simulation B-36

LIST OF FIGURES

Figure 1: Pump Station Cost Curves B-7
Figure 2: Certainty within $10,000,000 range B-38
Figure 3: Certainty within $20,000,000 range B-39

ADDITIONAL INFORMATION

Risk Analysis Results ..... Following page B-42

This page intentionally left blank

B.0 COST ESTIMATES

B.1 GENERAL INFORMATION

Corps of Engineers cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Instructions (EI) 01D010, Construction Cost Estimates, 1 September 1997 (also known as Unified Facilities Criteria 3-700-02A)
- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 31 March 1994
- ER 1110-2-1150, Engineering and Design For Civil Works Projects, 31 August 1999
- ER 1105-2-100, Planning Guidance Notebook, 22 April 2000, as amended
- Engineer Manual (EM) 1110-2-1304 (Tables revised 30 March 2007), Civil Works Construction Cost Index System, 31 March 2000

In addition, the set of plan formulation cost estimates used for plan selection rely on construction feature unit pricing and are prepared in Civil Works Breakdown Structure (CWBS) format to the subfeature level. The cost estimate supporting the National Ecosystem Restoration plan (Selected Alternative Plan) is prepared in MCACES/MII format to the CWBS subfeature level. This estimate is supported by the preferred labor, equipment, materials and crew/production breakdown. In addition, a fully funded (escalated for inflation through project completion) cost estimate, the Baseline Cost Estimate or Total Project Cost Summary, has been developed. A risk analysis was prepared that addresses uncertainties in Selected Alternative Plan cost items both qualitatively and quantitatively. The risk analysis is included at the end of this appendix. The goal of the cost estimating for the C-43 Reservoir study is to produce a final product (cost estimate) that is reliable and accurate and that defines the Government's and the non-Federal sponsor's obligations. The final product is also intended to support project authorization.

A 30 percent Preliminary Design Level Cost Estimate was developed for the project by Stanley Consultants for the South Florida Water Management District's Acceler8 program. This cost estimate was reviewed by Jacksonville District and used as the basis for the direct costs in the preparation of the plan formulation cost estimates and of the MCACES cost estimate for the Selected Alternative Plan. For this reason the MCACES cost estimate for the Selected Alternative Plan shows User Created Cost items in lieu of the traditional Labor, Materials and Equipment breakdown. The Labor, Materials and Equipment breakdown is found in Stanley Consultants cost estimate. The 30 percent cost estimate was prepared by Stanley Consultants using MCACES Gold 5.31 software. It is dated 31 May 2006. R.S. Means' 2006 database adjusted by the

Engineering News Record index was used as the basis for Stanley Consultants' crew based estimate. Vendors and equipment manufacturers were contacted by Stanley Consultants to confirm costs for specific items. Certain mechanical equipment was estimated using the Richardson (2004) guides as the database. Labor rates used in the 30 percent design cost estimate are the Davis Bacon Union Shop Labor Rates for Fort Meyers, Florida

First, the cost estimate for the Selected Alternative Plan was prepared by transcribing the direct costs from the Acceler8 contractor's estimate to the MII software. Markups and contractor/subcontractor structure consistent with Jacksonville District practices/conventions/history were added. A printout was made of the total project costs including unit pricing. Then, the unit pricing was used to prepare the plan formulation cost estimates. Finally, the Total Project Cost Summary was prepared using the estimate for the Selected Alternative Plan as its basis.

B.1.1 Selected Alternative Plan

The scope of work for the Selected Alternative Plan is found in Appendix A, Engineering. The MCACES/MII cost estimate for the Selected Alternative Plan (Section B.3, below) is based on that scope and is formatted in the Civil Works Breakdown Structure. In addition, it includes both construction and non-construction costs. The construction costs fall under the following feature codes:

- 02 Relocations
- 03 Reservoirs
- 04 Dams
- 09 Channels and Canals
- 13 Pumping Plant
- 14 Recreation Facilities
- 15 Floodway Control-Diversion Structures

The non-construction costs fall under the following feature codes:

- 01 Lands and Damages
- 30 Planning, Engineering and Design
- 31 Construction Management

Construction Costs. Direct costs for the construction features were taken from the 30% design cost estimate as described above. These direct costs are reported in the MCACES/MII estimate as 'User Defined' costs and are the sum of the labor, equipment and materials direct costs from the 30% design cost estimate. Sales tax of 7% is added in the 30% design cost estimate to material and

equipment costs and is therefore considered a direct cost. To the direct costs were added the following contractor markups:

* Job Office Overhead at 8%, running (4% on subcontracted work)
* Home Office Overhead at 5%, running (3% on subcontracted work)
* Bonds and Insurance at 1.5%, running (1.5% on subcontracted work)
* Contractor's profit at 8.55% (8.55% on subcontracted work)

Profit was determined using the weighted profit guidelines. Table 1 summarizes the prime contractor profit calculation. Separate profit percentages were calculated for each subcontractor, using the weighted profit guidelines.

TABLE 1. WEIGHTED PROFIT GUIDELINES CALCULATION-PRIME CONTRACTOR

	Value X	Weight =	Percentage
Risk	0.09	20	1.8
Difficulty	0.1	15	1.5
Size	0.03	15	0.45
Period	0.12	15	1.8
Contractor's Investment	0.07	5	0.35
Assistance by Government	0.07	5	0.35
Subcontracting	0.092	25	2.3
TOTAL		100	8.55

The indicator, 'running' means the cost is calculated based on the percentage entered (computed as shown in the table, above) multiplied by the running total. The running total is the sum of the direct costs (labor, equipment and materials, plus any sub-bid or user-defined items) and the values of any categories appearing above the present category in the hierarchy of the MII program, for this case, job office overhead, home office overhead, profit and bonds, in that order.

Also added are the following owner markups:

Contingency at 25%
Escalation at 2.79%

The contingency is a deviation from the guidance contingency of 20% for projects at the feasibility level with an expected cost greater then $10,000,000 (ER 1110-2-1302, Appendix D, Page 9). This is for cost consistency with Comprehensive

Everglades Restoration Program guidance DCM-7. In addition, certain features were assigned a contingency of 30% due to design uncertainties. These are primarily structures associated with the dam, whose exact designs have not yet been described.

Escalation was added to bring the direct costs, dated 31 May 2006, to fiscal year 2007 price levels (1 October 2007). Only the direct costs taken from Stanley Consultants' cost estimate are escalated (for use in the plan formulation cost estimates and the MCACES/MII cost estimate for the Selected Alternative Plan). Costs derived by other means are already in fiscal year 2007 price levels and therefore not escalated. Civil Works Construction Cost Indexing System composite yearly factors were used to determine the escalation rate. For fiscal year 2006 the factor is 641.50 and for fiscal year 2007 the factor is 659.42; therefore, costs in the 2006 price level are multiplied by 659.42/641.50 to arrive at costs in the 2007 price level.

It is assumed that the construction work will be performed under one contract. Subcontractors are identified as follows:

- Landscaping subcontractor
- Demolition subcontractor
- Structures subcontractor (with a Pumping Equipment subcontractor)
- Clearing and Grubbing subcontractor
- Instruments/Controls subcontractor

Subcontractor markups are defined as follows:

- Job Office Overhead at 8%, running (4% on subcontracted work)
- Home Office Overhead at 5%, running (3% on subcontracted work)
- Bonds and Insurance at 1.5%, running (1.5% on subcontracted work)
- Contractor's profit as determined using the weighted profit guidelines (same percentage on subcontracted work)

Non-construction Costs. Real Estate costs were provided by Real Estate Division. These costs are best described in the Real Estate Appendix, Appendix D. They include lands costs and administrative costs and are distinguished as non-Federal sponsor costs or government costs. Contingencies are applied as indicated in the Real Estate Appendix and vary by component.

Planning, Engineering and Design costs are broken down into Preconstruction, Engineering and Design (PED), or preparation of contract plans and specifications; Engineering During Construction (EDC); and the Project Implementation Report. PED costs were solicited from Engineering Division via the Project Manager, as suggested by the guidance. Ten percent of the total

construction cost is used as the total rate for engineering costs through construction, as is customary in Jacksonville District's Cost Branch. This percentage is broken down into eight percent of construction costs for PED and two percent for EDC. The cost for the PIR was provided to Cost Branch via the Project Manager and represents funds spent to date plus funds expected to be spent through report completion.

Construction Management costs were solicited from Construction-Operations Division via the Project Manager, again as suggested by the guidance. Seven and six-tenths percent is used as the rate for Construction Management costs for the cost estimate for the Selected Alternative Plan. This percentage is based on actual funds spent for construction management on past contracts. When this cost is calculated for planning projects it is itemized to show amounts allocated for each task anticipated to occur during construction.

B.1.2 Plan Formulation Cost Estimates

To iterate, unit prices for each major or variable construction element were taken from the cost estimate developed for the Selected Alternative Plan. These unit prices were entered into spreadsheets that differentiated each plan by the quantities required to construct the plans. The spreadsheets are included in this appendix (Section B.2). The spreadsheets are formatted according to the Civil Works Breakdown Structure and include construction and non-construction costs. Quantities for the construction elements were provided to Cost Branch by the Engineering Technical Lead. Real Estate costs were provided by Real Estate Division. Preconstruction, Engineering and Design costs and Construction Management costs were calculated using percentages; at this level of estimating they are assumed to be ten percent and eight percent, respectively. During ITR, slight adjustments were made to the Selected Alternative Plan cost estimate, but these tables were not updated, in order to keep the comparison of costs across the alternatives consistent. The selected plan cost went down due to changes in profit percentages. The cost change should not affect plan selection.

Section 5 of the main report describes the costed alternative plans in detail. They include the following:

- Plan 2; 100,000 acre-foot reservoir with 1,500 cubic feet per second pumping capacity
- Plan 3B; 170,000 acre-foot reservoir with 1,500 cubic feet per second pumping capacity
- Plan 3C; 170,000 acre-foot reservoir with 3,800 cubic feet per second pumping capacity
- Plan 4; 220,000 acre-foot reservoir with 3,800 cubic feet per second pumping capacity

The C-43 alternative plans include pump stations of 150 cubic feet per second (cfs), 1,500 cfs and 3,800 cfs. The 150 and 1,500 cfs pump stations are included in the Acceler8 30% design cost estimate so their direct costs are applied as described above in the project costing. The 3,800 cfs pump station was costed independently of the Acceler8 30 % design. Cost engineering guidance allows for use of historic pricing at this phase of a planning study. Historic bid data was collected from contracts awarded by Jacksonville District since 2000. This data was summarized in a total cfs/cost per cfs chart as well as a total cfs/total cost chart. Curves were fit to these charts/data points, equations determined for the curves, and predictions made for other cfs pump station costs based on these equations. For this analysis, all costs were indexed using the Corps Civil Works Construction Cost Indexing System (CWCCIS) to Fiscal Year 2007 levels. Note that the pump stations constructed since 2000 are lower head pump stations, of about ten feet static head. The pump stations for the plan formulation have static heads of about 30 and 40 feet (27 feet for the 150 cfs station and 42 feet for the 1,500 and 3,800 cfs stations). A second set of curves was superimposed on the first set to allow for additional pumping equipment costs to account for the higher head. This set of curves relies on the direct costs prepared by Stanley Consultants for the Acceler8 program of South Florida Water Management District. For the lower head pump station, costs were added of $3,800,000 and for the higher head pump stations, costs were added of $46,300,000. Shifting the historic curves upward in cost by these additional amounts is intended to account for the greater pumping equipment costs and possibly greater building costs for the higher head stations.

TABLE 2. HISTORIC PUMP STATION DATA

Pump Station	Date Awarded	Total Cost	Cost FY 07$	No of Pumps	Pump Size	Total cfs	Cost/Pump FY 07$	Cost/cfs FY 07$
361	4/19/2001	$2,170,000	$3,043,598	3	3e/25 cfs	75	$1,014,533	$40,581
9A	9/19/2000	$5,915,495	$8,370,163	4	2d/175 cfs, 2e/75 cfs	500	$2,092,541	$16,740
357	9/20/2005	$10,388,921	$11,306,565	5	4d/125 cfs,1e/75 cfs	575	$2,261,313	$19,664
362	9/30/2000	$29,109,915	$41,189,239	7	3d/960 cfs, 2d/550 cfs, 2e/110 cfs	4200	$5,884,177	$9,807
319	3/30/2000	$27,283,338	$38,604,714	5	3d/960 cfs, 2d/550 cfs	3980	$7,720,943	$9,700
385	5/17/2004	$3,988,583	$4,340,891	4	4e/40 cfs	160	$1,085,223	$27,131
382	9/26/2003	$9,617,529	$12,805,389	3	3d/160 cfs, 160 cfs, 60 cfs	380	$4,268,463	$33,698
383	9/26/2003	$1,012,371	$1,347,936	2	2e/15 cfs, 25 cfs	40	$673,968	$33,698

Notes: 1.)Under 'pump size', 'e' is for electric and 'd' for diesel. 2.)CFS is cubic feet per second.

TABLE 3. CURVE ADJUSTMENT CALCULATION

Size/cfs	Higher Head Cost	Lower Head Cost	Difference
150	$9,000,000	$5,200,000	$3,800,000
1500	$25,700,000	$29,500,000	
3800	$48,900,000	$52,700,000	
1500	$72,000,000	$25,700,000	$46,300,000
3800	$95,200,000	$48,900,000	
	$9,000,000 from a preliminary C-43 TSP estimate using Corps' markups.		
	$72,000,000 from a preliminary C-43 TSP estimate using Corps' markups.		

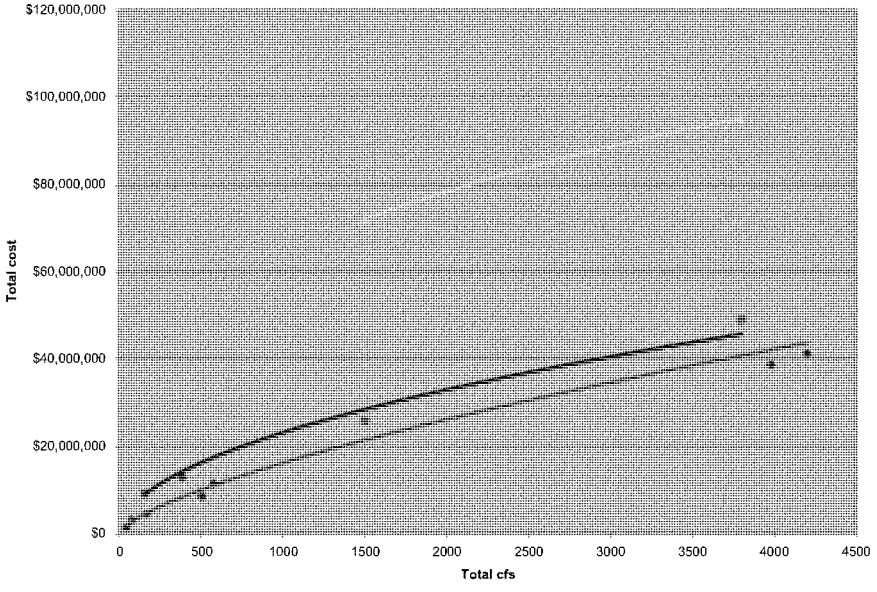


FIGURE 1: PUMP STATION COST CURVES

B.2 PLAN FORMULATION COST ESTIMATES

TABLE 4: ALTERNATIVE 2

Feature Description	Subfeature	Item	Quantity	Unit Of Measure	Unit Cost	Project Cost
CONSTRUCTION COST						
Reservoirs						
	Mobilization/demobilization		1	EA	$11,397,912.93	$11,397,912.93
	Demolition		1	EA	$70,320.65	$70,320.65
	Relocations		1	EA	$1,047,173.13	$1,047,173.13
	Dams					
	Perimeter Dam and Canal, Separator Dam					
		Clearing Grubbing & disposal	10,492	AC	$1,641.21	$17,219,575.32
		Stripping	1,070,000	CY	$1.90	$2,033,000.00
		Blanket Drain	192,852	CY	$73.95	$14,261,405.40
		Toe Drain	106,670	LF	$15.78	$1,683,252.60
		Random Fill Embankment	14,412,682	CY	$4.15	$59,812,630.30
		Chimney Drain	130,250	CY	$5.52	$718,980.00
		Slurry Wall	3,890,880	SF	$6.76	$26,302,348.80
		Soil Cement	652,754	CY	$79.62	$51,972,273.48
		Toe Drain Outfall End Treatment	174	TON	$74.10	$12,893.40
		Select Fill (Structural Backfill)	41,000	CY	$14.44	$592,040.00
		Seeding	234	AC	$3,111.20	$728,020.80
		Sodding	250	AC	$38,759.76	$9,689,940.00
		Cell Instruments & Controls	1	EA	$73,287.10	$73,287.10
		Sitework	1	EA	$4,099,814.01	$4,099,814.01
	Crested Spillways					
		CS-1	1	EA	$670,271.05	$670,271.05
		CS-2	1	EA	$472,476.54	$472,476.54
	Main Outlet Structures					
		S-1	1	EA	$4,130,848.79	$4,130,848.79
		S-8	1	EA	$4,321,791.54	$4,321,791.54
	Balancing Structure					
		S-12	1	EA	$3,038,179.76	$3,038,179.76

2218

	Perimeter Canal Structures					
		S-3	1	EA	$2,585,573.28	$2,585,573.28
		S-10	1	EA	$2,897,319.61	$2,897,319.61
		S-11	1	EA	$4,035,838.58	$4,035,838.58
	Gated Culverts					
		S-7	1	EA	$2,178,136.79	$2,178,136.79
		S-9	1	EA	$1,376,142.17	$1,376,142.17
		S-14	1	EA	$1,620,555.29	$1,620,555.29
		S-15	1	EA	$2,015,559.85	$2,015,559.85
	Pump Stations					
		P-1 1500 CFS	1	EA	$71,960,892.68	$71,960,892.68
		P-4 150 CFS	1	EA	$9,007,622.55	$9,007,622.55
	Townsend Canal Improvements					
		Channel Excavation/Rip Rap/Weir Removal	1	EA	$2,030,202.69	$2,030,202.69
	Manatee Protection Structure					
		Manatee Gate	1	EA	$2,577,164.74	$2,577,164.74
Recreation Facilities						
	Recreation Facilities					
		Entrance/Perimeter Area	1	EA	$504,000.00	$504,000.00
		Levee/Reservoir Area	1	EA	$2,015,000.00	$2,015,000.00
TOTAL CONSTRUCTION COST						**$319,152,443.83**
NON-CONSTRUCTION COST						
Lands and Damages						
	Lands and Damages		1	EA	$80,421,000.00	$80,421,000.00
Preconstruction Engineering and Design						
	Preconstruction Engineering and Design		1	EA	$31,915,244.38	$31,915,244.38
Construction Management						
	Construction Management		1	EA	$25,532,195.51	$25,532,195.51
TOTAL NON-CONSTRUCTION COST						$137,868,439.89
TOTAL COST						**$457,020,883.72**

TABLE 5: ALTERNATIVE 3B

Feature Description	Subfeature	Item	Quantity	Unit of Measure	Unit Cost	Project Cost
CONSTRUCTION COST						
Reservoirs						
	Mobilization/demobilization		1	EA	$11,397,912.93	$11,397,912.93
	Demolition		1	EA	$70,320.65	$70,320.65
	Relocations		1	EA	$1,047,173.13	$1,047,173.13
	Dams					
	Perimeter Dam and Canal, Separator Dam					
		Clearing Grubbing & disposal	10,365	AC	$1,641.21	$17,011,141.65
		Stripping	1,070,000	CY	$1.90	$2,033,000.00
		Blanket Drain	192,852	CY	$73.95	$14,261,405.40
		Toe Drain	106,670	LF	$15.78	$1,683,252.60
		Random Fill Embankment	22,011,438	CY	$4.15	$91,347,467.70
		Chimney Drain	130,250	CY	$5.52	$718,980.00
		Slurry Wall	4,485,936	SF	$6.76	$30,324,927.36
		Soil Cement	824,659	CY	$79.62	$65,659,349.58
		Toe Drain Outfall End Treatment	174	TON	$74.10	$12,893.40
		Select Fill (Structural Backfill)	41,000	CY	$14.44	$592,040.00
		Seeding	234	AC	$3,111.20	$728,020.80
		Sodding	250	AC	$38,759.76	$9,689,940.00
		Cell Instruments & Controls	1	EA	$73,287.10	$73,287.10
		Sitework	1	EA	$4,099,814.01	$4,099,814.01
	Crested Spillways					
		CS-1	1	EA	$670,271.05	$670,271.05
		CS-2	1	EA	$472,476.54	$472,476.54
	Main Outlet Structures					
		S-1	1	EA	$4,130,848.79	$4,130,848.79
		S-8	1	EA	$4,321,791.54	$4,321,791.54
	Balancing Structure					
		S-12	1	EA	$3,038,179.76	$3,038,179.76
	Perimeter Canal Structures					
		S-3	1	EA	$2,585,573.28	$2,585,573.28

2220

		S-10	1	EA	$2,897,319.61	$2,897,319.61
		S-11	1	EA	$4,035,838.58	$4,035,838.58
	Gated Culverts					
		S-7	1	EA	$2,178,136.79	$2,178,136.79
		S-9	1	EA	$1,376,142.17	$1,376,142.17
		S-14	1	EA	$1,620,555.29	$1,620,555.29
		S-15	1	EA	$2,015,559.85	$2,015,559.85
	Pump Stations					
		P-1 1500 CFS	1	EA	$71,960,892.68	$71,960,892.68
		P-4 150 CFS	1	EA	$9,007,622.55	$9,007,622.55
	Townsend Canal Improvements					
		Channel Excavation/Rip Rap/Weir Removal	1	EA	$2,030,202.69	$2,030,202.69
	Manatee Protection Structure					
		Manatee Gate	1	EA	$2,577,164.74	$2,577,164.74
Recreation Facilities						
	Recreation Facilities					
		Entrance/Perimeter Area	1	EA	$504,000.00	$504,000.00
		Levee/Reservoir Area	1	EA	$2,015,000.00	$2,015,000.00
TOTAL CONSTRUCTION COST						**$368,188,502.22**
NON-CONSTRUCTION COST						
Lands and Damages						
	Lands and Damages		1	EA	$80,421,000.00	$80,421,000.00
Preconstruction Engineering and Design						
	Preconstruction Engineering and Design		1	EA	$36,818,850.22	$36,818,850.22
Construction Management						
	Construction Management		1	EA	$29,455,080.18	$29,455,080.18
TOTAL NON-CONSTRUCTION COST						$146,694,930.40
TOTAL COST						**$514,883,432.62**

2221

TABLE 6: ALTERNATIVE 3C

Feature Description	Subfeature	Item	Quantity	Unit Of Measure	Unit Cost	Project Cost
CONSTRUCTION COST						
Reservoirs						
	Mobilization/demobilization		1	EA	$11,397,912.93	$11,397,912.93
	Demolition		1	EA	$70,320.65	$70,320.65
	Relocations		1	EA	$1,047,173.13	$1,047,173.13
	Dams					
	Perimeter Dam and Canal, Separator Dam					
		Clearing Grubbing & disposal	10,365	AC	$1,641.21	$17,011,141.65
		Stripping	1,070,000	CY	$1.90	$2,033,000.00
		Blanket Drain	192,852	CY	$73.95	$14,261,405.40
		Toe Drain	106,670	LF	$15.78	$1,683,252.60
		Random Fill Embankment	22,011,438	CY	$4.15	$91,347,467.70
		Chimney Drain	130,250	CY	$5.52	$718,980.00
		Slurry Wall	4,485,936	SF	$6.76	$30,324,927.36
		Soil Cement	824,659	CY	$79.62	$65,659,349.58
		Toe Drain Outfall End Treatment	174	TON	$74.10	$12,893.40
		Select Fill (Structural Backfill)	41,000	CY	$14.44	$592,040.00
		Seeding	234	AC	$3,111.20	$728,020.80
		Sodding	250	AC	$38,759.76	$9,689,940.00
		Cell Instruments & Controls	1	EA	$73,287.10	$73,287.10
		Sitework	1	EA	$4,099,814.01	$4,099,814.01
	Crested Spillways					
		CS-1	1	EA	$670,271.05	$670,271.05
		CS-2	1	EA	$472,476.54	$472,476.54
	Main Outlet Structures					
		S-1	1	EA	$4,130,848.79	$4,130,848.79
		S-8	1	EA	$4,321,791.54	$4,321,791.54
	Balancing Structure					
		S-12	1	EA	$3,038,179.76	$3,038,179.76
	Perimeter Canal Structures					
		S-3	1	EA	$2,585,573.28	$2,585,573.28

2222

		S-10	1	EA	$2,897,319.61	$2,897,319.61
		S-11	1	EA	$4,035,838.58	$4,035,838.58
	Gated Culverts					
		S-7	1	EA	$2,178,136.79	$2,178,136.79
		S-9	1	EA	$1,376,142.17	$1,376,142.17
		S-14	1	EA	$1,620,555.29	$1,620,555.29
		S-15	1	EA	$2,015,559.85	$2,015,559.85
	Pump Stations					
		P-1 3800 CFS	1	EA	$95,000,000.00	$95,000,000.00
		P-4 150 CFS	1	EA	$9,007,622.55	$9,007,622.55
	Townsend Canal Improvements					
		Channel Excavation/Rip Rap/Weir Removal	1	EA	$5,901,946.30	$5,901,946.30
	Manatee Protection Structure					
		Manatee Gate	1	EA	$2,577,164.74	$2,577,164.74
Recreation Facilities						
	Recreation Facilities					
		Entrance/Perimeter Area	1	EA	$504,000.00	$504,000.00
		Levee/Reservoir Area	1	EA	$2,015,000.00	$2,015,000.00
TOTAL CONSTRUCTION COST						**$395,099,353.15**
NON-CONSTRUCTION COST						
Lands and Damages						
	Lands and Damages		1	EA	$80,421,000.00	$80,421,000.00
Preconstruction Engineering and Design						
	Preconstruction Engineering and Design		1	EA	$39,509,935.32	$39,509,935.32
Construction Management						
	Construction Management		1	EA	$31,607,948.25	$31,607,948.25
TOTAL NON-CONSTRUCTION COST						$151,538,883.57
TOTAL COST						**$546,638,236.72**

2223

TABLE 7: ALTERNATIVE 4

Feature Description	Subfeature	Item	Quantity	Unit Of Measure	Unit Cost	Project Cost
CONSTRUCTION COST						
Reservoirs						
	Mobilization/demobilization		1	EA	$11,397,912.93	$11,397,912.93
	Demolition		1	EA	$70,320.65	$70,320.65
	Relocations		1	EA	$1,047,173.13	$1,047,173.13
	Dams					
	Perimeter Dam and Canal, Separator Dam					
		Clearing Grubbing & disposal	10,365	AC	$1,641.21	$17,011,141.65
		Stripping	1,070,000	CY	$1.90	$2,033,000.00
		Blanket Drain	192,852	CY	$73.95	$14,261,405.40
		Toe Drain	106,670	LF	$15.78	$1,683,252.60
		Random Fill Embankment	26,743,018	CY	$4.15	$110,983,524.70
		Chimney Drain	130,250	CY	$5.52	$718,980.00
		Slurry Wall	4,910,976	SF	$6.76	$33,198,197.76
		Soil Cement	947,448	CY	$79.62	$75,435,809.76
		Toe Drain Outfall End Treatment	174	TON	$74.10	$12,893.40
		Select Fill (Structural Backfill)	41,000	CY	$14.44	$592,040.00
		Seeding	234	AC	$3,111.20	$728,020.80
		Sodding	250	AC	$38,759.76	$9,689,940.00
		Cell Instruments & Controls	1	EA	$73,287.10	$73,287.10
		Sitework	1	EA	$4,099,814.01	$4,099,814.01
	Crested Spillways					
		CS-1	1	EA	$670,271.05	$670,271.05
		CS-2	1	EA	$472,476.54	$472,476.54
	Main Outlet Structures					
		S-1	1	EA	$4,130,848.79	$4,130,848.79
		S-8	1	EA	$4,321,791.54	$4,321,791.54
	Balancing Structure					
		S-12	1	EA	$3,038,179.76	$3,038,179.76
	Perimeter Canal Structures					
		S-3	1	EA	$2,585,573.28	$2,585,573.28

2224

		S-10	1	EA	$2,897,319.61	$2,897,319.61
		S-11	1	EA	$4,035,838.58	$4,035,838.58
	Gated Culverts					
		S-7	1	EA	$2,178,136.79	$2,178,136.79
		S-9	1	EA	$1,376,142.17	$1,376,142.17
		S-14	1	EA	$1,620,555.29	$1,620,555.29
		S-15	1	EA	$2,015,559.85	$2,015,559.85
	Pump Stations					
		P-1 3800 CFS	1	EA	$95,000,000.00	$95,000,000.00
		P-4 150 CFS	1	EA	$7,105,083.31	$7,105,083.31
	Townsend Canal Improvements					
		Channel Excavation/Rip Rap/Weir Removal	1	EA	$5,901,946.30	$5,901,946.30
	Manatee Protection Structure					
		Manatee Gate	1	EA	$2,577,164.74	$2,577,164.74
Recreation Facilities						
	Recreation Facilities					
		Entrance/Perimeter Area	1	EA	$504,000.00	$504,000.00
		Levee/Reservoir Area	1	EA	$2,015,000.00	$2,015,000.00
TOTAL CONSTRUCTION COST						**$425,482,601.49**
NON-CONSTRUCTION COST						
Lands and Damages						
	Lands and Damages		1	EA	$80,421,000.00	$80,421,000.00
Preconstruction Engineering and Design						
	Preconstruction Engineering and Design		1	EA	$42,548,260.15	$42,548,260.15
Construction Management						
	Construction Management		1	EA	$34,038,608.12	$34,038,608.12
TOTAL NON-CONSTRUCTION COST						$157,007,868.27
TOTAL COST						**$582,490,469.76**

B.3 MCACES COST ESTIMATE

2226



Print Date: Wed 20 January 2010
Eff. Date: 10/20/2009

U.S. Army Corps of Engineers
Project : save_C43_WBSR8_10_20_2009
COE Standard Report Selections

Time: 14:21:33
Title Page

This estimate is for the Selected Alternative Plan, Alternative 8B, a 170,000 acre-foot storage reservoir with 1,500 cubic feet per second pump capacity.

Estimated by: USACE- SAJ and Stanley Consultants/Accelar8/SFWMD
Designed by: Stanley Consultants/Accelar8/SFWMD
Prepared by: Milton Swiatasek
Preparation Date: 10/20/2009
Effective Date of Pricing: 10/20/2009
Estimated Construction Time: 1,825 Days
This report is not copyrighted, but the information contained herein is For Official Use Only.

Labor ID: LFL2009 SQ ID: EP07R3

Currency in US dollars

TRACES MII Version 3.01

Print Date: Mon 26 October 2009
Eff. Date: 10/26/2009

U.S. Army Corps of Engineers
Project : swf_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time: 10:17:39

Table of Contents

Description	Page
Project Notes	i
Project Cost Summary Report	1
CONSTRUCTION COST	1
02 Relocations	1
04 Dams	1
03 Reservoirs	1
14 Recreation Facilities	1
13 Pumping Plant	1
15 Floodway Control-Diversion Struc	1
09 Channels and Canals	1
NON-CONSTRUCTION COST	1
01 Lands and Damages	1
30 Planning, Engineering and Design	1
31 Construction Management	1
Project Forecast to Direct Cost Report	2
CONSTRUCTION COST	2
02 Relocations	2
04 Dams	2
03 Reservoirs	2
14 Recreation Facilities	2
13 Pumping Plant	2
15 Floodway Control-Diversion Struc	2
09 Channels and Canals	2
NON-CONSTRUCTION COST	2
01 Lands and Damages	2
30 Planning, Engineering and Design	2
31 Construction Management	2
Project Direct Cost Report	3
CONSTRUCTION COST	3
02 Relocations	3
04 Dams	3
03 Reservoirs	3
03 Reservoirs	4
14 Recreation Facilities	4
13 Pumping Plant	4
15 Floodway Control-Diversion Struc	4
09 Channels and Canals	5
NON-CONSTRUCTION COST	5
01 Lands and Damages	5
30 Planning, Engineering and Design	5
31 Construction Management	5

Labor ID: LFL2009 EQ ID: EP07R03 Currency in US dollars TRACES MII Version 3.01

2228

Print Date Mon 26 October 2009 | U.S. Army Corps of Engineers | Time 10:17:39
Eff. Date 10/20/2009 | Project : swt_C43_WSRB_10_20_2009 | Project Notes Page 1
Jacksonville District Cost report

Date	Author	Note
5/18/2007	T Leeser	Project Name:C43 Project Number: 114458 Project Type (e.g., Reconnaissance, Feasibility, Bid): PIR (Study Authority is the Water Resources Development Act of 2000) Scope of Work: Alternative B as described in the PIR, Appendix A, Engineering Authorized Cost (if any): Not yet authorized. Contingency Amount (if any): 25%. This is a variation from Corps' guidance to allow for uncertainties in the design of the embankment and auxiliary structures. Some features have 30% contingency. Contingency on real estate is 25% on Federal administrative costs and 7% on non-Federal administrative costs, zero on RE Fee costs (per RE e-mail from A.Ayuso dated 6/18/07.) PED Amount (if any): 19% S&A Amount (if any): 7.5% Backup itemized and provided by CO. Sales Tax: 7% Job Office Overhead: 8% Home Office Overhead: 5% Profit: 10.1% Computed by weighted guidelines method. Bonds and Insurance: 1.5% Estimated Contract Award Date (mo/yr): Based on A&SFWMD schedule (see below) as described in e-mail from LuAnn McVicar, SFWMD, to Gia Hightower, USACE, dated 14 May 2007. 1) Clearing & Grubbing contract - contract award 12 July 07. 2) Embankment Structure Pre-load contract - advertise week of 13 August 07; contract award 11 October 07. 3) Reservoir & Pump Stations contract (main contract) - Release RFP's on 18 September 07 (to pre-qualified group of contractors); Release RFBs (to RFP short-listed group of contractors) on 19 December 07; award contract on 14 February 08. Estimated Construction Start Date (mo/yr): 8/2007 (see above) Estimated Construction Midpoint Date (mo/yr): 2/2009 Estimated Construction Complete Date (mo/yr): Based on 1,026 days (per Stanley Consultants' 30% design cost estimate) this is 3 years or 8/2010. CWCCIS Indices used: Engineer Manual 1110-2-1304 dated 30 Mar 2007 Subfeature Date Index Published Index Composite 10/05 641.50 Composite 10/05 658.42 Estimate revised to reflect Tentatively Selected Plan, Alternative 3B. This estimate relies on the MCACES Gold cost estimate prepared by Stanley Consultant's for the Accelerate Program (A3)/South Florida Water Management District dated 5/31/06. Stanley Consultant's estimate uses the labor/equipment/materials makeup for costs and is crew/productivity based. The direct costs in Stanley Consultant's estimate are the basis of the unit costs in this estimate, for all cost items except as noted. The estimate is dated 5/31/06 so these costs are escalated to FY 2007 price levels. In addition, Stanley Consultants prepared a Technical Memorandum for the SFWMD/A3 program on the Townsend Canal Improvements. The TM included a cost summary; the costs are used herein. These costs are also escalated since the cost table in the TM equates the costs to their previous cost estimate and adds the two to obtain a revised total cost. Scope of Work: Taken from Draft Project Implementation Report dated April 2007, Engineering Appendix, beginning on page A-56. A two-cell 176,000 acre-foot above ground storage reservoir, a 1,500 cubic feet per second pumping station and a selection of water control structures. The reservoir project site would consist of approximately 10,500 acres. Site preparation: Clearing and grubbing the entire site to eight inches depth. Site work and access road: Maintenance of existing paved entrance road during construction and construction of a new entrance road after construction of the reservoir. Townsend Canal improvements: Widen channel bottom, add scour protection across entire channel width. Embankment: 14-foot wide crest (including soil cement protection), 3 horizontal to 1 vertical side slopes. Cell One elevation is +55 feet, NAVD, and Cell Two elevation is +84 feet. Construction material is random fill with the borrow area on-site. Upstream slope protection and an interior drain are included, as well as a soil-bentonite wall. Downstream of the embankment is a 100-foot wide bench with a 24-foot access road. There is an interior embankment separating Cells One and Two, with a crest elevation of +50 feet, NAVD, also covered in soil-cement. Side slopes: To be seeded and sodded.

Labor ID: LRL2009 EQ ID: EP07RC3 Currency in US dollars TRACES MII Version 3.01

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project: swit_C43_WSRB_10_20_2009
Jacksonville District Cost report

Time 10:17:39
Project Notes Page 4

Date	Author	Note
5/16/2007	T. Leeser	Relocations: Of electric and water utilities. Structures: Two pump stations, two outlet structure sluice gates, three perimeter canal structures (roller, slide and weir gates), two crested spillways, one balancing structure sluice gate and eight gated culverts (slide and weir gates). Demolition: Of two existing pump stations. Recreation features: A major recreation attraction of the C-43 Storage Reservoir. Part 1 will be an approximately 12-mile multi-purpose trail loop atop the levee constructed as part of the project. Recreation facilities proposed include: parking and toilet facilities (olivas multrum waterless vault toilets), information kiosk, canoe/kayak launch facility, a shade structure, traffic-control fencing and a pedestrian footbridge bridge over the perimeter canal to provide public access to the reservoir.
6/15/2007	T. Leeser	Revised estimate to remove four structures to be built by others, S-16 through S-19, per e-mail PM to EN-C (B. Marlowe to T. Leeser) on 15 June 2007. Changed real estate costs per e-mail from RE (A. Ayusc) dated 6/18/07.
6/27/2007	T. Leeser	Revised estimate to incorporate change in scope of work that raises dam/embankment height. Per DP e-mail on scope change and as coordinated through EN/ETL, increased quantities for random fill/embankment from 19,772,438 to 22,011,438 cy and for soil cement from 789,659 to 824,659 cubic yards. Also as directed through EN/ETL, increased contingency on other features expected to change slightly in design, by a corresponding amount (22,011,438/19,772,438=1.11), to 30% (25% X 1.11 = 28%, used 30%). Also per EN/ETL e-mail dated 26 June 2007, added manatee gate.
7/18/2007	T. Leeser	As a result of Independent Technical Review, profit on the prime contractor was changed by adjusting the weighted profit guidelines computation to better reflect project conditions. Also, separate profits were calculated for each subcontractor using the weighted profit guidelines (per EI 010010). As a result, the non-construction costs 'Planning, Engineering and Design' and 'Construction Management' were revised. The cost book was changed to Region III and cost factors were updated (e.g., fuel) to reflect current pricing.
10/20/2009	Switanek	Revised Estimate to reflect current 2008 cost book and escalated by Cost Growth Index (USACE) to 2010 dollars as of 20 Oct 09. Also included $84,554,000 real estate cost without escalation and contingency. Because escalation and contingency was already included in Real- Estates cost estimate.

2230

Print Date:Mon 26 October 2009 U.S. Army Corps of Engineers Time 10:17:39
Eff. Date 10/20/2009 Project: swfl_C43_WSRB_10_20_2009
Jacksonville District Cost report
Project Cost Summary Report Page 1

Description	Quantity	UOM	ContractCost	Escalation	Contingency	ProjectCost
Project Cost Summary Report			420,126,352	54,279,427	96,076,391	570,482,169
CONSTRUCTION COST	1	LS	276,228,352	44,992,453	81,670,071	402,892,876
02 Relocations	1	EA	815,000	131,867	236,717	1,183,584
0203 Cemetery, Utilities, & Structure	1	EA	815,000	131,867	236,717	1,183,584
04 Dams	1	EA	190,744,046	30,862,387	57,171,227	278,777,659
0401 Perimeter Dam and Canal, Separator Dam	1	EA	181,515,921	29,369,276	53,956,856	264,840,053
0402 Crested Spillways	1	EA	834,714	135,057	290,931	1,260,702
0403 Main Outlet Structures	1	EA	6,174,186	999,984	2,161,952	9,325,121
1500 Balancing Structure	1	EA	2,219,223	359,070	773,488	3,351,781
08 Reservoirs	1	EA	8,799,218	1,423,713	2,555,733	12,778,664
0800 Reservoirs	1	EA	8,799,218	1,423,713	2,555,733	12,778,664
14 Recreation Facilities	1	EA	2,519,000	407,574	0	2,926,574
1400 Recreation Facilities	1	EA	2,519,000	407,574	0	2,926,574
13 Pumping Plant	1	EA	57,357,660	9,280,453	16,659,503	83,297,617
1300 Pumping Plant	1	EA	57,357,660	9,280,453	16,659,503	83,297,617
15 Floodway Control-Diversion Struc	1	EA	12,415,183	2,008,777	4,009,884	18,433,844
1500 Floodway Control-Diversion Struc	1	EA	12,415,183	2,008,777	4,009,884	18,433,844
09 Channels and Canals	1	EA	3,570,345	577,692	1,037,097	5,185,033
0902 Canals	1	EA	3,570,345	577,692	1,037,097	5,185,033
NON-CONSTRUCTION COST	1	LS	143,906,000	9,286,974	14,406,320	167,599,294
01 Lands and Damages	1	EA	84,654,000	0	0	84,654,000
Construction Contracts Documents	1	EA	84,654,000	0	0	84,654,000
30 Planning, Engineering and Design	1	EA	37,852,000	6,092,694	8,132,690	51,876,694
Construction Contracts Documents	1	EA	28,000,000	4,530,400	8,132,690	40,663,000
Project Implementation Report	1	EA	9,852,000	1,561,694	0	11,213,694
31 Construction Management	1	EA	21,400,000	3,494,880	6,273,720	31,368,600
Construction Contracts	1	EA	21,400,000	3,494,880	6,273,720	31,368,600

Labor ID: LRL2009 EQ ID: EP07R03 Currency in US dollars TRACES MII Version 3.01

Print Date Mon 26 October 2009
Eff. Date 10/20/2009

U.S. Army Corps of Engineers
Project: awit_C43_WSRB_10_26_2009
Jacksonville District Cost report

Time 10:17:32
Project Barecost to Direct Cost Report Page 2

Description	Quantity	UOM	BareCost	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost
Project Barecost to Direct Cost Report			353,142,489	353,142,489	17,265,779	370,408,268	49,718,084	420,126,352
CONSTRUCTION COST	1	LS	209,236,489	209,236,489	17,265,779	226,502,268	49,718,084	276,220,352
02 Relocations	1	EA	815,000	815,000	0	815,000	0	815,000
0203 Cemetery, Utilities, & Structure	1	EA	815,000	815,000	0	815,000	0	815,000
04 Dams	1	EA	149,139,486	149,139,486	4,913,573	154,053,159	35,690,887	190,744,046
0401 Perimeter Dam and Canal, Separator Dam	1	EA	142,907,285	142,907,285	3,326,949	146,234,234	35,281,587	181,515,821
0402 Crested Spillways	1	EA	563,723	563,723	143,524	707,247	127,467	834,714
0403 Main Outlet Structures	1	EA	4,169,729	4,169,729	1,081,617	5,251,346	942,842	6,174,188
1506 Balancing Structure	1	EA	1,498,749	1,498,749	381,583	1,880,332	338,891	2,219,223
03 Reservoirs	1	EA	7,036,077	7,036,077	9,057	7,045,134	1,754,084	8,799,218
0300 Reservoirs	1	EA	7,036,077	7,036,077	9,057	7,045,134	1,754,084	8,799,218
14 Recreation Facilities	1	EA	2,519,000	2,519,000	0	2,519,000	0	2,519,000
1400 Recreation Facilities	1	EA	2,519,000	2,519,000	0	2,519,000	0	2,519,000
13 Pumping Plant	1	EA	38,736,345	38,736,345	9,862,308	48,598,653	8,758,907	57,357,560
1300 Pumping Plant	1	EA	38,736,345	38,736,345	9,862,308	48,598,653	8,758,907	57,357,560
15 Floodway Control-Diversion Struc	1	EA	8,384,576	8,384,576	2,134,721	10,519,297	1,895,887	12,415,183
1500 Floodway Control-Diversion Struc	1	EA	8,384,576	8,384,576	2,134,721	10,519,297	1,895,887	12,415,183
09 Channels and Canals	1	EA	2,606,005	2,606,005	346,929	2,952,025	618,320	3,570,345
0902 Canals	1	EA	2,606,005	2,606,005	346,929	2,952,025	618,320	3,570,345
NON-CONSTRUCTION COST	1	LS	143,906,000	143,906,000	0	143,906,000	0	143,906,000
01 Lands and Damages	1	EA	84,654,000	84,654,000	0	84,654,000	0	84,654,000
Construction Contracts Documents	1	EA	84,654,000	84,654,000	0	84,654,000	0	84,654,000
30 Planning, Engineering and Design	1	EA	37,652,000	37,652,000	0	37,652,000	0	37,652,000
Construction Contracts Documents	1	EA	28,000,000	28,000,000	0	28,000,000	0	28,000,000
Project Implementation Report	1	EA	9,652,000	9,652,000	0	9,652,000	0	9,652,000
31 Construction Management	1	EA	21,600,000	21,600,000	0	21,600,000	0	21,600,000
Construction Contracts	1	EA	21,600,000	21,600,000	0	21,600,000	0	21,600,000

Labor ID: LFL2008 EQ ID: EP07R09 Currency in US dollars TRACES MII Version 3.01

2232

Print Date Mon 26 October 2009 — U.S. Army Corps of Engineers — Time 10:17:39
Eff. Date 10/20/2009 — Project: savit_C43_WSRB_10_20_2009 — Jacksonville District Cost report — Project Direct Cost Report Page 1

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMat	DirectSubBid	DirectUserCost	DirectCost
Project Direct Cost Report			0	0	0	0	353,142,489	353,142,489
CONSTRUCTION COST	1	LS	0	0	0	0	269,238,489	269,238,489
02 Relocations	1	EA	0	0	0	0	815,000	815,000
0203 Cemetery, Utilities, & Structure	1	EA	0	0	0	0	815,000	815,000
020318 Utilities	1	EA	0	0	0	0	815,000	815,000
02031816 Electrical	1	EA	0	0	0	0	815,000	815,000
04 Dams	1	EA	0	0	0	0	149,139,486	149,139,486
0401 Perimeter Dam and Canal, Separator Dam	1	EA	0	0	0	0	142,907,285	142,907,285
Seeding	1	EA	0	0	0	0	359,136	359,136
Clearing and Grubbing	1	EA	0	0	0	0	8,727,333	8,727,333
Stripping	1	EA	0	0	0	0	1,108,400	1,108,400
Blanket Drain	1	EA	0	0	0	0	8,421,847	8,421,847
Toe Drain	1	EA	0	0	0	0	994,164	994,164
Toe Drain Outfall End Treatment	1	EA	0	0	0	0	7,919	7,919
Embankment/Random Fill	1	EA	0	0	0	0	56,129,167	56,129,167
Chimney Drain	1	EA	0	0	0	0	441,548	441,548
Slurry Wall	1	EA	0	0	0	0	18,615,634	18,615,634
Soil Cement	1	EA	0	0	0	0	40,325,826	40,325,826
Select Fill	1	EA	0	0	0	0	349,730	349,730
Sodding	1	EA	0	0	0	0	4,788,095	4,788,095
Instruments and Controls	1	EA	0	0	0	0	37,599	37,599
Sitework	1	EA	0	0	0	0	2,917,691	2,917,691
0402 Crested Spillways	1	EA	0	0	0	0	663,723	663,723
C43CS-1	1	EA	0	0	0	0	330,648	330,648
C43CS-2	1	EA	0	0	0	0	333,075	333,075
0403 Main Outlet Structures	1	EA	0	0	0	0	4,169,729	4,169,729
C43S-1	1	EA	0	0	0	0	2,037,798	2,037,798
C43S-8	1	EA	0	0	0	0	2,131,981	2,131,981
1500 Balancing Structure	1	EA	0	0	0	0	1,498,749	1,498,749
C43S-12	1	EA	0	0	0	0	1,498,749	1,498,749

Labor ID: LFL2009 EQ ID: EP07R03 — Currency in US dollars — TRACES MII Version 3.01

2233

Print Date: Mon 26 October 2009 | U.S. Army Corps of Engineers | Time 10:17:38
Eff. Date 10/20/2009 | Project : swt_C43_WSRB_10_20_2009 | Project Direct Cost Report Page 4
Jacksonville District Cost report

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	DirectUserCost	DirectCost
03 Reservoirs	1	EA	0	0	0	0	7,036,077	7,036,077
0300 Reservoirs	1	EA	0	0	0	0	7,036,077	7,036,077
030001 Mob, Demob & Preparatory Work	1	EA	0	0	0	0	7,000,000	7,000,000
030048 Demolition	1	EA	0	0	0	0	36,077	36,077
03004802 Site Work	1	EA	0	0	0	0	36,077	36,077
03004802 04 Removal of Structures	1	EA	0	0	0	0	36,077	36,077
Large Pump Station	1	EA	0	0	0	0	12,359	12,359
Small Pump Stations	1	EA	0	0	0	0	23,718	23,718
14 Recreation Facilities	1	EA	0	0	0	0	2,519,000	2,519,000
1400 Recreation Facilities	1	EA	0	0	0	0	2,519,000	2,519,000
Levee/Reservoir Area	1	EA	0	0	0	0	2,015,000	2,015,000
Double Lane Boat Ramp	1	EA	0	0	0	0	2,000,000	2,000,000
Vehicle Gate	1	EA	0	0	0	0	15,000	15,000
Entrance/Perimeter Area	1	EA	0	0	0	0	504,000	504,000
Shade Trees	1	EA	0	0	0	0	50,000	50,000
Footbridge	1	EA	0	0	0	0	138,000	138,000
Shade Shelter	1	EA	0	0	0	0	75,000	75,000
Canoe Launch	1	EA	0	0	0	0	39,000	39,000
Information Kiosk	1	EA	0	0	0	0	15,000	15,000
Parking Area Handicap Access	1	EA	0	0	0	0	50,000	50,000
Waterless Vault Toilet Facility	1	EA	0	0	0	0	90,000	90,000
Traffic Control Fencing	1	EA	0	0	0	0	50,000	50,000
13 Pumping Plant	1	EA	0	0	0	0	38,736,345	38,736,345
1300 Pumping Plant	1	EA	0	0	0	0	38,736,345	38,736,345
Pump Stations	1	EA	0	0	0	0	38,736,345	38,736,345
C43P-1	1	EA	0	0	0	0	34,395,990	34,395,990
C43P-4	1	EA	0	0	0	0	4,340,355	4,340,355
15 Floodway Control-Diversion Struc	1	EA	0	0	0	0	8,384,576	8,384,576
1500 Floodway Control-Diversion Struc	1	EA	0	0	0	0	8,384,576	8,384,576
Local Channel Gated Culverts	1	EA	0	0	0	0	3,668,599	3,668,599

Labor ID: LFL2009 EQ ID: EP07R03 | Currency in US dollars | TRACES MII Version 3.01

2234

Print Date: Mon 26 October 2009 — U.S. Army Corps of Engineers — Time: 10:17:39
Eff. Date 10/26/2009 — Project : swfl_C43_WSRB_10_20_2009 — Project Direct Cost Report Page 5
Jacksonville District Cost report

Description	Quantity	UOM	DirectLabor	DirectEQ	DirectMat	DirectSubBid	DirectUserCost	DirectCost
C42S-7	1	EA	0	0	0	0	1,117,465	1,117,465
C43S-9	1	EA	0	0	0	0	799,012	799,012
C43S-14	1	EA	0	0	0	0	831,405	831,405
C43S-15	1	EA	0	0	0	0	1,034,057	1,034,057
1500 Perimeter Canal Structures	1	EA	0	0	0	0	4,695,537	4,695,537
Gated Culvert C43S-3	1	EA	0	0	0	0	1,275,476	1,275,476
Gated Spillway C43S-10	1	EA	0	0	0	0	1,429,262	1,429,262
Gated Spillway C42S-11	1	EA	0	0	0	0	1,990,899	1,990,899
09 Channels and Canals	1	EA	0	0	0	0	2,606,005	2,606,005
0902 Canals	1	EA	0	0	0	0	2,606,005	2,606,005
Manatee Protection Structure	1	EA	0	0	0	0	1,359,070	1,359,070
Townsend Canal Improvements	1	EA	0	0	0	0	1,246,935	1,246,935
Channel Excavation	1	EA	0	0	0	0	430,318	430,318
Rip rap	1	EA	0	0	0	0	563,452	563,452
Remove Weir	1	EA	0	0	0	0	253,165	253,165
NON-CONSTRUCTION COST	1	LS	0	0	0	0	143,906,000	143,906,000
01 Lands and Damages	1	EA	0	0	0	0	84,654,000	84,654,000
Construction Contracts Documents	1	EA	0	0	0	0	84,654,000	84,654,000
30 Planning, Engineering and Design	1	EA	0	0	0	0	37,652,000	37,652,000
Construction Contracts Documents	1	EA	0	0	0	0	28,800,000	28,800,000
302301 Plans and Specifications (P&S)	1	EA	0	0	0	0	22,400,000	22,400,000
302316 Engineering & Design During	1	EA	0	0	0	0	6,400,000	6,400,000
Project Implementation Report	1	EA	0	0	0	0	8,852,000	8,852,000
31 Construction Management	1	EA	0	0	0	0	21,600,000	21,600,000
Construction Contracts	1	EA	0	0	0	0	21,600,000	21,600,000

Labor ID: LFL2009 EQ ID: EP07R03 — Currency in US dollars — TRACES MII Version 3.01

2235

B.4 TOTAL PROJECT COST SUMMARY

The Total Project Cost Summary includes escalation through project completion. The cost estimate for the Selected Alternative Plan is prepared with an identified price level date. Inflation factors are used to adjust the pricing to the project schedule. This estimate is known as the Fully Funded Cost Estimate or Total Project Cost Summary. It includes all Federal and non-Federal costs: Lands, Easements, Rights of Way and Relocations; construction features; Preconstruction Engineering and Design; Construction Management; Contingency; and Inflation. The summary is shown in the following table.

WBS 4 C-43 Basin Aquifer Storage Reservoir – Part 1 Project													
FY 2009 Fully Funded Estimate													
(Amounts in Thousands of Dollars)													
						Fully	Fully	Adj. to	Fully		Effective Date: October 1, 2007		
		Start	End	Mid Pt	Infl	Funded	Funded	Total	Funded				
Fea	Description	Date	Date	Date	Factor	Estimate	Cont		Total	Adj to Fed	Federal	Non-Federal	
						565,730		(30)	565,700		282,850	282,850	**Remarks**
01	**LANDS & DAMAGES**					86,429	0	0	86,429	0	43,214	43,214	
	C-43 Part 1 (DP1)	Oct 08	Feb 10	Jun-09	1,066	86,429	0		86,429		43,214	43,214	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
02	**RELOCATIONS**					1,175	0	0	1,175	0	588	588	
	Cemetery, Utilities & Structures	June 10	Oct 12	Aug 11	1,115	1,175	0		1,175		588	588	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
03	**RESERVOIRS**					12,689	0	(30)	12,659	0	6,330	6,330	
	Mob/Demob/Prep Work	June 10	Oct 12	Aug 11	1,115	12,689	0	(30)	12,659		6,330	6,330	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
04	**DAMS**					276,829	0	0	276,829	0	138,415	138,415	
	Perimeter Dam/Canal/Sep Dam	Jun 10	Oct 12	Aug 11	1,115	262,984	0		262,984		131,492	131,492	
	Crested Spillway	June 10	Oct 12	Aug 11	1,115	1,251	0		1,251		626	626	
	Main Outlet Structures	June 10	Oct 12	Aug 11	1,115	9,259	0		9,259		4,630	4,630	
	C-43S-12	June 10	Oct 12	Aug 11	1,115	3,334	0		3,334		1,667	1,667	

2237

				Aug 11	1,115	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
09	**CHANNELS & CANALS**					5,047	0	0	5,074	0	2,537	2,537	
	Townsend Canal Improvements	June 10	Oct 12	Aug 11	1,115	2,247	0		2,247		1,123	1,123	
	Manatee Protection Structure	June 10	Oct 12	Aug 11	1,115	2,827	0		2,827		1,413	1,413	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
13	**PUMPING PLANTS**					81,727	0	0	81,727	0	40,863	40,863	
	C43P-1	June 10	Oct 12	Aug 11	1,115	72,557	0		72,557		36,279	36,279	
	C43P-4	June 10	Oct 12	Aug 11	1,115	9,170	0		9,170		4,585	4,585	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
14	**RECREATION FAC**					2,827	0	0	2,827	0	1,414	1,414	
	Levee/Reservoir Area	June 10	Oct 12	Aug 11	1,115	2,262	0		2,262		1,131	1,131	
	Entrance/Perimeter Area	June 10	Oct 12	Aug 11	1,115	566	0		566		283	283	
		June 10	Oct 12	Aug 11	1,115	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
15	**FL CNTR & DIV STR**					18,304	0	0	18,304	0	9,152	9,152	
				N/A	1,000	0	0		0		0	0	
	Gated Culvert C43S-3	June 10	Oct 12	Aug 11	1,115	2,833	0		2,833		1,416	1,416	

	Gated Spillway C43S-10	June 10	Oct 12	Aug 11	1,115	3,174	0		3,174		1,587	1,587	
	Gated Spillway C43S-11	June 10	Oct 12	Aug 11	1,115	4,421	0		4,421		2,210	2,210	
	C43S-7	June 10	Oct 12	Aug 11	1,115	2,386	0		2,386		1,193	1,193	
	C43S-9	June 10	Oct 12	Aug 11	1,115	1,507	0		1,507		754	754	
	C43S-14	June 10	Oct 12	Aug 11	1,115	1,776	0		1,776		888	888	
	C43S-15	June 10	Oct 12	Aug 11	1,115	2,208	0		2,208		1,104	1,104	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
30	**PE&D**					49,062	0	0	49,062	0	24,531	24,531	
	PIR	Oct 06	Oct 07	Apr 07	1,000	9,652	0		9,652		4,826	4,826	
	P&S/EDC	Oct 06	Oct 07	Oct 09	1,114	39,410	0		39,410		19,705	19,705	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
31	**CONST MNGT**					31,614	0	0	31,614	0	15,807	15,807	
	S&A	June 10	Oct 12	Aug 11	1,159	31,614	0		31,614		15,807	15,807	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	
				N/A	1,000	0	0		0		0	0	

2239

B.5 RISK AND UNCERTAINTY ANALYSIS

B.5.1 Risk analysis methods

A study was made of risk associated with the C-43 reservoir construction costs. The MCACES/MII cost estimate for the Selected Alternative Plan was used as the basis for the risk study. Only the construction costs were examined for the risk study; Real Estate, Preconstruction, Engineering and Design and Construction Management Costs were not included. First, references were gathered that describe risk analysis as might be applied to Corps of Engineers projects. These references are the following:

1. Memorandum For Commander, Jacksonville District, From James C. Dalton, P.E., Subject: Risk Analysis in Construction Cost Estimates for Projects $10 Million and Greater, dated 23 April 2007
2. Risk Analysis Framework For Cost Estimation, Institute For Water Resources Report 00-R-9, December 2000

Then, a qualitative description of risk was prepared using the references as a guide. Finally, a quantitative description of risk was made using EXCEL software with the Crystal Ball add-in. The qualitative and quantitative descriptions of risk are presented below. The report from the Crystal Ball simulation is provided with this write-up, showing the level of detail of the quantitative assessment and the results of the assessment.

B.5.2 Qualitative description of risk

In order to identify and mitigate risk, the qualitative description of risk addresses risk assessment, risk management and risk communication, as follows:

1. Risk Assessment-Quantify and describe

- What can go wrong?
- How can it happen?
- How likely is it?
- What is the magnitude of the bad event should it happen?

2. Risk Management-Identify risk reducing actions

- What can be done to reduce the impact of the risk described?
- What can be done to reduce the likelihood of the risk described?
- What are the trade-offs of the available options?
- What is the best way to address the described risk?

3. Risk Communication

- With whom to communicate?
- How to get both the information that is needed and the information others have?
- How to convey the information to be communicated?
- When to communicate?

With a cost estimate, one of the worst things that can go wrong is that the cost can be greatly underestimated. On a Corps of Engineers construction project, the cost is truly known at the time of closeout, when all claims and modifications are submitted, negotiated, approved and paid. This can be several years after physical completion of the project, and many, many years after planning and authorization. Underestimating the cost of a construction project can happen in a myriad of ways, from differing site conditions to lower actual productivity rates to higher actual labor, equipment and material rates. On the surface, it is very likely that the point estimate of the total construction cost generated for a planning study is not dead on. At a deeper level, the question to be asked is, How far off could that point estimate be?

In investigating the range of uncertainty in a planning-level cost estimate one uncovers ideas about how to reduce the likelihood and the impact of underestimating the construction cost. Perhaps this takes the form of more geotechnical field investigations, increased hydrologic modeling, or further research into the current cost of certain construction materials or products. Sometimes a planner or engineer must choose between accepting risk in the long run and spending additional funds and time in the short run. Often when risk is identified at the planning stage it is accommodated with a higher cost contingency and addressing the risk is left for a later stage in the project life-cycle.

Risk may be a topic that members of a project delivery team do not prefer to discuss. However, risk does need to be communicated with all those on the project delivery team, and especially with those who have the authority to make decisions about managing the risk and on adapting to the risk. Including a risk analysis in a planning document is a first step toward sharing information about the uncertainty in a project. Of course, the identification of uncertainty is only helpful if that risk assessment is carried through and modified as the project progresses.

Potential sources of uncertainty in the cost estimate for the C-43 West Basin Reservoir project Selected Alternative Plan are listed below:

- Contractor's home office overhead
- Contractor's job office overhead
- Contractor's profit
- Contractor's bond
- Subcontractors' markups
- Subcontracting scheme
- Contracting scheme/multiple contracts
- Labor rates
- Crew makeup
- Equipment rates
- Equipment makeup
- Materials costs
- Productivity rates
- Construction duration
- Design parameters/quantities/sizes
- Fuel cost
- Weather
- Overtime
- Cost of money/cost of money discount
- Electricity rates
- Shipping costs
- Mobilization/demobilization cost
- Demolition cost
- Relocation cost
- Clearing and grubbing cost
- Stripping cost
- Blanket drain cost
- Toe drain cost
- Toe drain outfall end treatment cost
- Random fill cost
- Chimney drain cost
- Slurry wall cost
- Soil cement cost
- Select fill cost
- Sodding cost
- Cell instruments and controls cost
- Access road construction cost
- Vehicle barrier gate cost
- Floating safety barrier cost
- Floating weed barrier cost
- Silt fence cost
- CS-1 cost
- CS-2 cost
- C43S-1 cost

- C43S-8 cost
- C43S-12 cost
- C43S-3 cost
- C43S-10 cost
- C43S-11 cost
- C43S-7 cost
- C43S-9 cost
- C43S-14 cost
- C43S-15 cost
- C43P-1 cost pumping equipment
- C43P-1 cost trash rack and screen
- C43P-1 cost sitework and equipment building
- C43P-1 cost pump station building
- C43P-4 cost pumping equipment
- C43P-4 cost trash rack and screen
- C43P-4 cost sitework and equipment building
- C43P-4 cost pump station building
- Double lane boat ramp cost
- Vehicle gate cost
- Shade trees cost
- Footbridge cost
- Shade shelter cost
- Canoe launch cost
- Information kiosk
- Parking area/handicap access cost
- Waterless vault toilet facility

Potential sources of certainty are the following:

- Sales tax on materials
- Escalation
- Materials makeup

Sales tax on materials is included in this list since sales tax is charged on materials in Florida at the given rate prescribed by the County in which the construction will occur. Escalation, although arguable, is a source of certainty in that the indexing factors used to bring the direct costs prepared by the Acceler8 contractor from fiscal year 2006 to fiscal year 2007 prices are well-documented. These are the Civil Works Construction Cost Index System factors published twice a year by the Corps of Engineers. Materials makeup is a source of certainty at this level of planning in a relative sense due to the great detail with which the Acceler8 contractor's cost estimate is prepared. This cost estimate is the basis for the direct costs used in the estimate for the Selected Alternative Plan. For a feasibility level/project implementation report, the detailed cost

estimate goes well beyond what would be regularly prepared to meet Corps guidance.

Following the cost estimator's rule of thumb that 80% of the cost is in 20% of the line items, the items in the C-43 cost estimate with the greatest cost are the following:

- Embankment
- Pump Station (1,500 cubic feet per second)

On a qualitative basis, total cost consists of quantity and unit pricing. The quantity of the materials needed for the embankment is function of the embankment height, width and cross-sectional shape as well as factors such as shrink and swell. The unit pricing of the embankment is a function of, among many factors, equipment and labor employed, production rates (including from how far away the material must come and bad weather), and whether material must be purchased.

As for the pump station, again the quantity of the materials needed is a function of the design, which in turn relies on hydrologic modeling. The unit pricing is a function of materials purchased, including the pumping equipment and concrete with which to construct the buildings, production rates, and equipment needed and labor employed.

B.5.3 Quantitative description of risk

Purposes of quantifying risk include to identify a range of probable costs, to provide an assessment of the probability of completing the project at any given cost level within the identified range, to identify project variables which could contribute most significantly to cost overruns, and to allow for inclusion of the costs identified to mitigate these risks and reflect market conditions (that is, to set contingency).

The quantification of risk for the C-43 Selected Alternative Plan cost estimate is intended to meet the purposes of identifying a range of probable costs and providing an assessment of completing the project at a given cost level. Quantifying risk to set contingency is outside of the realm of this analysis.

The EXCEL add-in 'Crystal Ball' was used to define probability distributions for each variable cost component (quantity and unit cost), thereby describing the uncertainty in the numbers used in the cost estimate. A forecast of each cost component is then made using Monte Carlo simulation to show the entire range of possible cost outcomes and the likelihood of achieving each of them. By including Total Construction Cost as one of the components forecast, a range of

costs can be calculated as well as the certainty of achieving a total cost within a given range.

A list was made of the cost items in the Selected Alternative Plan cost estimate (see table below). For each item, the quantity, unit of measure, unit cost and project cost were extracted from the cost estimate. Note the exact costs used in the risk analysis vary slightly from the Selected Alternative Plan cost estimate. This is because the Selected Alternative Plan cost estimate was revised after the Independent Technical Review; altering the Contractors' profit values. The general results of the risk analysis remain, therefore, the risk analysis was not revised after the Independent Technical Review. Where the quantity varied, a minimum and maximum quantity were calculated, as 10% minus or plus the point estimate or most likely quantity value. Ten percent was used since the level of effort to determine and check these quantities was significant and therefore the quantities are not expected to vary much in the final design/bid documents. To account for unit cost variations, the minimum unit cost was taken to be the most likely cost without added contingency (varying from 25 to 30%) and the maximum cost to be the most likely cost with twice the contingency. The exception to the unit cost rule is the pumping stations, where vendor quotes were obtained for cost components such as the pumping equipment. For the pumping stations, the minimum and maximum were calculated at 10% of and 110% of the most likely cost.

Therefore, the variable quantities and unit costs were assumed to have triangular distributions, that is, ranging from a minimum value to a most likely value, to a maximum value. Further details of the distribution determinations are provided in the attached Crystal Ball report.

Forecasts of project cost were made using the distributions defined coupled with Monte Carlo simulation. The forecasts are described via graphs and statistics and are provided in the attached Crystal Ball report.

TABLE 8: INPUT FOR MONTE CARLO SIMULATION

CONSTRUCTION COST								Quantity		Unit Cost	
Feature Description	Subfeature	Item	Quantity	Unit Of Measure	Unit Cost	Project Cost	Percent of Total Cost	Minimum	Maximum	Minimum	Maximum
Reservoirs											
	Mobilization/demobilization		1	EA	$11,080,299.13	$11,080,299.13	0.034			$8,864,239.30	$13,296,358.96
	Demolition		1	EA	$63,896.05	$63,896.05	0.000			$51,116.84	$76,675.26
	Relocations		1	EA	$1,047,173.13	$1,047,173.13	0.003			$837,738.50	$1,256,607.76
	Dams										
	Perimeter Dam and Canal, Separator Dam										
		Clearing Grubbing & disposal	10,365	AC	$1,332.80	$13,814,472.00	0.043	9,329	11,402	$1,066.24	$1,599.36
		Stripping	1,070,000	CY	$1.77	$1,893,900.00	0.005	963,000	1,177,000	$1.36	$2.18
		Blanket Drain	192,852	CY	$69.13	$13,331,858.76	0.041	173,567	212,137	$53.18	$85.08
		Toe Drain	106,670	LF	$14.75	$1,573,382.50	0.004	96,003	117,337	$11.35	$18.15
		Random Fill Embankment	19,772,438	CY	$4.04	$79,880,649.52	0.249	17,795,194	21,749,682	$3.23	$4.85
		Chimney Drain	130,250	CY	$5.37	$699,442.50	0.002	117,225	143,275	$4.30	$6.44
		Slurry Wall	4,485,936	SF	$6.57	$29,472,599.52	0.092	4,037,342	4,934,530	$5.26	$7.88
		Soil Cement	789,659	CY	$77.40	$61,119,606.60	0.191	710,693	868,625	$61.92	$92.88
		Toe Drain Outfall End Treatment	174	TON	$72.04	$12,534.96	0.000	157	191	$57.63	$86.45
		Select Fill (Structural Backfill)	41,000	CY	$13.50	$553,500.00	0.001	36,900	45,100	$10.38	$16.62
		Seeding	234	AC	$2,429.39	$568,477.26	0.001	211	257	$1,868.76	$2,990.02
		Sodding	250	AC	$30,265.65	$7,566,412.50	0.023	225	275	$23,281.27	$37,250.03
		Cell Instruments & Controls	1	EA	$59,515.45	$59,515.45	0.000			$47,612.36	$71,418.54
		Sitework	1	EA	$3,985,521.94	$3,985,521.94	0.012			$3,188,417.55	$4,782,626.33
	Crested Spillways										
		CS-1	1	EA	$523,382.68	$523,382.68	0.001			$418,706.14	$628,059.22
		CS-2	1	EA	$368,934.39	$368,934.39	0.001			$295,147.51	$442,721.27
	Main Outlet Structures										
		S-1	1	EA	$3,225,582.71	$3,225,582.71	0.010			$2,580,466.17	$3,870,699.25

2246

CONSTRUCTION COST								Quantity		Unit Cost	
		S-8	1	EA	$3,374,680.80	$3,374,680.80	0.010			$2,699,744.64	$4,049,616.96
	Balancing Structure										
		S-12	1	EA	$2,372,369.61	$2,372,369.61	0.007			$1,897,895.69	$2,846,843.53
	Perimeter Canal Structures										
		S-3	1	EA	$2,018,950.80	$2,018,950.80	0.006			$1,615,160.64	$2,422,740.96
		S-10	1	EA	$2,262,378.64	$2,262,378.64	0.007			$1,809,902.91	$2,714,854.37
		S-11	1	EA	$3,151,393.78	$3,151,393.78	0.009			$2,521,115.02	$3,781,672.54
	Gated Culverts										
		S-7	1	EA	$1,768,835.21	$1,768,835.21	0.005			$1,415,068.17	$2,122,602.25
		S-9	1	EA	$1,117,546.31	$1,117,546.31	0.003			$894,037.05	$1,341,055.57
		S-14	1	EA	$1,316,030.87	$1,316,030.87	0.004			$1,052,824.70	$1,579,237.04
		S-15	1	EA	$1,636,808.70	$1,636,808.70	0.005			$1,309,446.96	$1,964,170.44
	Pump Stations										
		P-1 1500 CFS	1	EA	$56,560,118.86	$56,560,118.86	0.176			$50,904,106.97	$62,216,130.75
		P-4 150 CFS	1	EA	$7,105,083.31	$7,105,083.31	0.022			$6,394,574.98	$7,815,591.64
	Townsend Canal Improvements										
		Channel Excavation /Rip Rap/Weir Removal	1	EA	$1,973,792.51	$1,973,792.51	0.006			$1,579,034.01	$2,368,551.01
Fish and Wildlife Facilities											
	Recreation Facilities										
		Entrance/Perimeter Area	1	EA	$868,403.00	$868,403.00	0.002			$694,722.40	$1,042,083.60
		Levee/Reservoir Area	1	EA	$3,471,895.00	$3,471,895.00	0.010			$2,777,516.00	$4,166,274.00
TOTAL CONSTRUCTION COST						**$319,839,429.00**	0.985				

2247

The range in the total construction cost is from $287,000,000 to $354,000,000. Recall the total construction cost reported in the cost estimate for the Selected Alternative Plan is $320,000,000. The following two figures show the bounds of the range of costs. The certainty that the total construction cost will lie within $10,000,000 of the cost reported in the Selected Alternative Plan estimate is 66%. The certainty that the total construction cost will lie within $20,000,000 of the cost reported in the Selected Alternative Plan estimate is 94%.

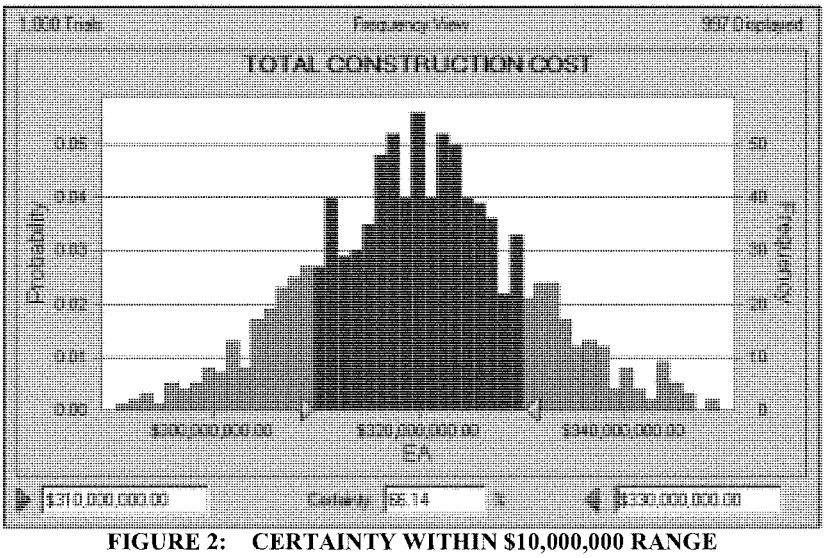


FIGURE 2: CERTAINTY WITHIN $10,000,000 RANGE

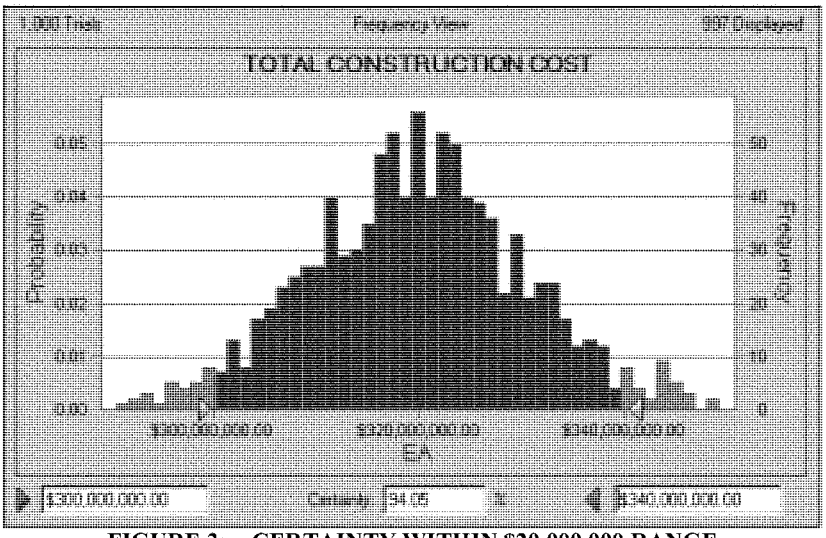


FIGURE 3: CERTAINTY WITHIN $20,000,000 RANGE

B.5.4 Monte Carlo Simulation Results

The report from the Monte Carlo simulation is provided in the following pages. Forecasts with statistics are provided for each cost component studied. Assumptions are documented, including probability distributions. No overlay charts were created. Finally, a sensitivity chart is given for the Total Construction Cost, showing the influence of the cost components. This chart confirms that the embankment/random fill item is the most influential.

This page intentionally left blank

REPORT1.xls

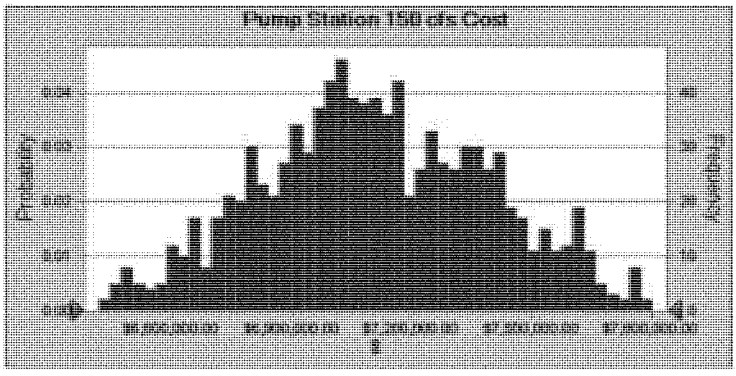
Crystal Ball Report - Full
Simulation started on 7/6/2007 at 8:15:30
Simulation stopped on 7/6/2007 at 8:15:32

Run preferences:	
Number of trials run	1,000
Extreme speed	
Monte Carlo	
Random seed	
Precision control on	
Confidence level	95.00%
Run statistics:	
Total running time (sec)	2.13
Trials/second (average)	470
Random numbers per sec	25,362
Crystal Ball data:	
Assumptions	54
Correlations	0
Correlated groups	0
Decision variables	0
Forecasts	41

Forecasts

Forecast: Pump Station 150 cfs Cost

Summary:
Entire range is from $6,416,881.89 to $7,798,525.50
Base case is $7,105,083.31
After 1,000 trials, the std. error of the mean is $9,000.25



Statistics:	Forecast values
Trials	1,000
Mean	$7,106,572.48
Median	$7,092,098.55
Mode	---
Standard Deviation	$284,612.76
Variance	$81,004,425,020.06
Skewness	0.0454
Kurtosis	2.48
Coeff. of Variability	0.0400
Minimum	$6,416,881.89
Maximum	$7,798,525.50
Range Width	$1,381,643.61
Mean Std. Error	$9,000.25

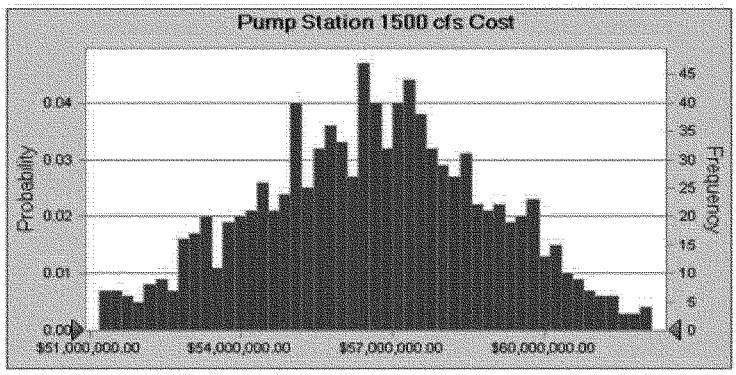
Forecast: Pump Station 150 cfs Cost (cont'd)

Percentiles:	Forecast values
0%	$6,416,881.89
10%	$6,742,256.23
20%	$6,852,435.41
30%	$6,954,153.76
40%	$7,024,207.51
50%	$7,092,098.55
60%	$7,165,792.78
70%	$7,266,129.94
80%	$7,366,094.81
90%	$7,484,615.60
100%	$7,798,525.50

REPORT1.xls

Forecast: Pump Station 1500 cfs Cost

Summary:
Entire range is from $51,201,364.30 to $62,113,095.21
Base case is $56,560,118.86
After 1,000 trials, the std. error of the mean is $72,198.21



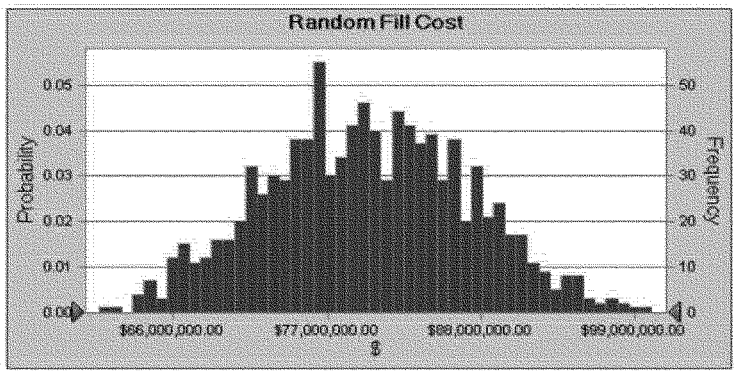
Statistics:	Forecast values
Trials	1,000
Mean	$56,590,455.67
Median	$56,658,822.80
Mode	---
Standard Deviation	$2,283,107.83
Variance	$5,212,581,365,801.39
Skewness	-0.0611
Kurtosis	2.50
Coeff. of Variability	0.0403
Minimum	$51,201,364.30
Maximum	$62,113,095.21
Range Width	$10,911,730.90
Mean Std. Error	$72,198.21

Forecast: Pump Station 1500 cfs Cost (cont'd)

Percentiles:	Forecast values
0%	$51,201,364.30
10%	$53,377,310.57
20%	$54,555,220.07
30%	$55,359,762.29
40%	$55,999,361.50
50%	$56,658,822.80
60%	$57,224,340.16
70%	$57,804,485.04
80%	$58,556,977.07
90%	$59,648,190.63
100%	$62,113,095.21

Forecast: Random Fill Cost

Summary:
Entire range is from $60,707,404.51 to $100,764,771.23
Base case is $79,880,649.52
After 1,000 trials, the std. error of the mean is $229,821.32



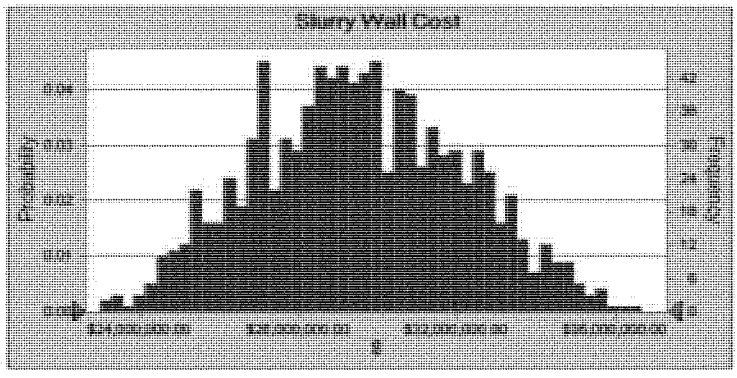
Statistics:	Forecast values
Trials	1,000
Mean	$79,859,443.02
Median	$79,744,447.03
Mode	---
Standard Deviation	$7,267,588.26
Variance	$52,817,839,162,004.60
Skewness	0.0734
Kurtosis	2.59
Coeff. of Variability	0.0910
Minimum	$60,707,404.51
Maximum	$100,764,771.23
Range Width	$40,057,366.73
Mean Std. Error	$229,821.32

Forecast: Random Fill Cost (cont'd)

Percentiles:	Forecast values
0%	$60,707,404.51
10%	$70,493,977.32
20%	$73,396,869.35
30%	$75,803,580.01
40%	$77,732,516.86
50%	$79,744,447.03
60%	$81,964,559.96
70%	$83,851,314.43
80%	$86,207,532.14
90%	$89,461,797.75
100%	$100,764,771.23

Forecast: Slurry Wall Cost

Summary:
Entire range is from $22,970,375.11 to $37,624,135.74
Base case is $29,472,599.52
After 1,000 trials, the std. error of the mean is $83,448.48



Statistics:	Forecast values
Trials	1,000
Mean	$29,534,854.73
Median	$29,456,720.06
Mode	---
Standard Deviation	$2,638,872.50
Variance	$6,963,648,045,281.19
Skewness	0.1256
Kurtosis	2.57
Coeff. of Variability	0.0893
Minimum	$22,970,375.11
Maximum	$37,624,135.74
Range Width	$14,653,760.63
Mean Std. Error	$83,448.48

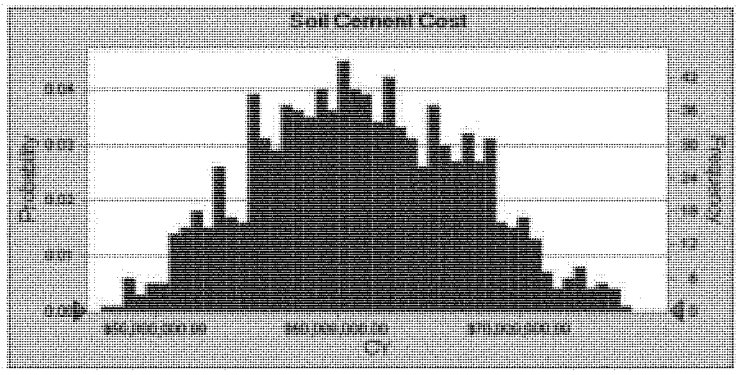
Forecast: Slurry Wall Cost (cont'd)

Percentiles:	Forecast values
0%	$22,970,375.11
10%	$26,051,278.72
20%	$27,092,861.67
30%	$28,075,872.06
40%	$28,753,487.83
50%	$29,456,720.06
60%	$30,122,305.48
70%	$30,929,209.75
80%	$31,854,117.56
90%	$33,017,347.90
100%	$37,624,135.74

REPORT1.xls

Forecast: Soil Cement Cost

Summary:
Entire range is from $46,998,837.45 to $77,458,211.58
Base case is $61,119,606.60
After 1,000 trials, the std. error of the mean is $181,027.47



Statistics:	Forecast values
Trials	1,000
Mean	$61,242,758.80
Median	$61,086,890.65
Mode	---
Standard Deviation	$5,724,591.12
Variance	$32,770,943,458,337.30
Skewness	0.0861
Kurtosis	2.44
Coeff. of Variability	0.0935
Minimum	$46,998,837.45
Maximum	$77,458,211.58
Range Width	$30,459,374.13
Mean Std. Error	$181,027.47

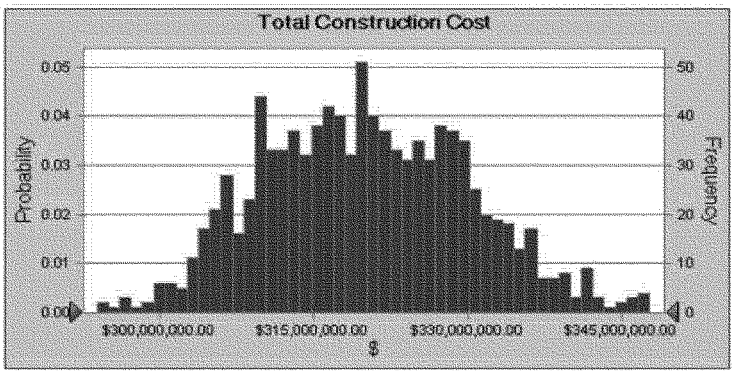
Forecast: Soil Cement Cost (cont'd)

Percentiles:	Forecast values
0%	$46,998,837.45
10%	$53,609,573.08
20%	$56,049,809.57
30%	$57,921,893.51
40%	$59,518,925.67
50%	$61,086,890.65
60%	$62,707,885.13
70%	$64,537,890.43
80%	$66,482,145.54
90%	$68,642,233.16
100%	$77,458,211.58

REPORT1.xls

Forecast: Total Construction Cost

Summary:
Entire range is from $293,962,393.17 to $347,653,809.11
Base case is $319,839,429.00
After 1,000 trials, the std. error of the mean is $314,168.91



Statistics:	Forecast values
Trials	1,000
Mean	$320,035,455.89
Median	$319,538,980.60
Mode	---
Standard Deviation	$9,934,893.32
Variance	$98,702,105,188,578.70
Skewness	0.1515
Kurtosis	2.59
Coeff. of Variability	0.0310
Minimum	$293,962,393.17
Maximum	$347,653,809.11
Range Width	$53,691,415.94
Mean Std. Error	$314,168.91

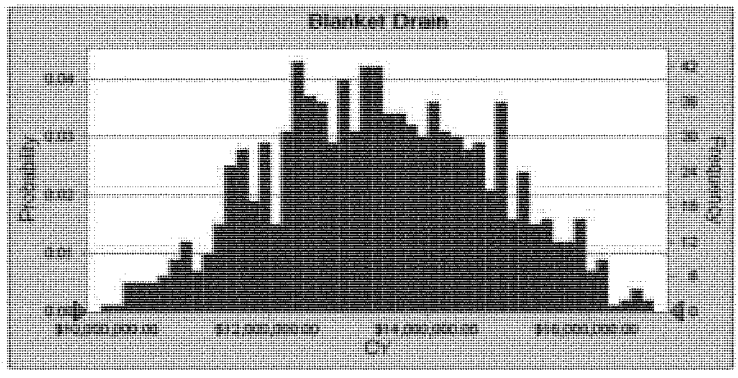
Forecast: Total Construction Cost (cont'd)

Percentiles:	Forecast values
0%	$293,962,393.17
10%	$306,952,839.76
20%	$310,911,305.12
30%	$314,146,681.86
40%	$316,955,238.65
50%	$319,538,980.60
60%	$322,202,083.63
70%	$325,737,477.37
80%	$328,729,596.80
90%	$333,020,353.09
100%	$347,653,809.11

REPORT1.xls

Forecast: Blanket Drain

Summary:
Entire range is from $9,917,361.95 to $16,810,651.51
Base case is $13,331,858.76
After 1,000 trials, the std. error of the mean is $43,525.00



Statistics:	Forecast values
Trials	1,000
Mean	$13,399,268.67
Median	$13,364,829.74
Mode	---
Standard Deviation	$1,376,381.27
Variance	$1,894,425,413,267.07
Skewness	0.0319
Kurtosis	2.40
Coeff. of Variability	0.1027
Minimum	$9,917,361.95
Maximum	$16,810,651.51
Range Width	$6,893,289.56
Mean Std. Error	$43,525.00

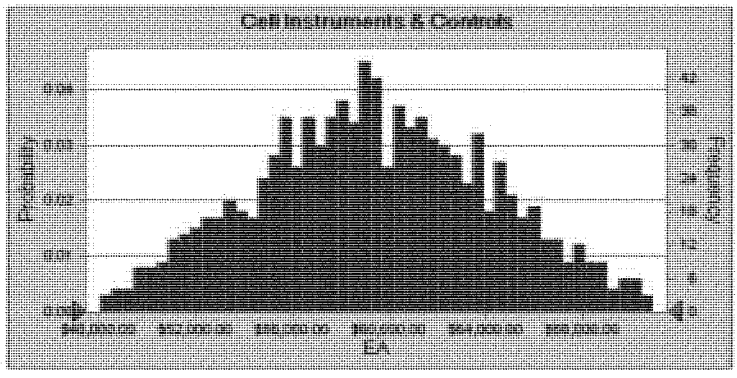
Forecast: Blanket Drain (cont'd)

Percentiles:	Forecast values
0%	$9,917,361.95
10%	$11,593,197.52
20%	$12,206,512.14
30%	$12,580,390.50
40%	$12,971,712.99
50%	$13,364,829.74
60%	$13,751,046.03
70%	$14,178,126.04
80%	$14,660,788.46
90%	$15,257,130.49
100%	$16,810,651.51

REPORT1.xls

Forecast: Cell Instruments & Controls

Summary:
Entire range is from $48,064.46 to $70,875.46
Base case is $59,515.45
After 1,000 trials, the std. error of the mean is $151.94



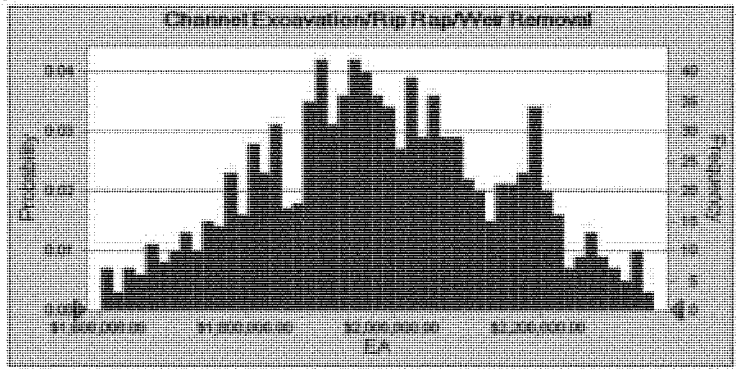
Statistics:	Forecast values
Trials	1,000
Mean	$59,377.52
Median	$59,271.80
Mode	---
Standard Deviation	$4,804.88
Variance	$23,086,845.46
Skewness	0.0285
Kurtosis	2.44
Coeff. of Variability	0.0809
Minimum	$48,064.46
Maximum	$70,875.46
Range Width	$22,811.01
Mean Std. Error	$151.94

Forecast: Cell Instruments & Controls (cont'd)

Percentiles:	Forecast values
0%	$48,064.46
10%	$52,837.52
20%	$55,136.56
30%	$56,757.37
40%	$58,097.02
50%	$59,271.80
60%	$60,598.70
70%	$61,991.46
80%	$63,626.13
90%	$65,826.80
100%	$70,875.46

Forecast: Channel Excavation/Rip Rap/Weir Removal

Summary:
Entire range is from $1,602,712.44 to $2,355,610.60
Base case is $1,973,792.51
After 1,000 trials, the std. error of the mean is $5,178.82



Statistics:	Forecast values
Trials	1,000
Mean	$1,982,805.71
Median	$1,975,194.14
Mode	—
Standard Deviation	$163,768.64
Variance	$26,820,165,847.22
Skewness	0.0012
Kurtosis	2.42
Coeff. of Variability	0.0826
Minimum	$1,602,712.44
Maximum	$2,355,610.60
Range Width	$752,898.16
Mean Std. Error	$5,178.82

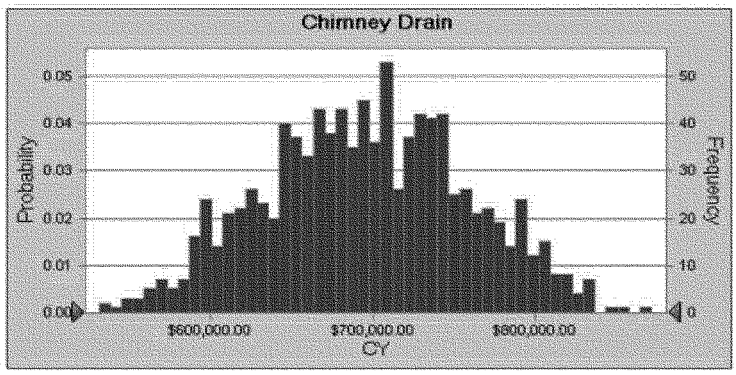
Forecast: Channel Excavation/Rip Rap/Weir Removal (cont'd)

Percentiles:	Forecast values
0%	$1,602,712.44
10%	$1,766,332.48
20%	$1,834,804.25
30%	$1,896,400.88
40%	$1,939,283.24
50%	$1,975,194.14
60%	$2,024,329.41
70%	$2,069,484.64
80%	$2,138,600.71
90%	$2,200,244.58
100%	$2,355,610.60

REPORT1.xls

Forecast: Chimney Drain

Summary:
Entire range is from $531,470.14 to $877,571.88
Base case is $699,442.50
After 1,000 trials, the std. error of the mean is $1,981.88



Statistics:	Forecast values
Trials	1,000
Mean	$696,234.04
Median	$696,171.93
Mode	—
Standard Deviation	$62,672.47
Variance	$3,927,838,898.79
Skewness	0.0290
Kurtosis	2.55
Coeff. of Variability	0.0900
Minimum	$531,470.14
Maximum	$877,571.88
Range Width	$346,101.73
Mean Std. Error	$1,981.88

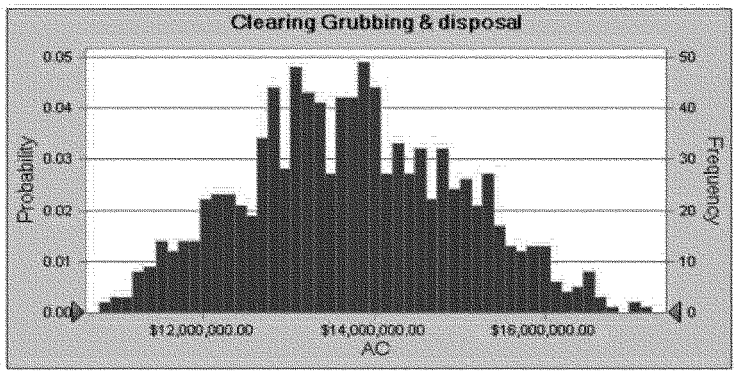
Forecast: Chimney Drain (cont'd)

Percentiles:	Forecast values
0%	$531,470.14
10%	$612,348.45
20%	$642,752.44
30%	$661,601.90
40%	$678,811.14
50%	$696,171.93
60%	$711,400.80
70%	$731,667.12
80%	$750,182.84
90%	$779,692.41
100%	$877,571.88

REPORT1.xls

Forecast: Clearing Grubbing & disposal

Summary:
Entire range is from $10,782,614.99 to $17,583,036.96
Base case is $13,814,472.00
After 1,000 trials, the std. error of the mean is $39,603.57



Statistics:	Forecast values
Trials	1,000
Mean	$13,739,501.48
Median	$13,695,495.53
Mode	---
Standard Deviation	$1,252,374.99
Variance	$1,568,443,124,173.57
Skewness	0.1565
Kurtosis	2.57
Coeff. of Variability	0.0912
Minimum	$10,782,614.99
Maximum	$17,583,036.96
Range Width	$6,800,421.97
Mean Std. Error	$39,603.57

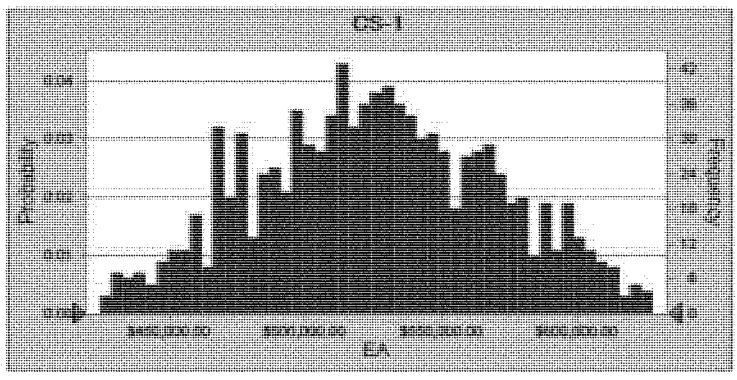
Forecast: Clearing Grubbing & disposal (cont'd)

Percentiles:	Forecast values
0%	$10,782,614.99
10%	$12,098,473.11
20%	$12,677,740.05
30%	$13,052,226.96
40%	$13,339,026.93
50%	$13,695,495.53
60%	$14,002,829.58
70%	$14,422,133.83
80%	$14,855,246.04
90%	$15,389,539.06
100%	$17,583,036.96

REPORT1.xls

Forecast: CS-1

Summary:
Entire range is from $424,590.43 to $627,471.17
Base case is $523,382.68
After 1,000 trials, the std. error of the mean is $1,382.39



Statistics:	Forecast values
Trials	1,000
Mean	$525,823.93
Median	$525,527.01
Mode	---
Standard Deviation	$43,715.02
Variance	$1,911,002,675.37
Skewness	0.0229
Kurtosis	2.38
Coeff. of Variability	0.0831
Minimum	$424,590.43
Maximum	$627,471.17
Range Width	$202,880.74
Mean Std. Error	$1,382.39

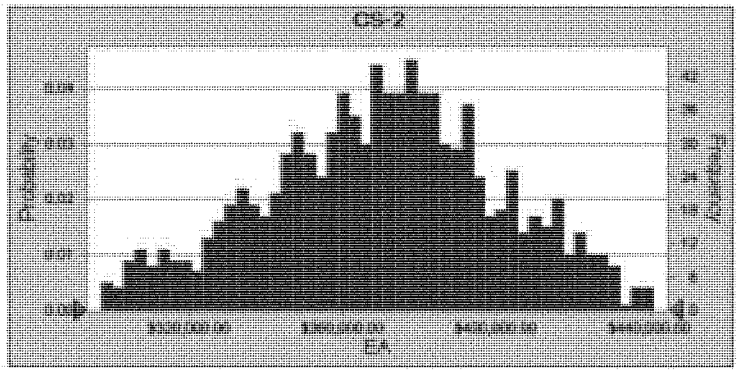
Forecast: CS-1 (cont'd)

Percentiles:	Forecast values
0%	$424,590.43
10%	$468,071.18
20%	$486,233.52
30%	$501,564.16
40%	$514,084.17
50%	$525,527.01
60%	$536,299.38
70%	$549,296.50
80%	$565,856.85
90%	$586,758.13
100%	$627,471.17

REPORT1.xls

Forecast: CS-2

Summary:
Entire range is from $296,760.05 to $440,655.98
Base case is $368,934.39
After 1,000 trials, the std. error of the mean is $961.43



Statistics:	Forecast values
Trials	1,000
Mean	$369,588.30
Median	$370,976.07
Mode	—
Standard Deviation	$30,403.06
Variance	$924,346,138.16
Skewness	-0.1046
Kurtosis	2.55
Coeff. of Variability	0.0823
Minimum	$296,760.05
Maximum	$440,655.98
Range Width	$143,895.93
Mean Std. Error	$961.43

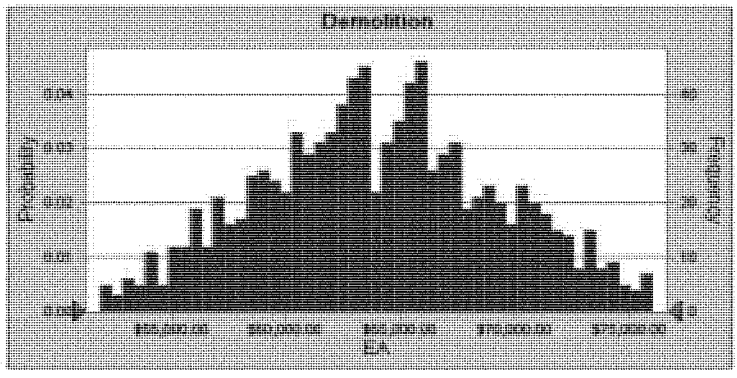
Forecast: CS-2 (cont'd)

Percentiles:	Forecast values
0%	$296,760.05
10%	$328,536.11
20%	$343,658.69
30%	$353,785.19
40%	$362,751.60
50%	$370,976.07
60%	$378,137.79
70%	$385,467.32
80%	$394,778.56
90%	$410,086.81
100%	$440,655.98

REPORT1.xls

Forecast: Demolition

Summary:
Entire range is from $51,892.18 to $75,956.34
Base case is $63,896.05
After 1,000 trials, the std. error of the mean is $163.79



Statistics:	Forecast values
Trials	1,000
Mean	$64,009.37
Median	$63,788.21
Mode	---
Standard Deviation	$5,179.45
Variance	$26,826,658.19
Skewness	0.0293
Kurtosis	2.43
Coeff. of Variability	0.0809
Minimum	$51,892.18
Maximum	$75,956.34
Range Width	$24,064.17
Mean Std. Error	$163.79

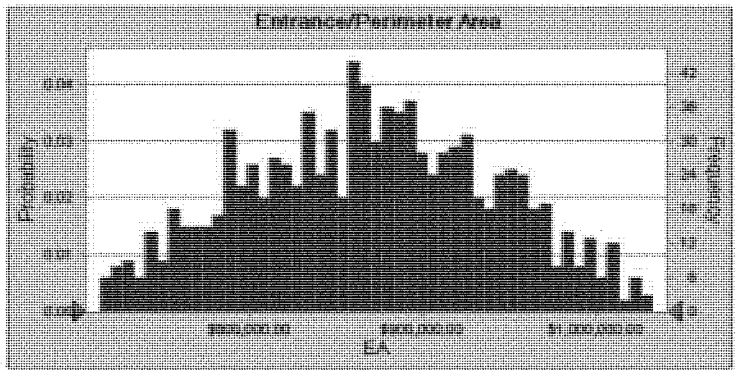
Forecast: Demolition (cont'd)

Percentiles:	Forecast values
0%	$51,892.18
10%	$57,114.51
20%	$59,337.03
30%	$61,126.28
40%	$62,637.35
50%	$63,788.21
60%	$65,390.59
70%	$66,736.70
80%	$68,698.93
90%	$71,099.16
100%	$75,956.34

REPORT1.xls

Forecast: Entrance/Perimeter Area

Summary:
Entire range is from $713,898.81 to $1,032,292.02
Base case is $868,403.00
After 1,000 trials, the std. error of the mean is $2,253.49



Statistics:	Forecast values
Trials	1,000
Mean	$869,271.81
Median	$868,946.51
Mode	---
Standard Deviation	$71,261.59
Variance	$5,078,214,695.18
Skewness	-0.0077
Kurtosis	2.29
Coeff. of Variability	0.0820
Minimum	$713,898.81
Maximum	$1,032,292.02
Range Width	$318,393.22
Mean Std. Error	$2,253.49

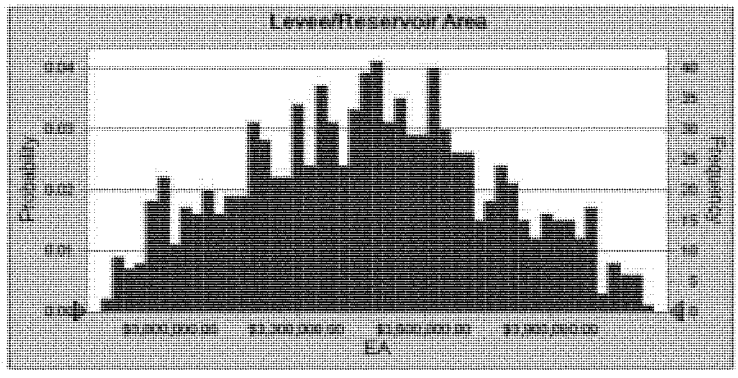
Forecast: Entrance/Perimeter Area (cont'd)

Percentiles:	Forecast values
0%	$713,898.81
10%	$772,241.48
20%	$801,860.51
30%	$828,774.88
40%	$851,084.36
50%	$868,946.51
60%	$888,821.07
70%	$910,131.28
80%	$934,526.01
90%	$964,191.53
100%	$1,032,292.02

REPORT1.xls

Forecast: Levee/Reservoir Area

Summary:
Entire range is from $2,834,168.80 to $4,140,637.13
Base case is $3,471,895.00
After 1,000 trials, the std. error of the mean is $9,255.81



Statistics:	Forecast values
Trials	1,000
Mean	$3,463,433.29
Median	$3,466,173.78
Mode	---
Standard Deviation	$292,694.46
Variance	$85,670,046,381.94
Skewness	0.0337
Kurtosis	2.29
Coeff. of Variability	0.0845
Minimum	$2,834,168.80
Maximum	$4,140,637.13
Range Width	$1,306,468.34
Mean Std. Error	$9,255.81

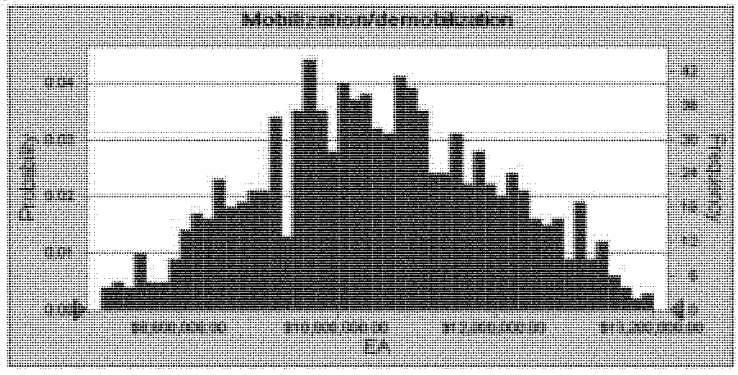
Forecast: Levee/Reservoir Area (cont'd)

Percentiles:	Forecast values
0%	$2,834,168.80
10%	$3,052,546.08
20%	$3,197,537.02
30%	$3,296,684.34
40%	$3,387,699.24
50%	$3,466,173.78
60%	$3,537,263.87
70%	$3,625,872.84
80%	$3,722,007.25
90%	$3,869,449.03
100%	$4,140,637.13

REPORT1.xls

Forecast: Mobilization/demobilization

Summary:
Entire range is from $8,994,004.87 to $13,202,925.18
Base case is $11,080,299.13
After 1,000 trials, the std. error of the mean is $28,245.13



Statistics:	Forecast values
Trials	1,000
Mean	$11,094,841.54
Median	$11,066,226.15
Mode	—
Standard Deviation	$893,189.35
Variance	$797,787,214,920.28
Skewness	0.0189
Kurtosis	2.39
Coeff. of Variability	0.0805
Minimum	$8,994,004.87
Maximum	$13,202,925.18
Range Width	$4,208,920.31
Mean Std. Error	$28,245.13

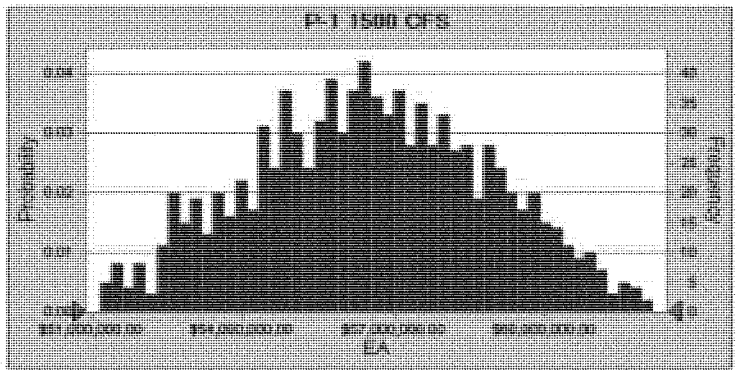
Forecast: Mobilization/demobilization (cont'd)

Percentiles:	Forecast values
0%	$8,994,004.87
10%	$9,902,052.21
20%	$10,310,738.01
30%	$10,593,111.35
40%	$10,848,173.64
50%	$11,066,226.15
60%	$11,313,501.78
70%	$11,580,328.70
80%	$11,892,932.70
90%	$12,324,275.98
100%	$13,202,925.18

REPORT1.xls

Forecast: P-1 1500 CFS

Summary:
Entire range is from $51,170,376.79 to $62,099,064.87
Base case is $56,560,118.86
After 1,000 trials, the std. error of the mean is $73,540.30



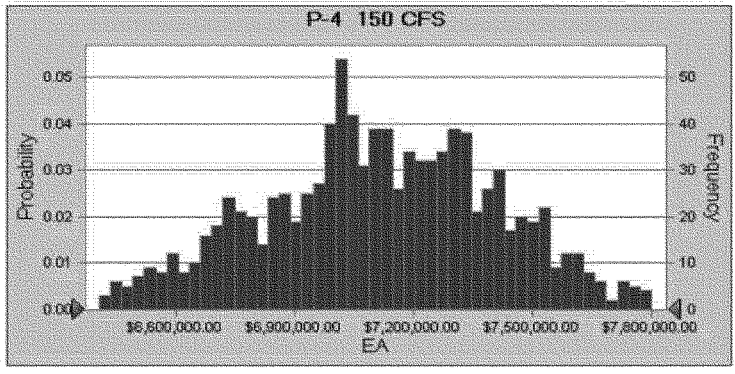
Statistics:	Forecast values
Trials	1,000
Mean	$56,496,450.35
Median	$56,470,243.96
Mode	—
Standard Deviation	$2,325,548.61
Variance	$5,408,176,358,181.55
Skewness	-0.0034
Kurtosis	2.37
Coeff. of Variability	0.0412
Minimum	$51,170,376.79
Maximum	$62,099,064.87
Range Width	$10,928,688.08
Mean Std. Error	$73,540.30

Forecast: P-1 1500 CFS (cont'd)

Percentiles:	Forecast values
0%	$51,170,376.79
10%	$53,345,602.19
20%	$54,458,105.17
30%	$55,156,140.16
40%	$55,870,687.82
50%	$56,470,243.96
60%	$57,086,522.38
70%	$57,837,023.09
80%	$58,574,718.89
90%	$59,625,377.74
100%	$62,099,064.87

Forecast: P-4 150 CFS

Summary:
Entire range is from $6,407,569.03 to $7,800,494.02
Base case is $7,105,083.31
After 1,000 trials, the std. error of the mean is $9,192.52



Statistics:	Forecast values
Trials	1,000
Mean	$7,113,080.65
Median	$7,113,637.59
Mode	—
Standard Deviation	$290,692.99
Variance	$84,502,412,206.26
Skewness	-0.0908
Kurtosis	2.48
Coeff. of Variability	0.0409
Minimum	$6,407,569.03
Maximum	$7,800,494.02
Range Width	$1,392,924.99
Mean Std. Error	$9,192.52

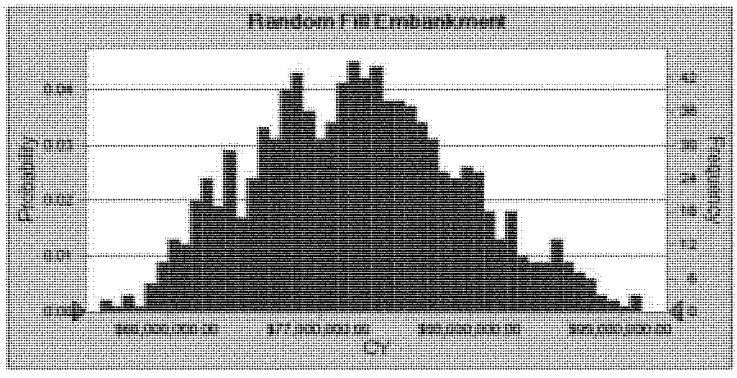
Forecast: P-4 150 CFS (cont'd)

Percentiles:	Forecast values
0%	$6,407,569.03
10%	$6,711,542.03
20%	$6,858,971.15
30%	$6,975,131.82
40%	$7,035,225.91
50%	$7,113,637.59
60%	$7,197,228.87
70%	$7,285,544.97
80%	$7,373,428.67
90%	$7,501,265.84
100%	$7,800,494.02

REPORT1.xls

Forecast: Random Fill Embankment

Summary:
Entire range is from $61,042,601.24 to $101,513,201.41
Base case is $79,880,649.52
After 1,000 trials, the std. error of the mean is $241,512.05



Statistics:	Forecast values
Trials	1,000
Mean	$79,799,869.39
Median	$79,550,014.82
Mode	—
Standard Deviation	$7,637,281.71
Variance	$58,328,071,910,350.70
Skewness	0.1896
Kurtosis	2.58
Coeff. of Variability	0.0957
Minimum	$61,042,601.24
Maximum	$101,513,201.41
Range Width	$40,470,600.17
Mean Std. Error	$241,512.05

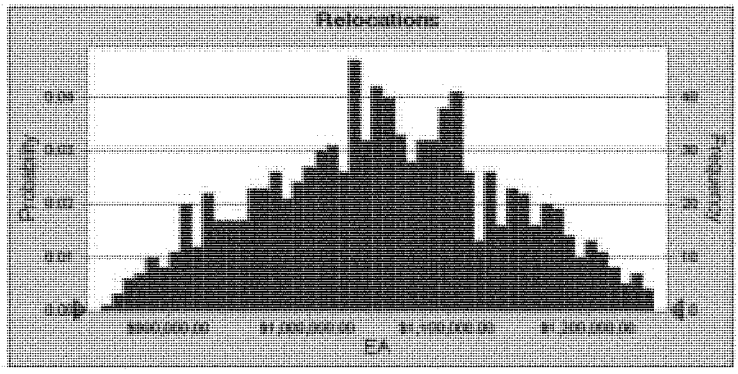
Forecast: Random Fill Embankment (cont'd)

Percentiles:	Forecast values
0%	$61,042,601.24
10%	$69,514,439.00
20%	$73,052,695.56
30%	$75,322,603.21
40%	$77,489,948.67
50%	$79,550,014.82
60%	$81,530,715.04
70%	$83,784,246.88
80%	$86,300,725.55
90%	$89,927,725.87
100%	$101,513,201.41

REPORT1.xls

Forecast: Relocations

Summary:
Entire range is from $851,783.72 to $1,245,756.86
Base case is $1,047,173.13
After 1,000 trials, the std. error of the mean is $2,711.62



Statistics:	Forecast values
Trials	1,000
Mean	$1,052,123.71
Median	$1,052,358.41
Mode	—
Standard Deviation	$85,748.96
Variance	$7,352,884,781.83
Skewness	-0.0115
Kurtosis	2.34
Coeff. of Variability	0.0815
Minimum	$851,783.72
Maximum	$1,245,756.86
Range Width	$393,973.15
Mean Std. Error	$2,711.62

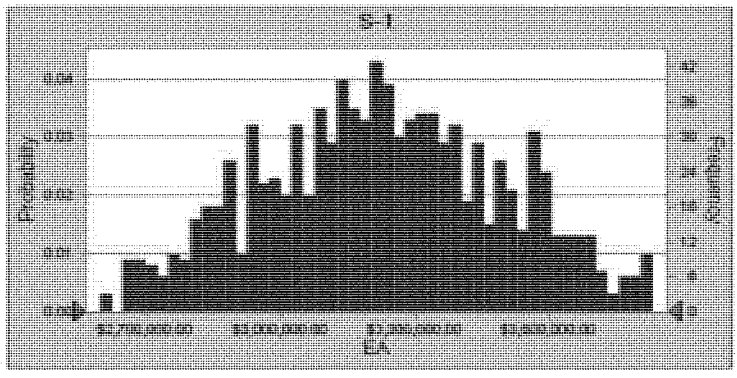
Forecast: Relocations (cont'd)

Percentiles:	Forecast values
0%	$851,783.72
10%	$931,933.68
20%	$973,392.12
30%	$1,005,768.42
40%	$1,031,860.78
50%	$1,052,358.41
60%	$1,076,075.91
70%	$1,100,084.94
80%	$1,128,105.49
90%	$1,169,229.02
100%	$1,245,756.86

REPORT1.xls

Forecast: S-1

Summary:
Entire range is from $2,596,882.63 to $3,827,205.20
Base case is $3,225,582.71
After 1,000 trials, the std. error of the mean is $8,462.26



Statistics:	Forecast values
Trials	1,000
Mean	$3,224,572.30
Median	$3,221,934.72
Mode	—
Standard Deviation	$267,600.27
Variance	$71,609,905,975.51
Skewness	0.0148
Kurtosis	2.37
Coeff. of Variability	0.0830
Minimum	$2,596,882.63
Maximum	$3,827,205.20
Range Width	$1,230,322.57
Mean Std. Error	$8,462.26

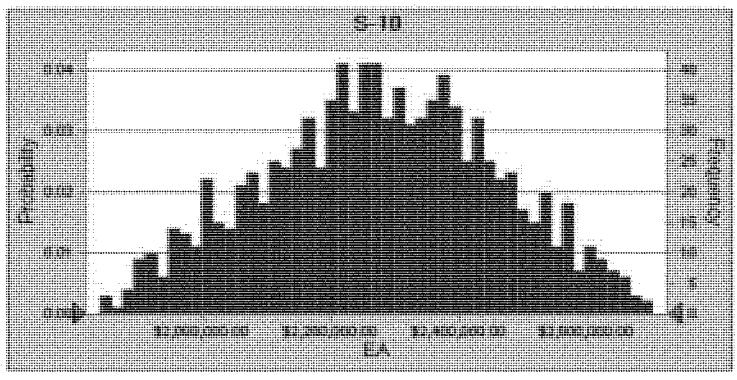
Forecast: S-1 (cont'd)

Percentiles:	Forecast values
0%	$2,596,882.63
10%	$2,858,359.72
20%	$2,976,580.17
30%	$3,080,884.98
40%	$3,152,580.65
50%	$3,221,934.72
60%	$3,295,025.85
70%	$3,372,625.00
80%	$3,475,067.09
90%	$3,580,948.34
100%	$3,827,205.20

REPORT1.xls

Forecast: S-10

Summary:
Entire range is from $1,839,622.91 to $2,700,873.71
Base case is $2,262,378.64
After 1,000 trials, the std. error of the mean is $5,707.54



Statistics:	Forecast values
Trials	1,000
Mean	$2,275,871.03
Median	$2,275,791.50
Mode	—
Standard Deviation	$180,488.37
Variance	$32,576,051,185.50
Skewness	-0.0536
Kurtosis	2.40
Coeff. of Variability	0.0793
Minimum	$1,839,622.91
Maximum	$2,700,873.71
Range Width	$861,250.80
Mean Std. Error	$5,707.54

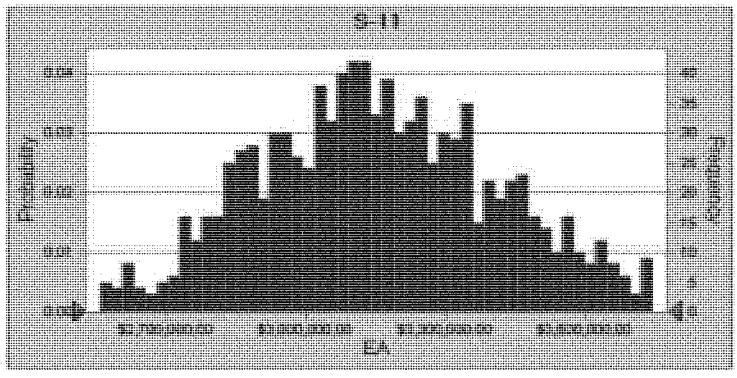
Forecast: S-10 (cont'd)

Percentiles:	Forecast values
0%	$1,839,622.91
10%	$2,018,877.71
20%	$2,114,352.81
30%	$2,180,052.28
40%	$2,230,818.08
50%	$2,275,791.50
60%	$2,325,336.53
70%	$2,377,893.47
80%	$2,433,488.68
90%	$2,515,752.26
100%	$2,700,873.71

REPORT1.xls

Forecast: S-11

Summary:
Entire range is from $2,557,555.40 to $3,742,620.58
Base case is $3,151,393.78
After 1,000 trials, the std. error of the mean is $7,972.87



Statistics:	Forecast values
Trials	1,000
Mean	$3,151,725.09
Median	$3,138,273.90
Mode	—
Standard Deviation	$252,124.14
Variance	$63,566,583,468.27
Skewness	0.0976
Kurtosis	2.46
Coeff. of Variability	0.0800
Minimum	$2,557,555.40
Maximum	$3,742,620.58
Range Width	$1,185,065.18
Mean Std. Error	$7,972.87

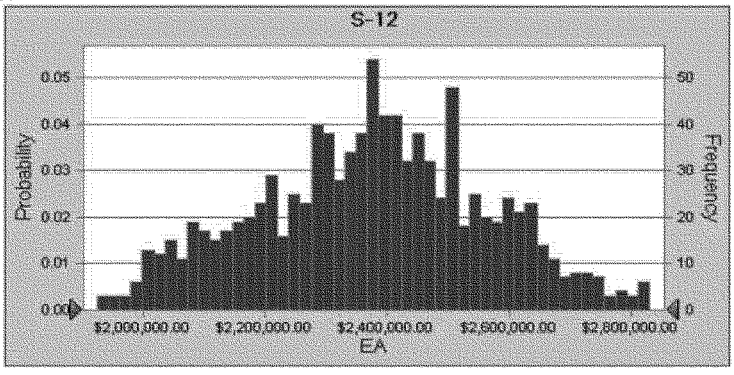
Forecast: S-11 (cont'd)

Percentiles:	Forecast values
0%	$2,557,555.40
10%	$2,829,186.12
20%	$2,923,968.75
30%	$3,010,483.19
40%	$3,078,649.25
50%	$3,138,273.90
60%	$3,210,215.81
70%	$3,291,309.92
80%	$3,377,342.81
90%	$3,492,823.07
100%	$3,742,620.58

REPORT1.xls

Forecast: S-12

Summary:
Entire range is from $1,925,397.54 to $2,829,863.13
Base case is $2,372,369.61
After 1,000 trials, the std. error of the mean is $5,921.38



Statistics:	Forecast values
Trials	1,000
Mean	$2,373,586.67
Median	$2,378,858.32
Mode	---
Standard Deviation	$187,250.58
Variance	$35,062,780,851.54
Skewness	-0.0495
Kurtosis	2.50
Coeff. of Variability	0.0789
Minimum	$1,925,397.54
Maximum	$2,829,863.13
Range Width	$904,465.59
Mean Std. Error	$5,921.38

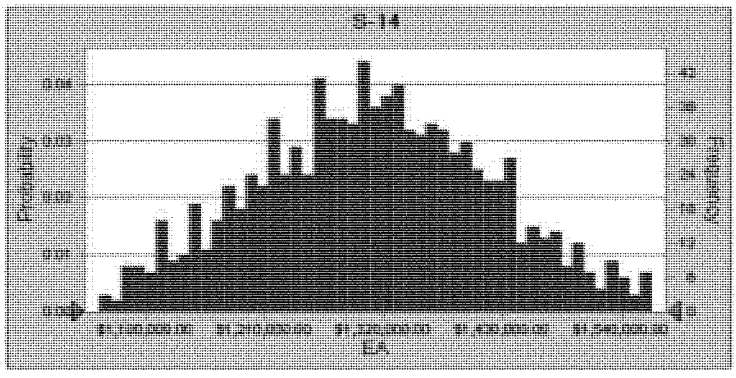
Forecast: S-12 (cont'd)

Percentiles:	Forecast values
0%	$1,925,397.54
10%	$2,107,180.76
20%	$2,205,395.86
30%	$2,280,435.32
40%	$2,335,755.62
50%	$2,378,858.32
60%	$2,420,049.07
70%	$2,475,229.40
80%	$2,537,607.46
90%	$2,620,367.67
100%	$2,829,863.13

REPORT1.xls

Forecast: S-14

Summary:
Entire range is from $1,057,120.30 to $1,566,360.30
Base case is $1,316,030.87
After 1,000 trials, the std. error of the mean is $3,392.16



Statistics:	Forecast values
Trials	1,000
Mean	$1,309,144.44
Median	$1,308,718.76
Mode	—
Standard Deviation	$107,269.55
Variance	$11,506,756,686.06
Skewness	0.0275
Kurtosis	2.49
Coeff. of Variability	0.0819
Minimum	$1,057,120.30
Maximum	$1,566,360.30
Range Width	$509,240.00
Mean Std. Error	$3,392.16

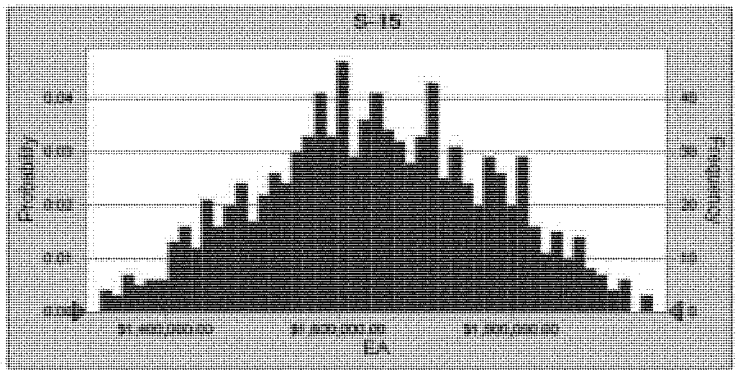
Forecast: S-14 (cont'd)

Percentiles:	Forecast values
0%	$1,057,120.30
10%	$1,166,450.49
20%	$1,214,206.45
30%	$1,250,037.97
40%	$1,280,990.32
50%	$1,308,718.76
60%	$1,335,813.76
70%	$1,368,145.47
80%	$1,405,121.96
90%	$1,450,374.10
100%	$1,566,360.30

REPORT1.xls

Forecast: S-15

Summary:
Entire range is from $1,324,105.53 to $1,960,981.25
Base case is $1,636,808.70
After 1,000 trials, the std. error of the mean is $4,184.45



Statistics:	Forecast values
Trials	1,000
Mean	$1,640,433.32
Median	$1,639,567.01
Mode	---
Standard Deviation	$132,323.89
Variance	$17,509,611,831.21
Skewness	-0.0145
Kurtosis	2.39
Coeff. of Variability	0.0807
Minimum	$1,324,105.53
Maximum	$1,960,981.25
Range Width	$636,875.72
Mean Std. Error	$4,184.45

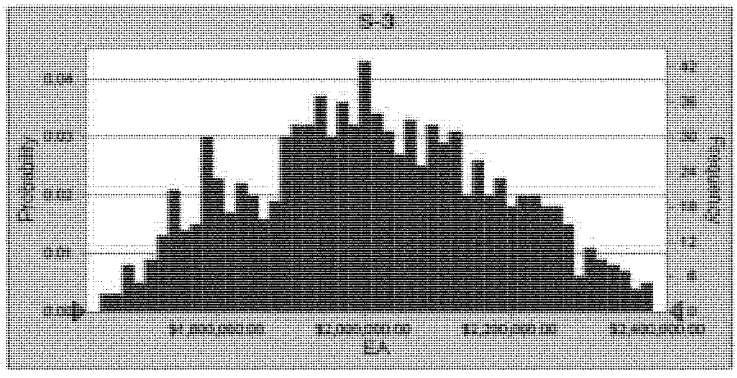
Forecast: S-15 (cont'd)

Percentiles:	Forecast values
0%	$1,324,105.53
10%	$1,460,956.78
20%	$1,523,485.28
30%	$1,568,293.28
40%	$1,603,026.42
50%	$1,639,567.01
60%	$1,675,956.32
70%	$1,713,534.58
80%	$1,765,003.62
90%	$1,814,641.47
100%	$1,960,981.25

REPORT1.xls

Forecast: S-3

Summary:
Entire range is from $1,640,563.07 to $2,391,435.53
Base case is $2,018,950.80
After 1,000 trials, the std. error of the mean is $5,268.59



Statistics:	Forecast values
Trials	1,000
Mean	$2,009,785.55
Median	$2,006,262.65
Mode	---
Standard Deviation	$166,607.51
Variance	$27,758,063,432.50
Skewness	0.0500
Kurtosis	2.28
Coeff. of Variability	0.0829
Minimum	$1,640,563.07
Maximum	$2,391,435.53
Range Width	$750,872.46
Mean Std. Error	$5,268.59

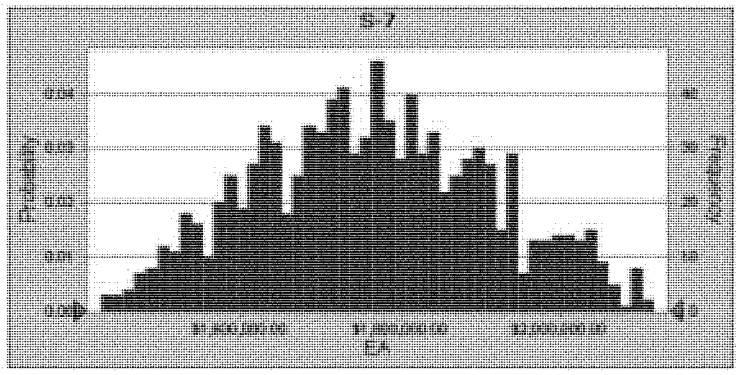
Forecast: S-3 (cont'd)

Percentiles:	Forecast values
0%	$1,640,563.07
10%	$1,785,235.47
20%	$1,854,268.44
30%	$1,916,345.33
40%	$1,962,453.66
50%	$2,006,262.65
60%	$2,052,367.92
70%	$2,103,359.28
80%	$2,162,115.98
90%	$2,238,514.46
100%	$2,391,435.53

REPORT1.xls

Forecast: S-7

Summary:
Entire range is from $1,424,957.70 to $2,115,971.01
Base case is $1,768,835.21
After 1,000 trials, the std. error of the mean is $4,660.71



Statistics:	Forecast values
Trials	1,000
Mean	$1,764,638.91
Median	$1,763,668.77
Mode	—
Standard Deviation	$147,384.61
Variance	$21,722,222,936.80
Skewness	0.0848
Kurtosis	2.37
Coeff. of Variability	0.0835
Minimum	$1,424,957.70
Maximum	$2,115,971.01
Range Width	$691,013.31
Mean Std. Error	$4,660.71

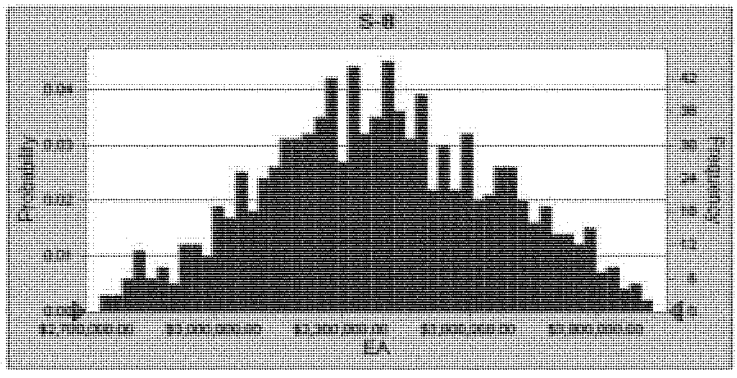
Forecast: S-7 (cont'd)

Percentiles:	Forecast values
0%	$1,424,957.70
10%	$1,571,938.81
20%	$1,628,496.13
30%	$1,683,483.30
40%	$1,721,543.81
50%	$1,763,668.77
60%	$1,800,811.46
70%	$1,841,449.03
80%	$1,899,358.61
90%	$1,966,568.16
100%	$2,115,971.01

REPORT1.xls

Forecast: S-8

Summary:
Entire range is from $2,730,624.52 to $4,030,380.86
Base case is $3,374,680.80
After 1,000 trials, the std. error of the mean is $8,667.22



Statistics:	Forecast values
Trials	1,000
Mean	$3,387,735.79
Median	$3,382,466.85
Mode	---
Standard Deviation	$274,081.68
Variance	$75,120,768,784.67
Skewness	0.0187
Kurtosis	2.42
Coeff. of Variability	0.0809
Minimum	$2,730,624.52
Maximum	$4,030,380.86
Range Width	$1,299,756.34
Mean Std. Error	$8,667.22

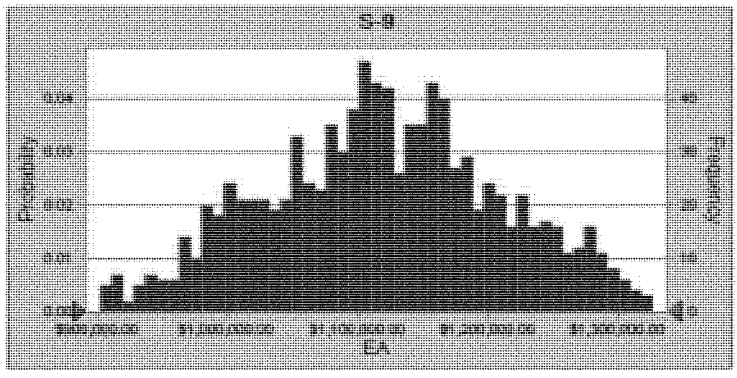
Forecast: S-8 (cont'd)

Percentiles:	Forecast values
0%	$2,730,624.52
10%	$3,027,841.88
20%	$3,147,173.68
30%	$3,234,704.24
40%	$3,308,731.97
50%	$3,382,466.85
60%	$3,451,372.18
70%	$3,537,742.72
80%	$3,639,760.12
90%	$3,761,302.67
100%	$4,030,380.86

REPORT1.xls

Forecast: S-9

Summary:
Entire range is from $902,027.83 to $1,325,045.34
Base case is $1,117,546.31
After 1,000 trials, the std. error of the mean is $2,828.66



Statistics:	Forecast values
Trials	1,000
Mean	$1,118,208.78
Median	$1,117,487.66
Mode	---
Standard Deviation	$89,450.09
Variance	$8,001,318,931.85
Skewness	-0.0301
Kurtosis	2.46
Coeff. of Variability	0.0800
Minimum	$902,027.83
Maximum	$1,325,045.34
Range Width	$423,017.50
Mean Std. Error	$2,828.66

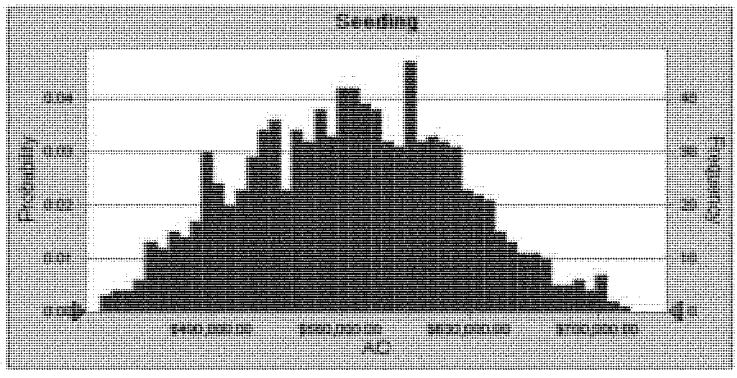
Forecast: S-9 (cont'd)

Percentiles:	Forecast values
0%	$902,027.83
10%	$996,906.97
20%	$1,037,301.33
30%	$1,071,769.28
40%	$1,097,515.99
50%	$1,117,487.66
60%	$1,142,954.39
70%	$1,165,009.88
80%	$1,196,882.36
90%	$1,240,653.54
100%	$1,325,045.34

REPORT1.xls

Forecast: Seeding

Summary:
Entire range is from $428,481.51 to $743,886.64
Base case is $568,477.26
After 1,000 trials, the std. error of the mean is $1,858.20



Statistics:	Forecast values
Trials	1,000
Mean	$565,293.54
Median	$565,708.95
Mode	—
Standard Deviation	$58,761.46
Variance	$3,452,908,869.90
Skewness	0.0666
Kurtosis	2.46
Coeff. of Variability	0.1039
Minimum	$428,481.51
Maximum	$743,886.64
Range Width	$315,405.13
Mean Std. Error	$1,858.20

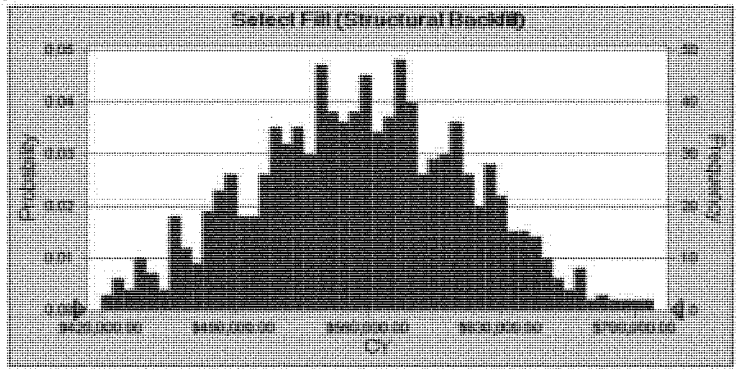
Forecast: Seeding (cont'd)

Percentiles:	Forecast values
0%	$428,481.51
10%	$486,980.13
20%	$511,479.32
30%	$531,605.70
40%	$550,098.08
50%	$565,708.95
60%	$581,376.54
70%	$598,350.23
80%	$616,191.36
90%	$640,639.63
100%	$743,886.64

REPORT1.xls

Forecast: Select Fill (Structural Backfill)

Summary:
Entire range is from $419,957.09 to $709,587.16
Base case is $553,500.00
After 1,000 trials, the std. error of the mean is $1,772.09



Statistics:	Forecast values
Trials	1,000
Mean	$556,029.11
Median	$556,674.10
Mode	—
Standard Deviation	$56,038.40
Variance	$3,140,302,803.14
Skewness	-0.0030
Kurtosis	2.56
Coeff. of Variability	0.1008
Minimum	$419,957.09
Maximum	$709,587.16
Range Width	$289,630.07
Mean Std. Error	$1,772.09

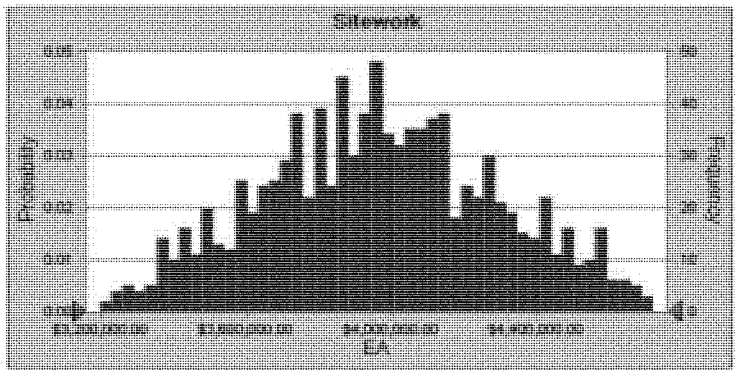
Forecast: Select Fill (Structural Backfill) (cont'd)

Percentiles:	Forecast values
0%	$419,957.09
10%	$480,938.06
20%	$507,938.65
30%	$525,463.03
40%	$541,994.37
50%	$556,674.10
60%	$571,974.61
70%	$585,688.79
80%	$605,048.48
90%	$628,145.57
100%	$709,587.16

REPORT1.xls

Forecast: Sitework

Summary:
Entire range is from $3,194,245.63 to $4,717,312.53
Base case is $3,985,521.94
After 1,000 trials, the std. error of the mean is $10,184.78



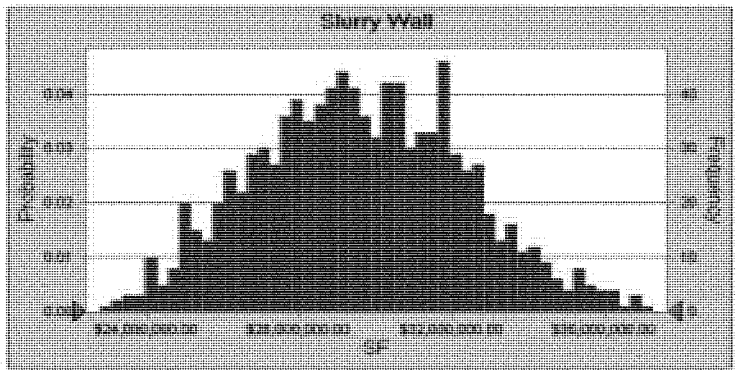
Statistics:	Forecast values
Trials	1,000
Mean	$3,962,860.29
Median	$3,955,697.12
Mode	—
Standard Deviation	$322,071.13
Variance	$103,729,813,591.10
Skewness	0.0405
Kurtosis	2.43
Coeff. of Variability	0.0813
Minimum	$3,194,245.63
Maximum	$4,717,312.53
Range Width	$1,523,066.91
Mean Std. Error	$10,184.78

Forecast: Sitework (cont'd)

Percentiles:	Forecast values
0%	$3,194,245.63
10%	$3,529,088.10
20%	$3,676,420.89
30%	$3,787,196.72
40%	$3,873,819.95
50%	$3,955,697.12
60%	$4,044,334.60
70%	$4,130,736.22
80%	$4,252,830.71
90%	$4,409,224.69
100%	$4,717,312.53

Forecast: Slurry Wall

Summary:
Entire range is from $22,782,089.22 to $37,257,196.32
Base case is $29,472,599.52
After 1,000 trials, the std. error of the mean is $86,228.51



Statistics:	Forecast values
Trials	1,000
Mean	$29,581,042.59
Median	$29,493,740.59
Mode	---
Standard Deviation	$2,726,784.87
Variance	$7,435,355,714,775.40
Skewness	0.1257
Kurtosis	2.61
Coeff. of Variability	0.0922
Minimum	$22,782,089.22
Maximum	$37,257,196.32
Range Width	$14,475,107.10
Mean Std. Error	$86,228.51

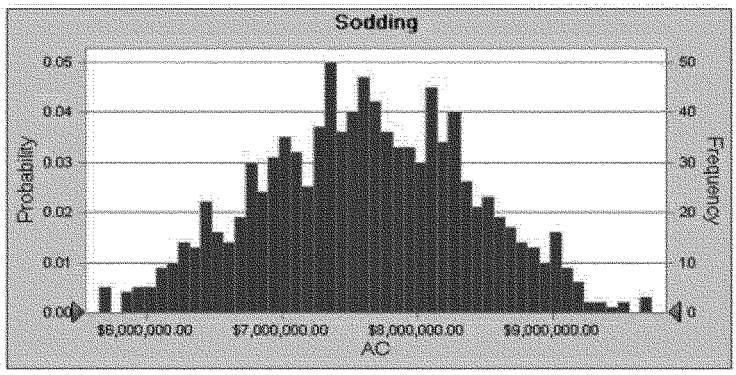
Forecast: Slurry Wall (cont'd)

Percentiles:	Forecast values
0%	$22,782,089.22
10%	$26,020,674.42
20%	$27,124,221.81
30%	$28,004,474.95
40%	$28,824,987.77
50%	$29,493,740.59
60%	$30,328,510.83
70%	$31,110,412.44
80%	$31,897,799.22
90%	$33,074,791.48
100%	$37,257,196.32

REPORT1.xls

Forecast: Sodding

Summary:
Entire range is from $5,653,155.33 to $9,726,333.46
Base case is $7,566,412.50
After 1,000 trials, the std. error of the mean is $24,497.41



Statistics:	Forecast values
Trials	1,000
Mean	$7,607,100.87
Median	$7,606,795.06
Mode	—
Standard Deviation	$774,676.10
Variance	$600,123,059,192.75
Skewness	-0.0127
Kurtosis	2.55
Coeff. of Variability	0.1018
Minimum	$5,653,155.33
Maximum	$9,726,333.46
Range Width	$4,073,178.14
Mean Std. Error	$24,497.41

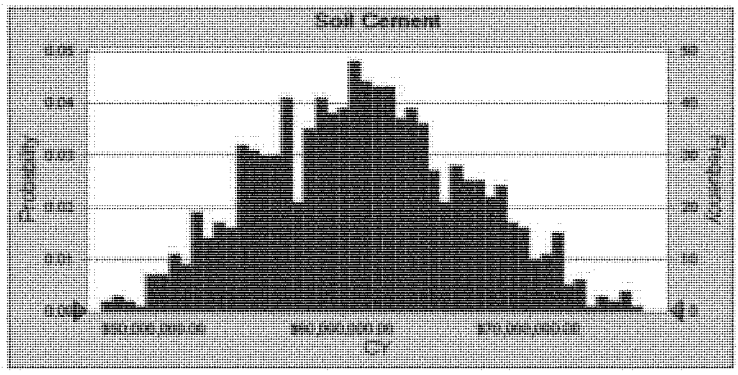
Forecast: Sodding (cont'd)

Percentiles:	Forecast values
0%	$5,653,155.33
10%	$6,538,029.27
20%	$6,928,814.00
30%	$7,176,701.08
40%	$7,398,259.29
50%	$7,606,795.06
60%	$7,810,737.12
70%	$8,073,220.75
80%	$8,274,341.23
90%	$8,619,896.85
100%	$9,726,333.46

REPORT1.xls

Forecast: Soil Cement

Summary:
Entire range is from $47,105,946.25 to $77,154,823.73
Base case is $61,119,606.60
After 1,000 trials, the std. error of the mean is $174,519.66



Statistics:	Forecast values
Trials	1,000
Mean	$61,100,724.85
Median	$61,006,581.93
Mode	---
Standard Deviation	$5,518,796.17
Variance	$30,457,111,140,409.60
Skewness	0.0965
Kurtosis	2.54
Coeff. of Variability	0.0903
Minimum	$47,105,946.25
Maximum	$77,154,823.73
Range Width	$30,048,877.47
Mean Std. Error	$174,519.66

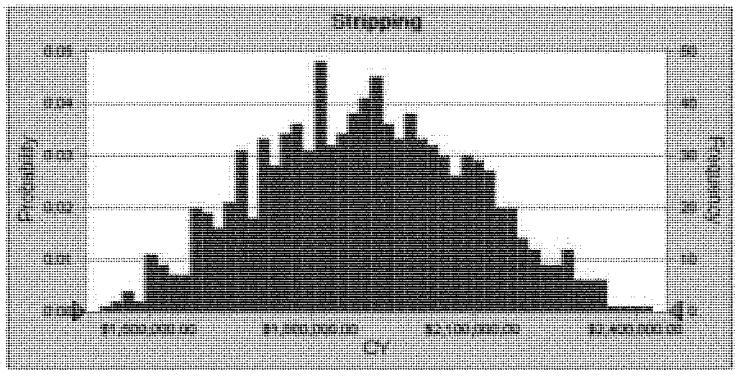
Forecast: Soil Cement (cont'd)

Percentiles:	Forecast values
0%	$47,105,946.25
10%	$54,063,898.65
20%	$56,093,539.42
30%	$58,048,899.23
40%	$59,579,243.71
50%	$61,006,581.93
60%	$62,394,257.35
70%	$63,902,516.45
80%	$66,065,998.03
90%	$68,497,948.83
100%	$77,154,823.73

REPORT1.xls

Forecast: Stripping

Summary:
Entire range is from $1,407,319.02 to $2,429,343.75
Base case is $1,893,900.00
After 1,000 trials, the std. error of the mean is $6,213.11



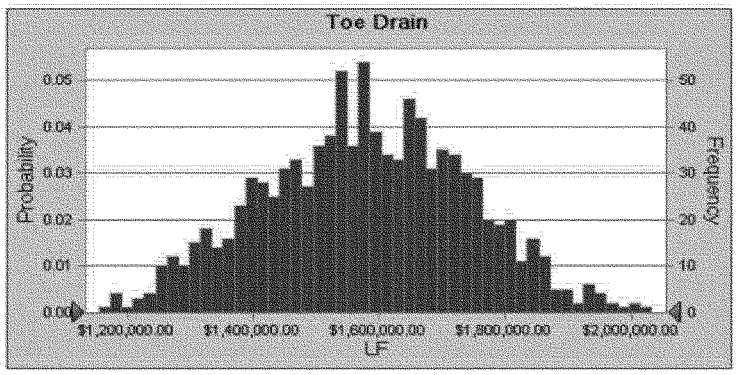
Statistics:	Forecast values
Trials	1,000
Mean	$1,897,234.36
Median	$1,897,017.26
Mode	---
Standard Deviation	$196,475.72
Variance	$38,602,708,011.97
Skewness	0.0510
Kurtosis	2.44
Coeff. of Variability	0.1036
Minimum	$1,407,319.02
Maximum	$2,429,343.75
Range Width	$1,022,024.73
Mean Std. Error	$6,213.11

Forecast: Stripping (cont'd)

Percentiles:	Forecast values
0%	$1,407,319.02
10%	$1,638,251.43
20%	$1,719,681.55
30%	$1,783,675.18
40%	$1,838,819.73
50%	$1,897,017.26
60%	$1,945,824.54
70%	$2,006,751.94
80%	$2,076,913.98
90%	$2,157,322.88
100%	$2,429,343.75

Forecast: Toe Drain

Summary:
Entire range is from $1,156,340.19 to $2,061,272.81
Base case is $1,573,382.50
After 1,000 trials, the std. error of the mean is $5,115.25



Statistics:	Forecast values
Trials	1,000
Mean	$1,578,642.03
Median	$1,579,930.22
Mode	—
Standard Deviation	$161,758.39
Variance	$26,165,777,586.23
Skewness	-0.0060
Kurtosis	2.60
Coeff. of Variability	0.1025
Minimum	$1,156,340.19
Maximum	$2,061,272.81
Range Width	$904,932.62
Mean Std. Error	$5,115.25

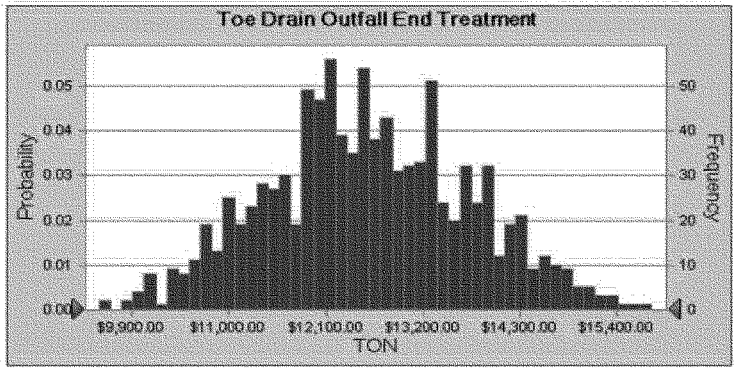
Forecast: Toe Drain (cont'd)

Percentiles:	Forecast values
0%	$1,156,340.19
10%	$1,359,772.65
20%	$1,435,682.37
30%	$1,491,512.31
40%	$1,538,344.99
50%	$1,579,930.22
60%	$1,624,561.11
70%	$1,668,428.21
80%	$1,718,299.88
90%	$1,786,364.97
100%	$2,061,272.81

REPORT1.xls

Forecast: Toe Drain Outfall End Treatment

Summary:
Entire range is from $9,536.42 to $15,879.40
Base case is $12,534.96
After 1,000 trials, the std. error of the mean is $36.27



Statistics:	Forecast values
Trials	1,000
Mean	$12,577.56
Median	$12,538.14
Mode	—
Standard Deviation	$1,146.91
Variance	$1,315,391.97
Skewness	0.0852
Kurtosis	2.62
Coeff. of Variability	0.0912
Minimum	$9,536.42
Maximum	$15,879.40
Range Width	$6,342.98
Mean Std. Error	$36.27

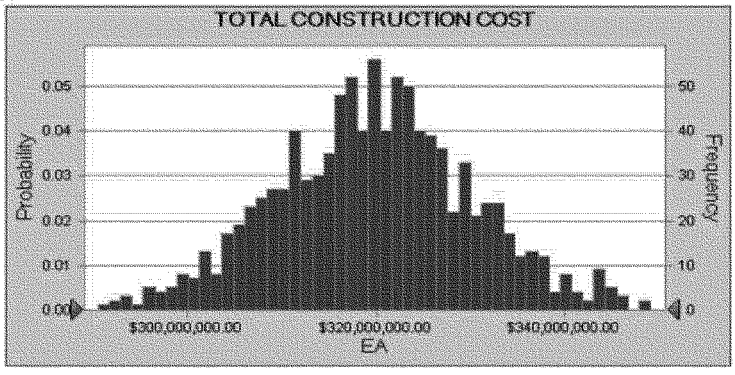
Forecast: Toe Drain Outfall End Treatment (cont'd)

Percentiles:	Forecast values
0%	$9,536.42
10%	$11,058.09
20%	$11,598.85
30%	$11,971.11
40%	$12,213.96
50%	$12,538.14
60%	$12,810.83
70%	$13,223.10
80%	$13,619.40
90%	$14,129.21
100%	$15,879.40

REPORT1.xls

Forecast: TOTAL CONSTRUCTION COST

Summary:
Entire range is from $287,405,908.87 to $354,272,455.21
Base case is $319,839,429.00
After 1,000 trials, the std. error of the mean is $329,641.80



Statistics:	Forecast values
Trials	1,000
Mean	$319,842,886.83
Median	$319,892,383.76
Mode	---
Standard Deviation	$10,424,189.08
Variance	$108,663,717,947,408.00
Skewness	0.0470
Kurtosis	2.98
Coeff. of Variability	0.0326
Minimum	$287,405,908.87
Maximum	$354,272,455.21
Range Width	$66,866,546.34
Mean Std. Error	$329,641.80

Forecast: TOTAL CONSTRUCTION COST (cont'd)

Percentiles:	Forecast values
0%	$287,405,908.87
10%	$306,433,082.60
20%	$310,980,570.88
30%	$314,603,533.53
40%	$317,332,223.56
50%	$319,892,383.76
60%	$322,475,330.22
70%	$324,896,750.54
80%	$328,375,530.76
90%	$333,091,049.78
100%	$354,272,455.21

End of Forecasts

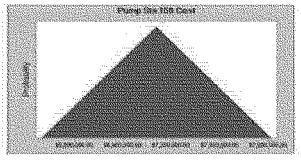
REPORT1.xls

Assumptions

Assumption: Pump Sta 150 Cost

Triangular distribution with parameters:

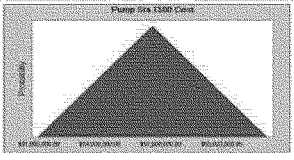
Minimum	$6,394,574.98
Likeliest	$7,105,083.31
Maximum	$7,815,591.64



Assumption: Pump Sta 1500 Cost

Triangular distribution with parameters:

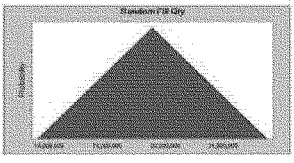
Minimum	$50,904,170.00
Likeliest	$56,560,118.86
Maximum	$62,216,208.00



Assumption: Random Fill Qty

Triangular distribution with parameters:

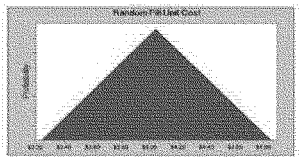
Minimum	17,795,194
Likeliest	19,772,438
Maximum	21,749,682



Assumption: Random Fill Unit Cost

Triangular distribution with parameters:

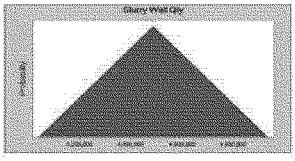
Minimum	$3.24
Likeliest	$4.04
Maximum	$4.85



Assumption: Slurry Wall Qty

Triangular distribution with parameters:

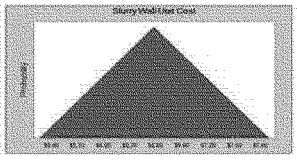
Minimum	4,037,342
Likeliest	4,485,936
Maximum	4,934,530



Assumption: Slurry Wall Unit Cost

Triangular distribution with parameters:

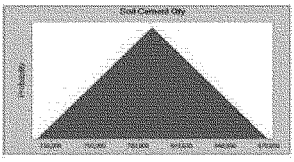
Minimum	$5.26
Likeliest	$6.57
Maximum	$7.89



Assumption: Soil Cement Qty

Triangular distribution with parameters:

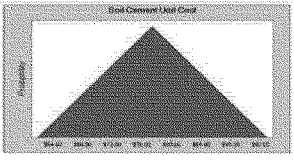
Minimum	710,693
Likeliest	789,659
Maximum	868,625



Assumption: Soil Cement Unit Cost

Triangular distribution with parameters:

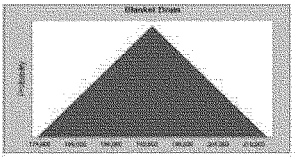
Minimum	$61.92
Likeliest	$77.40
Maximum	$92.88



Assumption: Blanket Drain

Triangular distribution with parameters:

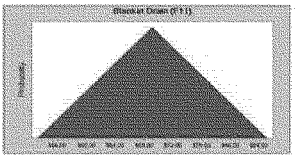
Minimum	173,567
Likeliest	192,852
Maximum	212,137



Assumption: Blanket Drain (F11)

Triangular distribution with parameters:

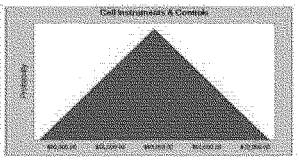
Minimum	$53.18
Likeliest	$69.13
Maximum	$85.08



Assumption: Cell Instruments & Controls

Triangular distribution with parameters:

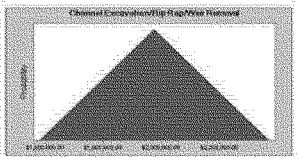
Minimum	$47,612.36
Likeliest	$59,515.45
Maximum	$71,418.54



Assumption: Channel Excavation/Rip Rap/Weir Removal

Triangular distribution with parameters:

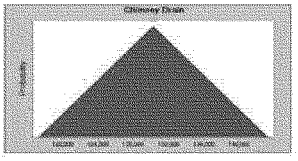
Minimum	$1,579,034.01
Likeliest	$1,973,792.51
Maximum	$2,368,551.01



Assumption: Chimney Drain

Triangular distribution with parameters:

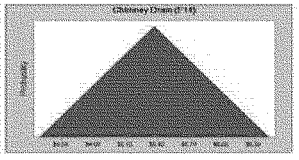
Minimum	117,225
Likeliest	130,250
Maximum	143,275



Assumption: Chimney Drain (F14)

Triangular distribution with parameters:

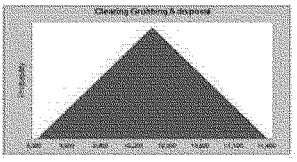
Minimum	$4.30
Likeliest	$5.37
Maximum	$6.44



Assumption: Clearing Grubbing & disposal

Triangular distribution with parameters:

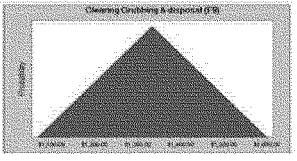
Minimum	9,329
Likeliest	10,365
Maximum	11,402



Assumption: Clearing Grubbing & disposal (F9)

Triangular distribution with parameters:

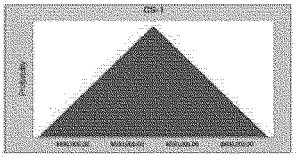
Minimum	$1,066.24
Likeliest	$1,332.80
Maximum	$1,599.36



Assumption: CS-1

Triangular distribution with parameters:

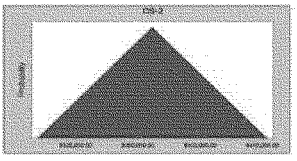
Minimum	$418,706.14
Likeliest	$523,382.68
Maximum	$628,059.22



Assumption: CS-2

Triangular distribution with parameters:

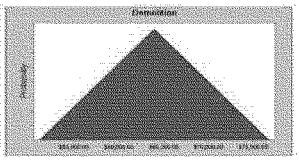
Minimum	$295,147.51
Likeliest	$368,934.39
Maximum	$442,721.27



Assumption: Demolition

Triangular distribution with parameters:

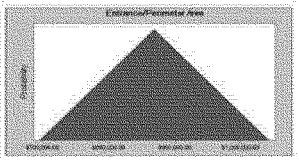
Minimum	$51,116.84
Likeliest	$63,896.05
Maximum	$76,675.26



Assumption: Entrance/Perimeter Area

Triangular distribution with parameters:

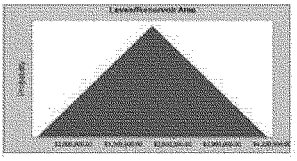
Minimum	$694,722.40
Likeliest	$868,403.00
Maximum	$1,042,083.60



Assumption: Levee/Reservoir Area

Triangular distribution with parameters:

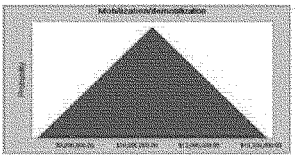
Minimum	$2,777,516.00
Likeliest	$3,471,895.00
Maximum	$4,166,274.00



Assumption: Mobilization/demobilization

Triangular distribution with parameters:

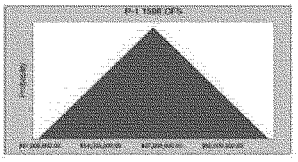
Minimum	$8,864,239.30
Likeliest	$11,080,299.13
Maximum	$13,296,358.96



Assumption: P-1 1500 CFS

Triangular distribution with parameters:

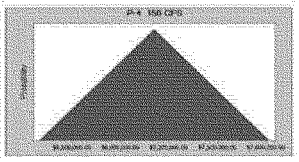
Minimum	$50,904,106.97
Likeliest	$56,560,118.86
Maximum	$62,216,130.75



Assumption: P-4 150 CFS

Triangular distribution with parameters:

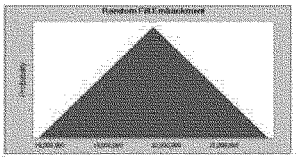
Minimum	$6,394,574.98
Likeliest	$7,105,083.31
Maximum	$7,815,591.64



Assumption: Random Fill Embankment

Triangular distribution with parameters:

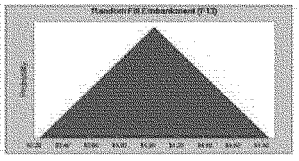
Minimum	17,795,194
Likeliest	19,772,438
Maximum	21,749,682



Assumption: Random Fill Embankment (F13)

Triangular distribution with parameters:

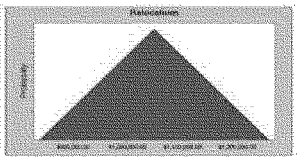
Minimum	$3.23
Likeliest	$4.04
Maximum	$4.85



Assumption: Relocations

Triangular distribution with parameters:

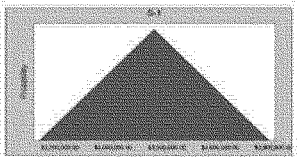
Minimum	$837,738.50
Likeliest	$1,047,173.13
Maximum	$1,256,607.76



Assumption: S-1

Triangular distribution with parameters:

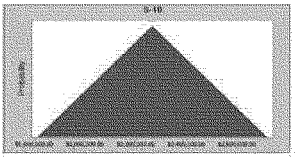
Minimum	$2,580,466.17
Likeliest	$3,225,582.71
Maximum	$3,870,699.25



Assumption: S-10

Triangular distribution with parameters:

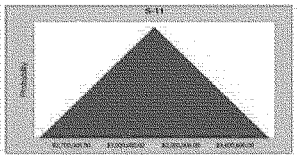
Minimum	$1,809,902.91
Likeliest	$2,262,378.64
Maximum	$2,714,854.37



Assumption: S-11

Triangular distribution with parameters:

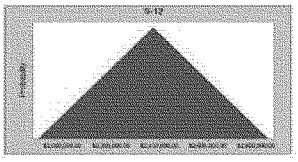
Minimum	$2,521,115.02
Likeliest	$3,151,393.78
Maximum	$3,781,672.54



Assumption: S-12

Triangular distribution with parameters:

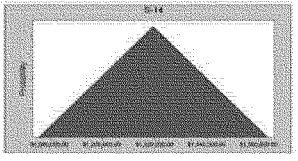
Minimum	$1,897,895.69
Likeliest	$2,372,369.61
Maximum	$2,846,843.53



Assumption: S-14

Triangular distribution with parameters:

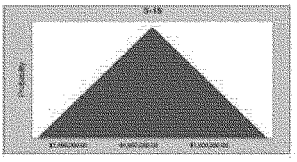
Minimum	$1,052,824.70
Likeliest	$1,316,030.87
Maximum	$1,579,237.04



Assumption: S-15

Triangular distribution with parameters:

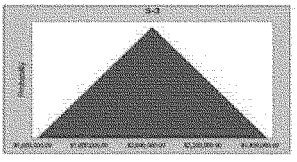
Minimum	$1,309,446.96
Likeliest	$1,636,808.70
Maximum	$1,964,170.44



Assumption: S-3

Triangular distribution with parameters:

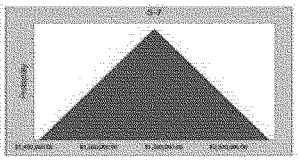
Minimum	$1,615,160.64
Likeliest	$2,018,950.80
Maximum	$2,422,740.96



Assumption: S-7

Triangular distribution with parameters:

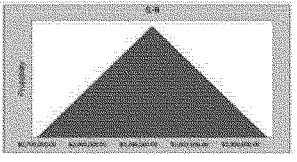
Minimum	$1,415,068.17
Likeliest	$1,768,835.21
Maximum	$2,122,602.25



Assumption: S-8

Triangular distribution with parameters:

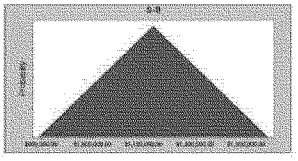
Minimum	$2,699,744.64
Likeliest	$3,374,680.80
Maximum	$4,049,616.96



Assumption: S-9

Triangular distribution with parameters:

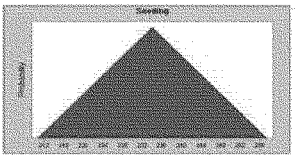
Minimum	$894,037.05
Likeliest	$1,117,546.31
Maximum	$1,341,055.57



Assumption: Seeding

Triangular distribution with parameters:

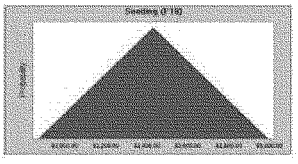
Minimum	211
Likeliest	234
Maximum	257



Assumption: Seeding (F19)

Triangular distribution with parameters:

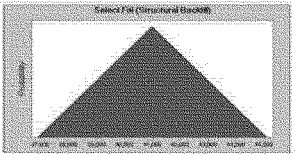
Minimum	$1,868.76
Likeliest	$2,429.39
Maximum	$2,990.02



Assumption: Select Fill (Structural Backfill)

Triangular distribution with parameters:

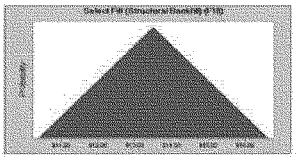
Minimum	36,900
Likeliest	41,000
Maximum	45,100



Assumption: Select Fill (Structural Backfill) (F18)

Triangular distribution with parameters:

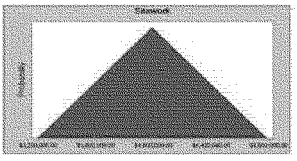
Minimum	$10.38
Likeliest	$13.50
Maximum	$16.62



Assumption: Sitework

Triangular distribution with parameters:

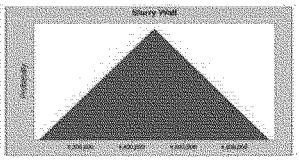
Minimum	$3,188,417.55
Likeliest	$3,985,521.94
Maximum	$4,782,626.33



Assumption: Slurry Wall

Triangular distribution with parameters:

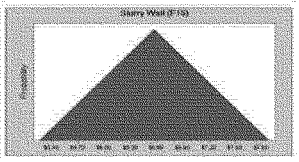
Minimum	4,037,342
Likeliest	4,485,936
Maximum	4,934,530



Assumption: Slurry Wall (F15)

Triangular distribution with parameters:

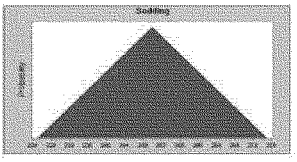
Minimum	$5.26
Likeliest	$6.57
Maximum	$7.88



Assumption: Sodding

Triangular distribution with parameters:

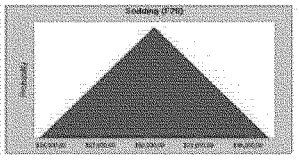
Minimum	225
Likeliest	250
Maximum	275



Assumption: Sodding (F20)

Triangular distribution with parameters:

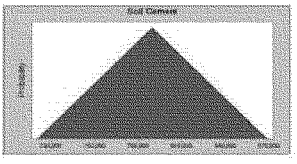
Minimum	$23,281.27
Likeliest	$30,265.65
Maximum	$37,250.03



Assumption: Soil Cement

Triangular distribution with parameters:

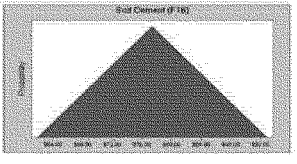
Minimum	710,693
Likeliest	789,659
Maximum	868,625



Assumption: Soil Cement (F16)

Triangular distribution with parameters:

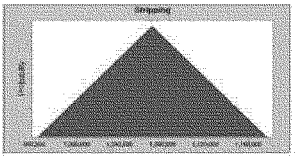
Minimum	$61.92
Likeliest	$77.40
Maximum	$92.88



Assumption: Stripping

Triangular distribution with parameters:

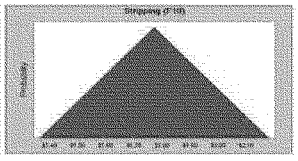
Minimum	963,000
Likeliest	1,070,000
Maximum	1,177,000



Assumption: Stripping (F10)

Triangular distribution with parameters:

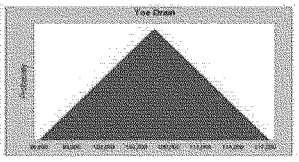
Minimum	$1.36
Likeliest	$1.77
Maximum	$2.18



Assumption: Toe Drain

Triangular distribution with parameters:

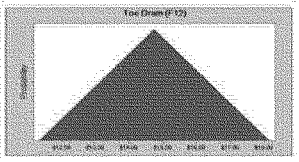
Minimum	96,003
Likeliest	106,670
Maximum	117,337



Assumption: Toe Drain (F12)

Triangular distribution with parameters:

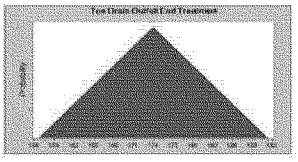
Minimum	$11.35
Likeliest	$14.75
Maximum	$18.15



Assumption: Toe Drain Outfall End Treatment

Triangular distribution with parameters:

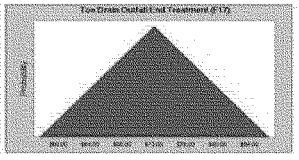
Minimum	157
Likeliest	174
Maximum	191



Assumption: Toe Drain Outfall End Treatment (F17)

Triangular distribution with parameters:

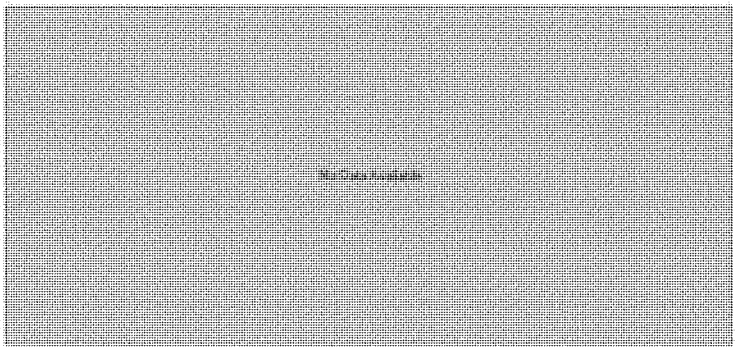
Minimum	$57.63
Likeliest	$72.04
Maximum	$86.45



End of Assumptions

REPORT1.xls

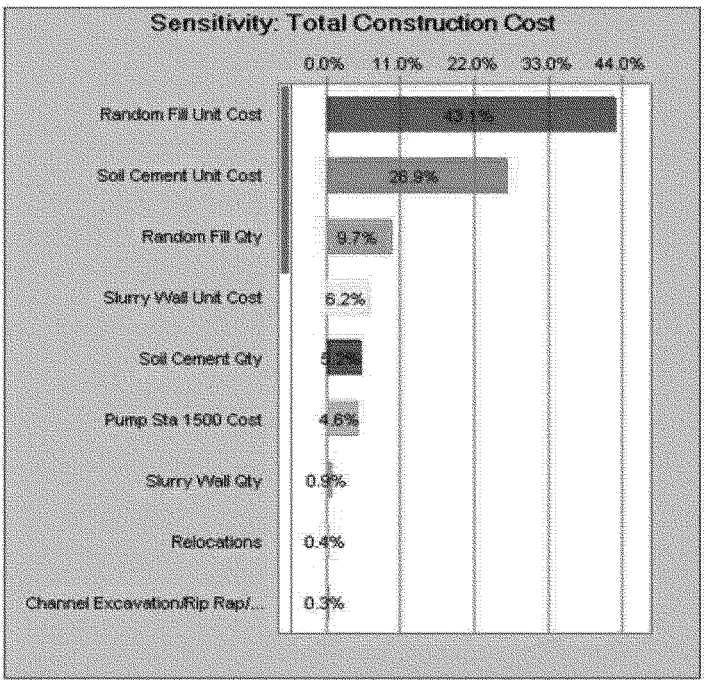
Overlay Charts



End of Overlay Charts

REPORT1.xls

Sensitivity Charts



End of Sensitivity Charts

This page intentionally left blank.

APPENDIX C
ENVIRONMENTAL INFORMATION

This page intentionally left blank

TABLE OF CONTENTS

C.0 ENVIRONMENTAL INFORMATION C-1
C.1 ECOLOGICAL ANALYSIS–SYSTEM FORMULATION (LAST ADDED INCREMENT) C-1
C.1.1 Background C-1
C.1.2 Geographic scope C-2
C.1.2.1 Oysters–5,899 Acres C-3
C.1.2.2 *Vallisneria*- 4,129 Acres C-4
C.1.2.3 Seagrasses –12,547 Acres C-5
C.1.3 HSI Overview C-6
C.1.3.1 HSI species C-6
C.1.3.2 Importance of Seasonality for This Project C-7
C.1.3.3 HSI Assumptions C-7
C.1.3.4 Summary of Benefits C-7
C.1.3.5 Extreme Events Background and Habitat Suitability Index Scores C-11
C.1.3.6 EST05 Background and Quality Index Scores C-12
C.1.3.7 Habitat Unit Combination Methodology C-12
C.1.3.8 Conclusions C-14
C.2 NAI ENVIRONMENTAL BENEFIT ANALYSIS C-14
C.2.1 Conclusions C-15
C.3 HABITAT SUITABILITY INDEX PROCESS C-15
C.3.1 Background C-15
C.3.2 HSI Formulas C-16
C.3.2.1 Spotted Seatrout C-16
C.3.2.2 Eastern Oyster C-17
C.3.2.3 Blue Crab C-17
C.3.2.4 Seagrass C-17
C.3.2.5 Vallisn eria C-17
C.4 HABITAT UNIT CALCULATIONS METHODOLOGY-JANUARY 2007 ..... C-17
C.4.1 Habitat Unit Methodology/Rules C-17
C.4.2 Habitat Unit Combination Methodology C-19
C.5 SUMMARY OF THE OYSTER HSI C-21
C.6 SUMMARY OF THE VALLISNERIA HSI C-41
C.7 TARGET FLOW INDEX (EST05) METHOD C-64
C.7.1 Background C-64
C.7.2 Target Flow Index Calculation C-64
C.8 OYSTER REEF RESTORATION PLAN C-67
C.8.1 Oyster Reef Restoration is Not Part of the Recommended Plan C-67
C.8.2 Introduction C-67
C.8.3 Methods C-68
C.8.3.1 Volunteer recruitment C-68
C.8.3.2 Reef Construction C-69
C.8.3.3 Yearly Costs C-69
C.8.4 References C-70
C.9 WATER QUALITY ANALYSIS FOR PLAN FORMULATION C-72

C.9.1 Background C-72
C.9.2 Methodology C-73
C.9.3 Results C-73
C.9.3.1 Annual TP and TN Loading at S-79 ..... C-73
C.10.11 Algae Production in the Reservoir C-77
C.9.3.2 Wet/Dry Season Nitrogen Loading C-79
C.9.3.3 Annual Nitrogen Loading C-81
C.9.3.4 Flow-weighted Nutrient Concentrations C-82
C.9.4 Risk and Uncertainty Analysis C-82
C.9.5 Conclusion C-82
C.10 WATER QUALITY EFFECTS FOR THE NEXT ADDED INCREMENT ANALYSIS C-83
C.10.1 Background C-83
C.10.2 Methodology C-84
C.10.3 Impact of Reservoir on Average Monthly TN Load at S-79 ..... C-85
C.10.4 Impact of Reservoir on Seasonal Nutrient Load at S-79 ..... C-87
C.10.5 Assessment of Annual TN Load C-89
C.10.6 Nutrient Removal Within Reservoir C-90
C.10.7 Assessment of Reservoir Dissolved Oxygen C-91
C.10.8 Accumulation of Reservoir Sediments C-92
C.10.9 Potential for Re-Suspension of Bottom Sediments C-93
C.10.10 Summary of Test Cell Water Quality Testing C-94
C.10.11 Algae Production in the Reservoir C-96
C.10.12 Risk and Uncertainty Analysis of Water Quality Predictions C-97
C.10.13 Use of Historic Data C-97
C.10.14 Use of Caloosahatchee River (C-43) West Basin Storage Reservoir Spreadsheet Model Flows C-97
C.10.15 Use of Mass Balance Calculations C-98
C.10.16 Use of FDEP Threshold Loads C-98
C.10.17 Summary of Water Quality Impacts of Reservoir C-98
C.11 SUPPLEMENTAL WQ ASSESSMENT BY USACE AND FDEP PREPARED JUNE 2007 ..... C-101
C.12 RECOMMENDED EST05 MEMORANDUM C-120
C.13 CHAMBERLAIN AND DOERING PAPER C-125
C.14 EXISTING LEGAL SOURCES OF WATER FOR THE CALOOSAHATCHEE ESTUARY C-135
C.15 FINAL CALOOSAHATCHEE RIVER (C-43) BASIN ECOLOGICAL PERFORMANCE MEASURES C-164
C.16 SOUTHWEST FLORIDA FEASIBILITY STUDY PRE-DEVELOPMENT VEGETATION MAP C-183
C.17 JURISDICTIONAL WETLANDS ON SITE C-184
C.18 SUMMARY OF THE SEAGRASS HSI C-185

LIST OF TABLES

Table C-1: Total Quality Index Numbers, System Formulation....C-2
Table C-2: Average Annual Habitat Unit Lift,....C-2
Table C-3: Oyster HSI Scores....C-9
Table C-4: Vallisneria HSI Scores....C-10
Table C-5: Seagrass HSI Scores....C-11
Table C-6: Extreme Events HSI Scores....C-11
Table C-7: EST05 HSI Scores....C-12
Table C-8: Total Average Annual Habitat Units Scores....C-14
Table C-9: Comparison of NAI and LAI Scores....C-15
Table C-10: Target frequency distribution (EST05) of mean monthly flows from S-79 for the 1965-2000 period of record (Caloosahatchee River (C-43) West Basin Storage Reservoir-Caloosahatchee Estuary Hydrologic Evaluation Performance Measures, 2005)....C-64
Table C-11: Target flow-range categories, the associated target frequency, and the formula for scoring flow scenarios within each category...C-65
Table C-12: Example of using the Target Flow Index-Table column depict the target flow-range categories, associated target frequency, the actual flow distribution frequency of S-79 flows during 1978-1986, and the resulting category scores using the formulas in Table C-11....C-66
Table C-13: Estimates of Annual TP and TN Loading at S-79 for 1978-1986 using MIKESHE Caloosahatchee River (C-43) Hydrology. Reservoir Effectiveness Factor = 0.0....C-74
Table C-14: Total Phosphorus and Total Nitrogen Loading and Percent Reduction Under Various Reservoir Phosphorus Removal Factors, where RF is the fraction of the pollutant removed by the reservoir....C-78
Table C-15: Frequency of exceeding monthly TN threshold loads for various reservoir removal efficiencies....C-80
Table C-16: Annual TN load (metric tons) for each year of simulation under various TN removal efficiencies in the reservoir....C-81
Table C-17: Frequency of Dry and Wet Season Monthly TN Loading at S-79 for 2000 NAI Hydrologic Conditions Assuming No Pollutant Removal in Reservoir....C-88
Table C-18: Frequency of Dry and Wet Season Monthly TN Loading at S-79 for 2000 NAI Hydrologic Conditions Assuming 100 Percent Increase in Reservoir TN Concentrations....C-89
Table C-19: Simulation Input used for DMSTA-2 Simulation of Phosphorus Dynamics in the Caloosahatchee River (C-43) West Basin Storage Reservoir....C-91
Table C-20: Simulation Output Generated by a DMSTA-2 Simulation of Phosphorus Dynamics in the Caloosahatchee River (C-43) West Basin Storage Reservoir....C-91

LIST OF FIGURES

Figure C-1: Total Area of Benefit....C-3
Figure C-2: Map of Oysters....C-4
Figure C-3: Map of Vallisneria....C-4
Figure C-4: Map of Seagrass....C-5
Figure C-5: Integration of HSI Indicators....C-8
Figure C-6: Habitat Unit Combination Methodology....C-13
Figure C-7: Habitat Unit Combination methodology January 2007....C-20
Figure C-8: Average monthly TN Load at S-79 Assuming 2000 Hydrology and No Treatment by Reservoir....C-86
Figure C-9: Average monthly TN Load at S-79 Assuming 2000 Hydrology and 60% Removal by Reservoir....C-87
Figure C-10. Exceedance Probability Curves for Reservoir Bottom Area Subject to Wind/Wave Scour (Sediment Re-suspension)....C-94

C.0 ENVIRONMENTAL INFORMATION

C.1 ECOLOGICAL ANALYSIS–SYSTEM FORMULATION (LAST ADDED INCREMENT)

C.1.1 Background

This project is expected to primarily benefit the Caloosahatchee Estuary. However, because Comprehensive Everglades Restoration Plan (CERP) projects are required to be selected and justified based on their system-wide benefits, the following analysis conducted for the plan selection process is based on a system formulation approach in which the Caloosahatchee River (C-43) West Basin Storage Reservoir project benefits would coincide with the rest of CERP being constructed. An additional analysis will be conducted to determine the difference between the average annual habitat unit lift for the Last Added Increment (LAI) and the Next Added Increment (NAI), to justify the stand-alone benefits of the project.

The environmental evaluation process used for plan selection was based on five attributes:

- Average habitat suitability indices (HSI) for oyster–based on all seasons of dry years and all seasons of wet years
- Average HSI for *Vallisneria*–based on dry seasons of dry years
- Average HSI for seagrass–based on wet seasons of wet years
- Extreme events–average HSI of oyster, *Vallisneria*, and seagrass during the three driest months and three wettest months in the period of record.
- EST05–This attribute reflects the percentage of weeks each alternative matches the target flow (EST05). EST05 is a time series of flow developed to maximize beneficial conditions for a suite of organisms in the Caloosahatchee River (C-43) Estuary. EST05 was adopted as the system-wide performance measure for the Caloosahatchee Estuary (NE-03) by the Restoration Coordination and Verification (RECOVER) team.

Scoring each of the attributes above resulted in a quality index number (HSI or percent) for each alternative. Those quality index numbers were then combined using a Habitat Unit Combination Method (HUCM) in order to arrive at one total Habitat Unit (HU) number for each alternative.

Table C-1 summarizes the five attributes and quality index calculations for the 2000 base case, 2050 future without project, and each of the alternatives.

TABLE C-1: TOTAL QUALITY INDEX NUMBERS, SYSTEM FORMULATION

Condition	Oyster	*Vallisneria*	Seagrass	Extreme Event	EST05
2000 Base (Existing)	.48	.16	.51	.28	.38
2050 Future W ithout Project	.52	.20	.54	.30	.43
Alternative 2	.60	.31	.59	.42	.64
Alternative 3b	.60	.33	.59	.43	.70
Alternative 3c	.61	.35	.59	.45	.80
Alternative 4A	.61	.35	.59	.45	.79

Table C-2 summarizes the four alternatives and their respective project Habitat Unit lift totals.

TABLE C-2: AVERAGE ANNUAL HABITAT UNIT LIFT, SYSTEM FORMULATION

Alternative	Average Annual Project Habitat Units
Alternative 2	10,628
Alternative 3b	12,809
Alternative 3c	16,397
Alternative 4	15,907

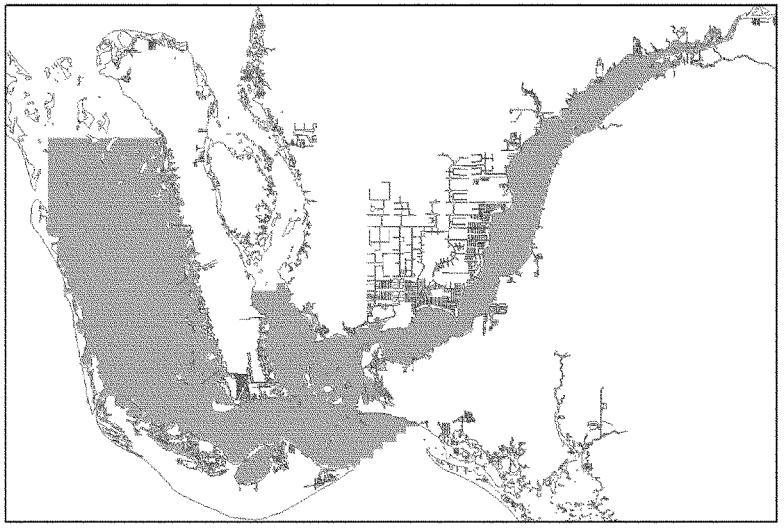
C.1.2 Geographic scope

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to restore more natural timing, volume, and duration of freshwater flows to the Caloosahatchee Estuary, and to provide a more appropriate range of salinity conditions by reducing extreme salinity fluctuations. The proposed alternatives may improve conditions for estuarine and marine resources throughout most of Lower Charlotte Harbor, including the Caloosahatchee Estuary, San Carlos Bay (Shell Point to Pine Island Sound), Pine Island Sound, and Matlacha Pass. Additionally, the Gulf-side of Fort Myers Beach and Sanibel Island near Point Ybel may also benefit from the proposed alternatives. However, calculation of habitat benefits achieved by each of the proposed alternatives was restricted to portions of the estuary where changes in salinity in relation to freshwater flows at S-79 could reasonably be predicted (***Figure C-1***).

The SFWMD has a record of monitored salinity levels at 19 stations throughout the estuary from S-79 downstream to San Carlos Bay, south to Point Ybel, north to Masters Landing in Matlacha Pass, and west and north to Useppa Island in Pine Island Sound. That data was used to predict changes in salinity based on flows at S-79 through regression analysis for the geographic extent of the estuary monitored (i.e., 71,095 acres). The resulting salinity model grid was then refined to 70,979 acres based on additional model input data, including

geographical information system (GIS) coverages of existing seagrasses, *Vallisneria,* and oyster distributions. This acreage is within the navigable waters of the United States and within the navigational servitude of the United States.

FIGURE C-1: TOTAL AREA OF BENEFIT

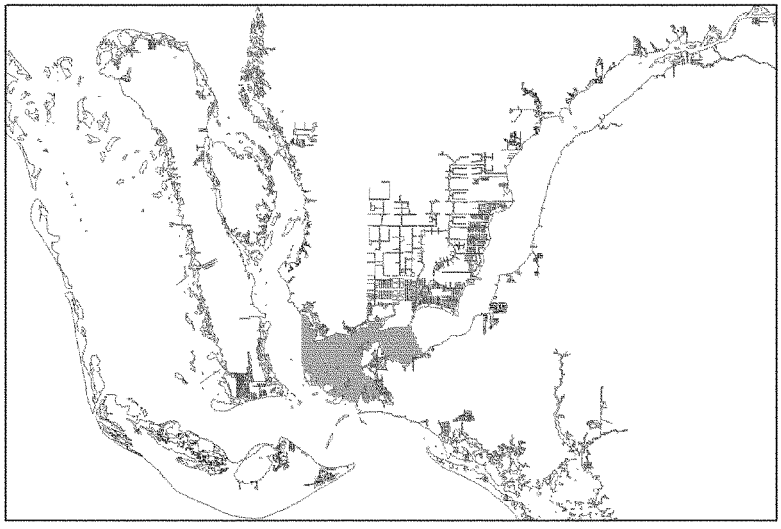


The species selected for modeling differ in their habitat requirements and range of tolerable conditions. Thus, the portion of the estuary for which the HSI models assessed habitat suitability changes resulting from each alternative varied according to the species or group of species being portrayed. For each species, the primary area of impact was used to determine total benefits. The ecological subteam determined these areas based on best professional judgment as well as model limitations. The total area of ecological benefit (used for Extreme Event and EST05) reflects total area covered by the HSI models. This is the best estimate available at the time of acreage impacted, and is therefore used as the total area benefited; although in reality, a larger area is probably impacted by Caloosahatchee flows, and will accrue benefits from this project.

C.1.2.1 Oysters–5,8 99 Acres

Oysters are sessile and are best suited for the middle portions of the estuary. Thus, the core oyster population and target area for recovery is limited to the San Carlos Bay area from Shell Point to Merwyn Key and Fisherman's Key, and habitat suitability changes for oysters were only assessed in that geographic area ***Figure C-2.***

FIGURE C-2: MAP OF OYSTERS



C.1.2.2 *Vallisneria*- 4,129 Acres

Vallisneria (tape grass or wild celery) is limited to the upper or fresher portions of the estuary extending from S-79 to Iona Cove and habitat suitability changes for *Vallisneria* were only assessed in that geographic area (***Figure C-3***).

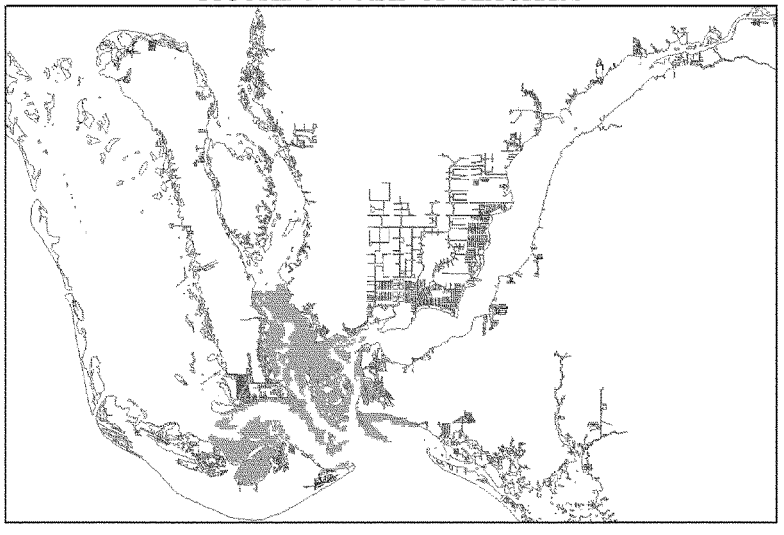
FIGURE C-3: MAP OF VALLISNERIA



C.1.2.3 Seagrasses –12,547 Acres

Habitat suitability changes for seagrasses were assessed separately for three contiguous geographic areas based on 1) species composition and their depth and salinity tolerance ranges, and on 2) the spatial differences in the frequency of exposure to extreme variation or fluctuations in salinity levels from freshwater flows at S-79 (***Figure C-4***). The furthest upstream seagrass area is Iona Cove and is dominated by *Halodule wrightii. Halodule* tolerates lower salinity levels than *Thalassia testudinum*, and as a result, is the only seagrass that occurs upstream of Shell Point in the Iona Cove area. The San Carlos Bay seagrass area is downstream from Shell Point and contains both *Halodule* and *Thalassia.* Habitat suitability changes in the San Carlos Bay area were modeled separately because the bay is at the mouth of the Caloosahatchee River. Thus, the bay may experience frequent extreme fluctuations in salinity during high freshwater flow events during the wet season (i.e., July through November) particularly of wet years. Both seagrass species also occur in the Pine Island Sound area. However, that area is the farthest area downstream of the primary freshwater source (i.e., S-79) and experiences few extreme variations in salinity. Likewise, the effects of the alternatives on seagrass habitat suitability in Pine Island sound were modeled separate from the Iona Cove and San Carlos Bay areas. Although all of these areas were modeled using the HSIs, the San Carlos Bay area was used for the HU calculations. The team decided that this area was most representative, as it contains both *Halodule* and *Thalassia*, and best reflects the impacts of differing alternatives.

FIGURE C-4: MAP OF SEAGRASS



C.1.3 HSI Overview

The purpose of this habitat suitability model for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to portray species response to changes in environmental variables resulting from restoration activities spatially and temporally to facilitate policy decisions. The intent of the habitat suitability model is not to simulate the life-cycles of the species. Rather, the intent is to estimate number of HUs to serve as a relative basis for comparing management alternatives.

Complete documentation on the oyster, *vallisneria*, and seagrass HSI models are available in this Appendix..

C.1.3.1 HSI species

Species selected for modeling (focal species) are ecologically, recreationally or economically important and have a well established linkage to stressors of management interest. They may also make good focal species because they engage the public in caring about the outcome of restoration projects. The habitat suitability models (HSI) were developed by choosing specific life stages of each species with the most limited, restricted, or tightest range of suitable conditions, to capture the highest sensitivities of the organisms to the environmental changes associated with the planned restoration activities.

The project team originally decided to use seven species–eastern oysters, blue crabs, *Vallisneria*, seagrass (*Halodule* and *Thalassia*), spotted seatrout, decapod larvae, and zooplankton. Once all models were run on all alternatives, the team decided to narrow down the full analysis to three species–oysters, *Vallisneria* and seagrass. It was useful to run all of the species models, as they affirmed that all species showed an improvement over base conditions. However, it was determined that some species would be dropped for purposes of quantification for the final analysis because:

- they were less sensitive to changes between alternatives
- they were redundant and added little additional value
- the team decided to focus on habitats rather than individual species

The chosen species also cover a full range of both temporal and spatial attributes–oysters are found in the middle estuary and are impacted by both wet and dry season, seagrass are found in the lower estuary and are most impacted by the wet season, and *Vallisneria* is found in the upper estuary and is most impacted by the dry season.

C.1.3.2 Importance of Seasonality for This Project

Upon review of the data, there is little value in averaging all HSIs for all seasons of all years. The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to help moderate flows–reduce flows during high flow periods and augment flows during low flow periods. Therefore, in order to present benefits, the impact must be determined during those periods of time. Thus the benefits were calculated using the appropriate seasons to reflect when species are most impacted. Wet years analyzed include 1979, 1982, and 1983. Dry years include 1980, 1981, and 1985. The wet season was defined as June through November. The dry season was defined as December through May.

C.1.3.3 HSI Assumptions

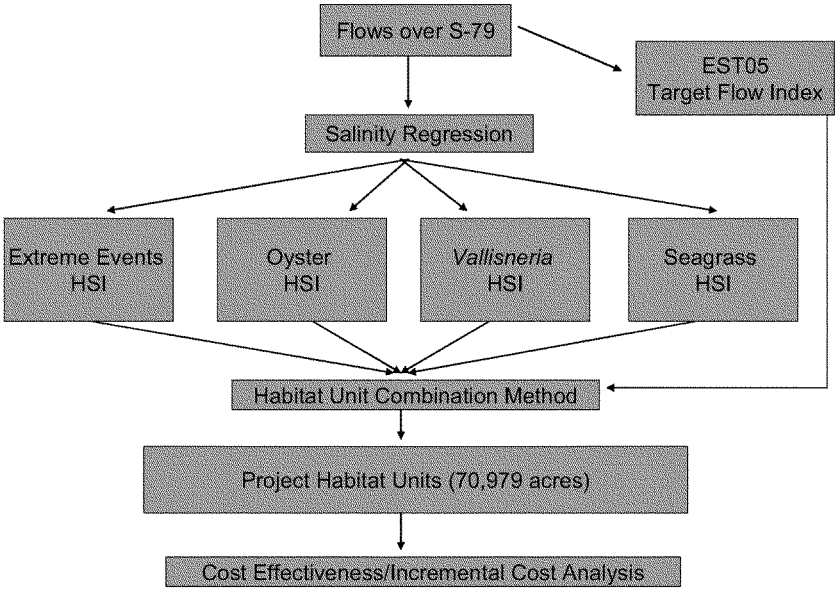
The following is a list of assumptions for the HSI models:

- Linear relationship between the index and individual habitat parameter
- Positive relationship between the index and habitat carrying capacity
- Time scales are appropriate to capture change
- Spatial scale appropriate to capture change
- Variables strongly correlated with habitat quality and can be quantified by the model
- Habitat quality for selected species is a good indicator of habitat quality for other estuarine species
- Input data used to create HSI curves are reliable
- Where local data is lacking, data is from other regions/estuaries are applied to models.

C.1.3.4 Summary of Benefits

The following sub-sections describe the quality index scores for the five attributes studied (three single species, extreme events, and hydrology). Ecological benefit index scores were then combined using a HU combination methodology to produce a single project habitat unit lift. A detailed description of the HSI model for each species, as well as the method for calculation of HUs, can be found later in this appendix. ***Figure C-5*** displays the integration of the indicators in order to calculate HUs.

FIGURE C-5: INTEGRATION OF HSI INDICATORS



C.1.3.4.1 Eastern Oyster Background and Habitat Suitability Index Scores

In the Caloosahatchee Estuary, oysters have been identified as a valued ecosystem component (VEC). Oysters are natural inhabitants of southern estuaries and were documented to be abundant in the system. The Eastern oyster is important for providing reef habitat that serves as areas of concentration (Wells, 1961; Bahr and Lanier, 1981) and as food (Burrell, 1986) for numerous estuarine species including gastropod mollusks, polychaete worms, decapod crustaceans, various boring sponges, fish, and birds, including the endangered oyster catcher. The Eastern oyster is the dominant species in the oyster reef community. There may be over 40 species of macrofauna living in oyster beds with the total number of species exceeding 300 (Wells, 1961).

Salinity, temperature, depth, substrate, and high flow frequency have been chosen as the particular requirements for determining habitat suitability for the Eastern oyster in the Caloosahatchee Estuary. Specific requirements have been pulled from scientific literature for both adults and larval oysters. For the purpose of alternative selection for the C43 West Basin Reservoir Project, depth and substrate have been turned off or removed from the model. This is because the depth within the model boundaries does not exceed three meters, except for within navigation channels, which are not available areas for restoration.

Including substrate in the model application limits restoration benefits to areas where oysters are already present, as that is the only hard substrate data available to the model. The addition of hard substrate to areas with high habitat suitability would be ideal, but is not part of the recommended plan for this project.

To determine benefits for the oyster, both wet and dry seasons of wet and dry years were considered. Wet periods can impact the oyster by flushing out the larvae. Dry periods make the oyster more susceptible to predation and disease. The oyster is this study's "middle estuary (mesohaline to euhaline)" indicator (***Table C-3***).

TABLE C-3: OYSTER HSI SCORES

Alternative	Habitat Suitability Index Score
2000 Base (Existing)	.48
2050 Future Without Project	.52
Alternative 2	.60
Alternative 3b	.60
Alternative 3c	.61
Alternative 4	.61

C.1.3.4.2 *Vallisneria* Background and Habitat Suitability Index Scores

Vallisneria americana (tape grass) is a salt-tolerant freshwater submerged aquatic vegetation (SAV) species that is located in the fresh, oligohaline, and mesohaline portion of estuaries in the eastern United States. Beds of tape grass can occur in the Caloosahatchee Estuary up to 30 kilometers (km) downstream of S-79 near the Mid-Point Bridge, but grow most luxuriantly upstream of the US-41 Bridges, especially where their greatest coverage occurs around Beautiful Island (Chamberlain and Doering 1998). When conditions are favorable, tape grass exhibits a seasonal pattern of growth, with highest biomass achieved in the late summer, flowering in the late summer-early fall, and a winter decline in biomass (Bortone and Turpin, 2000). Tape grass in the Caloosahatchee does not completely die back in the winter as it does in more temperate northern climates (Dawes and Lawrence, 1989). Laboratory experiments using Caloosahatchee plants determined that tape grass can grow throughout the year provided appropriate salinity and water quality conditions are available. Therefore, freshwater discharge commensurate with a suitable salinity for growth need not separately account for different seasonal or spatial salinity preferences or tolerances (Doering et al., 1999).

Previous condition, salinity, temperature, and light availability have been chosen as the particular requirements for determining habitat suitability for *Vallisneria* in the Caloosahatchee Estuary. "Previous condition" means that the

current month's suitability also depends on the how well the grass was doing last month.

To determine benefits for *Vallisneria*, the team looked at the dry season of dry years. *Vallisneria* prefers freshwater, so when the estuary does not receive enough flow and high salinities move into the upper estuary, the *Vallisneria* will suffer (***Table C-4)***.

TABLE C-4: VALLISNERIA HSI SCORES

Alternative	Habitat Su itability Index Score
2000 Base (Existing)	.16
2050 Future Without Project	.20
Alternative 2	.31
Alternative 3b	.33
Alternative 3c	.35
Alternative 4	.35

C.1.3.4.3 Seagrass Background and Habitat Suitability Index Scores

Beds of SAV are important to the ecology of shallow estuarine and marine environments. These beds provide habitat for many benthic and pelagic organisms, function as nurseries for juveniles and other early life stages, stabilize sediments, improve water quality, and can form the basis of a detrital food web (Kemp et al., 1984; Fonseca and Fisher, 1986; Carter et al., 1988; Killgore et al., 1989; Lubber et al. 1990). Because of their importance, estuarine restoration initiatives often focus on SAV (Batiuk et al., 1992; Johansson and Greening, 2000; Virnstein and Morris, 2000). SAV are commonly monitored to gauge the health of estuarine systems (Tomasko et al., 1996) and their environmental requirements can form the basis for water quality goals (Dennison et al., 1993; Stevenson et al., 1993).

In the Caloosahatchee Estuary, field and laboratory research was conducted by South Florida Water Management District (SFWMD) over a wide range of flows and salinities. This information, along with the results from researchers in other systems is used to estimate maximum freshwater inflow limits and associated water quality requirements to protect and restore *Halodule wrightii* (shoal grass) and *Thalassia testudinum* (turtle grass). Previous condition, salinity, temperature, and light availability have been chosen as the particular requirements for determining habitat suitability for seagrasses in the Caloosahatchee Estuary. "Previous condition" means that the current month's suitability also depends on the how well the grass was doing last month. This reflects the extended recovery period for seagrasses.

To determine benefits for seagrass, the team considered wet seasons of wet years. Seagrass is a marine organism that prefers high salinity conditions. When excess fresh water is flushed through the estuary, the salinity dips extremely low, stressing the seagrasses in the lower estuary (***Table C-5***).

TABLE C-5: SEAGRASS HSI SCORES

Alternative	Habitat Su itability Index Score
2000 Base (Existing)	.51
2050 Future Without Project	.54
Alternative 2	.59
Alternative 3b	.59
Alternative 3c	.59
Alternative 4	.59

C.1.3.5 Extreme Events Background and Habitat Suitability Index Scores

The extreme event attribute is perhaps the best indicator of how the reservoir alternatives will perform during high and low flow events. This calculation indicates the lift in benefits for Eastern oyster (wet and dry months), *Vallisneria* (dry months), and seagrass (wet months) during the three most extreme (wettest and driest) events for the nine-year period of record analyzed. This benefit is calculated by averaging the HSI for the most stressful months (based on highest and lowest average monthly flows during model runs for 2050 without project conditions) in the period of record for each of the three species. The months and years used were as follows:

- Wet October 82, March 83, April 83
- Dry March 81, April 81, May 81

After a score is calculated for each species during the extreme events, the HSI of the three species is averaged for a final extreme event HSI score (***Table C-6***).

TABLE C-6: EXTREME EVENTS HSI SCORES

Alternative	Habitat S uitability Index Score
2000 Base (Existing)	.28
2050 Future Without Project	.30
Alternative 2	.42
Alternative 3b	.43
Alternative 3c	.45
Alternative 4	.45

C.1.3.6 EST05 Background and Quality Index Scores

EST05 is a hydrologic target for a suite of estuarine organisms. Because it represents a time series/flow range necessary for an ecological balance within the estuary, it may not reflect the optimal hydrology for any one species. Because all of the species indicators are also somewhat dampened by the effect of averaging over months, seasons, spatially, the team thought it would be beneficial to have at least one benefit stream that depicts a more accurate picture of how well each alternative is matching this target flow. This is why a benefit stream has been derived by the percentage of fit to EST05. This time series of flows was initially created to benefit the ecology of the estuary and as a result, an alternative that can most closely mimic this time series would be most beneficial to the estuary as a whole.

A method for evaluating flows associated with the Caloosahatchee River (C-43) West Basin Storage Reservoir project was developed to easily compare potential project flows (cubic feet/second) with the percent distribution of the target flows from S-79 for any time period (one year or longer). The resulting index scale (0-1) reflects the relative amount that the project related flows move toward the target flows (score of 1) from the base condition (score of 0) for the period being evaluated. For application purposes, the Caloosahatchee River (C-43) West Basin Storage Reservoir project used the year 1982 as the base condition to calculate the TFI BC (target flow index base condition) for the representative years 1978-1986 that were evaluated by the project. This year represents the worst single year regarding flows that exceed EST05 on both the dry and wet extremes (***Table C-7***). This score can then be expressed as the percent toward achieving the target flows (percent of target achieved, or PTA). See TFI documentation for more information.

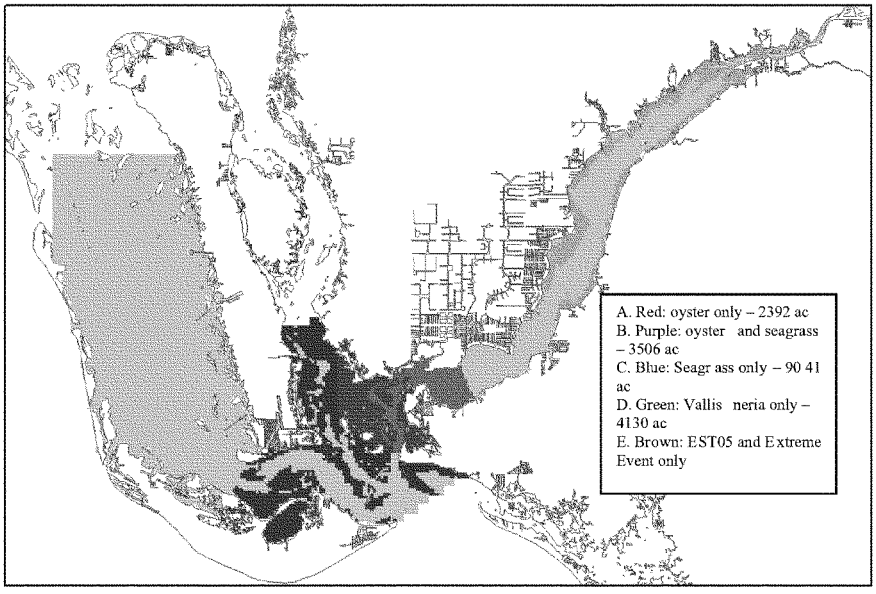
TABLE C-7: EST05 HSI SCORES

Alternative	Habitat Suitability Index Score
2000 Base (Existing)	.38
2050 Future Without Project	.43
Alternative 2	.64
Alternative 3b	.70
Alternative 3c	.80
Alternative 4	.79

C.1.3.7 Habitat Unit Combination Methodology

After a quality index was determined for each benefit stream, these were combined to calculate a total project HU score. This was done with the HUCM. Please refer to ***Figure C-6*** below.

FIGURE C-6: HABITAT UNIT COMBINATION METHODOLOGY



In order to use the HUs for the project in further comparisons (such as cost effectiveness/incremental cost analysis [CE/ICA]), it is useful to produce one single HU number for the project. Therefore a HUCM was created. The basis of the HUCM is that the total quality index values in any one area are summed and then divided by the total number of quality index scores for that area to find an average quality score for the area. Then that score is multiplied by the number of acres for that area. Two of the attributes cover the entire area of benefit (extreme event and EST05). Therefore, all areas have at least those two scores in addition to any species specific HSI values. For example, the only species specific HSI calculated for the area in red in ***Figure C-6*** was for oysters. To calculate the HUCM, the oyster score would be added to the extreme event score and the EST05 score, and the total would be divided by three. That value would then be multiplied by the number of acres in red. The HUs calculated for each area are then added together to quantify the total HUs for the project. By using this method, there is no "double counting" of benefits, even where scores have been calculated for overlapping attributes.

Based on ***Figure C-6*** above, the equation to calculate the total HUs for the Caloosahatchee River (C-43) West Basin Storage Reservoir project using the HUCM is as follows:

Total Project Habitat Units =
((*Vallisneria* score + Extreme Event score + EST05 score)/3) x 4130) +

((Oyster score + Extreme Event score + EST05 score)/3 x 2392) +
((Seagrass score + Extreme Event score + EST05 score)/3 x 9041) +
((Seagrass score + Oyster score + Extrem e Event score + E ST05 score)/4 x 3506) +
((Extreme Event score + EST05 score)/2 x 51910)

See ***Table C-8*** for the total average annual HUs for each alternative calculated using HUCM.

TABLE C-8: TOTAL AVERAGE ANNUAL HABITAT UNITS SCORES

Alternative	Average Annual Project Habitat Units
Alternative 2	10,628
Alternative 3B	12,809
Alternative 3C	16,397
Alternative 4A	15,907

C.1.3.8 Conclusions

Because of the complex, three dimensional nature of this ecosystem, there is no one benefit stream which tells the full story. The team used the HUCM to calculate a total project HU lift. Based on the methodology described in this section, the team has concluded that Alternative 3C has the highest number of HUs and therefore shows the most improvement to the estuary.

C.2 NAI ENVIRONMENTAL BENEFIT ANALYSIS

The system-wide formulation was conducted to determine the input for the CE/ICA and assist in the selection of the recommended plan. An additional analysis was also conducted to use in justifying and describing the benefits of the Caloosahatchee River (C-43) West Basin Storage Reservoir as a stand-alone project without the system-wide benefits attributed to other CERP projects, otherwise known as the NAI analysis.

An identical method was used for the NAI as was used for the system formulation (LAI). As described in the LAI analysis, five attributes were studied to determine system response. Oysters, *Vallisneria*, seagrasses, extreme events and EST05 were all measured and compared to 2050 in order to determine the benefit lift for the Selected Alternative Plan (SAP) (***Table C-9***). This methodology is described in the environmental benefits evaluation section.

Although the NAI and LAI are listed below, this is not a valid comparison due to different sources of data for the two analyses. Therefore, even though the HSIs are similar, the total project average annual HUs are based on different 2050

model conditions, resulting in a larger lift for the NAI analysis. The NAI analysis reflects 28 percent more benefits than the system-wide formulation. There are several variables which could explain the higher benefits with the NAI approach. The first and most influential of these results from the rest of CERP's impact on the overall water budget provided to the Caloosahatchee River (C-43) Basin. The system-wide analysis has a lower water budget than the NAI analysis, leading to diminished dry season conditions. The other variances may stem from differing models being utilized for the benefit analysis. The system-wide analysis utilized the MIKESHE model and the NAI run utilized spreadsheet flow models.

TABLE C-9: COMPARISON OF NAI AND LAI SCORES

Alternative	Oyster	Vallisneria	Seagrass	Extreme Events	EST05	Total Projec t Average Annual Habitat Units
3B LAI	.60	.33	.59	.43	.70	12,809
3B NAI	.59	.33	.52	.24	.70	15380

C.2.1 Conclusions

Both the system formulation (LAI) and the NAI evaluations of the selected plan demonstrate significant ecological benefits due to implementation of the Caloosahatchee River (C-43) West Basin Storage Reservoir project.

C.3 HABITAT SUITABILITY INDEX PROCESS

C.3.1 Background

The forecasting model used to evaluate alternatives for the Caloosahatchee River (C-43) West Basin Storage Reservoir project consisted of a set of stressor-response (habitat suitability) models for individual species. These HSI models were developed from scientific literature, expert knowledge, and available field data. The HSIs portray each stressor variable spatially and temporally across the study area at a scale appropriate to the organism or community being portrayed. HSI models were incorporated into a GIS to describe responses spatially and temporally for the selection of restoration alternatives for each project.

Models were created for species of ecological, recreational, or economic importance, or because they engage the public in caring about the outcome of restoration projects. The models include the Eastern oyster (*Crassostrea virginica*), blue crab (*Callinectes sapidus*), spotted seatrout (*Cynoscion nebulosus*), wild celery (*Vallisneria americana*), turtle grass (*Thalassia testudinum*), shoal grass (*Halodule wrightii*), and selected species of zooplankton. Additionally, each model has a well-established linkage to

stressors of management interest. Habitat suitability for each species was determined using specific life stages of the organism with the most limited, restricted, or tightest range of suitable conditions. By doing this, the highest sensitivities of the organisms to environmental changes associated with the planned restoration activities are captured. For the Eastern oyster, habitat suitability is modeled for both adult and larvae life stages because of the tighter range of suitable conditions necessary for larval success. The adult blue crab tolerates a very wide range of salinity conditions, so the limiting conditions for successful blue crab habitat are the more restricted conditions necessary for blue crab recruitment. As a result, the blue crab HSIs are focused on the megalopae larvae and spawning female life stages. Spotted seatrout require specific conditions for forage and spawning, including suitable habitat and the proximity of that habitat to deeper refugia. Flow is important, as large inputs of freshwater can cause spotted seatrout eggs to sink, reducing survival of the larvae. Therefore, the spotted seatrout model will include forage and spawn components.

Each HSI model describes a response surface of habitat suitability values between 0 (unsuitable) and 1 (most suitable) that varies spatially according to stressor levels throughout the estuary and temporally according to temporal patterns in stressor variables. Much of the temporal variation is a result of temporal cycling of important stressor inputs, such as salinity. The models calculate habitat suitability monthly as the weighted geometric mean of the environmental variables identified as important for each model. The geometric mean is derived from the product of the variables rather than the sum (as in the arithmetic mean), and has the appropriate property that if any of the individual variables are unsuitable for species success (i.e., the value of the variable is zero) then the entire index goes to zero. This HSI value was then multiplied by the area within each grid cell and the grid cell values added to calculate HUs for each species. ***Figure C-5*** represents how the various HSIs were combined to generate HU scores and support the CE/ICA effort.

C.3.2 HSI Formulas

Where "w" is a weight between 0 and 1 assigned to each variable and where "previous" means that the current month's suitability also depends on the how well the grass was doing last month (previous score) (e.g. Previous = previous_month_HSI + 0.05 (not to exceed 1.0); this allows for growth from month to month if other conditions are suitable).

C.3.2.1 Spotted Seatrout

Spotted Seatrout HIS $_{(May–October)}$ = MAX (ForageComponent, SpawnComponent)
Spotted Seatrout HSI $_{(November–April)}$ = ForageComponent

Forage Component Index = (HabitatwSeagrass%Cover * Salinity^{w} * Temperature^{w})
Spawn Component Index = (HabitatwDropoff&SeagrassProximity ^{w}* Salinity^{w})
Spawning is May - October

C.3.2.2 Eastern Oyster

Eastern Oyster HIS $_{(May\text{-}November)}$ = MIN (LarvaeComponentIndex, AdultComponentIndex)
Eastern Oyster HIS $_{(December\text{-}April)}$ = (AdultComponentIndex)
LarvalComponentIndex = (Salinity^{w} * Temperature^{w} * Flow^{w})
AdultComponentIndex = (Salinity^{w} * Temperature^{w})

C.3.2.3 Blue Crab

Blue Crab HIS $_{(June\text{-}October)}$ = (LarvaeComponentIndex^{w} + SpawningFemaleComponentIndex^{w})
Blue Crab HIS $_{(March\text{-}May,\ Nov,\ Dec)}$ = (SpawningFemaleComponentIndex)
LarvalComponentIndex = (Salinity^{w} * Temperature^{w} * Flow^{w})
Spawning FemaleComponentIndex = (Salinity^{w} * Temperature^{w})

C.3.2.4 Seagrass

Seagrass HSI = (Previous^{w} * Salinity^{w} * Temperature^{w} * LightAvailability^{w})

C.3.2.5 Vallisneria

Vallisneria HSI = (Previous^{w} * Salinity^{w} * Light Availability^{w} * Temperature^{w})

C.4 HABITAT UNIT CALCULATIONS METHODOLOGY-JANUARY 2007

C.4.1 Habitat Unit Methodology/Rules

This section describes an approach to calculating HUs that was applied in January 2007.

1. Flows over S-79 are calculated using a spreadsheet model or MIKESHE model.
2. These flows are then run through a salinity regression model which outputs a salinity grid for the full area of benefit.
3. These salinities (along with other parameters) are then used as input for the oyster, V*allisneria*, and seagrass HSI models.
4. The following rules were applied to the HSI models (some new model rules, some post processing rules):
   I. Oyster
      i. Mask the core area with no temperature variable

ii. If HSI is less than or equal to .1 in any given month, then the following month is also scored at less than or equal to .1 (this represents the recovery lag)
iii. Include Iona Cove in the potential habitat area
iv. Consider all seasons of three wet years (79, 82, 83) and dry years (80, 81, 85)

II. Seagrass
i. Apply mask to core area and calculate HSI for San Carlos Bay only, as this is the area with the highest potential for improvement
ii. Establish a lower depth threshold of seven feet in San Carlos Bay
iii. If HSI is less than or equal to .1 in any month, then the HSI stays at less than or equal to .1 for the remainder of that season
iv. Consider wet seasons (June–November) only of three wet years (79, 82, 83)

III. *Vallisneria*
i. Establish a lower depth threshold of five feet
ii. If HSI is less than or equal to .2 for one month, then HSI is less than or equal to .2 for the remainder of that season
iii. If HSI is less than or equal to .1 in any month, then HSI = 0 for 12 subsequent months
iv. Consider dry seasons (December–May) only of three dry years (80, 81, 85)

5. Two additional quality indices were calculated. Those are as follows:

I. Extreme Event
i. This is calculated by averaging the HSI for the most stressful months (based on model runs for 2050 without project conditions) in the period of record for each of the three species. The months and years used were as follows:
ii. Oysters – (wet)Oct 82, March 83, April 83
iii. Oysters - (dry) March 81, April 81, May 81
iv. Vallisneria-March 81, April 81, May 81
v. Seagrasses–Oct 82, March 83, April 83
vi. After each species is averaged, the HSI of the three species is averaged for a final extreme event HSI number.

II. EST05
i. The team wanted to present an accurate picture of how well each alternative was matching the EST05 time series of flows over S-79, as this flow is considered ideal for the overall health of the estuary ecosystem.
ii. A method for evaluating flows associated with the Caloosahatchee River (C-43) West Basin Storage Reservoir project was developed to easily compare potential project flows

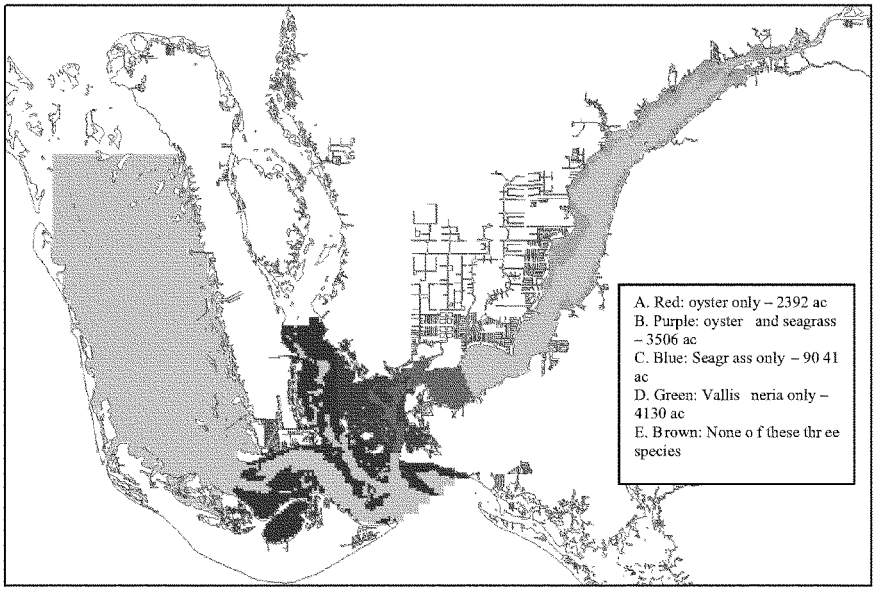
(cubic feet/second) with the percent distribution of the target flows from S-79 for any time period (one year or longer). The resulting index scale (0-1) reflects the relative amount that the project related flows move toward the target flows (score of 1) from the base condition (score of 0) for the period being evaluated. For application purposes, the Caloosahatchee River (C-43) West Basin Storage Reservoir project uses the year 1982 as the base condition to calculate the TFI BC for the representative years 1978-1986 that were evaluated by the project. This year represents the worst single year regarding flows that exceed EST05 on both the dry and wet extremes. This score can then be expressed as the percent toward achieving the target flows (percent of target achieved [PTA]). See TFI documentation for more information

C.4.2 Habitat Unit Combination Methodology

After a quality index was determined for each benefit stream, these were combined to calculate a total project HU score. This was done with the HUCM. Please refer to ***Figure C-7*** below.

In order to use the HUs for the project in further comparisons (such as CE/ICA), it is useful to produce one single HU number for the project. Therefore a HUCM was created. The basis of the HUCM is that the total quality index values in any one area are summed and then divided by the total number of quality index scores for that area to find an average quality score for the area. Then that score is multiplied by the number of acres for that area. Two of the attributes cover the entire area of benefit (extreme event and EST05). Therefore, all areas have at least those two scores in addition to any species specific HSI values. For example, the only species specific HSI calculated for the area in red in ***Figure C-7*** was for oysters. To calculate the HUCM, the oyster score would be added to the extreme event score and the EST05 score, and the total would be divided by three. That value would then be multiplied by the number of acres in red. The HUs calculated for each area are then added together to quantify the total HUs for the project. By using this method, there is no "double counting" of benefits, even where scores have been calculated for overlapping attributes.

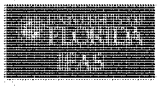
FIGURE C-7: HABITAT UNIT COMBINATION METHODOLOGY JANUARY 2007



Based on ***Figure C-7*** above, the equation to calculate the total HUs for the Caloosahatchee River (C-43) West Basin Storage Reservoir project using the HUCM is as follows:

Total Project Habitat Units =
((*Vallisneria* score + Extreme Event score + EST05 score)/3) x 4130) +
((Oyster score + Extreme Event score + EST05 score)/3 x 2392) +
((Seagrass score + Extreme Event score + EST05 score)/3 x 9041) +
((Seagrass score+ Oyster score+ Extreme Event score + EST05 score)/4 x 3506) + ((Extreme Event score + EST05 score)/2 x 51910)

C.5 SUMMARY OF THE OYSTER HSI



Final Report for Technical Assistance for an Ecological Evaluation of the Southwest Florida Feasibility Study

STRESSOR RESPONSE MODEL FOR THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

By Frank J. Mazzotti, Leonard G. Pearlstine, Tomma Barnes, Aswani Volety, Kevin Chartier, Alicia M. Weinstein, and Donald DeAngelis

Joint Ecosystem Modeling Laboratory
Technical Report Series

FINAL REPORT
For

Technical Assistance for an Ecological Evaluation of the

Southwest Florida Feasibility Study

STRESSOR RESPONSE MODELS FOR THE EASTERN OYSTER, CRASSOSTREA VIRGINICA

Prepared By:
Frank J. Mazzotti[1], Leonard G. Pearlstine[1], Tonnna Barnes[2], Aswani Volety[3], Kevin Chartiere[1], Alicia M. Weinstein[1], and Donald DeAngelis[4]

[1]University of Florida
Ft. Lauderdale Research and Education Center
3205 College Ave
Davie, FL 33314
(954) 577-6304

[2]South Florida Water Management District
Fort Myers Service Center
2301 McGregor Blvd.
Fort Myers, FL 33901

[3]Florida Gulf Coast University
10501 FGCU Blvd. south
Fort Myers, FL 33965

[4]United States Geological Survey
University of Miami, Dept. of Biology
1301 Memorial Dr. RM 215
Coral Gables, FL 33146

Prepared For:
South Florida Water Management District
Fort Myers Service Center
2301 McGregor Blvd.
Fort Myers, FL 33901

United States Geological Survey
1301 Memorial Dr. RM 215
Coral Gables, FL 33146
(305) 284-3974

Cooperative Agreement No. 1434-00HQAG0212
Account No. 728525712

JUNE 2006

2

University of Florida

This report should be cited as:

Manzotti, F.J., Pearlstine, L.G., Barnes, T., Volety, A., Chartier, K., Weinstein, A. and DeAngelis, D. 2006. *Stressor response models for the Eastern oyster, Crassostrea virginica*. IFM Technical Report. Final report to the South Florida Water Management District and U.S. Geological Survey. University of Florida, Florida Leaderdale Research and Education Center, Fort Lauderdale, Florida. 15 pages.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the University of Florida.

Although this report is in the public domain, permission must be secured from the individual
copyright owners to reproduce any copyrighted material contained within this report.

3

Contents

Introduction 1
Southwest Florida Feasibility Study 1
C43 West Reservoir 1
Forecasting Models 1
Habitat Suitability Indices 2
Ecology of the Eastern Oyster 3
HSI for the Eastern Oyster 4
HSI Formula 9
HSI Graphs 10
References Cited 12

Figures

Figure 1. Index value for eastern oyster larvae response to salinity 9
Figure 2. Index value for eastern oyster larvae response to temperature 9
Figure 3. Index value for eastern oyster adult response to salinity 10
Figure 4. Index value for eastern oyster adult response to temperature 10
Figure 5. Index value for eastern oyster larvae response to high flows 11

Tables

Table 1. Habitat requirements for the eastern oyster 6

STRESSOR RESPONSE MODEL FOR THE EASTERN OYSTER, *CRASSOSTREA VIRGINICA*

By Frank J. Mazzotti, Leonard G. Pearlstine, Tomma Barnes, Aswani Volety, Kevin Chartier, Alicia M. Weinstein, and Donald DeAngelis

Introduction

A key component in adaptive management of Comprehensive Everglades Restoration Plan (CERP) projects is evaluating alternative management plans. Regional hydrological and ecological models will be applied to evaluate restoration alternatives and the results will be applied to modify management actions.

Objective

The purpose of this habitat suitability model for the C-43 West Basin Reservoir and Southwest Florida Feasibility Study projects is to portray species responses to changes in environmental variables resulting from restoration activities spatially and temporally to facilitate policy decisions. The intention of the habitat suitability model is not to simulate the life-cycles of the species. Rather, the intent is to estimate numbers of habitat units to serve as a relative basis for comparing management alternatives.

Southwest Florida Feasibility Study

The Southwest Florida Feasibility Study (SWFFS) is a component of the Comprehensive Everglades Restoration Plan (CERP). The SWFFS is an independent but integrated implementation plan for CERP projects and was initiated in recognition that there were additional water resource issues (needs, problems, and opportunities) within Southwest Florida that was not being addressed directly by CERP. The SWFFS identifies, evaluates, and compares alternatives that address those additional water resource issues in Southwest Florida. An adaptive assessment strategy is being developed that will create a system-wide monitoring program to measure and interpret ecosystem responses. The SWFFS provides an essential framework to address the health and sustainability of aquatic systems. This includes a focus on water quantity and quality, flood protection, and ecological integrity.

C43 West Reservoir

The purpose of the C43 Basin Storage Reservoir project is to improve the timing, quantity, and quality of freshwater flows to the Caloosahatchee River estuary. The project includes an above ground reservoir with a total storage capacity of approximately 197 million

cubic meters (160,000 acre-feet) and will be located in the C-43 Basin in Hendry, Glades, or Lee Counties. The initial design of the reservoir assumed 8094 hectares (20,000 acres) with water levels fluctuating up to 2.4 meters (8 feet) above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design.

Forecasting Models

Forecasting models bring together research and monitoring to ecosystems of Southwest Florida and place them into an adaptive management framework for the evaluation of alternative plans. There are two principle ways to structure adaptive management: (1) *passive* by which policy decisions are made based on a forecasting model and the model is revised as monitoring data become available, and (2) *active* by which management activities are implemented through statistically valid experimental design to better understand how and why natural systems respond to management (Wilhere 2002).

In an integrated approach that includes both passive and active-adaptive management, a forecasting model simulates system response and is validated by monitoring programs to measure actual system response. Monitoring can then provide information for passive-adaptive management for recalibration of the forecasting model. Directed research, driven by model uncertainties, is an active-adaptive management strategy for learning and the reduction of uncertainties in the model.

The forecasting models for the C-43 West Reservoir Project and the Southwest Florida Feasibility Study consist of a set of stressor response (habitat suitability) models for individual species. These stressor response models have been developed principally with literature, expert knowledge, and currently available field data.

Habitat Suitability Indices

Habitat Suitability Indices (HSI) models were developed with each stressor variable portrayed spatially and temporally across systems of the study area at scales appropriate to the organism or community being portrayed. The HSI models have been incorporated into a GIS to portray responses spatially and temporally to facilitate policy decisions. That is, the model describes a response surface of habitat suitability values that vary spatially according to stressor levels throughout the estuary and temporally according to temporal patterns in stressor variables. Much of the temporal variation is a result of temporal cycling of important stressor inputs, such as water temperature and salinity. Temporal change for other important variables may not be cyclical, such as rising sea level and increasing land use and fresh water demands in the region. Areas predicted to be suitable and those predicted to be less suitable or disturbed should be targeted for additional sampling as part of the model validation and adaptive management process.

Species selected for modeling (focal species) are ecologically, recreationally or economically important and have a well established linkage to stressors of management interest. They may also make good focal species because they engage the public in caring about the outcome of restoration projects. The habitat suitability models (HSI) were developed by choosing specific life stages of each species with the most limited, restricted, or tightest range of suitable conditions, to capture the highest sensitivities of the organisms to the environmental

2

changes associated with the planned restoration activities. Values used in the models are listed in Table 1.

The models calculate habitat suitability monthly as the weighted arithmetic mean of the environmental variables identified as important for each model.

Ecology of the Eastern Oyster

The eastern oyster is a bivalve in the family Ostreidae. It is important both commercially and recreationally in fisheries along the Atlantic and Gulf of Mexico coasts of North America. It requires a proper substrate and suitable salinity conditions for existence. Due to its sedentary nature, the Eastern oyster is susceptible to undesirable natural and artificial environmental changes, as well as pollution within its habitat. Environmental disruptions are responsible for reducing oyster populations and their traditional habitats (Cake 1983).

Eastern oysters live in estuaries and behind barrier islands from the Gulf of St. Lawrence, Canada, through the Gulf of Mexico to the Bay of Campeche, Mexico, and into the West Indies. They exist in every major bay system within their range but are not evenly distributed among or within bays. The availability of clean, firm substrate sites for attachment restricts the distribution of Eastern oyster. The Eastern oyster is most abundant in the Gulf of Mexico, Chesapeake Bay, and Long Island Sound (Stanley and Sellers 1986).

Eastern oysters filter feed for planktonic organisms and detritus. They are prey to protozoan, anemones, coelenterates, helminths, mollusks, crustaceans, and fish (Berrigan et al.1991; Tolley et al. 2005). In the Gulf of Mexico, Eastern oysters typically reach about 3" long in 18–24 months and 5.9" long in 5 or 6 years. They can live as long as 25 to 30 years and reach a maximum size of 11.8". Eastern oysters are protandrous hermaphrodites, but can become alternate hermaphrodites after an initial male state, even alternating sex within a spawning season (Galtsoff 1964). Maturity is reached in as little as 4 weeks after setting.

The eastern oyster in the Gulf of Mexico spawns between March and November (Butler 1954). Locally oyster spawning begins late March and continues through October, with most larvae present May through November specifically in the Caloosahatchee estuary between March or April and October (Volety per. com. 2004). Gametogenesis and spawning are initiated and maintained when water temperatures reach about 20 °C with mass spawning at temperatures above 25°C in the Gulf of Mexico (Stauber 1950, Schlesselman 1955, Hopkins 1931, Ingle 1951, Menzel 1955, Hayes and Menzel 1981), and locally between 26°C and 28°C (Savarese et al. 2003, 2004, Volety et al. 2003). Optimal salinity for spawning is 10‰-30‰ (Menzel 1951). Males are usually the first to spawn, and their spermatozoa and gamones stimulate other males and females to spawn. Eggs and sperms are released directly into the water column and fertilization is external (Galtsoff 1964). Mature oysters spawn numerous times through the spawning season but peaks are in late spring when water temperatures increase and in fall when water temperatures begin to drop (Pollard 1973). Each female produces 23 to 86 million eggs per spawning (Davis and Chanley 1955). The egg hatches 6 hours after fertilization at water temperatures near 24°C (Loosanoff 1965, Berrigan et al. 1991).

Oyster larvae are meroplankton and develop in the water column within the estuary. At the larval stage, the Eastern oyster is able to withstand a wide range of salinities and salinity tolerance depends on the salinity at which the parents were held during gametogenesis (Davis 1958). Hopkins (1931) monitored abundances of larvae and spat in Texas and found that even

3.

though the water was well populated with larvae, they would not attain setting stage unless salinities reaches 20‰ to 21‰. In Louisiana, setting occurred at 10‰ to 22‰ with a peak at 20‰ to 22‰ (Chatry et al 1983). Other authors say that metamorphosing oyster larvae will set at salinities between 5‰ and 35‰ with optimal setting occurring between 10‰ and 30‰ and peaks at 18‰ to 22‰ (Carriker 1951, Davis 1958, Calabrese and Davis 1970, Chantry and Dugus (MS). Locally, optimal salinities for oyster larvae appear to be between 10‰ to 30‰ and the most favorable being between 15‰ and 25‰ (Savarese et al. 2003, 2004, Volety et al. 2003).

Water temperatures that are above or below seasonal norms shorten or lengthen, respectively, the normal 2 week larval development period (Cake 1983). Under laboratory conditions larvae held at 30°C began to settle 10-12 days after fertilization, larvae held at 24°C set after 24-26 days, but few larvae held at 20°C set within 35 days (Loosanoff and Davis 1963). Optimal water temperatures for growth range from about 20°C to 30°C (Stanley and Sellers 1986). In Southwest Florida, favorable temperatures tend to be slightly higher at 26° to 30°C (Savarese et al. 2003, 2004, Volety et al. 2003).

Oyster larvae must settle on a relatively clean, sediment-free, stable surface that is not heavily fouled with other encrusting organisms (Cake 1983) in areas with stable salinities (Stanley and Sellers 1986). It will attach to a variety of materials including occupied or empty oyster shells, calcareous remains of other mollusks, wooden materials, rocks, gravel, and solid refuse (Hedgpeth 1953, Butler 1954, Lunz 1958, Galtsoff 1964, Gunter and Demoran 1971, Mackenzie 1977, 1981, 1983). Optimal cultch material includes shells of live or recently dead oysters and calcareous remains of other estuarine mollusks (Butler 1054, Galtsoff 1964, Gunter and Demoran 1971, Mackenzie 1977, 1981, 1983). Successful colonies occur at depths from 0.3 m (1 ft) above mean low water to 12m (40 ft) (Butler 1954). Optimal depth in the Gulf of Mexico estuaries is .5 m to 3 m (Volety pers. com. 2003).

Adult oysters are sessile. Their distribution depends on where the larvae set and on the subsequent survival of the spat. Oysters are filter feeders and may filter 1500 times their body volume in and hour (Loosanoff and Nomejko 1946). Adult oysters typically live in clumps called reefs, beds, or bars. Most growth occurs during the first 3 months of life and is influenced by temperature, salinity, intertidal exposure, turbidity, food, and position and density in the oyster reef (Stanley and Sellers 1986). The Eastern oyster is the dominant species in the oyster reef community, with over 40 additional macrofaunal species or groups living in oyster beds (Bahr and Lanier 1981; Savarese et al. 2003, 2004, Tolley et al. 2005). Predators, diseases, and parasites can affect oyster populations and limit the abundance of oysters.

American oysters in the Gulf of Mexico have a normal salinity range of 10‰ to 30‰ but can survive in salinities from 5‰ to 40‰ (Gunder and Geyer 1955, Butler 1954, Galtsoff 1964, Stenzel 1971). Optimal salinity ranges for physiological purposes, food abundance, and stenohaline predator avoidance is 10‰ to 20‰ (Butler 1954, Eleuterius 1977). Larval settlement and growth is decreased at low salinities and peaks at 25‰ – 29‰ (Menzel et al. 1966, Chatry et al. 1983) and 20‰ -22‰ (Castagna and Chanley 1973), respectively.

Oysters can tolerate ambient water temperatures from 1°C to 49°C (Galtsoff 1964), but typically stop feeding at 6°-7°C and at 42°C most physiological processes stop or are greatly reduced (Galtsoff 1964). Optimal water temperatures for growth, reproduction, and survival range from about 20°C to 30°C (Stanley and Sellers 1986). In the Gulf of Mexico, oysters

cannot withstand freezing temperatures or temperatures above 37°C (Copeland and Hoese 1966, Cake 1983). In South Florida, cold temperatures are not a problem for oysters but high temperatures often can be. Local studies show that adult oysters do best at temperatures between 20°C and 32°C and peak at between 23°C and 30°C (Savarese et al. 2003, 2004, Volety et al. 2003).

HSI for the Eastern Oyster

In the Caloosahatchee Estuary, oysters have been identified as a Valued Ecosystem Component (VEC). Oysters are natural components of southern estuaries and were documented to be abundant in the system. The Eastern oyster is important for providing reef habitat that serves as areas of concentration (Wells 1961, Bahr and Lanier 1981) and as food (Burrell 1986) for numerous estuarine species including gastropod mollusks, polychaete worms, decapod crustaceans, various boring sponges, fish, and birds, including the endangered oyster catcher. The Eastern oyster is the dominant species in the oyster reef community. There may be over 40 species of macrofauna living in oyster beds with the total number of species exceeding 300 (Wells 1961).

Salinity, temperature, depth, substrate, and high flow frequency have been chosen as the particular requirements for determining habitat suitability for the Eastern oyster in the Caloosahatchee Estuary. Specific requirements have been pulled from scientific literature are listed, along with their source, in the table below for both adults and larval oysters. For the purpose of alternative selection for the C43 West Basin Reservoir Project, depth and substrate have been turned off or removed from the model. This is because the depth within the model boundaries does not exceed 3 meters, except for within navigation channels, which are not available areas for restoration. Including substrate in the model application limits restoration benefits to areas where oysters are already present, as that is the only hard substrate data available to the model. The addition of hard substrate to areas with high habitat suitability will be included as part of the restoration plan.

A user interface for running coastal southwestern Florida HSI models is documented in Mazzotti *et al.* (2006).

Table 1. Habitat Requirements for the Eastern Oyster.

Variable	Value	Source
Oyster Larvae: Salinity	Limits: 5‰ and 35‰ Optimal: 10‰-30‰ Peak: 20‰-22‰ Settlement peak: 25‰ - 29‰. In Caloosahatchee most favorable: 15‰-25‰	Calabrese, A. and H.S. Davis. 1970. Tolerances and requirements of bivalve molluscus. Helgol. Wiss. Meeresunters. 20:553-564. Carriker, M.R. 1951. Ecological observations on the distribution of oyster larvae in New Jersey estuaries. Ecol. Monogr. 21(1):19-38. Costagna, M. and P. Chanley. 1973. Salinity tolerance of some marine bivalves from inshore and estuarine environments in Virginia waters on the western mid-Atlantic coast. Malacologia 12:47-96. Chatry, M., R.J. Dugas, and K.A. Easley. 1983. Optimum salinity regime for oyster production on Louisiana's state seed grounds. Contrib. Mar. Sci. 26:81-94. Davis, H.C. 1958. Survival and growth of clam and oyster larvae at different salinities. Biological Bulletin 114(3): 296-307. Hopkins, A.E. 1931. Factors influencing the spawning and setting of oysters in Galveston Bay, Texas. Bull. U.S. Bur. Fish. 47:57-83. Menzel, R.W., N.C. Hellings, and R.R. Hathaway. 1966. Oyster abundance in Apalachicola Bay, Florida in relation to biotic associations influenced by salinity and other factors. Gulf Res. Rep. 2:73-98 Savarese, M., A.K. Volety, and S.G. Tolley. 2001. Oyster health and habitat quality in Fakahatchee estuary: establishing a baseline performance for ten thousand island estuarine restoration. Final Report Submitted to the South Florida Water Management District, Big Cypress Basin. 42 pp. Savarese, M., A.K. Volety, and S.G. Tolley. 2003. Influence of watershed alteration on oyster health and oyster-reef habitat: management implications for the Faka-Union and Estero Bays. Final Report (Award # C-13252) submitted to the South Florida Water Management District, 86 pp. Volety, A.K., S.G. Tolley, and J.T. Winstead. 2003. Investigations into effects of seasonal and water quality parameters on oysters (*Crassostrea virginica*) and associated fish populations in the Caloosahatchee Estuary. Interpretive Report (Award #C12412-A1) submitted to the South Florida Water management District, West Palm Beach, FL. 111 pp.
Oyster Larvae: Temperature	Optimal: 20°C-30°C With peaks at the higher end	Loosanoff, V.L. and H.C. Davis. 1963. Rearing of bivalve mollusks. Adv. Mar. Biol. 1:1-136. Stanley, J.G. and M.A. Sellers 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) – Eastern oyster. Report No. Biological-82 (11.64); National Wetlands Research Center, Slidell, LA; Army Engineer Waterways Experiment Station, Vicksburg, MS.
Oyster Adult: Temperature	Optimal: 20°C-30°C Can tolerate: 1°C-49°C Stop feeding: 6°-7°C	Cake, E.W., Jr. 1983. Habitat suitability index models: Gulf of Mexico Eastern oyster. U.S. Fish Wildl. Ser.FWS/OBS-82/10.57.37p. Copeland, B.J., and H.D. Hoese. 1966. Growth and mortality of the Eastern

6

	Physiological functions cease: 42°C	oyster: *Crassostrea virginica*, in high salinity shallow bay in central Texas. Publ. Inst. Mar. Sci. Univ. Tex. 11:149-158.
		Galtsoff, P. S. 1964. *The Eastern Oyster: Crassostrea virginica Gmelin.* Fishery Bulletin. U.S. Fish and Wildlife. Service Publication 64. pp.480.
		Stanley, J.G. and M.A. Sellers 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) -- Eastern oyster. Repot No. Biological-82 (11.64). National Wetlands Research Center, Slidell, LA; Army Engineer Waterways Experiment Station, Vicksburg, MS.
		Stenzel, H.B. 1971. Oysters. Treatise on invertebrate paleontology. Part N, Bivalvia 3:953-1224
Oyster Adult: Salinity	Optimal: 10°C-20°C Normal range: 10°C-30°C Can tolerate: 5°C-40°C	Butler, P.A. 1954. Summary of our knowledge of the oyster in the Gulf of Mexico. U.S. Fish Wildl. Serv. Bull. 89:479-489.
		Eleuterius, C.K. 1977. Location of the Mississippi Sound oyster reefs as related to salinity of bottom waters during 1973-1975. Gulf Res. Rep. 6:17-23.
		Galtsoff, P.S. 1964. The American Oyster Crassostrea virginica Gmelin. Fishery Bulletin. U.S. Fish and Wildlife. Service Publication 64.
		Gunter, G. and R.A. Geyer. 1955. Studies of fouling organisms in the northwestern Gulf of Mexico. Publ. Inst. Mar. Sci. Univ. Tex. 4(1):114-116.
		Stenzel, H.B. 1971. Oysters. Treatise on invertebrate paleontology. Part N, Bivalvia 3:953-1224.
Oyster Larvae and Adult: Depth	Optimal: .5 – 3 m	Volety, Aswani, Florida Gulf Coast University. Pers. Com 10/2003.
Oyster Larvae and Adult: Substrate	Oyster shells, calcareous remains of other mollusks, wooden material, rocks, gravel, and solid refuse	Butler, P.A. 1954. Summary of our knowledge of the oyster in the Gulf of Mexico. U.S. Fish Wildl. Serv. Bull. 89:479-489. Galtsoff, P. S. 1964. *The Eastern Oyster: Crassostrea virginica Gmelin.* Fishery Bulletin. U.S. Fish and Wildlife. Service Publication 64. Gunter, G. and W.J. Demoran. 1971. Mississippi oyster culture. Am. Fish. Farmer 2(5):8-12. Hedgepeth, J.W. 1953. An introduction to the zoogeography of the northwest Gulf of Mexico with reference to the invertebrate fauna. Publ. Inst. Mar. Sci. Univ. Tex. 3:107-224. Lunz, G.R. 1958.Unused oyster shell in South Carolina suitable for seed oyster production. Proceedings of the National Shellfisheries Association 48: 44-51. MacKenzie, C. L., Jr. 1977. Development of an aquaculture program for rehabilitation of damaged oyster reefs in Mississippi. Mar. Fish. Rev. 39(8):1-13. MacKenzie, C.L., Jr. 1981. Biotic potential and environmental resistance in the Eastern oyster (Crassostrea virginica) in Long Island Sound. Aquaculture 22:229-268. MacKenzie, C.L., Jr. 1983. To increase oyster production in the Northeast United States. Mar. Fish. Rev. 45(3):1-22.
Oyster Larvae Flow	Optimal: 500 – 2500 CFS in the Caloosahatchee River resulting in salinities above 5 -10 ppt	Shumway, S.E. 1996. Natural environmental factors. Pages 467-513 in V.S. Kennedy, R.I.E. Newell & A.F. Eble (eds.). The Eastern Oyster *Crassostrea virginica*. Maryland Sea Grant College Publication, College Park, Maryland

	Flows >4,000 cfs will restrict larval settlement.	Volety, A. K., S. G. Tolley, and J. T. Winstead. 2003. Investigations into effects of seasonal and water quality parameters on oysters (*Crassostrea virginica*) and associated fish populations in the Caloosahatchee Estuary. Interpretive Report (Award #C12412-A1) submitted to the South Florida Water management District, 111 pp. Volety, Aswani, Florida Gulf Coast University. Pers. Com 10/2003. Wilson, C., L. Scotto, J. Scarpa, A. Volety, S. Laramore, and D. Haunert. Survey of water quality, oyster reproduction and oyster health status in the St. Lucie estuary. J. Shellfish Res. 21: 157-165.

HSI Formula

Oyster

Calculated monthly

Component Indices are the weighted geometric mean of the variables. The final HSI is an arithmetic mean of the larval and adult component indices.

Eastern Oyster *LarvalComponentIndex* = (Salinity^{w} * Temperature^{w} * Flow^{w})

Eastern Oyster *AdultComponentIndex* = (Salinity^{w} * Temperature^{w})

$HSI_{May\text{-}November}$ = MIN (*LarvaeComponentIndex* + *AdultComponentIndex*)

$HSI_{December\text{-}April}$ = (*AdultComponentIndex*) where:

The default weight, $w = 1/(number\ of\ variables)$. The weight can take on different values for the different variables, however, the sum of the weights must be equal to one.

Temperature values used in model are average monthly water temperatures and do not change with hydrologic alternatives.

9

HSI Graphs

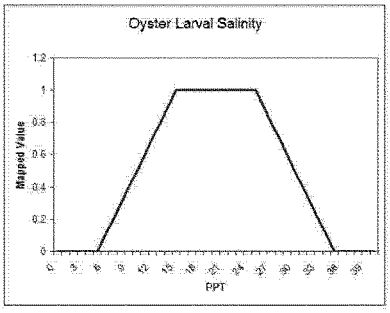


Figure 1. Index value for eastern oyster larvae response to salinity.

Comment [TKB1]: Change graph. Limits 3-35 HSI of .5 at 10 and 30 HSI of 1 at 15-25

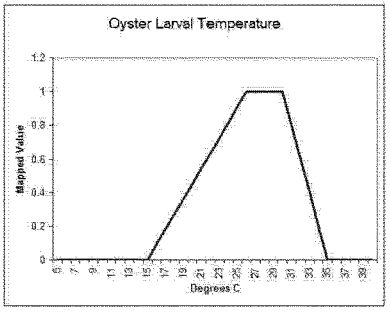


Figure 2. Index value for eastern oyster larvae response to temperature.

10

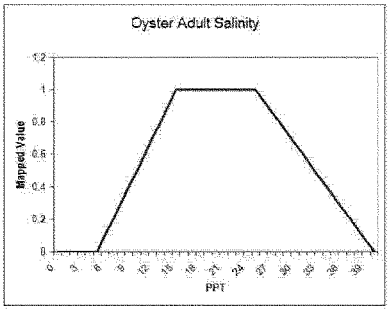


Figure 3. Index value for eastern oyster adult response to salinity

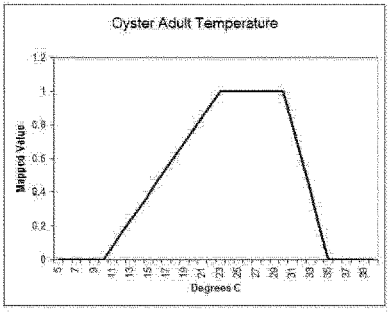


Figure 4. Index value for eastern oyster adult response to temperature.

Larvae Flow

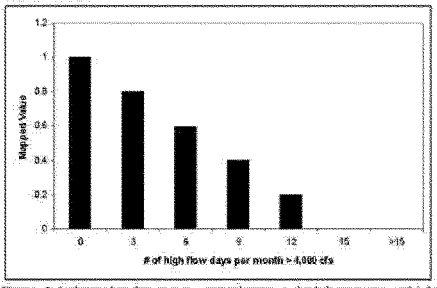


Figure 5. Index value for eastern oyster larvae and adult response to high flow events at S-79. Flow values were established by local scientists and are general for the flushing effect on zooplankton which prevents larval settlement. These values are specific for the Caloosahatchee estuary.

References Cited

Bahr, B. M., and W. P. Lanier. 1981. The ecology of intertidal oyster reefs of the south Atlantic: a community profile. US Fish and Wildlife Service, Office of Biological Services, Washington, D.C., FWS/OBS-81/15.

Berrigan, M.E., T. Candies, J. Cirino, R. Dugas, C. Dyer, J. Gray, T. Herrington, W. Keithly, R. Leard, J.R. Nelson, and M.V. Hoose. 1991. The oyster fishery of the Gulf of Mexico, United States: a regional management plan. Gulf States Mar. Fish. Comm. Ocean Springs, MS.

Butler, P.A. 1954. Summary of our knowledge of the oyster in the Gulf of Mexico. U.S. Fish Wildl. Serv. Bull. 89:479-489.

Cake, E.W., Jr. 1983. Habitat suitability index models: Gulf of Mexico American oyster. U.S. Fish Wildl. Ser.FWS/OBS-82/10.57. 37p.

Calabrese, A. and H.S. Davis. 1970. Tolerances and requirements of bivalve molluscs. Helgol. Wiss. Meeresunters. 20:553-564.

Carriker, M.R. 1951. Ecological observations on the distribution of oyster larvae in New Jersey estuaries. Ecol. Monogr. 21(1):19-38.

Castagna, M. and P. Chanley. 1973. Salinity tolerance of some marine bivalves from inshore and estuarine environments in Virginia waters on the western mid-Atlantic coast. Malacologia 12:47-96.

Chatry, M., R.J. Dugas, and K.A. Easley. 1983. Optimum salinity regime for oyster production on Louisiana's state seed grounds. Contrib. Mar. Sci. 26:81-94.

Copeland,B.J., and H.D. Hoese. 1966. Growth and mortality of the American oyster, *Crassostrea virginica*, in high salinity shallow bay in central Texas. Publ. Inst. Mar. Sci. Univ. Tec. 11:149-158.

Davis, H.C. 1958. Survival and growth of clam and oyster larvae at different salinities. Bio Bull. 114(3): 296-307.

Davis, H.C. and P.E. Chanley. 1955. Spawning and egg production of oysters and clams. Bio. Bull. 110:117-128.

Eleuterius, C.K. 1977. Location of the Mississippi Sound oyster reefs as related to salinity of bottom waters during 1973-1975. Gulf Res. Rep. 6:17-23.

Galtsoff, P.S. 1964. The American Oyster: Crassostrea virginica Gmelin. Fishery Bulletin. US. Fish and Wildlife. Service Publication 64.

Gunter, G. and R.A. Geyer. 1955. Studies of fouling organisms in the northwestern Gulf of Mexico. Publ. Inst. Mar. Sci. Univ. Tex. 4(1):114-116.

Gunter, G. and W.J. Demoran. 1971. Mississippi oyster culture. Am. Fish Farmer 2(5):8-12.

Hayes, P.F. and R.W. Menzel. 1981. The reproductive cycle of early setting *Crassostrea virginica* (Gmelin) in the northern Gulf of Mexico, and its implications for population recruitment. Biol. Bull. 160:80-88.

Hedgepeth, J.W. 1953. An introduction to the zoogeography of the northwest Gulf of Mexico with reference to the invertebrate fauna. Publ. Inst. Mar. Sci. Univ. Tex. 3:107-224.

Hopkins, A.E. 1931. Factors influencing the spawning and setting of oysters in Galveston Bay, Texas. Bull. U.S. Bur. Fish. 47:57-83.

Ingle, R.M. 1951. Spawning and settling of oysters in relation to seasonal environmental changes. Bull. Mar. Sci. Gulf. Caribb. 1:111-35.

Loosanoff, V.L. and C.A. Nomejko 1946. Feeding of oysters in relation to tidal stages and to periods of light and darkness. Biol. Bull. 90(3):82-94.

Loosanoff, V.L. and H.C. Davis. 1963. Rearing of bivalve mollusks. Adv. Mar. Biol. 1:1-136.

Loosanoff, V.L. 1965. The American or Eastern Oyster. U.S. Fish and Wildlife Service Circular 205.

Lunz, G.R. 1958. Unused oyster shell in South Carolina suitable for seed oyster production. Proceedings of the National Shellfisheries Association 48: 44-51.

MacKenzie, C.L., Jr. 1977. Development of an aquacultural program for rehabilitation of damaged oyster reefs in Mississippi. Mar. Fish. Rev. 39(8):1-13.

MacKenzie, C.L., Jr. 1981. Biotic potential and environmental resistance in the American oyster (Crassostrea virginica) in Long Island Sound. Aquaculture 22:229-268.

MacKenzie, C.L., Jr. 1983. To increase oyster production in the Northeast United States, Mar. Fish. Rev. 45(3):1-22.

Mazzotti, F.J., L.G Pearlstine, K. Chartier, and T. Barnes. 2006. User's Guide for the Southwest Florida Biological Modeling Interface. Final report to the U.S. Geological Survey. University of Florida, Florida Lauderdale Research and Education Center, IFAS Technical Report.

Menzel, R.W. 1951. Early sexual development and growth of the American oyster in Louisiana waters. Science 113(2947):719-720.

Menzel, R.W. 1955. Some phases of the biology of *Ostrea equestris* Say and a comparison with *Crassostrea virginica* (Gmelin). Publ. Inst. Mar. Sci. Univ. Tex. 4:70-153.

Menzel, R.W., N.C. Hullings, and R.R. Hathaway. 1966. Oyster abundance in Apalachicola Bay, Florida in relation to biotic associations influenced by salinity and other factors. Gulf Res. Rep. 2:73-96.

Pollard, J.E. 1973. Experiments to reestablish historical oyster seed grounds and to control the southern oyster drill. La. Wild Life Fish. Comm. Tech. Bull. 6.

Savarese, M., A.K. Volety, and S.G. Tolley. 2004. Oyster health and habitat quality in Fakahatchee estuary: establishing a baseline performance for ten thousand island estuarine restoration. Final Report Submitted to the South Florida Water Management District, Big Cypress Basin. 42 pp.

Savarese, M., A.K. Volety, and S.G. Tolley. 2003. Influence of watershed alteration on oyster health and oyster-reef habitat: management implications for the Faka-Union and Estero Bays. Final Report (Award # C-13252) submitted to the South Florida Water Management District, 86 pp.

Schlesselman, G.W. 1955. The Gulf Coast oyster industry of the United States. Geogr. Rev. 45:531-541.

Shumway, S.E. 1996. Natural environmental factors. Pages 467-513 *in* V.S. Kennedy, R.I.E. Newell & A.F. Eble (eds.), The Eastern Oyster *Crassostrea virginica*. Maryland Sea Grant College Publication, College Park, MarylandStanley, J.G. and M.A. Sellers 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) – American oyster. Report No. Biological-82 (11.64). National Wetlands Research Center, Slidell, LA; Army Engineer Waterways Experiment Station, Vicksburg, MS.

Stauber, L.A. 1950. The problem of physiological species with special reference to oysters and oyster drills. Ecology 31:109-118.

Stenzel, H.B. 1971. Oysters. Treatise on invertebrate paleontology. Part N, Bivalvia 3:953-1224.

Tolley, S.G., A. K. Volety, and M. Savarese. 2005. Influence of salinity on the habitat use of oyster reefs in three Southwest Florida estuaries. J. Shellfish Res. 24: 127-138.

Volety, Aswani, Florida Gulf Coast University. Pers. Com. 10/2003.

Volety, A.K., S.G. Tolley, and J.T. Winstead. 2003. Investigations into effects of seasonal and water quality parameters on oysters (*Crassostrea virginica*) and associated fish populations in the Caloosahatchee Estuary. Interpretive Report (Award #C12412-A1) submitted to the South Florida Water management District, West Palm Beach, FL. 111 pp.

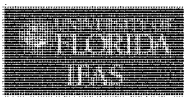
Wilhere, G.F. 2002. Adaptive management in habitat conservation plans. Conserv. Biol. 16(1): 20-29.

Wells, H.W. 1961 The fauna of oyster beds with special reference to the salinity factor. Ecol. Monogr. 31:239-266.

Wilson, C.L. Scotto, J. Scarpa, A.K. Volety, S. Lanamore, and D. Haunert. 2005 Survey of water quality, oyster reproduction and oyster health status in the St. Lucie estuary. J. Shellfish Res. 24: 157-165.

15

C.6 SUMMARY OF THE VALLISNERIA HSI



Final Report for Technical Assistance for an Ecological Evaluation of the Southwest Florida Feasibility Study

STRESSOR RESPONSE MODEL FOR *Vallisneria americana*

By Frank J. Mazzotti, Leonard G. Pearlstine, Robert H. Chamberlain, Melody J. Hunt, Tomma Barnes, Kevin Chartier, Alicia M. Weinstein, and Donald DeAngelis

Joint Ecosystem Modeling Laboratory
Technical Report Series

FINAL REPORT
for

Technical Assistance for an Ecological Evaluation of the

Southwest Florida Feasibility Study

STRESSOR RESPONSE MODELS FOR *Vallisneria americana*

Prepared By:
Frank J. Mazzotti[1], Leonard G. Pearlstine[1], Robert H. Chamberlain [2], Melody J. Hunt[2], Tomma Barnes[3], Kevin Chartier[1], and Donald DeAngelis[4]

[1]University of Florida
Ft. Lauderdale Research and Education Center
3205 College Ave
Davie, FL 33314
(954) 577-6304

[2]South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

[3]Post, Buckley, Schuh and Jernigan
3501 North Causeway Blvd., Suite 725
Metairie, LA 70001
(504) 862-1481

[4]United States Geological Survey
University of Miami, Dept. of Biology
1301 Memorial Dr. RM 215
Coral Gables, FL 33146

Prepared For:
South Florida Water Management District
Fort Myers Service Center
2301 McGregor Blvd.
Fort Myers, FL 33901

United States Geological Survey
1301 Memorial Dr. RM 215
Coral Gables, FL 33146
(305) 284-3974

November 2006

University of Florida

This report should be cited as:

Mazzotti, F.J., Pearlstine, L.G., Chamberlain, R.H., Hunt, M.J., Barnes, T., and Chartier, K., and DeAngelis, D. 2006, Stressor response models for *Vallisneria Americana*. JEM Technical Report 2006-06. Final report to the South Florida Water Management District and the U.S. Geological Survey. University of Florida, Florida Lauderdale Research and Education Center, Fort Lauderdale, Florida, 12 pages.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the University of Florida.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted material contained within this report.

Contents

Introduction 1
Southwest Florida Feasibility Study 1
C43 West Reservoir 1
Forecasting Models 1
Habitat Suitability Indices 2
Ecology of *Vallisneria americana* 2
HSI for *Vallisneria americana* 10
HSI Formula 10
HSI Curves and Application 10
References Cited 16

Figures

Figure 1. Caloosahatchee Estuary sampling area 3
Figure 2. Field survey results of shoot counts *vs.* salinity 4
Figure 3. Tape grass in upper Caloosahatchee Estuary 4
Figure 4. Laboratory experimental results of growth rate *vs.* salinity 5
Figure 5. Field survey results of shoot counts *vs.* inflow from S-79 6
Figure 6. HSI value for *Vallisneria americana* in response to salinity 11
Figure 7. HSI value for *Vallisneria americana* response to average daily bottom light in low salinity range 12
Figure 8. HSI value for *Vallisneria americana* response to average daily bottom light in high salinity range 12
Figure 9. Equation to determine ADBL 13
Figure 10. Average monthly incident PAR 13
Figure 11. HSI relationship between average daily flow and K value 14
Figure 12. HSI value for *Vallisneria americana* in response to temperature 15
Figure 13. Daily average temperature from historical records 15

Tables

Table 1. Summary of freshwater inflow and water quality requirements for *Vallisneria americana* in the Caloosahatchee estuary 8

Table 2. Changes to HSI model's spatial boundaries and post processing routines 8

STRESSOR RESPONSE MODEL FOR *Vallisneria americana*

By Frank J. Mazzotti, Leonard G. Pearlstine, Robert H. Chamberlain, Melody J. Hunt, Tomma Barnes, Kevin Chartier, and Donald DeAngelis

Introduction

A key component in adaptive management of Comprehensive Everglades Restoration Plan (CERP) projects is evaluating alternative management plans. Regional hydrological and ecological models will be applied to evaluate restoration alternatives and the results will be applied to modify management actions.

Southwest Florida Feasibility Study

The Southwest Florida Feasibility Study (SWFFS) is a component of the Comprehensive Everglades Restoration Plan (CERP). The SWFFS is an independent but integrated implementation plan for CERP projects and was initiated in recognition that there were additional water resource issues (needs, problems, and opportunities) within Southwest Florida not being addressed directly by CERP. The SWFFS identifies, evaluates, and compares alternatives that address those additional water resource issues in Southwest Florida. An adaptive assessment strategy is being developed that will create a system-wide monitoring program to measure and interpret ecosystem responses. The SWFFS provides an essential framework to address the health and sustainability of aquatic systems. This includes a focus on water quantity and quality, flood protection, and ecological integrity.

C43 West Reservoir

The purpose of the C43 Basin Storage Reservoir project is to improve the timing, quantity, and quality of freshwater flows to the Caloosahatchee River estuary. The project's initial phase includes an above-ground reservoir with a total water storage capacity of approximately 170,000 acre-feet and will be located in the C-43 Basin in Lee County. The initial design of the reservoir assumed 8094 hectares (20,000 acres) with water levels fluctuating up to 2.4 meters (8 feet) above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design.

Forecasting Models

Forecasting models bring together research and monitoring to ecosystems of Southwest Florida and place them into an adaptive management framework for the evaluation of alternative plans. There are two principle ways to structure adaptive management: (1) *passive* by which policy decisions are made based on a forecasting model and the model is revised as monitoring data

become available, and (2) *active* by which management activities are implemented through statistically valid experimental design to better understand how and why natural systems respond to management (Wilhere 2002).

In an integrated approach that includes both passive and active-adaptive management, a forecasting model simulates system response and is validated by monitoring programs to measure actual system response. Monitoring can then provide information for passive-adaptive management for recalibration of the forecasting model. Directed research, driven by model uncertainties, is an active-adaptive management strategy for learning and the reduction of uncertainties in the model.

The forecasting models for the C-43 West Reservoir Project and the Southwest Florida Feasibility Study consist of a set of stressor response (habitat suitability) models for individual species. These stressor response models have been developed principally with literature, expert knowledge, and currently available field data.

Habitat Suitability Indices

Habitat Suitability Index (HSI) models were developed with each stressor variable portrayed spatially and temporally across systems of the study area at scales appropriate to the organism or community being portrayed. The HSI models have been incorporated into a GIS to portray responses spatially and temporally to facilitate policy decisions. That is, the model describes a response surface of habitat suitability values that vary spatially according to stressor levels throughout the estuary and temporally according to temporal patterns in stressor variables. Much of the temporal variation is a result of temporal cycling of important stressor inputs, such as water temperature and salinity. Temporal change for other important variables may not be cyclical, such as rising sea level and increasing land use and fresh water demands in the region. Areas predicted to be suitable and those predicted to be less suitable or disturbed should be targeted for additional sampling as part of the model validation and adaptive management process.

Species selected for modeling (focal species) are ecologically, recreationally or economically important and have a well-established linkage to stressors of management interest. They may also make good focal species because they engage the public in caring about the outcome of restoration projects. The habitat suitability models (HSI) models were developed by choosing specific life stages of each species with the most limited, restricted, or tightest range of suitable conditions, to capture the highest sensitivities of the organisms to the environmental changes associated with the planned restoration activities. Values used in the models are listed in Table 1.

The models calculate habitat suitability monthly as the weighted geometric mean of the environmental variables identified as important for each model. Because the geometric mean is derived from the product of the variables rather than the sum (as in the arithmetic mean) and has the appropriate property that if any of the individual variables are unsuitable for species success (i.e., the value of the variable is zero) then the entire index goes to zero.

Ecology of *Vallisneria americana*

One of the factors contributing to high productivity in estuaries has been the historic abundance of submerged aquatic vegetation (SAV). SAV also provide food for waterfowl and are critical habitat for shellfish and finfish. In addition, submerged plants affect nutrient cycling, sediment stability, and water clarity (Batiuk et al. 1992). Because SAV beds provide habitat for

benthic and pelagic organisms, many of their water chemistry requirements overlap, including preferred salinity and temperature ranges. However, SAV also serve well as indicators of water clarity and nutrient levels. Habitat requirements developed for fish and birds do not normally incorporate these conditions. In addition, "many of the restoration goals for fish and birds involve changes in both environmental quality and management of human harvesting activities" (Dennison et al. 1993). In contrast, SAV goals can more directly be linked to environmental and water quality, thus providing for more direct establishment of targets and protection goals in areas of the estuary where SAV are located (Batiuk et al. 1992, Dennison et al. 1993, Doering et al. 2002).

Tape grass, *Vallisneria americana*, is a salt-tolerant freshwater SAV species that is located in the fresh, oligohaline, and mesohaline portion of estuaries in the eastern United States. Beds of tape grass can occur in the Caloosahatchee Estuary up to 30 km downstream of S-79 (near Area 4: Figure 1), but grow most luxuriantly upstream of Area 3, especially where their greatest coverage occurs around Area 2 and Beautiful Island (Chamberlain and Doering 1998a, and b). Like other populations in Florida (Dawes and Lawrence 1989), tape grass in the Caloosahatchee does not completely die back in the winter as it does in more temperate northern clines. Field observations indicate that mature plants can be found year round that probably are of a sufficient height and density to provide habitat for other organisms. Field observations also indicate that canopy height and shoot density (Figure 2; SFWMD 2003) begin to decline as salinity rises above 10‰ (Chamberlain and Doering 1998a, Bortone and Turpin 2000). When conditions are favorable, tape grass exhibits a seasonal pattern of growth, with highest biomass achieved in the late summer (Figure 3, SFWMD 2006), flowering in the late summer-early fall, and a winter decline in biomass (Bortone and Turpin 2000). Laboratory experiments using Caloosahatchee plants also determined that tape grass can grow throughout the year (Figure 4; SFWMD 2003) provided that conducive salinity and sufficient light are available (Barko et al. 1984, Bortone and Turpin 2000). Therefore, freshwater discharge commensurate with a suitable salinity and clarity need not separately account for different seasonal or spatial tolerances (Doering et al. 1999).

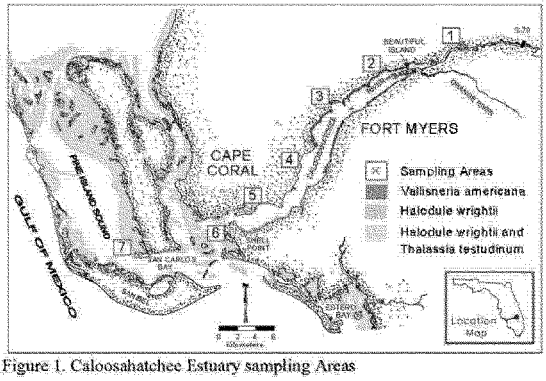


Figure 1. Caloosahatchee Estuary sampling Areas

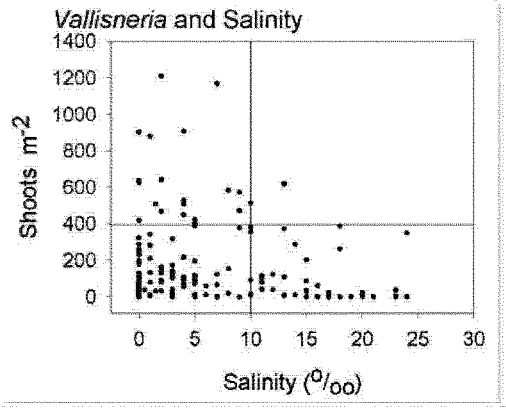


Figure 2. Field survey results of shoot counts vs. salinity (SFWMD 2003).

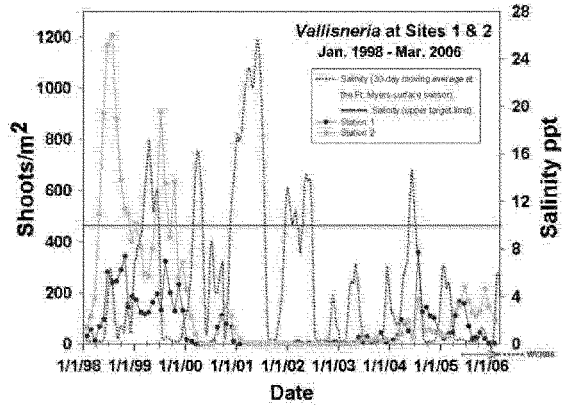


Figure 3. Tape grass (*Vallisneria americana*) shoot density in the upper Caloosahatchee Estuary (Sites 1 and 2 in Area 2, Figure 1). Recent data are from stations monitored by the Sanibel-Captiva Conservation Foundation and Mote Marine Laboratory (SFWMD 2006).

4

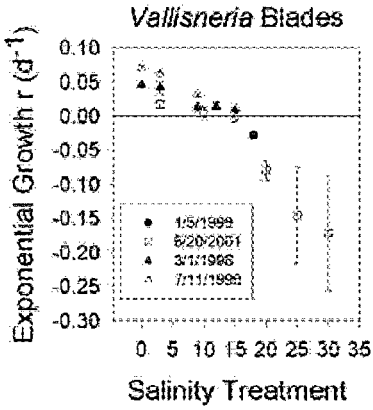


Figure 4. Laboratory experimental results of growth rate vs. salinity (SFWMD 2003).

General non-quantitative observations of tape grass during 1956-1989 found that relative abundance greatly varied annually throughout its range (Chamberlain et al. 1995) and indicated that healthy plants during the winter dry season lead to good coverage, taller plants, and reproduction during the peak summer growing months. Quantitative sampling since 1998 confirms this observation (Bortone and Turpin 2000).

In the upper estuary, temporal and spatial fluctuation in salinity and other important water quality parameters are largely driven by freshwater discharge at S-79. During periods of high discharge, usually during the summer wet season, the system turns fresh. During periods of low discharge during the winter and spring, salt water intrudes up the estuary.

Literature information, field studies, and laboratory investigations of tape grass salinity tolerance (SFWMD 2003) was used to establish hydrologic targets for developing the Minimum Flow and Level Rule (as per Florida Administrative Code, Section 40E-8.021(24)). After analysis of historical salinity records from the estuary along with an initial salinity model, a flow of 300 cfs from S-79 (Figure 5) was identified as the average minimum flow needed (SFWMD 2003) to support tape grass growth in the critical region of the estuary where it has historically been most abundant (Figure 1; Area 2). This designated flow volume, along with about 200 cfs input from the tidal tributaries and ground water, should maintain salinity at $\leq$ 10‰ under average conditions and support tape grass growth. The MFL rule includes two salinity criteria measured near the Ft. Myers Yacht Basin (near Area 3, Figure 1). An MFL exceedance occurs if: (1) the 30-day moving average salinity rises above 10‰ or (2) a single daily average salinity rises above 20‰. The first criterion recognizes that tape grass in the critical region (Figure 1; Area 2) grows well at salinity below 10‰. The second accounts for the effect of exposure to high salinity for short time periods. Upon additional consideration and analysis (Chamberlain 2005, Chamberlain and Doering 2004), a

minimum flow of 450 cfs is now promoted to better insure tape grass protection during very dry conditions when the tidal tributary flow contribution is diminished well below the required 200 cfs.

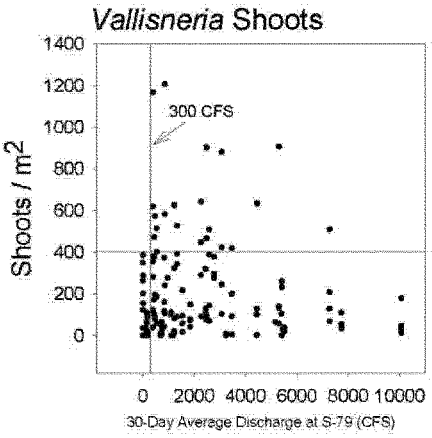


Figure 5. Field survey results of shoot counts vs. inflow from S-79 (Doering et al. 2002, SFWMD 2003).

Although viable rosettes (short immature plants) are almost always present, total denuding of the bottom and loss of all plants can occur. This situation became evident after the year 2000 drought (Figure 3). Plants did not return in appreciable numbers after 2 years, thus confirming significant harm to this portion of the estuary as defined by the MFL Rule (SFWMD 2003).

Doering et al. (1999) reported decreasing growth of tape grass as salinity increased (Figure 3) whereby positive growth became zero when salinity exceeded 10‰. Doering et al. (1999) also found that tape grass survived at 15‰ for over 40 days under ample light conditions and mortality was observed at 18‰, with a few viable plants persisting after 70 days (Doering et al., 2001). Analysis of long-term records reveals saltwater intrusion into the upper estuary that results in salinity of ≥10‰ may last for over 100 days, but almost always is less than 70 days. Median durations are 5-12 days. Therefore, approximately 50% of the intrusion events that occur may last long enough to impact tape grass growth. Peak salinities during these intrusion average 13-14‰, which is near the tape grass limit for growth, but approximately 25% of the peak salinities are ≥18‰, which can severely reduced coverage and bed morphometrics (Kraemer et al. 1999, Doering et al. 2001). During a field experiment in the Caloosahatchee Estuary, Kraemer et al (1999) found that exposure to salinities approaching 18‰ for longer than 2 weeks - 1 month resulted in tape grass mortality from which plants did not recover. Based on the results of studies and information

6

discussed above, the HSI curve in Figure 6 was formulated for a model described in Hunt and Doering (2005).

Both long term and short term exposures (if repeated) during the late winter may result in tape grass not fulfilling its growth potential needed to provide habitat during the spring and summer season. In addition, other growth parameters, such as water clarity and temperature can also influence contiguous plant coverage and recovery after population declines. Therefore, rules were developed (Table 2) for applying to the HSI model, in order to insure previous conditions are considered when determining the new HSI value each month.

Research to date indicates that the flow distributions specified by Chamberlain and Doering (2004) should promote good water quality (Doering and Chamberlain 1998, Chamberlain et al. 2003) in the ranges suggested by Dennison et al. (1993). The numeric tape grass model developed by Hunt and Doering (2005) uses salinity, light attenuation, and temperature as independent variables to predict tape grass density. The model confirms that light is an important variable for tape grass growth in the Caloosahatchee. Even though high flows are not a concern for tape grass regarding salinity, they are associated with reduced plant density (Figure 5). Water clarity decreases during increased flows due to suspended solids, color and in some cases increased incident of algal blooms. These factors may contribute to a decrease in tape grass growth, recovery, distribution along the estuary, and the depth it can survive.

Batiuk et al. (1992) and Dennison et al. (1993) reviewed water quality requirements for SAV that are found in estuaries and suggested guideline values for water clarity, suspended solids, nutrients, and chlorophyll-a for tape grass (Table 1). In the field transplant studies by Kraemer et al. (1999), salinity tolerances appeared lower than in laboratory experiments, and it was suggested that other factors, particularly light co-varying with salinity can influence the distributional limits. Further evidence of the importance of light in this ecosystem was reported by Bortone and Turpin (2000). In a field study, they found *V. americana* biomass to be significantly associated with six factors: location, temperature, depth, secchi depth, TSS and color – making four of the six factors associated with light conditions. Additional laboratory mesocosm experiments were conducted to quantify the effects of light stress at different salinities (Hunt et al, 2003; 2004). Photosynthesis/ Irradiance (P/I) curves were developed and showed that light utilization varies with salinity. Based on this work by Hunt et al. (2003; 2004), two HSI curves were developed for different ranges of salinity. Figure 7 and 8 depict the index values for tape grass response to average daily bottom light (ADBL) when salinity is < 9.5‰ and ≥9.5‰, respectively. Figure 9 provides the formula for calculating ADBL, which requires knowing (1) incident light in the PAR (Photosynthetic Active Radiation) spectral range; (2) water column light attenuation (K); and (3) depth. Average monthly incident PAR for the Caloosahatchee is depicted in Figure 10 and was calculated from a daily average PAR dataset, recorded by a continuous sensor during 1998-2004, located in the nearby Estero Bay Watershed. Light attenuation was calculated based on freshwater inflow from S-79 (resulting regression line-Figure 11). This relationship was determined from analysis that predicted secchi disk readings (dependent variable) from the 30-day average S-79 flow volume (cfs). Average daily flow is recorded by the USGS since structure 1965 and the secchi disk data to support the regression analysis came from field measurements collected intermittently since 1986. Light attenuation (K) is calculated form the predicted secchi value by the formula, -1.65/secchi (Batiuk et al. 1992). Depth was determined from bathymetry surveys of the Caloosahatchee Estuary and the resulting information supplied in a GIS data file that matched the grid cell points of the model.

7

Table 1. Summary of freshwater inflow and water quality requirements for *Vallisneria americana* in the Caloosahatchee Estuary.

Estuary Area	Value	Source
Throughout its range	Water Quality: (1) Light for *Val* to 1m: (a) atten (K_d)= 1.5-2.0 m^{-1} (b) Secchi Disk depth = 0.85 to 1.1m (c) Light saturatn ~150-200µE/m^2s (d) Minimum (model) ~ 17 µE/m^2s (2) Chlorophyll –a = 15 µg/l (3) Tot.Susp.Solids=15 mg/l (4) Dissolved Inorg. N = 0.15 mg/l (5) Dissolved Inorg. P = 0.07 mg/l (6)Temperature: (a) Estimated Min.(model) ~14-16°C (b) Optimum (model) ~ 34°C (b) Est'd Max (model) >34 °C, < 50°C	(1, 2, 3, 4, 5) - Batiuk et al. 1992, Dennison et al. 1993, Chamberlain et al. 2003 (1, 6) - Hunt and Doering 2005, Hunt et al. 2003, 2004
Throughout its range	Salinity: (1) Optimum growth @ 0-3 ‰ (2) Net month growth if: (a) < 10‰ (b) Exposure @ 18‰ ≤ 5 days (3) Growth/day cessation ~10-15‰ (4) No net growth in month following 18‰ for 11-20 days. (5) Plant growth/day decline as approach ~15‰ (6) Month growth potential decreased after 1 day @ 18‰ (7) ~40% mortality after 20 days @ 18‰ (8) Lethal limit @ ~ 18‰ ~2-4 weeks	(1, 2, 3, 5, 6, 5, 7) - Doering et al. 1999, 2001, 2002 (2) - Chamberlain et al. 1995a,b (8) - Kraemer et al. 1999
Target Area2 - Beautiful Isl.	Salinity targets: (1) Monthly average < 10‰ (2) 1 day peak ≤ 18‰	SFWMD 2003
Ft.MyersBridge Salinity Probe	Salinity targets (MFL): (1) Monthly average ≤ 10‰ (2) 1 day peak ≤ 20‰	SFWMD 2003
Target Area2 - Beautiful Isl.	Hydrologic (flow) Targets: (1) Minimum flow (a) 450 cfs avg monthly flow @ S-79 (b) combined 500 cfs avg monthly flow S-79 & tidal basin (near & upstrm Ft.Myers Bridges) (2) Max flows consistent to protect downstrm SAV (2800-4500 cfs) will prevent exceedence of WQ guidelines.	(1) - Chamberlain 2005, Chamberlain et al. 1995, Chamberlain and Doering 2004 (2) - Doering and Chamberlain 1998

8

	(3) Defined preferred flow distribution (EST05) that maximizes flows (75%) in 450-800 cfs range will maximize WQ for growth	(3) – Chamberlain et al. 2003
Target Area2 - Beautiful Isl.	Target Plant Morphometricts (June-Sept growing season): (1) Minimum 20% of average potential shoot density (~200-300 shoots/m^2 of potential > 1,000 shts/m^2). (2) Minimum avg. blade length 15cm (3) Most years $\geq$ 300-600 shts/m^2 (4) Most years-plant reproduction (sexual) (5) Run tape grass model to evaluate/select preferred flows	(1, 2) Chamberlain 2005, Chamberlain et al. 2003 (3) - SFWMD 2006 (4) - Doering et al. 1999, 2002 (5) - Hunt et al. 2003, 2004, 2005

Temperature is an additional factor that may influence tape grass growth. In general, temperature changes primarily influence growth of SAV over predictable seasonal cycles. In northern environments there is a distinct seasonal growth pattern involving the production of vegetative tubers and winter dormancy period during the cold winter months. Different temperature growth ranges have been reported for *V. americana* in populations growing in different climates and under different environmental conditions. Titus and Adams (1979) report a temperature optimum for *V. americana* obtained from University Bay, Madison, WI. of 32.6°C. In the Detroit River, *V. americana* grew at water temperatures ranging from 19 to 31.5 °C (Hunt 1963). Barko et al. (1982, 1984) reported growth of commercially obtained juvenile plants was severely restricted below 20°C.

Consistent with the southern ecotype of *V. americana* reported by Smart and Dorman (1993), no over-wintering buds or tubers have been reported in the Caloosahatchee Estuary. The acute limits or effects of the colder winter water temperatures on the growth and survival in Florida is not known. Water temperatures in the upper Caloosahatchee Estuary over the period 1998-2005 have varied between 14°C in the winter to 34°C in the summer. Inter-annual variation in seasonal high and low water temperatures are also apparent over this time period. Lower water temperature during some years may adversely impact tape grass. High freshwater inflow that increases water color may result in dark water that absorbs solar energy and raises water temperature near tape grass tolerance limits. Given the span in water temperatures in the Caloosahatchee Estuary, ranging from potentially above optimal conditions to below tolerance levels in any given year and the importance of over-wintering survival, water temperature may be an important variable that influences *V. americana* survival

A habitat suitability temperature curve (Figure 12) was developed for tape grass in the Caloosahatchee based on an equation of O'Neill et al. (1972). Input values for the lower lethal, optimum, and upper lethal limits came from general literature values (not specific to Florida) and calibrated based on a growth model described by Hunt and Doering (2005). Non-linear regression was employed to predict daily average temperature in the Caloosahatchee Estuary using historical data collected by continuous sensors since 1992 (Figure 13). Note, that as a daily average data set predicted from historical records, it does not reflect the high or low conditions that might be expected in any given year.

9

HSI for *Vallisneria americana*

HSI Formula

Calculated monthly:

$HSI = (Previous^{W} * Salinity^{W} * Light\ Availability * Temperature^{W})$

Previous
"Previous" variable included because current month's HSI score should depend on the how well the grass was doing last month (previous score).
Previous = previous_month_HSI score + 0.05 (not to exceed 1.0), in order to allow for growth from month to month if other conditions are suitable.

Table 2. Changes to HSI model's spatial boundaries (A) and post-processing routines (B and C) for adjusting the final HSI ecological model scores to better reflect long-term impacts of severe reduction in *Vallisneria americana* density due to low HSI scores of environmental variables (salinity, light and temperature in above model formula).

Routine	Model output criteria	Model score adjustment
A.	Establish a lower depth threshold of 5 ft	Model areas > 5 feet are not scored
B.	If HSI score $\leq$ 0.2 for one month,	Than HSI remains $\leq$0.2 for remainder of the season
C.	If HSI score $\leq$ 0.1 for one month,	Than HSI = 0 for 12 subsequent months

Adjustments were agreed to by ecological benefits sub-team (6/14/06)

HSI Curves and Application (for determining input values to HSI model formula)

Salinity

The freshwater inflow associated with base conditions and management alternatives serve as input for the hydrodynamic model (CH3D with regression routine) that estimates salinity concentration at key locations in the estuary. An immolator program used the salinity output to further estimate salinity at the remaining model grid cells. This salinity was compared to the curve in Figure 6 to determine the HSI score for that grid cell and input to the model formula.

10

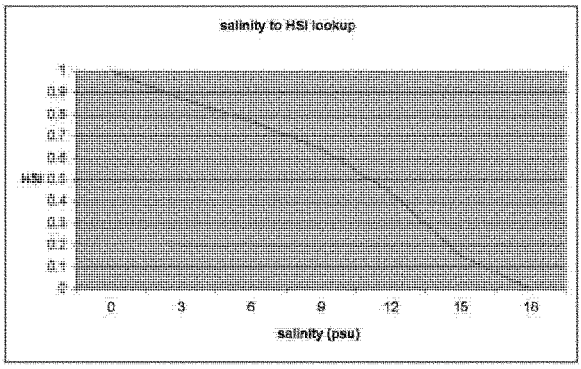


Figure 6. HSI value for *Vallisneria americana* in response to salinity (formulated from Doering et al. 1999; Hunt and Doering 2005).

Light

The formula in Figure 9 was employed to calculate the average daily bottom light (ABDL) during the month. The average incident PAR component of this formula, for the month of interest, is supplied by the data values associated with Figure 10. The light attenuation (K) component was supplied by the data values associated with Figure 11, which depends on the average flow for the month. Depth data was supplied from a GIS file with survey data that matched the model grid cell points. Once the ADBL value is determined for the month, it is used to estimate the index score as depicted in Figures 7 or 8, depending on the salinity value for the model cell during the month.

11

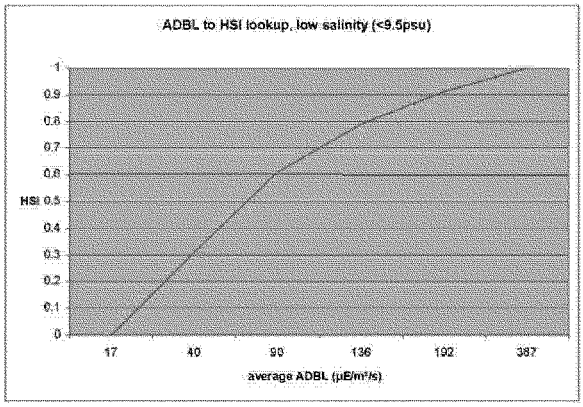


Figure 7. HSI value for *Vallisneria* response to average daily bottom light in low salinity range (<9.5psu) conditions (Hunt et al. 2004 and 2003; Hunt and Doering, 2005).

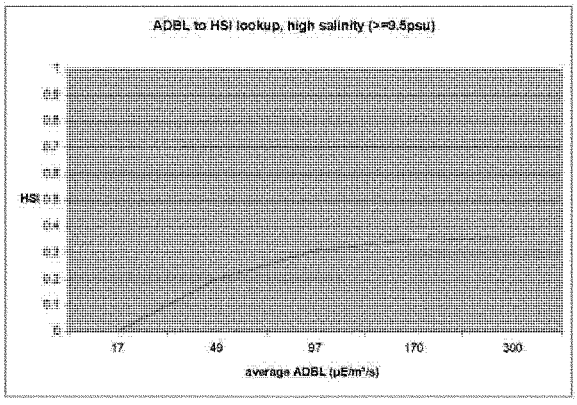


Figure 8. HSI value for *Vallisneria* response to average daily bottom light in low salinity range (≥9.5psu) conditions (Hunt et al. 2004 and 2003; Hunt and Doering, 2005).

12

$$ADBL = (average\ monthly\ incident\ PAR)*(1-surface\ reflectance)*e^{-K*depth},$$

$$surface\ reflectance = 0.9 * incident\ PAR$$

Figure 9. Equation to determine ADBL

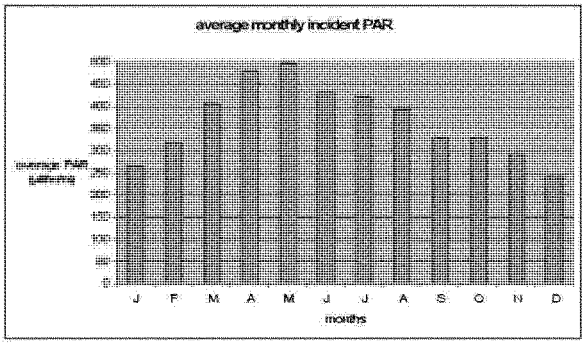


Figure 10. Average monthly Incident PAR (calculated form daily average PAR measurements collected during 1998-2004 at a continuous recording station in the Estero Bay watershed).

13

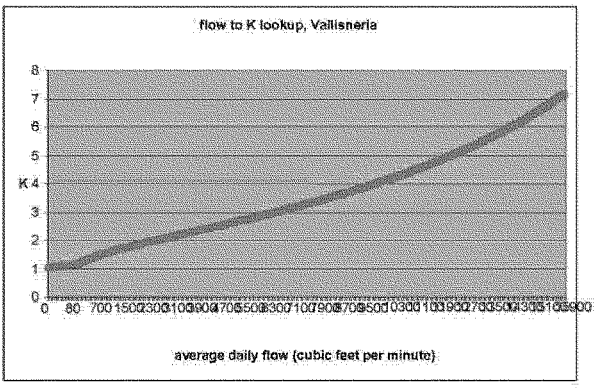


Figure 11. HSI relationship between average daily flow and light attenuation (K values).

Temperature

Daily average temperature was estimated from continuous in-water recorders that have been measuring near surface temperature since 1992. Depending on the HSI model requirements, these daily values (Figure 13) can be averaged over the time period of interest (e.g., monthly average). The resulting temperature is then used to determine the index value in Figure 12 for input to the HSI model formula.

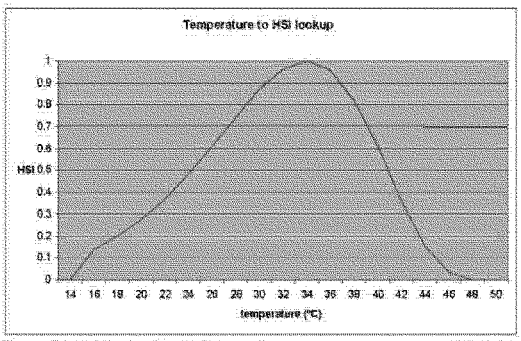


Figure 12. HSI value for *Vallisneria* in response to temperature (O'Neill et al., 1972, Hunt and Doering 2005).

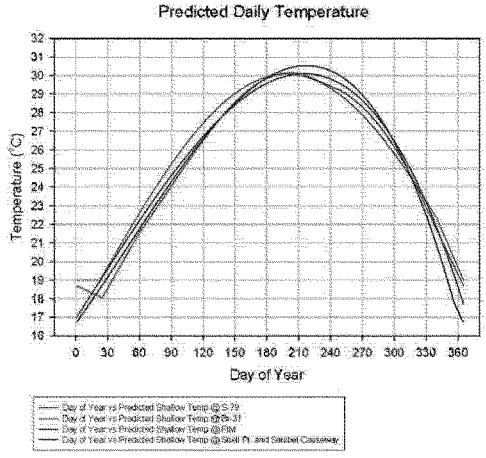


Figure 13. Daily average temperature estimated from historical records in the Caloosahatchee.

References Cited

Chamberlain, R.H. 2005. C-43 Basin Storage Reservoir Project - Caloosahatchee Estuary Hydrologic Evaluation Performance Measures. C-43 BSR Study Team Adopted Draft, June 28, 2005.

Chamberlain, R. H. and P.H. Doering. 1998a. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation, p. 81-90. *In* S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington, D.C.

Chamberlain, R. H. and P.H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach, p. 121-130. *In* S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington, D.C.

Chamberlain, R. H. and P.H. Doering. 2004. Recommended Flow Distribution (the Caloosahatchee Estuary and the C-43 basin Storage Reservoir Project). Technical Memorandum, South Florida Water Management District.

Chamberlain, R.H., P.H. Doering, and K.M. Haunert. 2003. Preliminary assessment of water quality and material loading in the Caloosahatchee Estuary, FL. Poster Presentation, 17th Biennial Conference of the Estuarine Research Federation.

Chamberlain, R.H., D.E. Haunert, P.H. Doering, K.M. Haunert, and J.M. Otero. 1995. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary, Florida. Technical report, South Florida Water Management District, West Palm Beach, Florida.

Barko, J. W., D. G. Hardin and M. S. Matthews. 1982. Growth and morphology of submerged freshwater macrophytes in relation to light and temperature. *Canadian J. Bot.* 60:877-887

Barko, J. W., D. G. Hardin, and M. S. Matthews. 1984. Interactive Influences of Light and Temperature on the Growth and Morphology of Submerged Freshwater Macrophytes. Technical Report A-84-3, U. S. Army Corps of Engineers, Waterways Experimental Station, Vicksburg, Miss. 24 pp.

Batiuk, R.A., R.J. Orth, K.A. Moore, W.C. Dennison, J.C. Stevenson, L.W. Staver, V. Carter, N.B. Rybicki, R.E. Hickman, S. Kollar, S. Bieber, and P. Heasly 1992. Chesapeake Bay submerged aquatic vegetation habitat requirements and restoration targets: A technical synthesis. Chesapeake Bay Program CBP/TRS 83/92. 186 pp.

Bortone, S.A., and R.K. Turpin. 2000. Tape grass life history metrics associated with environmental variables in a controlled estuary. In: Bortone, S.A. (ed.), Seagrasses: Monitoring, Ecology, Physiology, and Management. CRC Press, Boca Raton, Florida, pp. 65-79.

16

Dawes, C. J. and J. M. Lawrence. 1989. Allocation of energy resources in the freshwater angiosperms *Vallisneria americana* Michx. and *Potomogeton pectinatus* L. in Florida. *Florida Scientist*. Volume 52: pp 59 - 63.

Dennison, W.C., R.J. Orth, K.A. Moore, J.C. Stevenson, V. Carter, S. Kollar, P. W. Bergstrom and R.A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation. *Bioscience* 43(2):86-94.

Doering, P.H. and R.H. Chamberlain 1998. Water quality in the Caloosahatchee Estuary, San Carlos Bay and Pine Island Sound. Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16; Punta Gorda, FL. Pp 229-240. Charlotte Harbor National Estuary Program Technical Report No. 98-02. 274 p.

Doering, P. H., R. H. Chamberlain, K. M. Donohue, and A. D. Steinman. 1999. Effect of salinity on the growth of *Vallisneria americana* Michx. from the Caloosahatchee Estuary, Florida. *Florida Scientist*. Vol. 62, No.2. pp. 89-105

Doering, P. H., R. H. Chamberlain, and D.E. Haunert. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. *Estuaries* 25 (1343-1354).

Doering, P. H., R. H. Chamberlain, and J. M. McMunigal. 2001. Effects of simulated saltwater intrusions on the growth and survival of wild celery, *Vallisneria americana*, from the Caloosahatchee Estuary (South Florida). *Estuaries*. Vol. 24. No. 6A, pp. 894-903.

Hunt, G. S. 1963. Wild Celery in the lower Detroit River. *Ecology* 44:360-370

Hunt, M.J. 2003. An Ecological Model to Predict *V. americana* Densities in the Upper Caloosahatchee Estuary. In Proceedings of Greater Everglades Restoration Science Conference, Palm Harbor, FL. April 13-18.

Hunt, M.J. and P.H. Doering. 2005. Significance of Considering Multiple Environmental Variables When Using Habitat as an Indicator of Estuarine Condition. In Bortone, S. A. (ed.), Estuarine Indicators, CRC Press, Boca Raton, Fl, pp.221-227.

Hunt, M.J., P.H. Doering, R.H. Chamberlain, and K.M. Haunert. 2003. Light and Salinity Stress for SAV Determined by Modeling and Experimental Work in the Oligohaline Zone of an Estuary. In Proceedings of Estuarine Research Federation, Seattle, WA. September

Hunt, M.J., P.H. Doering, R.H. Chamberlain, and K.M. Haunert. 2004. Grass Bed Growth and Estuarine Condition: Is size a Factor worth Considering? In Conference Proceedings of the Southeastern Estuarine research Society, Harbor Branch Oceanographic Institution, Fort Pierce, FL. April 15-17.

Kraemer, G. P., R. H. Chamberlain, P. H. Doering, A. D. Steinman, and M. D. Hanisak. 1999. Physiological responses of transplants of the freshwater angiosperm *Vallisneria americana* along a

salinity gradient in the Caloosahatchee Estuary (Southwestern Florida). *Estuaries*. Vol. 22, No. 1 pp. 138-148.

O'Neill, R.V., R. A. Goldstein, H. H. Shugart, and J.B. Manki. 1972. Terrestrial Ecosystem Energy Model. U.S. IBP Eastern Deciduous Forest Biome Memo Report 72-19 Oak Ridge National Laboratory, Oak Ridge, TN

Smart, R. M., and J. D. Dorman. 1993. Latitudinal differences in the growth strategy of a submerged aquatic plant: ecotype differences in *Vallisneria americana? Bull.Ecol. Soc. Am.* 74 (Suppl.):439

South Florida Water Management District. 2003. Technical Documentation to Support Development of Minimum Flows and Levels for the Caloosahatchee River and Estuary, Status Update Report. May 2003.

South Florida Water Management District. 2006. South Florida Environmental Report (Draft). Chapter 12 - Caloosahatchee River, Estuary, and Southern Charlotte Harbor.

Titus, J. E. and M. S. Adams. 1979. Coexistence and the comparative light relations of the submerged macrophytes *Myriophyllum spicatum* L. and *Vallisneria americana* Michx. *Oecologia*. 40:273-286

Wilhere, G.F. 2002. Adaptive management in habitat conservation plans. Conserv. Biol. 16(1): 20-29.

C.7 TARGET FLOW INDEX (EST05) METHOD

C.7.1 Background

A method for evaluating flows associated with the Caloosahatchee River (C-43) West Basin Storage Reservoir project was developed to easily compare potential project flows (cubic feet/second) with the percent distribution of the target flows from S-79 for any time period (one year or longer). The resulting index scale (0-1) reflects the relative amount that the project related flows move toward the target flows (score of 1) from the base condition (score of 0) for the period being evaluated. This score can then be expressed as the percent toward achieving the target flows (PTA).

C.7.2 Target Flow Index Calculation

The 36 year period of record (1965-2000) target flows (EST05) is depicted in ***Table C-10*** and should be the reference target flow condition for comparing project flows.

TABLE C-10: TARGET FREQUENCY DISTRIBUTION (EST05) OF MEAN MONTHLY FLOWS FROM S-79 FOR THE 1965-2000 PERIOD OF RECORD (CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR-CALOOSAHATCHEE ESTUARY HYDROLOGIC EVALUATION PERFORMANCE MEASURES, 2005)

Discharge Range (cfs) From S-79	Percent Distribution Of Flows From S-79
0 to 450	0%
450 to 500	42.8%
500 to 800	31.7%
800 to1500	19.2%
1500 to 2800	5.6%
2800 to 4500	0.7%
>4500	0%

The TFI evaluation method calculates a score for each of the ***Table C-10*** flow categories using the target percent distribution (frequency) compared with the percent frequency of the project flows being evaluated. The formulas for calculating the score are identified in column 3 of ***Table C-11***. The flows above (>4500 cfs) and below (<450 cfs) the target distribution are each divided into three additional categories to account for increasing adverse environmental impacts the farther the evaluated flows are from the target flows. Each of these three additional categories is progressively weighted (3 to 5), with the flows farthest from the target having the greatest multiplication weight of 5. Using the same weighting at both ends of the distribution avoids favoring the upper estuary or lower estuary. The range of flows in each category is also spatially

based. For example, in the upper estuary, as flows decrease below 450 cfs, tape grass (*Vallisneria americana*) productivity declines due to increasing salinity and this decline increases farther upstream as flows tend toward 0 cfs. As flows increase in each category above 4500 cfs, oyster mortality increases and impacts on seagrass becomes more severe in eastern San Carlos Bay, to the western side, and up into lower Pine Island Sound.

Ideally, most of the flows (~75%) should fall into the 450–800 cfs range. Therefore, a fractional based score is calculated to most heavily penalize the proposed project related flows that fall short in these two categories. A governor is included for these two categories to avoid falsely rewarding a proposed project if more then the desired flow frequency is provided, such that if the category score exceeds 0, then the category score will be set at 0.

Flows in the three categories covering the range between 800 cfs and 4500 cfs are differential based in their comparison. The absolute value of the difference between the evaluated and target flows is multiplied by a weight that equally increases (by 0.83) with each added flow category, because harm also increases to downstream ecosystem components as flows differ from the target in each increasing category.

TABLE C-11: TARGET FLOW-RANGE CATEGORIES, THE ASSOCIATED TARGET FREQUENCY, AND THE FORMULA FOR SCORING FLOW SCENARIOS WITHIN EACH CATEGORY.

Target Flows Ranges	Frequency of Target Flows	Calculation formulas to compare target flows (**Q**) with frequency (*f*) of Project **Q** (f_{PQ})
0-150	0	$(0 - f_{PQ}) * 5$
150 -300	0	$(0 - f_{PQ}) * 4$
300 – 450	0	$(0 - f_{PQ}) * 3$
450 – 500	0.428	$(f_{PQ} / 0.428)$ **-1**: If >0, then = 0
500 – 800	0.317	$(f_{PQ} / 0.317)$ **-1:** If >0, then = 0
800 – 1500	0.192	**I** $(0.192 - f_{PQ})$ **I** * (- 0.83)
1500 – 2800	0.056	**I** $(0.056 - f_{PQ})$ **I** * (- 1.67)
2800 – 4500	0.007	**I** $(0.007 - f_{PQ})$ **I** * (- 2.50)
4500 – 5500	0	$(0 - f_{PQ}) * 3$
5500 – 6500	0	$(0 - f_{PQ}) * 4$
>6500	0	$(0 - f_{PQ}) * 5$

The score for each category is summed to calculate a total score for the project related flows being evaluated. Any flows different from the target flows will

produce a negative score, which becomes more negative as the flows tend toward the two tails. An example is provided in ***Table C-12*** that uses the actual flow distribution from S-79 during 1978-1986, which encompasses a period of very high, very low and average flows. The total score for this period is - 4.047.

TABLE C-12: EXAMPLE OF USING THE TARGET FLOW INDEX-TABLE COLUMN DEPICT THE TARGET FLOW-RANGE CATEGORIES, ASSOCIATED TARGET FREQUENCY, THE ACTUAL FLOW DISTRIBUTION FREQUENCY OF S-79 FLOWS DURING 1978-1986, AND THE RESULTING CATEGORY SCORES USING THE FORMULAS IN TABLE C-11.

Target Flows Ranges (cfs)	Frequency Of Target Flows	Frequency Distribution of S-79 flows during 1978-1986	Category Score of 1978-1986 flows
0-150	0	0.157	- 0.787
150 -300	0	0.130	- 0.519
300 – 450	0	0.046	-0.139
450 – 500	0.428	0.037	- 0.913
500 – 800	0.317	0.093	- 0.708
800 – 1500	0.192	0.130	- 0.052
1500 – 2800	0.056	0.157	- 0.169
2800 – 4500	0.007	0.148	- 0.353
4500 – 5500	0	0.028	- 0.083
5500 – 6500	0	0.046	- 0.185
>6500	0	0.028	- 0.139
Total	1.000	1.000	**- 4.047**

To compare TFI scores, a base condition must first be identified. This based condition should represent the flow distribution without project components during the period of record being evaluated. The TFI score for the base condition (TFI_{BC}) can then be used as the bottom of the range for comparison to the project flow scores (TFI_P) for the same period of record. Since the target flows (***Table C-11***) are based on the 36 year period of record (1965-2000), then using a smaller period of record may not have the same frequency distribution of flows (e.g., a period of record that disproportionately contains drought years or tropical storm years). Therefore, the 36 year target flows (***Table C-11***) should be adjusted by calculating a target TFI (TFI_T) using the actual target flow distribution for the same period of record being evaluated.

These three TFI values are then combined to determine a flow comparison index (FCI) value, with a scale from 0 to 1, which indicates the relative amount that the flow distribution associated with a project alternative moves toward

achieving the target flow distribution (score of 1) for the period of record being evaluated. The formula for calculating the FCI is as follows:

$$\mathbf{FCI} = (1 - [(TFI_P - TFI_T) / (TFI_{BC} - TFI_T)])$$

For example purposes, assume the period of record being evaluated is 1978-1986, the base condition TFI_{BC} = -4.047 (from ***Table C-12***), the expected target flow TFI_T = -0.8, and the alternative project flow TFI_P score is -3.0. Therefore, inserting these values into the formula provides an alternative's flow FCI value of 0.323. Multiplying this value by 100 indicates the percent toward the target flows that is achieved (e.g., PTA = 32.3%) by a project alternative when compared to the base condition for the period of record being evaluated.

For application purposes, the Caloosahatchee River (C-43) West Basin Storage Reservoir project uses the year 1982 as the base condition to calculate the TFI_{BC} for the representative years 1978-1986 that were evaluated by the project. This year represents the worst single year regarding flows that exceed EST05 on both the dry and wet extremes.

C.8 OYSTER REEF RESTORATION PLAN

C.8.1 Oyster Reef Restoration is Not Part of the Recommended Plan

Although an oyster reef restoration plan is included in this document, it is not part of the recommended plan. The team feels it would be a valuable addition to the Caloosahatchee Estuary and encourages other organizations to implement this restoration. The plan is included for information purposes only.

C.8.2 Introduction

The Eastern oyster, *Crassostrea virginica* is important both commercially and recreationally in fisheries along the Atlantic Ocean and Gulf of Mexico coasts of North America. While this role of oysters as a fishery is well known, their ecological significance remains under-appreciated and under-studied (Coen et al. 1999a). Individual oysters filter 4-34 liters of water per hour, removing phytoplankton, particulate organic carbon, sediments, pollutants, and microorganisms from the water column. This filtration results in greater light penetration immediately downstream, promoting growth of SAV. Although oysters assimilate most of the organic matter that they filter, the remainder is deposited on the bottom where it provides food for benthic organisms. Furthermore, the oyster's ability to form large biogenic reefs (Coen et al. 1999b) qualifies it as a keystone species.

Oysters and the complex, three-dimensional, reef structure they form, attract numerous species of invertebrates and fishes (Ingle & Smith 1956, Woodburn 1965, McDonald 1982, Peters 1981, Meyer 1994). To date, over 300 species have

been identified as depending, either directly or indirectly, on oyster reefs (Tolley and Volety 2005). Many of these organisms in turn serve as forage for important fisheries species (Marshall 1958, Tabb and Manning 1961, Fore and Schmidt 1973, Gilmore et al. 1983, Peters and McMichael 1987, McMichael and Peters 1989).

Due to its sedentary nature, the Eastern oyster is susceptible to natural and artificial ecosystem changes. Environmental disruptions are responsible for reducing oyster populations and their traditional habitats (Cake 1983). Although not currently harvested in the Caloosahatchee Estuary, oysters have been identified in this area as a VEC (Chamberlain and Doering 1998a, 1998b). Historical records indicate that oyster reefs were once significant features of Gulf of Mexico estuaries, including the Caloosahatchee Estuary and adjacent San Carlos Bay. However, populations have declined (Volety et al. unpublished results).

Based on 2004 surveys, there are presently only 3.02 acres of Eastern oysters in the Caloosahatchee Estuary. Most of this possible habitat is located in the Shell Point region of the estuary. A preliminary target for the aerial extent of oysters in the lower estuary with the proper changes in salinity and flow is a 30-acres increase over the next 10-15 years. With the addition of hard substrate over the next ten years, this target can be increased to 100 acres of oyster reefs. This substantial increase in the oyster population will not only provide essential habitat for many species, thus providing a food source for larger estuarine dependent organisms such as game fishes and birds, but will additionally contribute to better water quality.

In the last five years, 23 small-scale oyster reefs have been constructed locally by volunteers lead by investigators from Florida Gulf Coast University (FGCU) and SFWMD (and other local agencies). FGCU has a network of local volunteers including middle school, high school and undergraduate students, environmental and civic organizations, and local media, which have aided in these restoration efforts. Involving the public not only makes them aware of the SFWMD and U.S. Army Corps of Engineers (USACE) efforts in restoration, but also enhances environmental education and creates vested interest in the water quality in the estuary and become local stewards.

C.8.3 Methods

C.8.3.1 Volunteer recruitment

Community volunteer involvement should be a critical and integral component of this project. FGCU, a state university with excellent community collaborations on various projects, will aid with coordination of the restoration efforts including volunteer recruitment. It is also home to the local public

television and radio stations, WGCU and FM 90.1 and 89.9, respectively. Through FGCU volunteer list and recruitment over television and radio stations, investigators in southwest (SW) Florida were able to recruit over 200 community volunteers per year for reef restoration and oyster gardening activities in our previous four to five years. Volunteers have been willing to participate in the project including donating time and boat resources.

C.8.3.2 Reef Construction

Recycled and fossil oyster shell and stabilizing mesh (where needed) will be used to establish suitable substrate for oyster recruitment. This approach has been initiated in South Carolina and successfully implemented in SW Florida. Previous studies indicate that mesh laid over the top of deployed shell and anchored at the edges with rebar significantly decreases subsequent loss due to boat wakes and waves, while unprotected shell washes away in a matter of days. Once recruitment of oysters and other stabilizing organisms such as mussels occurs, the deployed shell becomes stabilized and the mesh may be removed or becomes part of the reef.

Each year, reefs of approximately two acres total area will be constructed with recycled and fossil oyster shell in the Caloosahatchee Estuary. Each reef will be created with shell bags at the periphery to prevent erosion and filled with shell in the middle. Shells will be loaded into bundles of wire-mesh bags and will then be placed into the water to form a reef. Given the large scale nature of the reef, while community volunteers will assist in the shell bags and reef construction, loose shell will be transported to the sites via barges and shell deposited in the water using high pressure hose systems. Reef construction will be done in early spring to maximize the recruitment of new spat onto the constructed reefs. In order to speed up reef creation, seeding of the constructed reefs with reproductively mature adult oysters will also be considered. Appropriate permits (Florida Department of Environmental Protection [FDEP], USACE) will be secured prior to the construction of the reefs. As part of the permit requirements, aerial photographs of the constructed reefs and monitoring of the reefs for success needs to be provided to the USACE.

C.8.3.3 Yearly Costs

Shell and transportation to the location:	$30,000
Barge, winch, crane costs:	$10,000
Personnel:	$25,000
Chopper and monitoring:	$7,000

Indirect costs (approx)	$10,000
Miscellaneous:	$20,000
Total:	**$102,000**

These figures represent a cost estimate and not exact pricing. The cost is estimated to be between $100,000 and $150,000 per year.

C.8.4 References

Cake, E. W., Jr. 1983. Habitat suitability index models: Gulf of Mexico Eastern oyster. U.S. Fish Wildl. Ser.FWS/OBS-82/10.57. 37p.

Chamberlain, R. H. and P. H. Doering. 1998a. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation. Pages 88-91. In Treat, S. F. (ed.) Proceedings of the Charlotte Harbor Public Conference and Technical Symposium. Charlotte Harbor Estuary Program, North Fort Myers, Florida. Technical Report No. 98-02.

Chamberlain, R. H. and P. H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: a resource based approach. p. 111-120. In Treat, S. F. (ed.) Proceedings of the Charlotte Harbor Public Conference and Technical Symposium. Charlotte Harbor Estuary Program, North Fort Myers, FL, USA. Technical Report No. 98-02.

Chamberlain, R. H., P. H. Doering, K. M. Haunert, and D. Crean. 2003. Impacts of Freshwater Inflows on the Distribution of Zooplankton and Ichthyoplankton in the Caloosahatchee Estuary, Florida. Appendix pages C1-C20. In Technical Documentation to Support Development of Minimum Flows and Levels for the Caloosahatchee River and Estuary. Draft January 2003 Status Update Report Appendices. South Florida Water Management District. West Palm Beach, Florida.

Chamberlain, R. H. 2005 unpublished manuscript. Caloosahatchee Riv er (C-43) West Basin Storage Reservoir project - Caloosahatchee Estuary Hydrologic Evaluation Performance Measures. South Florida Water Management District, West, Palm Beach, Florida.

Coen, L. D., M. W. Luckenbach and D. L. Breitberg. 1999a. The role of oyster reefs as essential fish habitat: a review of current knowledge and some new perspectives. American Fisheries Society Symposium 22: 438-454.

Coen, L. D., D. M. Knott, E. L. Wenner, N. H. Hadley, A. H. Ringwood and M. Y. Bobo. 1999b. Intertidal oyster reef studies in South Carolina: design, sampling and experimental focus for evaluating habitat value and function. Pages 133–158. In Luckenbach, M. W., R. Mann & J. A. Wesson (eds.), Oyster Reef Habitat Restoration: a Synopsis and Synthesis of Approaches.

Fore, P. L. and T. W. Schmidt. 1973. Biology of juvenile and adult snook, *Centropomus undecimalis*, in the Ten Thousand Islands, Florida. Pages XVI 1-18. In Carter, M. R., Burns, L. A., Cavinder, T. R., Dugger, K. R., Fore, P. L., Hicks, D. B., Revells, H. L., and Schmidt, T. W. (eds.), Ecosystems Analysis of the Big Cypress Swamp and Estuaries. U. S. Environmental Protection Agency, Surveillance and Analysis Division, Athens, Georgia.

Gilmore, R. G., C. J. Donohoe and D. W. Cooke. 1983. Observations on the distribution and biology of east-central Florida populations of the common snook, *Centropomus undecimalis* (Bloch). Florida Scientist 46:306-313.

Ingle, R. M. and F. G. W. Smith. 1956. Oyster culture in Florida. Florida Board of Conservation, Educational Series 5, 25 pp.

Marshall, A. R. 1958. A survey of the snook fishery of Florida, with studies of the biology of the principal species, *Centropomus undecimalis* (Bloch). Florida State Board of Conservation, Technical Series No. 22, 39 pg.

McDonald, J. 1982. Divergent life history patterns in the co-occurring intertidal crabs *Panopeus herbstii* and *Eurypanopeus depressus* (Crustacea: Brachyura: Xanthidae). Marine Ecology Progress Series 8:173-180.

McMichael, R. H., Jr. and K. M. Peters. 1989. Early life history of spotted seatrout, *Cynoscion nebulosus* (Pisces: Sciaenidae) in Tampa Bay, Florida. Estuaries 12:98-110.

Meyer, D. L. 1994. Habitat partitioning between the xanthid crabs *Panopeus herbstii* and *Eurypanopeus depressus* on intertidal oyster reefs (*Crassostrea virginica*) in southeastern North Carolina. Estuaries 17:674-679.

Peters, K. M. 1981. Reproductive biology and developmental osteology of the Florida blenny, *Chasmodes saburrae* (Perciformes: Blenniidae). Northeast Gulf Science 4:79-98.

Peters, K. M. and R. H. McMichael, Jr. 1987. Early life history of the red drum, *Sciaenops ocellatus* (Pisces: Sciaenidae) in Tampa Bay, Florida. Estuaries 10:92-107.

Tabb, D. C. and R. B. Manning. 1961. A checklist of the flora and fauna of northern Florida Bay and adjacent brackish waters of the Florida mainland collected during the period July, 1957 through September, 1960. Bulletin of Marine Science of the Gulf and Caribbean 11:552-649.

Tolley, S. G., and A. K. Volety. 2005. The role of oysters in habitat use of oyster reefs by resident fishes and decapod crustaceans. Journal of Shellfish Research. 24: 1007-1012.

Woodburn, K. D. 1965. Clams and oysters in Charlotte County and vicinity. Florida Board of Conservation, no. 62-12, 29 pg.

C.9 WATER QUALITY ANALYSIS FOR PLAN FORMULATION

C.9.1 Background

The construction and operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir will affect the quality and quantity of water released at S-79 and the resulting change will impact the downstream Caloosahatchee Estuary. As stated in other places within this document, the primary ecological goals of the project are to improve the quantity and timing of water delivered to the estuary at S-79. While water quality improvement is a not a primary goal of the project, changes to water quality conditions that result from the project must be estimated as part of the benefit assessment. In addition, since the USACE will be obtaining a water quality certificate from the FDEP, the USACE will also have to demonstrate that the reservoir does not cause degradation of water quality conditions downstream of the project.

The project delivery team (PDT) and the FDEP have identified the following five issues as the primary measures of the acceptability of the project in terms of water quality:

1. The quality of the water discharged from the reservoir should be no worse than the quality of the water pumped into the reservoir. This is measured in terms of projected flow-weighted nutrient concentrations at the reservoir.
2. Operation of the reservoir should not result in an increase in the frequency of wet or dry season high nutrient loading periods. This is measured as the number of times monthly Total Nitrogen (TN) loading exceeds the critical load estimates developed for the FDEP by Janicki in 2003. These critical loading thresholds are 190 tons of TN in the dry season and 350 tons of TN in the wet season.
3. Operation of the reservoir should not result in an increase in the frequency in which annual nutrient loads exceed a previously defined threshold quantity. The critical annual loading threshold is 3000 tons of TN per year.
4. Operation of the reservoir should not result in an increase in the total nutrient load discharged into the estuary at the S-79 structure.
5. The operation of the reservoir should not result in a substantial shift of nutrient loading from the wet season to the dry season.

The FDEP has focused on nutrient concentration and loading as the primary indicators of the project's impact. This approach recognizes the direct role that nutrients play in the ecological health of the river and estuary in terms of dissolved oxygen concentrations, as well as water clarity (i.e., chlorophyll-a concentration, secchi depth, photosynthetically available radiation or PAR). Other water quality constituents such as pesticides and metals play an

important role in the health of the Caloosahatchee River and Estuary; however, these are not expected to be adversely affected by the construction of the reservoir since 12,000 acres of agricultural land which contribute these pollutants will be taken out of production. While it is possible that some contaminants become mobilized from the reservoir sediments into the water column, low concentrations of these contaminants in the sediments and high volumes of flow through the reservoir will not result in violations of water quality standards for these pollutants. A discussion of the effects of soil contamination is found in the hazardous, toxic and radioactive waste (HTRW) section of the report.

C.9.2 Methodology

This water quality assessment is focused on nitrogen and phosphorus nutrient loading and concentrations calculated using a mass balance approach. Estimates of future nutrient concentrations and loads were prepared using measured TN and total phosphorus (TP) concentrations at S-79 coupled with simulated reservoir and S-79 flows from the Caloosahatchee River (C-43) Basin MIKESHE model. Given that the Caloosahatchee River (C-43) West Basin Storage Reservoir project as a stand-alone project and as an element of CERP significantly changes the S-79 hydrograph, reliable predictions of the impact of the project on water quality at S-79 can be made using a mass-balance water quality assessment approach used in conjunction with simple reservoir pollutant removal assumptions.

C.9.3 Results

The FDEP has stated that the USACE has to demonstrate that the construction and operation of the reservoir will not cause or contribute to degradation of water quality within the Caloosahatchee River or downstream of the S-79 structure in the estuary. The analysis below presents the water quality impact of several reservoir configurations.

C.9.3.1 Annual TP and TN Loading at S-79

C.9.3.1.1 Scenario 1: No Removal in Reservoir

Table C-13 shows the predicted average monthly TP and TN loading at S-79 for future conditions with and without the reservoir project. The results shown in this table are computed under the assumption that the reservoir pollutant removal effectiveness factor for TP and TN is 0.0. (The reservoir pollutant removal effectiveness factor is defined as the fraction of pollutant that is removed and retained in the reservoir.).

C.9.3.1.1.1 Project vs. 2050 Future Without Project Conditions

Compared to the future (Project versus 2050 Future Without Project), the installation of any of the proposed reservoir/pump combinations will result in an average annual reduction in TP load at S-79 ranging from 29 to 34 percent. For TN, the reduction will range from 28 to 33 percent. From these results it appears that neither significant increases in either the pump size or reservoir size results in markedly reduced nutrient loads at S-79. More than doubling the reservoir size provides only four percent more TP removal and three percent more TN removal, while increasing the pump size from 1500 to 3800 cfs provides about three percent more nutrient removal. A comparison of the results for Alternative 3A and Alternative 3B which have identical reservoir sizes and pump capacities shows that the operation scheme used to control inflow to and outflow from the reservoir may have a significant impact on the amount of nutrients that are sent to S-79.

The comparison of 2050 with and without project flow conditions shows that the overall CERP project will reduce flows at S-79 by an estimated 28 to 33 percent. The projected flow reduction for each alternative is very close to the projected reduction in TN and TP loads. This is expected since nutrient loading at S-79 is highly correlated to flows.

TABLE C-13: ESTIMATES OF ANNUAL TP AND TN LOADING AT S-79 FOR 1978-1986 USING MIKESHE CALOOSAHATCHEE RIVER (C-43) HYDROLOGY. RESERVOIR EFFECTIVENESS FACTOR = 0.0[1]

Alternatives VS 2050 Conditions						
Alternative Name	2050 FWO	ALT2	ALT3A	ALT3B	ALT3C	ALT4B
Reservoir Size (ac-ft)	0	100,000	170,000	170,000	170,000	220,000
Pump Capacity (cfs)	0	1,500	1,500	1,500	3,800	3,800
TP Average Annual Load (tons)	136	95	87	97	92	90
TP % Reduction VS 2050*	0%	30%	36%	29%	32%	34%
TN Average Annual Load (tons)	1,516	1,069	1,015	1,089	1,049	1,037
TN % Reduction VS 2050*	0%	29%	33%	28%	31%	32%
FLOW % Reduction VS 2050	0%	30%	33%	28%	31%	31%

C.9.3.1.2 Scenario 2: Nutrient Removal by Reservoir

[1] All nutrient reduction estimates presented here are calculated as the difference between loads expected without any CERP implementation and the loads expected with a given C-43 alternative combined with the rest of CERP implemented. Nutrient load reduetion due solely to the C-43 West Reservoir Project is much less than that shown in this table.

Error! Reference source not found. shows the impact of various reservoir effectiveness estimates on TP and TN loads at S-79. For TP, the net reduction in load at S-79 is shown for reservoir effectiveness factors of 0.4, 0.6, and 0.9. For TN, the net change in load at S-79 is shown for reservoir effectiveness factors of 0.2 0.4, -0.5 and -1.0. The highest reduction factor for TP represents optimal removal possibly through the addition of a stormwater treatment area (STA) or other downstream water quality treatment feature. The prediction of the concentration of TN in the reservoir discharge is not as straight forward as that for phosphorus since a mass-balance approach for calculating TN must take into account the possibility of the fixation of atmospheric nitrogen by blue-green algae. These algae normally fix atmospheric nitrogen into ammonia which is released back into the water column upon death. Under optimal conditions, the removal of TN from natural waters through treatment in wetland systems is constrained to a lower limit of approximately one milligram per liter (mg/L) TN. This minimal TN concentration is composed of the less bio-available organic nitrogen fraction which is not removed from the water column as readily as nitrate or ammonia. Given these constraints, the effect of the reservoir on S-79 TN loads was tested using removal effectiveness factors of 0, 0.20, 0.40, -0.50, and -1.0. The two negative removal rates, -0.50 and -1.0 test the effect of algal blooms in the reservoir on loads and concentrations of TN at S-79. Although algal blooms are extremely unlikely to occur continuously within the reservoir, the calculations presented here conservatively apply the negative removal rates on a continuous basis in order to test worse-case conditions.

C.9.3.1.2.1 Project versus 2050 Future Without Project Conditions

If pollutant removal occurs in the reservoir, relative to future conditions (2050 Future Without Project), the installation of the ALT3B and the rest of CERP would result in a reduction of 29% to 38% of the TP load at S-79 (From ***Table C-14***). Most of this removal is due to the reduction in flow resulting from the implementation of CERP components other than the C43 West Reservoir component; however, up to an additional 9% of load reduction can be achieved if the reservoir provides 90% removal of TP. The highest potential removal rate of 90% would occur with a large reservoir coupled with a STA that provides optimal treatment of all reservoir discharges. However, given that future nutrient loading to the basin is expected to decrease (as a result of urbanization and Best Management Practices implementation) and that an STA would likely not fully treat all of the reservoir discharges, the maximum removal is likely to be less than that predicted here.

Compared to future conditions (2050 Future Without Project), Alt3B could be expected to provide a reduction in annual expected TN load of 18% to as much as 32% if nitrogen removal was to occur in a reservoir or a downstream STA. Given that nitrogen loading to the basin is expected to decrease as a result of urbanization and that a STA would be unlikely to treat all reservoir discharges,

the maximum decrease in TN load attributable to reservoir treatment would likely be less than that predicted here.

As part of the Acceler8 design efforts, two test cells of approximately four acres in size were constructed in early 2006 on the project lands to primarily test seepage conditions on the site. Water quality monitoring of nutrients, algae, physical parameters and toxics was performed on a monthly basis for a period of 12 months at the test cells. The intent of the test cell water quality study was to supplement the desktop evaluation of future reservoir water quality conditions. The significant observations and potential implications of the test cell water quality data to the full-scale reservoir are listed below.

1. Low dissolved oxygen conditions developed in the lower depths of the test cells during the summer season. The full-scale reservoir can be operated such that the discharge of low dissolved oxygen water is avoided by releasing water from the upper portion of the reservoir water column.
2. The pH of the water in the test cells frequently exceeded the 8.5 pH Class III surface water quality standard. This increase in pH is thought to be related to algal growth. Increased pH will also occur in the full-scale reservoir but to a lesser extent. Since the inflow to the full-scale reservoir will be 0.4 pH units less than that observed in the test cell inflow, it is much less likely that the Class III pH water quality standard will be regularly exceeded in the full scale reservoir.
3. The observed chlorophyll-a concentration in the test cells was less than that observed in the inflow water and also less than the estuary target of 11 ug/l recommended by the DEP. However, the chlorophyll-a concentration within the test cells was still trending up at the conclusion of the study. This is an indication that the average chlorophyll—a concentration in the reservoir is likely to be higher than that observed in the test cells.
4. Nutrient concentrations (TN and TP) were reduced in the test cells relative to the inflow concentrations. This indicates that some nutrient removal will likely occur within the full-scale reservoir.
5. Water column light transmittance in the test cells was increased relative to the inflow water. This is likely to also occur within the full-scale reservoir.

While this study is useful, it is not prudent to base the prediction of future reservoir water quality entirely upon the results of the test cell water quality study because of the large differences in size and operations between the test cell and full-scale reservoir. The small scale of the test cells limited the potential for wind induced mixing conditions which would reduce the tendency of the reservoir to thermally stratify. The likely difference between test cell operations

and full-scale reservoir operations means that water quality processes that are affected by hydraulic residence time, such as nutrient removal, would behave differently in the full-scale reservoir as compared to that observed in the test cells. While the test cell study lasted 12 months, it is probable that water quality conditions within the full-scale reservoir will continue to stabilize over a multi-year period. Thus, the test cell data is perhaps a useful predictor of the water quality conditions within the reservoir directly after construction rather than an indication of long-term conditions once the reservoir has matured.

C.10.11 Algae Production in the Reservoir

Like the Caloosahatchee Estuary and Lake Okeechobee, algal production will occur in the full-scale reservoir as a result of excess nutrient concentrations and favorable temperature conditions. Algal production will be limited to the upper portion of the reservoir water column which experiences adequate light transmittance for photosynthesis. Some mixing of the upper portions of the water column that contain the algal growth will occur as a result of wind induced mixing; however, given the depth of the reservoir and the low velocity wind conditions typically experienced in the project area, it is not likely that elevated chlorophyll-a concentrations which are a result of algal production will be found at all depths of the reservoir. In the test cell water quality study, chlorophyll-a was found to average around 6 ug/l which is less than the 11 ug/l target concentration recommended by the DEP for the Caloosahatchee Estuary. Because the chlorophyll-a concentrations within the test cells were trending upward at the conclusion of the study, it is likely that the full-scale reservoir would experience higher chlorophyll-a concentrations that that observed in the test cells once the reservoir has operated for several years. The draft test cell water quality report (WSI, Inc, 2007) used four different predictive equations to estimate the potential chlorophyll-a concentration in the upper portion of the reservoir water column for each month of the year. The average predicted annual average concentration of chlorophyll was between 12.2 and 24 ug/l. The predictive equations were all developed for Florida lakes which differ from the proposed reservoir in that they are generally much shallower and likely have a significantly higher average hydraulic residence time. Given these differences, the average chlorophyll-a concentrations as predicted by these equation are probably higher than that which will occur in the reservoir. When the reservoir periodically does generate algae such that chlorophyll-a concentrations exceed the target of 11 ug/L, discharges can then be made from lower depths of the reservoir which will likely have a chlorophyll-a concentration below the target. Other treatment options such as aeration or wetland treatment will be considered in the future in the event that careful management of discharges does not largely control the release of water containing elevated concentrations of algae and its byproducts.

TABLE C-14: TOTAL PHOSPHORUS AND TOTAL NITROGEN LOADING AND PERCENT REDUCTION UNDER VARIOUS RESERVOIR PHOSPHORUS REMOVAL FACTORS, WHERE RF IS THE FRACTION OF THE POLLUTANT REMOVED BY THE RESERVOIR.

Alternatives VS 2050 Conditions						
Alternative Name	2050 FWO	ALT2	ALT3A	ALT3B	ALT3C	ALT4B
Reservoir Size (ac-ft)	0	100,000	170,000	170,000	170,000	220,000
Pump Capacity (cfs)	0	1,500	1,500	1,500	3,800	3,800
TP % Reduction VS 2050						
RF = 0.0		30%	36%	29%	32%	34%
RF = 0.20		32%	37%	31%	35%	36%
RF = 0.40		34%	39%	33%	37%	39%
RF = 0.60		36%	40%	35%	40%	41%
RF = 0.90		38%	43%	38%	44%	45%
TN % Reduction VS 2050						
RF = 0.0		29%	33%	28%	31%	32%
RF = 0.20		31%	35%	30%	33%	34%
RF = 0.40		33%	36%	32%	36%	37%
RF = -0.50		25%	29%	23%	24%	25%
RF = -1.0		20%	25%	18%	18%	19%

C.9.3.1.3 Effect of Reservoir Seepage on S-79 Concentrations

One proposal for the construction of the reservoir involves the installation of a sub-surface slurry wall to reduce seepage losses from the reservoir pool. In the original calculations, seepage was assumed to have different water quality characteristics than reservoir structure discharges. To test the effect of a seepage barrier configuration on nutrient loading at S-79, the original water quality calculations were redone using the assumption that all reservoir outflows (seepage and structure discharge) have the same water quality. This assumption reduced the effective removal percentage of TP by about three percent. For TN, the calculations indicate that the average load is not affected by the presence or absence of a seepage wall. This is largely because in the original calculations, the concentration of TN was assumed to be minimally changed as it seeps from the reservoir.

C.9.3.2 Wet/Dry Season Nitrogen Loading

The downstream estuary has historically been affected by nutrient loads coming from the S-79 structure. A study by ERD (2003) found that discharge from S-79 contributes from 90 to 95 percent of the mean annual mass of TN and TP to the tidal Caloosahatchee River. The next largest contributor to the tidal Caloosahatchee River was the Orange River with 1.1 to 3.8 percent of the daily mass of TN and TP. Due to the naturally occurring high levels of phosphorus in the watershed, it is generally believed that nitrogen is the limiting nutrient in the downstream Caloosahatchee Estuary. The FDEP (Janicki 2003) determined that the nitrogen/chlorophyll-a relationship was the best means of predicting nutrient impairment in the estuary. The FDEP (Janicki 2003) report has identified two preliminary seasonal threshold loads for TN loading to the estuary from releases at S-79 in order to achieve a chlorophyll-a concentration limit of 11 ug/L in the estuary:

1. Dry season monthly load less than 190 tons/month, and
2. Wet season monthly load less than 350 tons/month.

Controlling nitrogen loading from upstream of the S-79 structure will positively impact the downstream estuary by reducing the frequency and magnitude of algal blooms. The net impact of the reservoir project on monthly nitrogen loading threshold exceedance events is shown in ***Table C-15***. In this table, the net change in the number of wet and dry season monthly nitrogen load threshold exceedance events is shown relative to 2050 Future Without Project condition.

C.9.3.2.1 Project versus 2050 Future Without Project Conditions

In ***Table C-15***, regardless of whether TN concentrations fall by 40 percent or increase by 50 percent, the reservoir project will reduce the number of dry

season target (> 190 tons/month) exceedances from seven to one or two over the nine year simulation period when compared to the 2050 future without condition. For the wet season, the number of monthly TN threshold (350 tons/month) exceedance events falls from six to two or fewer regardless of how TN concentrations are changed by the reservoir. The number of exceedance events for the dry and wet season thresholds (190 and 350 tons/month) are not substantially affected by the sizes of the pumps and reservoirs. However, at lower loading thresholds such as 100 tons/month, the effect of reservoir operations influence the number of exceedance events (comparison of Alternative 3A to Alternative 3B).

TABLE C-15: FREQUENCY OF EXCEEDING MONTHLY TN THRESHOLD LOADS FOR VARIOUS RESERVOIR REMOVAL EFFICIENCIES

Estimated TN Removal Rate =>	**0.00**					
DRY SEASON						
RANGE	2050	ALT2	ALT3a	ALT3b	ALT3c	ALT4
Number of Months < 100 Tons	49	55	60	56	56	56
Number of Months > 100 Tons	14	8	3	7	7	7
Number of Months > 190 Tons	7	1	2	1	2	1
WET SEASON						
RANGE	2050	ALT2	ALT3a	ALT3b	ALT3c	ALT4
Number of Months < 100 Tons	14	18	25	19	21	21
Number of Months > 100 Tons	31	27	20	26	24	24
Number of Months > 350 Tons	6	1	1	1	0	0
Estimated TN Removal Rate =>-0.50						
DRY SEASON						
RANGE	2050	ALT2	ALT3a	ALT3b	ALT3c	ALT4
Number of Months < 100 Tons	49	53	58	53	54	54
Number of Months > 100 Tons	14	10	5	10	9	9
Number of Months > 190 Tons	7	1	2	1	2	1
WET SEASON						
RANGE	2050	ALT2	ALT3a	ALT3b	ALT3c	ALT4
Number of Months < 100 Tons	14	15	23	16	19	19
Number of Months > 100 Tons	31	30	22	29	26	26
Number of Months > 350 Tons	6	1	1	2	0	0

C.9.3.3 Annual Nitrogen Loading

In addition to seasonal nitrogen threshold loads, the FDEP (Janicki 2003) identified an annual maximum nitrogen threshold load for flows at S-79. The target of 3000 tons/year of TN is based on the desire to achieve a chlorophyll-a concentration limit of 11 ug/L. ***Table C-16*** shows the annual TN load and the number of times that the annual TN threshold load of 3000 tons/year is exceeded during the 1978-1986 simulation period for various nitrogen removal scenarios. Compared to 2050 future without conditions, it appears that the number of annual TN load exceedance events will fall from one to zero regardless of the impact of the reservoir on TN concentrations.

TABLE C-16: ANNUAL TN LOAD (METRIC TONS) FOR EACH YEAR OF SIMULATION UNDER VARIOUS TN REMOVAL EFFICIENCIES IN THE RESERVOIR

Reservoir TN Removal Efficiency ==>0.0						
YEAR	2050	ALT2	ALT3a	ALT3b	ALT3c	ALT4
1978	944	835	754	869	857	859
1979	2064	1266	1114	1270	1112	1115
1980	805	763	786	794	824	819
1981	391	559	591	571	587	581
1982	2790	1610	1276	1677	1587	1579
1983	2966	1593	1714	1591	1528	1437
1984	1459	933	902	895	907	902
1985	984	966	937	1010	992	982
1986	1239	1099	1060	1119	1045	1059
Count > 3000 tons/year	+/- 1	0	0	0	0	0
Reservoir TN Removal Efficiency ==>-0.5						
YEAR	2050	ALT2	ALT3a	ALT3b	ALT3c	ALT4
1978	944	897	809	935	946	947
1979	2064	1351	1171	1360	1218	1221
1980	805	847	875	883	954	949
1981	391	571	672	587	614	606
1982	2790	1676	1293	1745	1680	1669
1983	2966	1685	1745	1685	1634	1541
1984	1459	1023	957	984	994	989
1985	984	1053	1025	1107	1104	1090
1986	1239	1185	1132	1222	1166	1190
Count > 3000 tons/year	+/- 1	0	0	0	0	0

C.9.3.4 Flow-weighted Nutrient Concentrations

The operation of the reservoir is likely to alter the average flow-weighted TN and TP concentrations as measured at S-79. The long-term average flow-weighted TP concentration at the reservoir outfall will most likely be less than the long-term flow-weighted average inflow TP concentration. It is possible that reservoir releases made during periods of reduced storage will have elevated TP concentrations. The potential for these high TP release events can be minimized through modifications to the design and operation of the reservoir (minimum pool maintenance, for instance). A water quality modeling tool such as -Dynamic Model for Stormwater Treatment Areas-2 (DMSTA) could be used to optimize reservoir operations for TP reduction.

As discussed earlier, the prediction of TN concentration within the reservoir is difficult given the possibility of fixation of atmospheric nitrogen by certain algal species. While it is possible that TN concentrations might increase as a result of seasonal algal blooms, these events will not be continuous. If TN concentrations in the reservoir increased by 50 percent as a result of algal blooms, then relative to the present condition, the project would not result in an increase in the annual average TN flow-weighted concentration. However, with algal blooms increasing reservoir TN concentrations by 50 percent, the project would increase the annual average TN flow-weighted concentration at S-79 by as much as 0.20 mg/L (or 11 percent) when compared to 2050 Future Without Project conditions.

C.9.4 Risk and Uncertainty Analysis

As with any prediction of the future it is impossible to determine its accuracy. The assumptions that are employed in any analysis can increase or decrease the confidence that decision makers have in the results. A risk and uncertainty discussion of the water quality analysis methodology is found in the Environmental Effects chapter of the integrated EIS.

C.9.5 Conclusion

The methodology and assumptions used in this analysis were not intended to predict daily water quality concentrations but rather to provide an estimate of the impact of the Caloosahatchee River (C-43) West Basin Storage Reservoir project on average nutrient loads and concentrations at S-79. Under the conservative assumption that no water quality treatment occurs in the reservoir, Alternative 3B including the rest of CERP will reduce TP and TN loading at S-79 by approximately 30 percent in comparison to the future without condition. If critical components of CERP such as EAA Storage or ASR are not implemented, the ability to reduce lake discharges and S-79 flows will limit the overall reduction in nutrient load predicted here. While it is possible that nitrogen fixation within the reservoir will result in short-term increases in TN loading to

S-79, the average annual TN load at S-79 will most likely be reduced. The project should result in an improvement in overall average water quality conditions at S-79 as well as downstream in the estuary. Given the uncertainty in the threshold chlorophyll-a concentration required for the restoration of the ecological function of the estuary, the degree to which the reservoir project will improve downstream water quality is unknown at this time. Based on the evidence presented here, and in the Supplemental Water Quality Analysis in Chapter 11 of Appendix C, it appears that the project will not cause or contribute to water quality degradation under future conditions. During the development of follow on CERP projects within the Caloosahatchee Basin, more sophisticated water quality prediction tools such as reservoir and estuary water quality models should be developed and used to optimize the reservoir operations with the goal of improving downstream water quality.

C.10 WATER QUALITY EFFECTS FOR THE NEXT ADDED INCREMENT ANALYSIS

C.10.1 Background

The NAI analysis is used to measure the benefits of the project in the absence of the implementation of any other CERP project. While the with-project hydrologic conditions for the alternative assessment analysis included CERP features other than the Caloosahatchee River (C-43) West Basin Storage Reservoir project, the with-project hydrologic conditions for the NAI analysis include only the Caloosahatchee River (C-43) West Basin Storage Reservoir project. Since the FDEP will be considering the water quality impact of the Caloosahatchee River (C-43) West Basin Storage Reservoir project in the absence of any other CERP project, the comparison provided by a NAI analysis is the most appropriate for determining the water quality impact of the project prior to the implementation of the remainder of CERP.

The construction and operation of the Caloosahatchee River (C-43) West Basin Storage Reservoir will affect the quality and quantity of water released at S-79 and the resulting change will impact the downstream Caloosahatchee Estuary. As stated in other places within this document, the primary ecological goals of the project are to improve the quantity and timing of water delivered to the estuary at S-79. While water quality improvement is a not a primary goal of the project, the USACE will have to obtain a water quality certificate from the FDEP. For the water quality certificate, the USACE will have to demonstrate that the reservoir does not cause degradation of water quality conditions downstream of the project. The PDT and the FDEP have identified the following five issues as the primary measures of the acceptability of the project in terms of water quality:

1. The quality of the water discharged from the reservoir should be no worse than the quality of the water pumped into the reservoir.
2. Operation of the reservoir should not result in an increase in the frequency of wet or dry season high nutrient loading periods. This is measured as the number of times monthly TN loading exceeds the critical load estimates developed for the FDEP by Janicki in 2003. These critical loading thresholds are 190 tons of TN in the dry season and 350 tons of TN in the wet season.
3. Operation of the reservoir should not result in an increase in the frequency in which annual nutrient loads exceed a previously defined threshold quantity. The critical annual loading threshold is 3000 tons of TN per year.
4. Operation of the reservoir should not result in an increase in the TN load discharged into the estuary at the S-79 structure.
5. The operation of the reservoir should not result in a substantial shift of nutrient loading from the wet season to the dry season.

The FDEP has focused on nutrient concentration and loading as the primary indicators of the project's impact. This approach recognizes the direct role that nutrients play in the ecological health of the river and estuary in terms of dissolved oxygen concentrations, as well as water clarity (chlorophyll-a concentration, secchi depth, PAR). Other water quality constituents such as pesticides and metals play an important role in the health of the Caloosahatchee River and Estuary; however, these are not expected to be adversely affected by the construction of the reservoir.

C.10.2 Methodology

Two different approaches were used to predict the impact of the reservoir on downstream water quality. The first approach was to create a simple mass balance model of TN loads at S-79. The second approach was to use the DMSTA-2 model to predict the net removal of phosphorus in the reservoir. The mass balance approach is a sufficient method to calculate the effect of the reservoir on nutrient loads at S-79 since less than 20 percent of the total flow at S-79 is expected to be routed through the reservoir. The mass balance approach tracks the load into and out of the reservoir and the impact of this routing on the timing and magnitude of nutrient loads at S-79. Estimates of with and without project nutrient concentrations and loads were prepared using measured TN and TP concentrations at S-79 coupled with simulated reservoir and S-79 flows from the Caloosahatchee River (C-43) West Basin Storage Reservoir project spreadsheet model. Since the Caloosahatchee River (C-43) West Basin Storage Reservoir project spreadsheet model simulates the period from 1965 through 2000 and that water quality data is available at S-79 for the period from 1981 through the present, the period of analysis used for the NAI water quality assessment was from 1981 through 2000.

Two comparison datasets were available from the spreadsheet hydrology model, the 2000 With Project and the 2000 Without Project conditions. Using these datasets, water quality mass balance calculations were performed using TN and TP concentrations and loads at S-79. The effect of the reservoir on nutrient loads at S-79 was estimated using the simplified approach of reducing or increasing the concentration of reservoir discharges by a set percentage. The simplified assumptions resulted in similar predictions of impacts to TN and TP in terms of load and concentration at S-79. Given similar results for both parameters and the fact that FDEP has focused on TN loading within the estuary, mass balance results only for TN are presented here.

C.10.3 Impact of Reservoir on Average Monthly TN Load at S-79

The impact of the reservoir on monthly average TN loads at S-79 is shown in ***Figure C-8*** and ***Figure C-9***. ***Figure C-8*** shows that average monthly TN loads in the dry season will be greater with the project than without the project given 2000 hydrology conditions. The increase in dry season loading is a direct result of holding wet season water in the reservoir and releasing it in the dry season when normally there is little flow. Without treatment, the average monthly TN load in the wet season will be reduced by as much as ten percent for some months. ***Figure C-9*** shows the impact on S-79 loads if the reservoir provides 60 percent removal of TN. Under this scenario, it appears that the average monthly load during the dry season for the with-project condition is nearly the same as the without project condition. The actual rate of TN removal is probably somewhere between 0 and 60 percent depending upon operating conditions.

FIGURE C-8: AVERAGE MONTHLY TN LOAD AT S-79 ASSUMING 2000 HYDROLOGY AND NO TREATMENT BY RESERVOIR

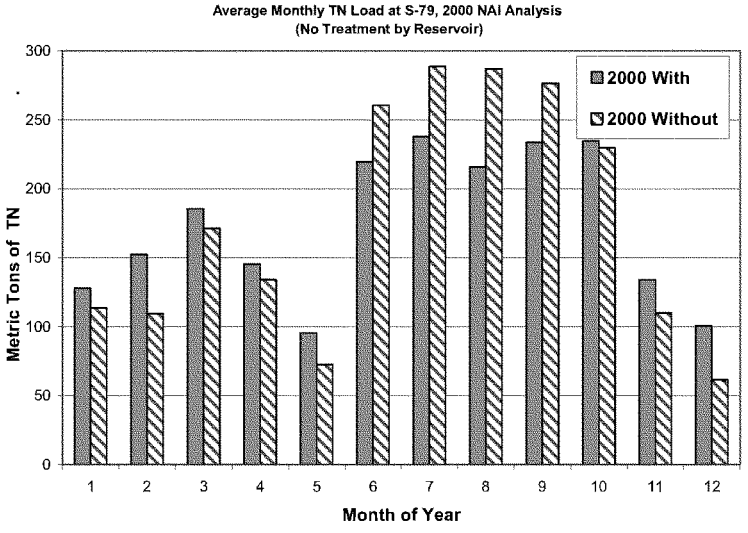
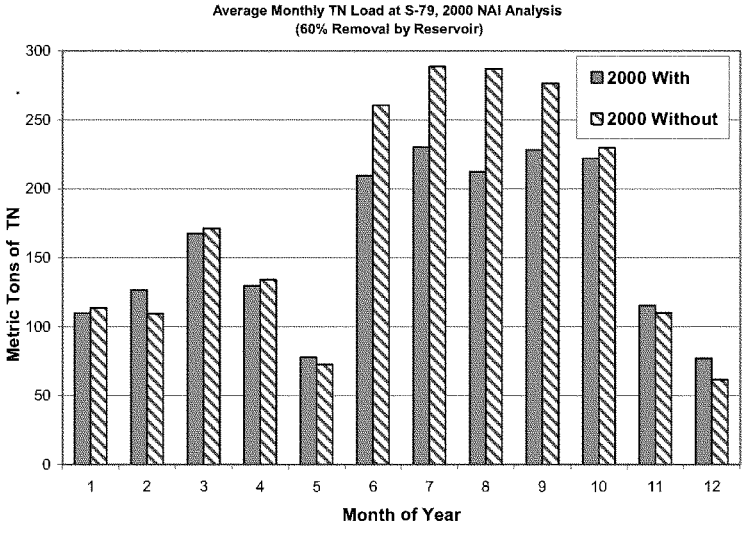


FIGURE C-9: AVERAGE MONTHLY TN LOAD AT S-79 ASSUMING 2000 HYDROLOGY AND 60% REMOVAL BY RESERVOIR



C.10.4 Impact of Reservoir on Seasonal Nutrient Load at S-79

The FDEP is concerned that the reservoir project may cause a significant shift in TN load from the wet season to the dry season. In 2003, the FDEP developed dry season and wet season threshold loads for TN load at S-79. The dry season threshold is 190 tons/month. The wet season threshold is 350 tons/month. A project that resulted in an increase in the frequency of exceeding these threshold loads may be considered by the FDEP to cause water quality degradation. To test whether the project might cause a significant seasonal load shift, the frequency of monthly TN loads at S-79 for with- and without project conditions was estimated using the 2000 NAI hydrology for the period from 1981 through 2000. These calculations were done using two conservative assumptions. The first assumption is that the reservoir provides no pollutant removal. The second tested assumption is that the fixation of nitrogen by algal blooms within the reservoir causes TN concentrations in the daily discharge to increase by 100 percent over the daily average flow-weighted reservoir concentration. The results for the no pollutant removal assumption, shown in ***Table C-17***, lists the number of months that the total TN load falls within ten different bins. In the dry season it appears that the without project condition results in more than half of the months having less than 50 tons of TN. The number of dry season months with less than 50 tons of TN for the with project condition is less than 25

percent. The dry season frequency of monthly loads between 50 and 100 tons is much greater for the with project condition than for the without project condition. However, the number of month where the load exceeds the FDEP threshold load of 190 tons/month is somewhat less (29 versus 31) for the with project condition than for the without project condition. For the wet season, the number of months exceeding the FDEP threshold of 300 tons/month is 20 for the with project condition and is 28 for the without project condition. Based on these results it appears that with little or no pollutant removal within the reservoir, the number of times that the dry season or wet season TN threshold loads are exceeded will decrease as a result of the implementation of the project.

TABLE C-17: FREQUENCY OF DRY AND WET SEASON MONTHLY TN LOADING AT S-79 FOR 2000 NAI HYDROLOGIC CONDITIONS ASSUMING NO POLLUTANT REMOVAL IN RESERVOIR

Frequency Analysis of Monthly Total Nitrogen Load at S-79					
DRY SEASON			WET SEASON		
BINS (Monthly Tons of TN)	2000 With	2000 Without	BINS (Monthly Tons of TN)	2000 With	2000 With out
0 to 10	7	61	0 to 10	1	5
10 to 25	7	12	10 to 25	4	5
25 to 50	15	17	25 to 50	3	5
50 to 100	68	8	50 to 100	20	11
100 to 190	14	11	100 to 190	29	19
190 to 250	8	7	190 to 250	7	13
250 to 350	8	9	250 to 350	16	13
350 to 500	7	9	350 to 500	10	13
500 to 700	2	2	500 to 700	6	11
700 to 1000	4	4	700 to 1000	4	5
Number of Months > 190	29	31	Number of Months > 350	20	29

The results of the frequency of monthly nutrient loads calculated using the assumption that TN concentrations in reservoir discharge will increase by 100 percent is shown in ***Table C-18***. These results show that with project condition increases the number of dry season threshold exceedance events by two months over the without project condition. These results indicate that even under the conservative assumption that TN discharge concentrations double as a result of nitrogen fixation by algal blooms, the net increase in dry season threshold exceedance events will be moderate (from 31 to 33 months out of 140). Given that it is not likely that algal blooms would occur on a continuous basis, it is unlikely that the frequency of exceeding the dry season TN threshold load would increase as predicted in this extreme scenario.

TABLE C-18: FREQUENCY OF DRY AND WET SEASON MONTHLY TN LOADING AT S-79 FOR 2000 NAI HYDROLOGIC CONDITIONS ASSUMING 100 PERCENT INCREASE IN RESERVOIR TN CONCENTRATIONS

Frequency Analysis of Monthly Total Nitrogen Load at S-79					
DRY SEASON			WET SEASON		
Monthly Tons of TN	2000 With	2000 Without	Monthly Tons of TN	2000 With	2000 Without
0	0	0	0	0	0
10	7	61	10	1	5
25	3	12	25	3	5
50	5	17	50	4	5
100	34	8	100	12	11
190	58	11	190	32	19
250	7	7	250	12	13
350	12	9	350	14	13
500	8	9	500	12	13
700	2	2	700	5	11
1000	4	4	1200	5	5
Number of Months > 190	**33**	**31**	**Number of Months > 350**	**20**	**28**

C.10.5 Assessment of Annual TN Load

The FDEP has determined that exceeding an annual load of 3000 tons of TN at S-79 is undesirable. The reservoir could potentially change the frequency of exceeding the 3000 tons/year threshold by either providing substantial removal of TN or by causing an increase in TN load by serving as an incubator of nitrogen fixing algae. To test the maximum impact of the reservoir on annual TN loading at S-79, the reservoir was assumed to provide either 100 percent removal of TN or increase discharge concentrations of TN by 100 percent over inflow concentrations. The frequency of exceeding the 3000 tons/year threshold under these various assumptions was estimated using the 2000 NAI hydrology conditions. With no project, the 3000 tons/year threshold was exceeded four times over the 1981 to 2000 period. Under the impossible assumption that the reservoir provides 100 percent removal of TN before discharge, the frequency of exceeding the threshold would not change from the without project condition given 2000 NAI hydrology. With 100 percent removal effectiveness by the reservoir, the net decrease in total TN load at S-79 would be approximately ten percent.

If nitrogen fixation by algal blooms in the reservoir resulted in an increase of 100 percent in discharge TN concentrations relative to the flow-weighted inflow concentration, the number of times that the annual TN threshold load of 3,000

tons/year would be exceeded would increase from four to five. The total TN load at S-79 would increase by ten percent under this scenario. While this scenario shows an increase in the number of annual load target exceedances, the probability that reservoir discharges would consistently have TN concentrations twice the inflow flow-weighted concentrations is limited since severe algal blooms within the reservoir are not likely to occur continuously.

C.10.6 Nutrient Removal Within Reservoir

The DMSTA 2, (Walker 2005) was used to estimate the net reduction in phosphorus load achieved by the reservoir. The 2000 NAI hydrologic conditions from the Caloosahatchee River (C-43) West Basin Storage Reservoir Spreadsheet Hydrology Model were input into DMSTA. The default parameters recommended by the DMSTA developer for a reservoir were used in the simulation. A partial list of input parameters is shown in ***Table C-19***. A partial list of the model output is shown in ***Table C-20***. In ***Table C-20***, it appears that the reservoir will reduce the phosphorus loads in the discharge by 22percent in comparison to the inflow phosphorus load. The flow-weighted TP concentration in the outflow will be approximately 135 parts per billion (ppb) in comparison to the flow-weighted inflow concentration of 179 ppb. The reliability of these DMSTA results are somewhat compromised by the simulation error message indicating that the average water depth for the simulation period was 4.1 meters which exceeds the upper bound of the DMSTA reservoir calibration range of 3.04 meters.

Although a STA is not planned as part of this project, the impact of constructing and operating a 3,000 acre STA in conjunction with the reservoir was simulated with DMSTA. The results of this simulation indicate that a combination of the reservoir and a STA will reduce TP load from the reservoir discharges by around 39 percent.

The net impact on S-79 loads from the reservoir and the reservoir/STA combination can be estimated using the results of the DMSTA simulations. Since the reservoir may remove up to 22 percent of the load from the 20 percent of total S-79 flows will pass through the reservoir, the net decrease in total TP load at S-79 will be approximately four percent. In terms of the total annual TP load for the estuary, the net reduction resulting from the operation of the reservoir would be around three percent since 25 to 30 percent of the total estuary load is from below S-79. If a reservoir/STA combination was to remove 39 percent of the load from the 20 percent of S-79 flow, the net result would be an eight percent reduction in TP load at S-79.

TABLE C-19: SIMULATION INPUT USED FOR DMSTA-2 SIMULATION OF PHOSPHORUS DYNAMICS IN THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR

Surface Area	km2	37.97
Mean Width of Flow Path	km	3.75
Outflow Weir Depth	cm	30
Inflow Seepage Rate	(cm/d) / cm	0
Outflow Seepage Rate	(cm/d) / cm	0
Max Outflow Seepage Conc	ppb	20
Initial Water Column Conc	ppb	30
Initial P Storage Per Unit Area	mg/m2	500
Initial Water Column Depth	cm	30
C0 = Conc at 0 g/m2 P Storage	ppb	3
C1 = Conc at 1 g/m2 P storage	ppb	150
C2 = Conc at Half-Max Uptake	ppb	0
K = Net Settling Rate at Steady State	m/yr	5.0
Z1 = Saturated Uptake Depth	cm	40
Z2 = Lower Penalty Depth	cm	100
Z3 = Upper Penalty Depth	cm	400

TABLE C-20: SIMULATION OUTPUT GENERATED BY A DMSTA-2 SIMULATION OF PHOSPHORUS DYNAMICS IN THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR

Run Date	-	03/08/07
Starting Date for Simulation	-	01/01/81
Ending Date	-	12/31/00
Cell Inflow Volume	hm3/yr	206.6
Cell Inflow Load	kg/yr	37054.3
Cell Inflow Conc	ppb	179
Treated Outflow Volume	hm3/yr	212.7
Treated Outflow Load	kg/yr	28796.5
Treated FWM Outflow Conc	ppb	135
Surface Load Reduction	kg/yr	8258
Load Trapped in Sediments	kg/yr	9529
Overall Load Reduction	%	22%
Frequency Outflow Conc > 50 ppb	%	100%
Mean Depth	cm	418
Maximum Depth	cm	684.9
HRT Days	days	280.8

C.10.7 Assessment of Reservoir Dissolved Oxygen

Anoxic conditions at depth within the reservoir are most likely to occur if the reservoir becomes thermally stratified. Thermal stratification in reservoirs tends to set up during the summer months. By itself, wind/wave mixing at the reservoir is not likely to be extensive enough to prevent thermal stratification at depth. In Cell 1, inflows to the reservoir are likely to disrupt the vertical

stratification process at least near the pump station discharge. Fortunately, most reservoir inflows will occur during the summer months when stratification is most likely to setup. Flow into Cell 2 will also disrupt stratification in this cell however to a lesser extent than for the pump induced mixing of Cell 1. It might be possible that periodic operation of the inflow pumps and discharge structures can be scheduled to disrupt thermal stratification and reduce the potential for the formation of anoxic deep waters.

Regardless of whether thermal stratification occurs at the lower depths of the reservoir, the concentration of DO in the upper portion of the reservoir water column is expected to typically meet or exceed the state standard of 5 mg/L. The concentration of dissolved oxygen in the discharge water will be heavily influenced by how the outfall structures are operated. The outfall structures in Cell 1 and Cell 2 are designed such that the water can be withdrawn from the reservoir at three elevations (Cell 1: 18 ft, 25 ft, 32 ft, Cell 2: 21 ft, 26 ft, 33 ft). Discharge water can be released from two or more elevations so that high DO water from the upper water column is blended with reduced DO water from the lower water column.

It is difficult to predict with any certainty the actual dissolved oxygen dynamics of the reservoir at this time given the lack of sufficient water quality data. However, modeling just thermal stratification instead of a complete list of water quality constituents can be done in the near future without having operational water quality data. Since thermal stratification plays a big role in reservoir water quality dynamics, this type of modeling will provide some indication of future reservoir water quality. Such a modeling effort can be done during the construction and initial operations phases of the project as part of developing a refined operations plan. Models that might be applied in this manner include CE-QUAL-R1 or EFDC (Environmental Fluid Dynamics Code).

C.10.8 Accumulation of Reservoir Sediments

Sediments will accumulate in the reservoir over time. The total amount of sediments that could accumulate in the reservoir can be estimated by multiplying the average total suspended solids (TSS) content by the total flow that passes through the reservoir over the simulation period from 1965 to 2000. The average TSS concentration at S79 over the last 25 years is 2.1 mg/L. If it is assumed that this average concentration will be as high as 10 mg/L, that the reservoir will retain all suspended solids, and that the accumulated material will contain 2% solids and 98% water, the total amount of accumulated material is 310 acre-feet in volume over the 35 year simulation period. This is equivalent to approximately ½ inch of material spread out over the entire reservoir bottom surface. Another source of material accumulation is decayed aquatic vegetation. Since the reservoir will be fairly deep and constantly varying in depth, only floating aquatic vegetation is likely to thrive in the absence of a control program.

Given the limited quantity of sediments carried in the inflow water and the implementation of an aquatic vegetation control program, sediments and decayed material should not accumulate such that a material removal effort is required for many years to come.

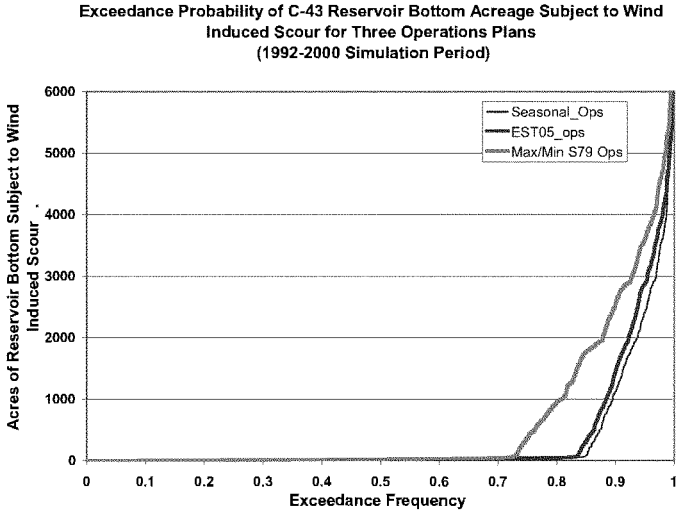
C.10.9 Potential for Re-Suspension of Bottom Sediments

Several of the important factors that control wind induced sediment re-suspension are the depth of water within the reservoir, the strength of the wind and the longest fetch for wave buildup. The depth of wind induced wave mixing is typically calculated as one-half of the wavelength. For this analysis, the relationship between wind speed, fetch length and depth of wave mixing was taken from Table 4-1, of Section 4 of the Institute of Food and Agricultural Sciences (IFAS) document, entitled "Wind, Waves, and Water Mixing in Lakes". This table was combined with daily stage, and storage data from the IMC's C-43 Reservoir Spreadsheet Modeling effort. The available wind velocity data was not accompanied with directional data. This did not present a problem since the C-43 West Reservoir is composed of two nearly square cells which mean that the maximum and minimum fetch lengths would be essentially identical regardless of wind direction. The potential surface area of wind induced re-suspension was assumed to be evenly distributed between five fetch zones within each cell. Using the fetch lengths and the daily wind velocity, a maximum depth of mixing was calculated for each zone for each day. The elevation of the bottom of the mixing layer was calculated for each of the five fetch zones by subtracting the depth of wave mixing from the daily predicted reservoir stage from the IMC model output. The surface area where re-suspension would occur on a given day was calculated by subtracting the surface area for the elevation of the bottom of the mixing layer for that day from the surface area for the elevation of the reservoir stage for that day.

The attached ***Figure C-10*** shows the exceedance frequency curve for bottom acreage potentially subject to sediment re-suspension for the ESTO5 operations, Seasonal Stage Criteria Operations, or the Min/Max S79 Operations as simulated by the IMC's spreadsheet model of the reservoir. From ***Figure C-10*** it appears that the frequency and extent of bottom area potentially exposed to wind/wave scour will depend upon the final operations plan. For the Max/Min S79 Operations, during 80% of the time less than 1000 acres are subject to wind induced re-suspension. For the ESTO5 or Seasonal Operations plans, during 90% of the time less than 1000 acres are subject to wind induced re-suspension. Overall, depending upon the operation plan in place, between 3.6% and 7% of the bottom area on average would be subject to wind forces that might induce re-suspension of sediments or muck.

While there may be times when wind induced scour re-suspends bottom sediments, the amount of bottom area subjected to wave induced scour is relatively small in comparison to the total reservoir surface area regardless of the selected operations plan.

FIGURE C-10. EXCEEDANCE PROBABILITY CURVES FOR RESERVOIR BOTTOM AREA SUBJECT TO WIND/WAVE SCOUR (SEDIMENT RE-SUSPENSION).



C.10.10 Summary of Test Cell Water Quality Testing

As part of the Acceler8 design efforts, two test cells of approximately four acres in size were constructed in early 2006 on the project lands to primarily test seepage conditions on the site. Water quality monitoring of nutrients, algae, physical parameters and toxics was performed on a monthly basis for a period of 12 months at the test cells. The intent of the test cell water quality study was to supplement the desktop evaluation of future reservoir water quality conditions. Results of the test cell water quality monitoring program are described in a report prepared by Wetland Solutions, Inc., for Stanley Consultants (Wetland Solutions, Inc., 2007, C-43 West Storage Reservoir Test Cell Water Quality Summary, Draft Report, July 2007, Prepared for Stanley Consultants, Inc.). Significant observations and potential implications of the test cell water quality data to the full-scale reservoir are listed below.

1. Low dissolved oxygen conditions developed in the lower depths of the test cells during the summer season. The full-scale reservoir can be operated such that the discharge of low dissolved oxygen water is avoided by releasing water from the upper portion of the reservoir water column.
2. The pH of the water in the test cells frequently exceeded the 8.5 pH Class III surface water quality standard. This increase in pH is thought to be related to algal growth. Increased pH will also occur in the full-scale reservoir but to a lesser extent. Since the inflow to the full-scale reservoir will be 0.4 pH units less than that observed in the test cell inflow, it is much less likely that the Class III pH water quality standard will be regularly exceeded in the full scale reservoir.
3. The observed chlorophyll-a concentration in the test cells was less than that observed in the inflow water and also less than the estuary target of 11 ug/l recommended by the DEP. However, the chlorophyll-a concentration within the test cells was still trending up at the conclusion of the study. This is an indication that the average chlorophyll—a concentration in the reservoir is likely to be higher than that observed in the test cells.
4. Nutrient concentrations (TN and TP) were reduced in the test cells relative to the inflow concentrations. This indicates that some nutrient removal will likely occur within the full-scale reservoir.
5. Water column light transmittance in the test cells was increased relative to the inflow water. This is likely to also occur within the full-scale reservoir.

Limited groundwater quality testing was also performed at the test cells. The results of this testing indicated high levels of total dissolved solids, aluminum, arsenic, and iron, in the groundwater directly adjacent to the slurry cutoff wall installed in test cell #2. The source or cause of this limited contamination is not known at this time. Additionally, since the metals analyses were done using unfiltered samples, it is not known what fraction of the metals detected are particulate or dissolved. If it is determined that the elevated concentrations are a result of particulate matter, then it is possible that sampling methods or monitoring well construction contributed to the elevated metals concentrations. However, elevated dissolved metals concentrations would indicate that levee construction methods should be carefully reviewed in terms of minimizing its effects on near field groundwater chemistry.

While this study is useful, it is not prudent to base the prediction of future reservoir water quality entirely upon the results of the test cell water quality study because of the large differences in size and operations between the test cell and full-scale reservoir. The small scale of the test cells limited the potential for wind induced mixing conditions which would reduce the tendency of the reservoir to thermally stratify. The likely difference between test cell

operations and full-scale reservoir operations means that water quality processes that are affected by hydraulic residence time, such as nutrient removal, would behave differently in the full-scale reservoir as compared to that observed in the test cells. While the test cell study lasted 12 months, it is probable that water quality conditions within the full-scale reservoir will continue to stabilize over a multi-year period. Thus, the test cell data is perhaps a useful predictor of the surface water quality conditions within the reservoir directly after construction rather than an indication of long-term conditions once the reservoir has matured. Given the results of the test cell groundwater quality monitoring, a review of reservoir construction methods and materials should be done prior to the initiation of construction. Additionally, groundwater quality testing at the existing reservoir piezometers should be performed during and after construction of the reservoir.

C.10.11 Algae Production in the Reservoir

Like the Caloosahatchee Estuary and Lake Okeechobee, algal production will occur in the full-scale reservoir as a result of excess nutrient concentrations and favorable temperature conditions. Algal production will be limited to the upper portion of the reservoir water column which experiences adequate light transmittance for photosynthesis. Some mixing of the upper portions of the water column that contain the algal growth will occur as a result of wind induced mixing; however, given the depth of the reservoir and the low velocity wind conditions typically experienced in the project area, it is not likely that elevated chlorophyll-a concentrations which are a result of algal production will be found at all depths of the reservoir. In the test cell water quality study, chlorophyll-a was found to average around 6 ug/l which is less than the 11 ug/l target concentration recommended by the DEP for the Caloosahatchee Estuary. Because the chlorophyll-a concentrations within the test cells were trending upward at the conclusion of the study, it is likely that the full-scale reservoir would experience higher chlorophyll-a concentrations that that observed in the test cells once the reservoir has operated for several years. The draft test cell water quality report (WSI, Inc, 2007) used four different predictive equations to estimate the potential chlorophyll-a concentration in the upper portion of the reservoir water column for each month of the year. The average predicted annual average concentration of chlorophyll was between 12.2 and 24 ug/l. The predictive equations were all developed for Florida lakes which differ from the proposed reservoir in that they are generally much shallower and likely have a significantly higher average hydraulic residence time. Given these differences, the average chlorophyll-a concentrations as predicted by these equation are probably higher than that which will occur in the reservoir. When the reservoir periodically does generate algae such that chlorophyll-a concentrations exceed the target of 11 ug/L, discharges can then be made from lower depths of the reservoir which will likely have a chlorophyll-a concentration below the target. Given the possibility of algal blooms occurring within the reservoir, the final

OMM&R plan should include monitoring and posting of health warnings, per the WHO (World Health Organization) guidelines for recreational contact with algae. In the event that careful management of discharges does not largely control the release of water containing elevated concentrations of algae and its byproducts, other treatment options such as aeration or wetland treatment will be considered.

C.10.12 Risk and Uncertainty Analysis of Water Quality Predictions

As with any prediction of the future it is impossible to determine its accuracy. The assumptions that are employed in any analysis can increase or decrease the confidence that decision makers have in the results. Several of the key assumptions used in this water quality assessment are discussed below in order to characterize the risk and uncertainty inherent in the results presented here.

C.10.13 Use of Historic Data

As is typically done, the past history of TP and TN concentrations measured at S-79 are used in the prediction of future water quality conditions. The use of historic data to predict long-term water quality conditions can result in error particularly when future conditions are expected to be substantially different from past conditions. Within the Caloosahatchee River (C-43) Basin there are substantial changes anticipated over the 50-year design period that will significantly affect water quality. For instance, the reduction in flow from the lake is expected to reduce nutrient loads at S-79 but might also result in an increase in flow-weighted nutrient concentrations since lake water is generally cleaner than basin runoff. Future implementation of best management practices and the conversion of agricultural lands to urban uses will likely result in a reduction of basin nutrient loads. Given the anticipated changes in the basin, the use of historical data to predict future water quality conditions appears in this case to be a conservative assumption given that most of the anticipated changes result in reduced nutrient loading and concentrations at S-79.

C.10.14 Use of Caloosahatchee River (C-43) West Basin Storage Reservoir Spreadsheet Model Flows

The Caloosahatchee River (C-43) West Basin Storage Reservoir spreadsheet model output used in this water quality assessment may differ significantly from actual reservoir operations in terms of the timing and magnitude of reservoir inflows and outflows. The actual reservoir operations might result in a somewhat different shifting of seasonal nutrient load than that predicted using the spreadsheet hydrology if seepage losses are significant in terms of the total water pumped into the reservoir. The effect of reservoir seepage on water quality should improve the average nutrient concentration in the discharge and also somewhat attenuate the predicted seasonal shift in nutrient load.

C.10.15 Use of Mass Balance Calculations

This water quality assessment did not attempt to predict a time history of nutrient concentrations at the reservoir outfall. Instead a simple mass-balance approach was coupled with various estimates of long-term nutrient removal rates. This approach is predicated on the assumption that project related increased nutrient loading causes a overall decrease in estuary water quality conditions while project related decreased nutrient loading causes an overall improvement in estuary water quality conditions. Coupled hydrodynamic/water quality models of the reservoir and estuary would be capable of integrating the effect of seasonal shifts in flow and load and predicting daily trends in water quality indicators such as dissolved oxygen and chlorophyll-a concentration. These tools are best used after project implementation when actual water quality data are available for model calibration and verification.

C.10.16 Use of FDEP Threshold Loads

Threshold loads used in this analysis were taken from the FDEP (Janicki, 2003). In this document, the FDEP developed chlorophyll-a concentration targets at S-79 using two approaches, the standards/rules based approach and the reference site approach. The reference site approach provided a target of 3.8 ug/L chlorophyll-a. The standards/rules based approach provided a target of 11 ug/L. The FDEP has decided to use the 11 ug/L chlorophyll-a target, which results in TN thresholds of 190 tons/month dry-season, 350 tons/month wet-season, and 3000 tons/year. These thresholds were used in this analysis and the results indicated that the project would decrease the number of times that the seasonal and annual TN thresholds were exceeded. If it turns out that the reference site value of 3.8 ug/L chlorophyll-a is a more realistic restoration threshold, the TN thresholds would be zero (0) tons/month dry-season, 43 tons/month wet-season, and 210 tons/year. A comparison of seasonal and annual TN loads against these lower thresholds would show that the project does not decrease the number of exceedance events because all of the predicted monthly and annual loads are much greater than these lower thresholds. Realistically, the low wet and dry season TN thresholds that correspond to the 3.8 ug/L chlorophyll-a are not achievable unless S-79 flows are greatly reduced from present levels. For the dry season, a drastic reduction in flow is undesirable since this would result in increased estuarine salinity downstream of S-79.

C.10.17 Summary of Water Quality Impacts of Reservoir

The analysis presented here shows that the reservoir is unlikely to cause or contribute to water quality degradation downstream of the project site. (Supplemental water quality analysis is presented in Chapter 11 of this appendix.) While some shift in nutrient load from the wet season to the dry

season will occur as expected, the frequency of exceeding the FDEP's threshold for dry season monthly load of 190 tons/month is unlikely to increase as a result of the project. The frequency of exceeding the wet season monthly TN threshold load will be reduced by approximately 25 percent. The project is not unlikely to increase the average annual TN load at S-79 nor is it likely to increase the frequency of exceeding the threshold of 3,000 tons/year of TN. Based on the results of a DMSTA-2 model run, it appears that the reservoir would remove approximately 20 percent of the TP load that passes through the reservoir.

Although the proposed reservoir reduces the expected annual average nutrient load at S-79 and is expected to improve overall average water quality conditions, there will be limited periods in which the project may cause some downstream water quality degradation. It is possible that on a periodic basis the water quality conditions within the reservoir will result in the occurrence of algal blooms. While it is likely that algal blooms will occur in the reservoir, the possibility that the reservoir will serve as a key source of algal seed is less likely given that water quality conditions within the Caloosahatchee River (C-43) and upstream in Lake Okeechobee already provide substantial quantities of algal material to the estuary.

It is possible that during some periods of the year, the reservoir may become thermally stratified and anoxic at depth. This was shown in the test cell water quality data. These adverse water quality conditions can be mitigated to a great extent through operational schemes that induce vertical mixing of the reservoir water column. Dissolved oxygen levels in the discharge water can be manipulated by using multiple discharge ports that draw off water from the upper and lower water column.

Given the low suspended sediment content of the inflow water, the reservoir is unlikely to accumulate enough sediment such that it will have to be removed in the foreseeable future. Periodic dry down events can be used to consolidate low density sediments and limit re-suspension into the water column. The potential for wind driven re-suspension of sediment is limited given the average operating depth of the reservoir and the low velocity winds typical of Southwest Florida.

The addition of an STA to the reservoir project has been considered and rejected by the PDT at this time. It is apparent from the expected hydrologic flow conditions that the reservoir will not process enough of the Caloosahatchee River (C-43) flows to result in more than a ten percent reduction in the total nutrient load at S-79. Furthermore, the addition of an STA to the project would result in less operational flexibility in meeting the desired flow regime at S-79 and thus potentially reduce overall project benefits. A comprehensive water quality study of the basin should be done once the reservoir is built to determine if adding an STA is the most cost-effect means of improving basin water quality or if non-

structural measures are more cost effective. In addition to reservoir outflows being of equal or better quality than inflows, the reservoir is expected to achieve state water quality standards.

While it can be demonstrated that overall nutrient loading at S-79 will decrease as a result of this project, the magnitude of improvement in water quality conditions within the estuary cannot be predicted with certainty at this time. Given that the primary ecological benefit of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to improve the timing and quantity of freshwater flow to the estuary, the risk that this project may not be able to markedly improve water quality in the estuary should not be seen as a critical flaw.

C.11 SUPPLEMENTAL WQ ASSESSMENT BY USACE AND FDEP PREPARED JUNE 2007

Supplemental Analysis of C-43 West Reservoir Effects on Dry Season Water Quality Downstream of S-79

Mark Shafer, USACE
Ken Weaver FDEP

June 4, 2007

1.0 Introduction

The Corps C-43 West Reservoir draft Project Implementation Report (PIR) includes an assessment of the nitrogen load shift that results from holding wet season flows and discharging them to the dry season. The assessment clearly shows that the average monthly total nitrogen (TN) during the dry season months will increase as a result of the project. This shift of nutrient load from the wet season to the dry season is an unavoidable result of operating the project as intended. The analysis presented in the draft PIR demonstrates that even though a shift of nutrient load to the dry season occurs, the project does not increase the frequency in which the recommended 190 tons/month dry season and the 350 tons/month wet season targets are exceeded. Given that the recommended loading targets were developed for the entire estuary, additional analysis is warranted to demonstrate that the project will not "cause or contribute" to water quality degradation downstream of S-79. The results of four additional assessments are presented below.

2.0 Flow-Weighted Average Nutrient Concentrations

The potential impact of shifting nutrient loads from the wet season to the dry season has been assessed by comparing the with- and without project flow-weighted average nutrient concentrations at S-79. This analysis was done using historical WQ data coupled with spreadsheet hydrology results (IMC) for the period 1981 through 2001. Table 1 shows the wet and dry season TN and TP flow weighted average concentrations for without project conditions compared to with project conditions. This table shows that the with-project dry season and wet season flow-weighted TN concentrations are less than the without project condition. There is a slight increase in the flow-weighted TP concentration for the with project condition when assuming no treatment by the reservoir; however, if 20% removal is achieved by the reservoir as predicted by the DMSTA-2 model run done for the PIR, there would be no increase.

Table 2 shows the monthly TN and TP flow-weighted average concentrations for with- and without project conditions. Under the conservative assumption that the reservoir provides no removal of TN, the with-project condition provides insignificant increases to the February and March average monthly flow-weighted TN concentrations in comparison to the without project condition. The projected increases are well within the accuracy limits of the water quality data. With no TP removal, several of the months

show an increase in the average flow-weighted concentrations. Under the assumption that the reservoir provides approximately 20% removal of TP (as predicted by DMSTA-2), the average monthly flow-weighted TP concentrations for the with-project condition are similar to the without project condition.

3.0 Exceedance Probability Curves of Nutrient Concentrations

The potential impact of shifting nutrient loads from the wet season to the dry season has been assessed by comparing the exceedance probability curves of estimated daily nutrient concentrations for the with- and without project conditions. Figures 1 through 4 show the dry and wet season exceedance probability curves for TN and TP. These curves were developed using the spreadsheet hydrology model and historic S79 water quality data. The comparison of dry season TN concentration exceedance probability curves shown in Figure 1 indicates that the with-project condition provides a slight improvement above the 60% exceedance probability under the assumption that no TN removal occurs in the reservoir. The comparison of dry season TP concentration exceedance probability curves shown in Figure 2 indicates that the with-project condition provides increased TP concentration above the 20% exceedance probability under the assumption of no treatment. Using a reasonable assumption that the reservoir removes 20% of the TP (as estimated by DMSTA-2 modeling), the with-project condition provides TP concentration return frequencies for the dry season equivalent to the without project condition. Figures 3 and 4 show that the wet season TN concentration return frequency for the with-project condition are slightly improved over the without project condition; however, for TP it appears that the project will result in an increase in the frequency of higher concentrations during the wet season. As above, if 20% TP removal is assumed in the reservoir, the project will not cause an increase in the frequency of higher TP concentrations at S-79 during the wet season.

4.0 Temporal Changes in 30-Day Total TN Loads

The project will shift flows and nutrient loads from the wet season to the dry season. Within the dry season itself, periods of low flow and load under the without project condition will be supplemented by releases from the reservoir under the with project condition. Conversely, periods of high flow and load that occur under the without project condition will be reduced by pumping C-43 flows into the reservoir. Figures 5 shows the number of days where the 30-day running total TN load exceeds TN load thresholds. In this figure, it is apparent that the with project condition results in a doubling of the number of days in which the 30-day total TN load is approximately 80 tons. However, above the 150 ton TN threshold, the with project frequency of days exceeding a given threshold load is slightly reduced relative to the without project condition. Figure 6 shows the relationship between the net difference of with and without project 30-day running total TN loads as compared to the without project 30-day running total TN loads. This plot shows that for without project days where the 30-day running total TN load is less than 30 tons, the corresponding with project days tend to result in 50 to 100

additional tons over the preceding 30-day period. Based on the data presented in Figures 5 and 6, it appears that whether the project causes and contributes to water quality degradation due to an increase in dry season loads is dependant upon the effect of shifting the dry season TN load frequency distribution from one dominated by monthly loads in the 0 to 10 tons/30-days range to one dominated by loads between 50 and 80 tons/30 days. The effect of shifting the dry season load frequency distribution can be determined by examining the existing relationship between nutrient loading at S-79 and downstream water quality conditions.

5.0 Relationship Between S-79 TN Loads and Chlorophyll-a.

There have been several attempts to link nutrient discharges at S79 with estuary water quality conditions downstream. Janicki Environmental (2003), under contract with FDEP, developed dry and wet season TN loading targets using historic estuary chlorophyll-a data and S-79 TN loads. This study was cited in the PIR as the source of recommended dry season, wet season, and annual loading targets for TN discharged from S-79. The Janicki recommendation for nitrogen loading to maintain a chlorophyll-a target of 11 µg/l is based an analysis of chlorophyll-a data from the entire estuary. However, since the state's 303(d) listings for the estuarine portions of the Caloosahatchee are based on multiple segments rather than an average condition of the entire estuary, the Janicki targets may not be protective of all portions of the estuary, particularly those where the median concentrations are substantially less than 11 µg/l. (The 11 µg/l concentration is the default threshold concentration used by the DEP's Impaired Water Rule (IWR) as an indication of water quality degradation in coastal estuaries.)

Doering and Chamberlain (2005) described current median chlorophyll-a conditions in four sections of the estuary (upper, mid, lower estuary above Shell Pt, and in San Carlos Bay). The median values calculated by Doering and Chamberlain for the upper (10.7 µg/L) and mid (12.7 µg/L) estuary are at or above the 11 µg/L default threshold used in the IWR; therefore, it can be reasonably assumed that Janicki's critical loads which are based on 11 µg/L would be protective of the existing condition in these two portions of the estuary. However, the existing median chlorophyll-a concentration within San Carlos Bay is 4.2 µg/L and in the lower estuary is (5.3 µg/L). Since Janicki's threshold loads are based on 11 µg/L chlorophyll-a, these loads are not likely low enough to ensure that no water quality degradation occurs in the lower estuary or San Carlos Bay.

5.1 Dry Season S79 Load versus Chlorophyll-a

The comparison of chlorophyll-a concentrations and the dry season 30-day total TN load at S79 is shown for each estuary zone in Figures 7 through 10. Regression equations were fit to each set of data. In general, these equations are not robust predictors of chlorophyll-a concentrations; however, they can be used as an indication of the effect of increasing dry season nutrient loads. For instance, in Figure 7, it appears that for the upper estuary, increased TN load may result in reduced chlorophyll-a concentration since

the slope of the best fit equation is negative. For the middle and lower estuary and San Carlos Bay (Figures 8 through 10), the fitted polynomial equations indicate that increasing TN loading up to approximately 450 tons/month may result in an increase in chlorophyll-a. Given the low regression coefficient (r-squared) for the fitted equations, another analytical method not dependent upon strong correlation between chlorophyll-a and TN load is required before drawing final conclusions regarding the impact of the project caused seasonal load shift.

5.2 Conditional Probability Analysis of TN load versus Chlorophyll-a

The final test to determine the probable effect of the project on dry season chlorophyll-a concentrations in the estuary is a conditional probability analysis. Conditional probability analysis was proposed by Paul and McDonald (2005) as a method of developing geographically specific water quality criteria in the absence of a demonstrably strong relationship between the discharge of a pollutant and a measured biological response to that discharge. Conditional probability is the probability of an event occurring once a preceding event has occurred. In this analysis, the test is whether the increased dry season loads will significantly increase the probability of exceeding the chlorophyll-a threshold concentrations relative to the existing condition. For this analysis, the threshold chlorophyll-a concentration of interest for the upper and middle estuary is the Impaired Water Rule's default 11 µg/L since the median chlorophyll-a concentrations for these two estuary zones are approximately 11 µg/L. For waters where the median concentration is below 11 µg/L such as the lower estuary and San Carlos Bay, the Impaired Water Rule (IWR) specifies listing as impaired these water bodies "if data indicate annual mean chlorophyll a values have increased by more than 50% over historical values". Using this logic, the determination of whether the project causes or contributes to water quality degradation as a result of the shift of nutrient loads to the dry season can be made by testing to see if the project is likely to increase median chlorophyll-a concentrations by 50% over existing conditions within the lower estuary and San Carlos Bay.

Based on Figures 5 and 6, it appears that the project condition is dominated by loads in the 50-100 ton range while the existing condition is dominated by loads less than 10 tons per preceding 30-day periods. If it can be demonstrated that the expected increased dry season loads, particularly in the 30-day 50 to 100 ton range, will not significantly increase existing chlorophyll-a levels by more than the default 11 µg/L in the upper and middle estuary and by no more than 50 percent over present conditions in the lower estuary and San Carlos Bay then it can be concluded that the project will not cause or contribute to water quality degradation downstream of S-79. A significant increase in the conditional probability can be determined based on non-overlapping 90% confidence intervals; that is, the load at which the lower 90% confidence interval is greater than the chlorophyll-a threshold exceedance probability associated with a 0 ton load. Use of a 0 ton baseline represents a conservative assumption, since the baseline dry season condition is dominated by loads in the 0 to 10 ton range.

Figure 11 shows the probability of observing chlorophyll-a concentrations greater than 11 µg/L in the (A) upper and (B) mid estuary segments if specific 30-day TN loads are exceeded. The solid blue line and dashed red lines are the conditional probability distribution and the 90 percent confidence intervals of the conditional probability distribution, respectively. The location of the horizontal dashed line is determined by the upper 90 percent confidence interval associated with a 0 30-day TN load. Since the lower confidence interval lines for the upper and middle estuary segments do not exceed the horizontal dashed lines set at the probability of the 0 ton baseline condition, the expected increase in dry season nutrient loads associated with the project will not result in a statistically significant increase in the median chlorophyll-a concentrations for the upper and middle estuary. Thus, by this measure it is demonstrated that the project will not cause or contribute to water quality degradation in these two upper estuary segments.

Figure 12, shows the probability of observing chlorophyll-a concentrations greater than (A) 5.3 µg/L, (B) 7.95 µg/L, and (C) 11 µg/L in the lower estuary segment if specific 30-day TN loads are exceeded. The solid blue line and dashed red lines are the conditional probability distribution and the 90 percent confidence intervals of the conditional probability distribution, respectively. The horizontal dashed line is placed at the upper 90 percent confidence interval probability associated with a 0 30-day TN load at the S-79. Since the lower confidence interval lines for the lower estuary segments does exceed the horizontal dashed line set at the probability of the 0 ton baseline condition, in the top graph ($P(Chla > 5.3ug/L|X \geq X_o)$), the expected increase in dry season nutrient loads associated with the project will result in a statistically significant increase in the median chlorophyll-a concentrations for the lower estuary. However, using the IWR logic, the critical test in this case is whether the project will result in a 50% increase in the median chlorophyll-a concentration (or 7.95 µg/L). The middle graph of Figure 12 shows that for $P(Chla > 7.95ug/L|X \geq X_o)$, the lower confidence interval line does not exceed the horizontal dashed line set at the upper confidence interval probability of the 0 ton baseline condition. Thus, the expected increase in dry season nutrient loads associated with the project will not result in a statistically significant increase in the probability that chlorophyll-a will exceed 150% of the existing median concentration in the lower estuary. By this measure it is demonstrated that the project will not cause or contribute to water quality degradation in the lower estuary segment.

Figure 13, shows the Probability of observing chlorophyll-a concentrations greater than (A) 4.2 µg/L, (B) 6.3 µg/L, and (C) 11 µg/L in San Carlos Bay if specific 30-day TN loads are exceeded. The solid blue line and dashed red lines are the conditional probability distribution and the 90 percent confidence intervals of the conditional probability distribution, respectively. The horizontal dashed line is placed at the upper 90 percent confidence interval probability associated with a 0 30-day TN load at the S-79. Since the lower confidence interval lines for San Carlos Bay does exceed the horizontal dashed line set at the probability of the 0 ton baseline condition, in the top graph (A) ($P(Chla > 4.2ug/L|X \geq X_o)$), the expected increase in dry season nutrient loads associated with the project may result in an increase in the median chlorophyll-a

concentrations in San Carlos Bay. (The potential increase is not statistically significant since the lower 90% confidence interval remains below the horizontal dashed line.) Again, the critical test in this case is whether the project will result in a 50% increase in the median chlorophyll-a concentration which for San Carlos Bay is 6.3 µg/L. The middle graph (B) of Figure 13 shows that for $P(Chla > 6.3ug/L | X \geq X_o)$, the lower confidence interval line does not exceed the horizontal dashed line set at the upper confidence interval probability of the 0 ton baseline condition. Thus, the expected increase in dry season nutrient loads associated with the project will not result in a statistically significant increase in the probability that chlorophyll-a exceeds 150% of median concentration in San Carlos Bay. By this measure it is demonstrated that the project will not cause or contribute to water quality degradation in San Carlos Bay.

6.0 Conclusions

To assist in the review of the tables and figures presented in the paper, short summary statements are included below:

1.) The project will not result in an increase in the frequency of dry season or wet season exceedances of the targets presented in Janicki (2003) (Draft PIR, April 2007).
2.) The shift in nutrient load will not increase dry season flow-weighted TN concentrations (Table 1)
3.) The shift in nutrient load will not result in a significant increase in the average monthly TN concentrations (Table 2).
4.) The daily flow-weighted TN concentrations for the with-project condition is very similar to the without project condition) with the exception that at higher TN concentrations the project provides a slight improvement in return frequencies (Figures 1 and 3).
5.) The daily flow-weighted TP concentrations for the with-project condition is somewhat higher than without project conditions if no removal by reservoir is assumed. Under a reasonable assumption that 20% TP removal can be achieved within the reservoir, the with project flow-weighted TP return frequency matches the without project conditions (Figures 2 and 4).
6.) Project will result in an increase in the frequency of dry season 30-day loads in the 50 to 100 ton range while decreasing the frequency of dry season 30-day loads in the 0 to 10 ton range and 150 plus tons range (Figure 5).
7.) The project will result in an increase in 30-day loads by approximately 50 to 100 tons for those days when without project conditions provide 30-day loads less than approximately 150 tons. At the same time, the project will reduce 30-day loads by approximately 50 to 100 tons for those days when without project conditions provide 30-day loads in excess of 150 tons. Above 30-day loads of 400 tons under without project conditions, the project will generally not result in an increase or decrease in 30-day loads (Figure 6).

8.) During the dry season, increased flow tends to result in reduced chlorophyll-a concentrations in the upper estuary (Figure 7).
9.) During the dry season, increased TN load tends to result in increased chlorophyll-a concentrations in the middle, lower estuary and San Carlos Bay when 30-day preceding loads are less than less than 450 tons TN (Figure 8-10).
10.) Shifting TN loads during the dry is not expected to have a significant effect on the probability (frequency) of high chlorophyll-a events (>11 µg/L) in the upper or mid estuary (Figures 11A and 11B).
11.) The project may reduce the probability of high chlorophyll events in the upper estuary (Figure 11A), most likely related to increased flushing of the estuary associated with higher flows during the dry season.
12.) There is a potential for an increase in the median chlorophyll-a concentration within the lower estuary at TN loads greater than 64 tons (Figure 12A). However, the increase is expected to be less than 50% (Figure 12B); therefore, it would not be considered a violation of the IWR requirements nor would it be expected to result in a noticeable or deleterious change to the system.
13.) Increased frequency of monthly loads in the 50 to 100 ton range may potentially increase the median chlorophyll-a levels slightly in San Carlos Bay (Figure 13A), although the change in the probability of exceedance is not significant. Furthermore, the increase in median chlorophyll-a concentration is expected to be less than 50% (Figure 13B).

In summary, given the evidence presented in this paper, it is reasonable and prudent to conclude that the project is not expected to have significant negative effects on dry season chlorophyll-a conditions in the four segments of the estuary, i.e., it is not expected to cause or contribute to nutrient response violations in downstream waters.

Table 1. Comparison of Historic Seasonal TN and TP Concentrations Against Estimated Seasonal Flow-Weighted TN and TP Concentrations At S-79 Assuming 0 to 30% Removal by Reservoir

SEASON	Historic Without Project, S79 TN Concentration (mg/L)	No Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)	10% Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)	20% Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)	30% Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)
Dry Season	1.66	1.58	1.50	1.42	1.34
Wet Season	1.65	1.60	1.57	1.54	1.52

SEASON	Historic Without Project, S79 TP Concentration (mg/L)	No Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)	10% Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)	20% Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)	30% Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)
Dry Season	0.12	0.13	0.13	0.12	0.11
Wet Season	0.17	0.17	0.16	0.16	0.16

Page 8 of 18 Additional WQ Assurances June 4, 2007
Mark Shafer P.E. (USACE), Ken Weaver (FDEP)

8

Table 2. Comparison of Historic Monthly TN and TP Concentrations Against Estimated Monthly Flow-Weighted TN and TP Concentrations At S-79 Assuming 0 to 30% Removal by Reservoir

MONTH	Historic Without Project, S79 TN Concentration (mg/L)	No Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)	10% Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)	20% Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)	30% Removal by Reservoir, Flow-Weighted TN Concentration at S79 (mg/L)
January	1.70	1.64	1.56	1.47	1.39
February	2.04	1.78	1.69	1.59	1.50
March	1.52	1.54	1.47	1.40	1.33
April	1.53	1.54	1.47	1.40	1.34
May	1.61	1.46	1.40	1.34	1.28
June	1.66	1.55	1.52	1.50	1.47
July	1.69	1.61	1.59	1.58	1.56
August	1.65	1.62	1.61	1.60	1.58
September	1.63	1.62	1.60	1.58	1.56
October	1.60	1.58	1.53	1.47	1.41
November	1.58	1.55	1.46	1.38	1.29
December	1.65	1.57	1.46	1.35	1.24

SEASON	Historic Without Project, S79 TP Concentration (mg/L)	No Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)	10% Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)	20% Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)	30% Removal by Reservoir, Flow-Weighted TP Concentration at S79 (mg/L)
January	0.11	0.14	0.13	0.12	0.11
February	0.11	0.13	0.12	0.11	0.10
March	0.11	0.12	0.12	0.11	0.10
April	0.11	0.12	0.11	0.11	0.10
May	0.15	0.12	0.12	0.11	0.11
June	0.19	0.16	0.16	0.16	0.15
July	0.20	0.18	0.18	0.18	0.18
August	0.18	0.18	0.18	0.18	0.17
September	0.16	0.16	0.16	0.16	0.15
October	0.14	0.15	0.14	0.13	0.13
November	0.12	0.15	0.14	0.13	0.12
December	0.12	0.15	0.14	0.13	0.11

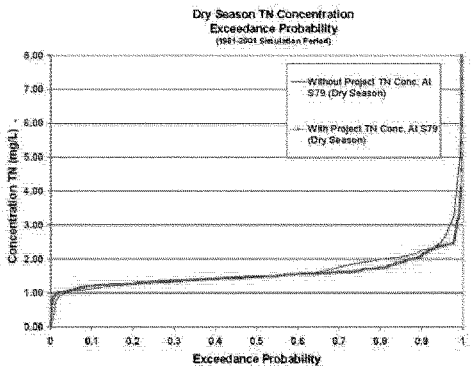


Figure 1. Exceedance Probability Curve for Dry Season TN Concentration at S79.

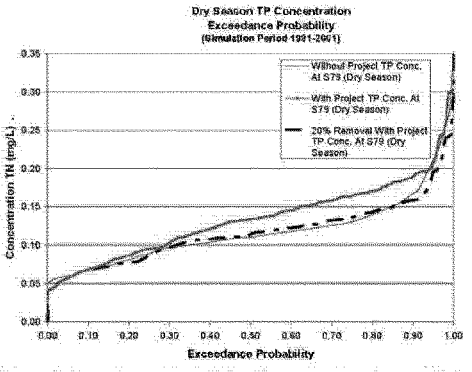


Figure 2. Exceedance Probability Curve for Dry Season TP Concentration at S79.

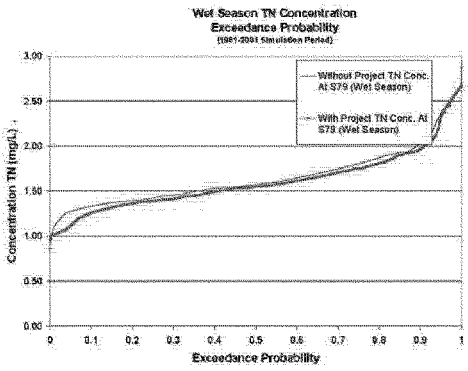


Figure 3. Exceedance Probability Curve for Wet Season TN Concentration at S79.

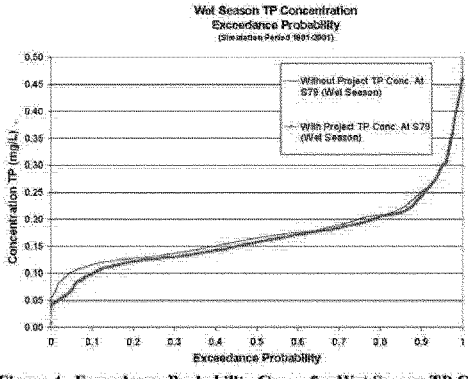


Figure 4. Exceedance Probability Curve for Wet Season TP Concentration at S79.

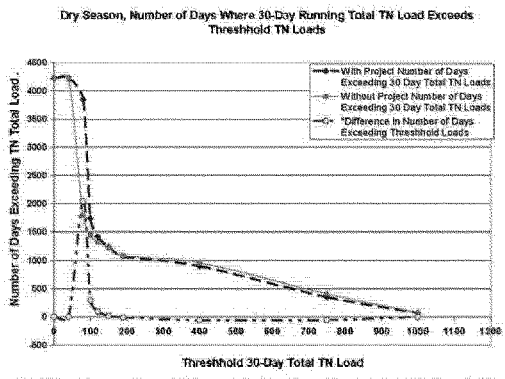


Figure 5. Number of Days Where 30-Day Running Total TN Load Exceeds Threshhold TN Loads for Dry Season Conditions.

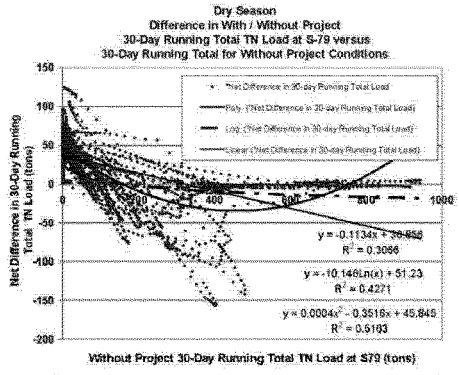


Figure 6. Plot of Difference in With and Without Project 30-day Running Total TN Load at S-79 versus Without Project 30-Day Running Total TN Load.

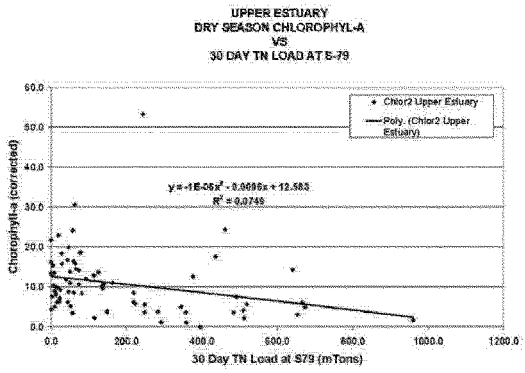


Figure 7. Dry Season Chlorophyll-a (corrected) versus 30-Day TN Load at S-79 for Upper Estuary.

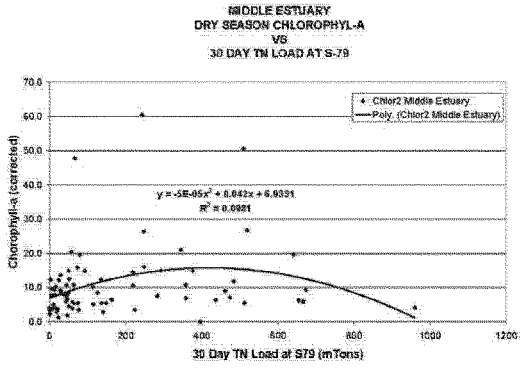


Figure 8. Dry Season Chlorophyll-a (corrected) versus 30-Day TN Load at S-79 for Middle Estuary.

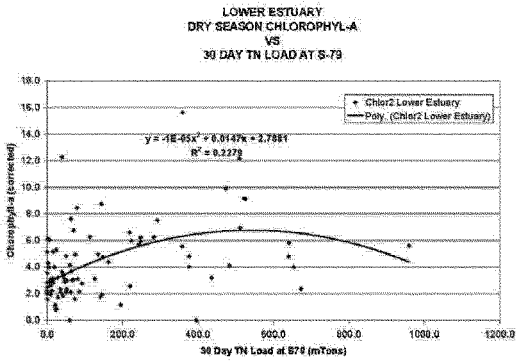


Figure 9. Dry Season Chlorophyll-a (corrected) versus 30-Day TN Load at S-79 for Lower Estuary

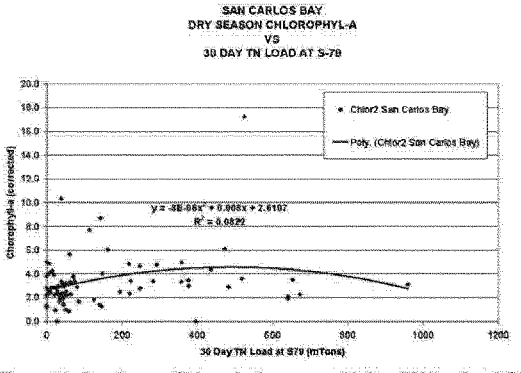


Figure 10. Dry Season Chlorophyll-a versus 30-Day TN Load at S-79 for San Carlos Bay.

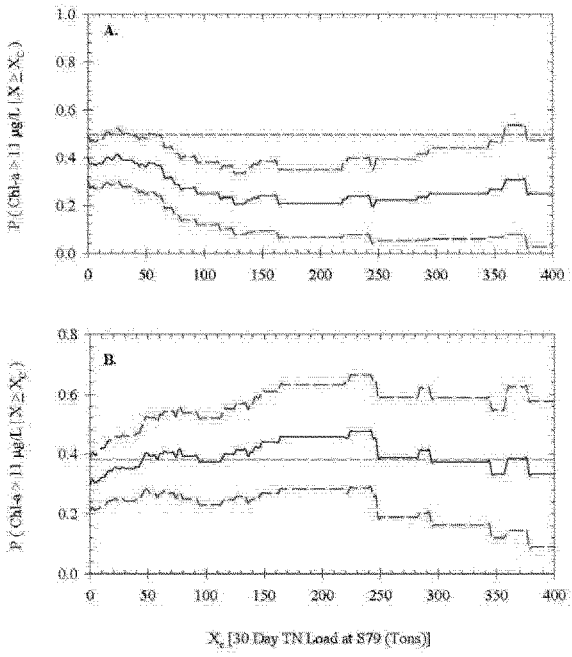


Figure 11. Probability of observing chlorophyll-a concentrations greater than 11 µg/L in the (A) upper and (B) mid estuary segments if specific 30-day TN loads are exceeded. The solid blue line and dashed red lines are the conditional probability distribution and the 90 percent confidence intervals of the conditional probability distribution, respectively. The location of the horizontal dashed line is determined by the upper 90 percent confidence interval associated with a 30-day TN load at the S-79 of 0 tons.

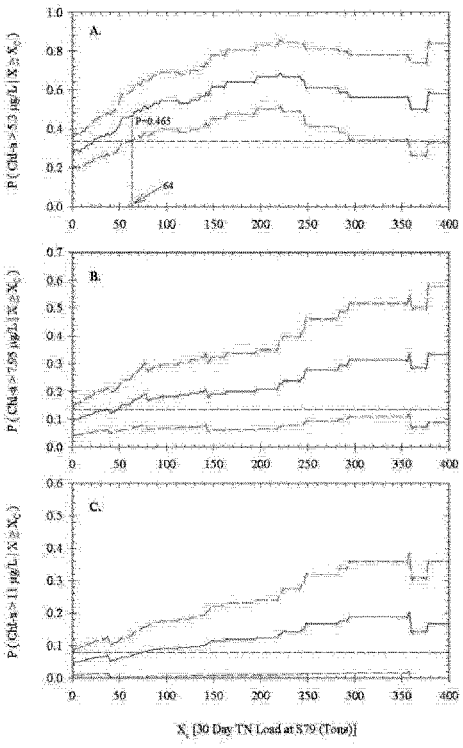


Figure 12. Probability of observing chlorophyll-a concentrations greater than (A) 5.3 µg/L, (B) 7.95 µg/L, and (C) 11 µg/L in lower estuary segment if specific 30-day TN loads are exceeded. The solid blue line and dashed red lines are the conditional probability distribution and the 90 percent confidence intervals of the conditional probability distribution, respectively. The location of the horizontal dashed line is determined by the upper 90 percent confidence interval associated with a 30-day TN load at the S-79 of 0 tons.

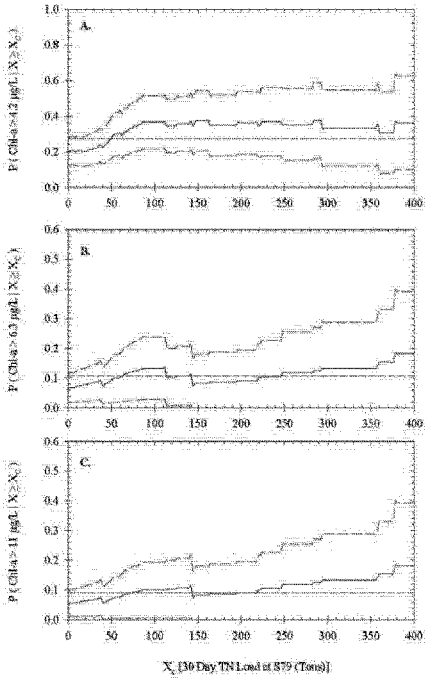


Figure 13. Probability of observing chlorophyll-a concentrations greater than (A) 4.2 µg/L, (B) 6.3 µg/L, and (C) 11 µg/L in San Carlos Bay if specific 30-day TN loads are exceeded. The solid blue line and dashed red lines are the conditional probability distribution and the 90 percent confidence intervals of the conditional probability distribution, respectively. The location of the horizontal dashed line is determined by the upper 90 percent confidence interval associated with a 30-day TN load at the S-79 of 0 tons.

8.0 References

Doering and Chamberlain, 2005, Water Quality in the Caloosahatchee Estuary: Status, Trends and Derivation of Potential Chlorophyll a Goals and Associated Total Nitrogen Loads, Deliverable Number 1, Water Quality Report, Florida Coastal Management Program, South Florida Water Management District, West Palm Beach, FL.

Janicki Environmental, 2003, Development of Critical Loads for the C-43 Basin, Caloosahatchee River, Prepared for the Florida Department of Environmental Protection, Tallahassee Florida.

Paul, John F. and Michael E. McDonald, 2005, Development of Empirical, Geographically Specific Water Quality Criteria: A conditional Probability Analysis Approach, October 2005, Journal of the American Water Resources Association (JAWRA), page 1211.

C.12 RECOMMENDED EST05 MEMORANDUM

MEMORANDUM

TO: Janet Starnes, Accelerated C-43 BSR Project Manager, SFWMD

FROM: Robert H. Chamberlain, Lead. Env. Sci., CED, SFWMD
Peter H. Doering, Sr. Supv. Env. Sci., CED, SFWMD

DATE: December 6, 2004

SUBJECT: Recommended Flow Distribution for S-79

As per your request, we have discussed which distribution of S-79 flows is currently preferred for the Caloosahatchee Estuary. We have decided that EST05 will best promote estuarine health and meet the adopted Minimum Flows and Levels (MFL) requirements. There have been a number of proposed flow distributions during the last decade. We thought it would benefit the project team to briefly review these iterations in order to reduce confusion and also to explain why we recommend EST05.

During the mid-1990s we were charged with providing an estimate of the optimum freshwater inflows to the estuary, based on the results of our previously conducted research (Chamberlain and Doering 1995, 1998a, and 1998b). As part of this analysis, we made the first attempts to define a preferred distribution of flows from S-79 that would better support the estuary's biotic resources. We began by evaluating the inflows that had occurred during the 25 year period 1966-1990. These flows were obviously skewed toward the very low end of the range (Figure 1 and 2a), which routinely threatened the low salinity zone of the estuary where the submerged plant *Vallisneria americana* provides important habitat when allowed to flourish. A distribution of inflows that has the greatest frequency range from 300 to 1,500 cfs, with a peak between 300-800 cfs was determined to be the most beneficial to the range of species evaluated. However, we also recognized that a percent of flows outside the preferred range is an important component of the natural variability inherent in estuaries. An optimization program was employed as a first attempt to define the percent of acceptable violations (Labadie 1995: Otero et al 1995). The desired inflow ranges (limits for biota) were input variables to the model, along with the natural periodicity of violations of the upper and lower limits (estimated from the 1966-1990 historic data). For the Caloosahatchee, 20.5% violation of the low flow limit created inflows that emulated the natural variability established from the rainfall during 1966-1990. In addition to natural variation, this original frequency distribution (Figure 2b) generated by the model revealed that (1) the appropriate inflows limits were attained (300-2,800 cfs); and (2) the greatest frequency of inflows were within the range from 300-1,300 cfs, with a peak of inflows between

300-800 cfs. This original frequency distribution was reported as provisional, with the intent to update it as more information became available about the salinity requirements of key biota.

More resent modeling efforts use a 2000 Base condition (Figure 3a), which have approximate 51% of the flows falling below 300 cfs. Additional field and laboratory research since the Chamberlain and Doering (1998b) publication indicates that *Vallisneria* is more sensitive to water quality conditions related to high salinity during low flows, as well as poor water clarity during excessive discharges. The last major drought constituted significant harm to the *Vallisneria* beds, which have still not fully recovered after 4 years. Subsequent hydrologic modeling work related to the RESTUDY, the Caloosahatchee Water Management Plan, and the development of MFLs produce less low flow violations than the original 20.5% and will better protect *Vallisneria*. Two flow distributions were created during this time: (1) EST01 with 14% of the flows $\leq$ 300 cfs, represented the best determination of a "safe" redistribution of existing non-tidal Caloosahatchee water deliveries; and (2) EST02 (Figure 3b), was based on improving minimum deliveries at S-79. A primary purpose of the C-43 Project is to modify existing watershed runoff so that it falls within the flow envelope for the estuary. EST02 is more likely to achieve this goal. It also is the best available estimate of pre-development delivery. EST05 (Figure 3c) was developed specifically to addresses *Existing Legal Sources for the Caloosahatchee Estuary at S-79*. It is similar to EST02, except that mean monthly inflows at S-79 are maintained above 300 cfs. Therefore, EST05 provides a slightly higher level of protection (against lower salinity) in the upper estuary than the other two time series.

For the accelerated C-43 Project, we recommend using EST05. Although EST02 flows are probably more representative of pre-development conditions, the reality is that permanent alterations have occurred. Addition of a base flow in EST05 recognizes the estuary has been modified, especially by installation of S-79, which truncated the salinity gradient, preventing upstream migration of low salinity water during the dry season, thus eliminating the dry season oligohaline low salinity zone that historically existed. EST05 is consistent with the 300 cfs minimum flow threshold established for the Caloosahatchee Estuary at S-79 (Doering et al. 2002) and is commensurate with the MFL and the recovery strategy for MFL that C-43/CERP needs to provide. Even with EST05's additional protection against low flow conditions, there will be instances of high salinity above the MFL criteria, in part due to low tidal basin inflow. Also, the alternatives to be considered will likely not always produce flows $\geq$ 300, so there will still be occurrences of very low flow consistent with the natural variability of estuarine systems.

C: Deb Drum

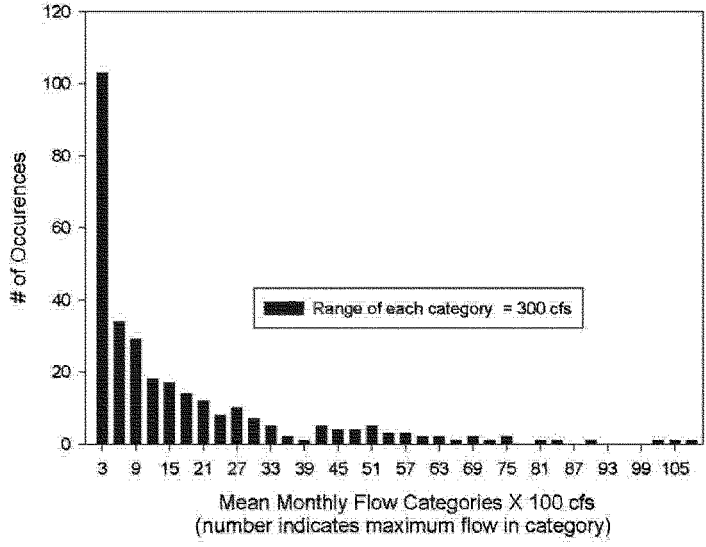


Figure 1. Frequency of mean monthly flow (cubic feet per second) from S-79 during the period 1966-1990.

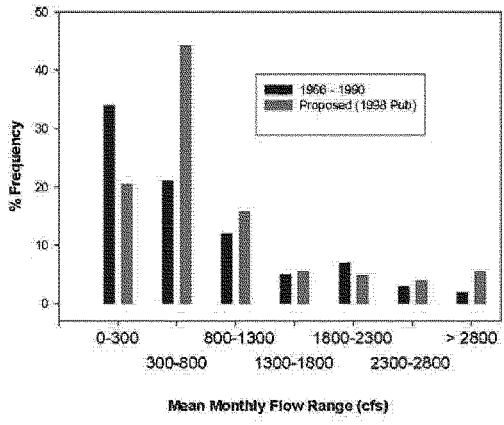


Figure 2. Percent frequency of mean monthly flows from S-79 for: (a) 1966 – 1990, and (b) initially proposed during 1998 publication.

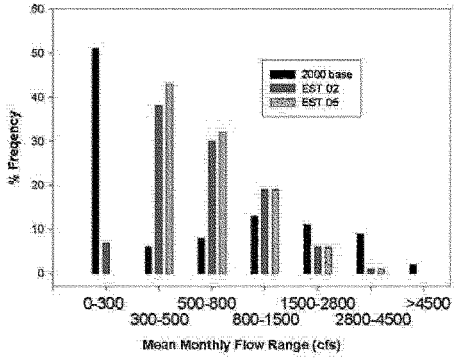


Figure 3. Percent frequency of mean monthly flows from S-79 for: (a) 2000 Base Condition, (b) EST 02, and (c) EST 05.

C.13 CHAMBERLAIN AND DOERING PAPER

PRELIMINARY ESTIMATE OF OPTIMUM FRESHWATER INFLOW TO THE CALOOSAHATCHEE ESTUARY: A RESOURCE-BASED APPROACH

R.H. Chamberlain[1]
P.H. Doering[1]

ABSTRACT

In the Caloosahatchee Estuary, establishing a suitable salinity environment is the most basic prerequisite for promoting estuarine biota in this system. The South Florida Water Management District has adopted a resource-based research strategy with the intent of prescribing an acceptable freshwater discharge distribution within the salinity tolerance range of key estuarine species. To test this approach, submerged aquatic vegetation were selected as key species. This paper presents preliminary results and recommends a provisional inflow distribution.

INTRODUCTION

The Caloosahatchee River (canal C-43) and estuary (Figure 1) have been drastically altered to convey more basin runoff and regulatory releases from Lake Okeechobee (Chamberlain and Doering, this proceedings). These changes have caused large fluctuations in: freshwater inflow volume; frequency of inflow events; timing of discharges; and water quality in the downstream estuary. Therefore, the South Florida Water Management District (SFWMD) initiated a long-term research program in 1985 to quantify the impacts of freshwater inflow from Franklin Lock and Dam (structure S-79) on downstream estuarine organisms. Chamberlain and Doering (this proceedings) described the resource-based management approach of this program and explained that it seeks to define limits for freshwater inflow which provide a suitable salinity and water quality environment for key species. To test this research strategy, submerged vascular plants have been selected as key species.

One aspect of the estuarine research has been field monitoring of water quality and biota during a wide range of discharge events. The purpose of this paper is to report preliminary results of the relationship between freshwater inflow, salinity, submerged aquatic vegetation (SAV) and other estuarine species. These results are based on analysis of field monitoring efforts, in order to: (1) establish provisional limits for the quantity of freshwater discharged to the estuary via S-79, and (2) examine one of the major assumptions of the resource-based approach: that environmental conditions suitable for key species also will be suitable for other important biota.

METHODS

A computational salinity model developed by Bierman (1993) for the Caloosahatchee Estuary (CE) was employed to mathematically define the influence of various freshwater inflows on salinity at every 2 kilometers upstream from Shell Point to S-79. Modeling results compared freshwater inflow influence on the preferred salinity and distribution of SAV and other biota, which were determined from field sampling and the literature. The model also determined that salinity downstream to Shell Point is dependent (97%) on inflow from S-79 and that during average inflow conditions (~1,000 cfs) the hydraulic residence time averages about one month. Therefore, for this report, freshwater discharge to the estuary is considered in terms of mean monthly inflow from S-79.

[1]South Florida Water Management District, Ecosystem Restoration Department, 3301 Gun Club Road, West Palm Beach, FL 33406

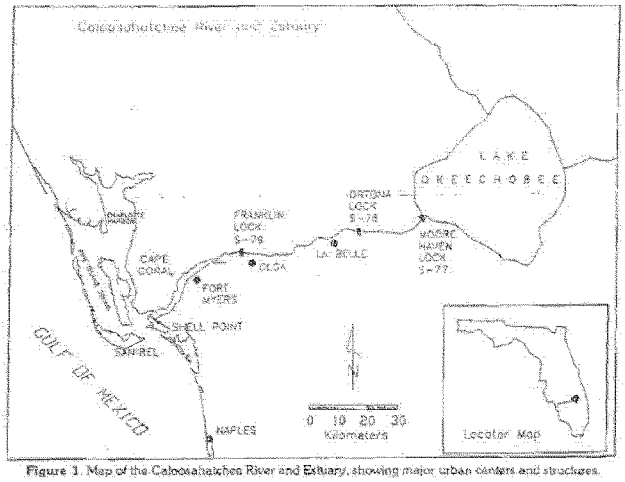


Figure 1. Map of the Caloosahatchee River and Estuary, showing major urban centers and structures.

Field observations of *Vallisneria americana* by Hoffacker (1994), the authors of this paper, and others (Gunter and Hall 1962; Phillips and Springer 1960), served to establish a qualitative abundance index for comparison with salinity at the time of observation. Information from Hoffacker (1994) and the SFWMD were combined to produce a map of SAV distribution upstream of Shell Point (Figure 2).

Monthly water quality and biota sample collections occurred in three phases: phase 1 ran from 1986 into 1989 when S-79 inflows were usually low to moderate; phase 2 was conducted during 1994–1996 when discharges were often large; and two follow-up sample trips (phase 3) to evaluate seagrass recovery were conducted in 1997. Sampling centered around seven locations in phase 1 (Figure 2), areas 1–6 in phase 2, and only location 6 in 1997.

Repetitive random samples of the seagrasses *Halodule wrightii* and *Thalassia testudinum* were collected at locations 5–7 during phase 1 and area 6 in the remaining two phases. For this report, only the photosynthetic blades that were collected within 0.1 m^2 quadrat samples, then dried and weighed, were analyzed (dry weight biomass).

For this preliminary analysis, the effects of freshwater discharge on zooplankton, ichthyoplankton, and benthic macroinvertebrates were evaluated using the data obtained during phase 1 of the SFWMD field monitoring. All data that were not normally distributed were logarithmically transformed. The biota from each station were separated into flow categories (factor levels). A simple one-factor analysis of variance (ANOVA) was

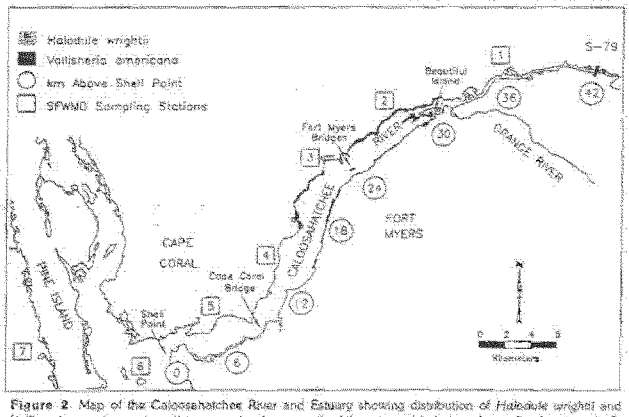


Figure 2. Map of the Caloosahatchee River and Estuary showing distribution of *Halodule wrightii* and *Vallisneria americana*, river distances in km from mouth of the estuary (circles), and sampling locations (1–7, squares).

calculated to test for statistical difference between the mean monthly inflow categories ($p<0.05$). A hierarchy evaluation (Scheffe multiple range test) for mean density between inflow categories was performed to determine which inflow levels were associated with significantly more or less biota. Because adult finfish, crabs, and shrimp were not sampled, we relied on literature information from the CE and other Florida estuaries to estimate desired inflow conditions for these biota.

RESULTS AND DISCUSSION

Salinity And Freshwater Inflow

The salinity model results (Bierman 1993) indicate that more than half the estuary upstream of Shell Point will become nearly freshwater and, salinity will be reduced drastically downstream during even moderate mean monthly discharges of 2,000 cfs (Figure 3). Inflows greater than 4,000 cfs will cause most of the estuary upstream of Shell Point to become freshwater and depress salinity (<15 ppt)in portions of San Carlos Bay. At the other extreme, prolonged low to no flow (<100 cfs) results in salinity conditions near S-79 that exceed 15 ppt, eliminating any tidal freshwater or oligohaline zone within the estuary.

V. americana longitudinal distribution is about 18 km during ideal growing conditions and stretches from its upstream limit at 32 km, as measured from Shell Point, to its downstream limit at 14 km (Figure 2). Based on this distribution, we estimated that over 80% of the total area covered by moderate to dense stands of *V. americana* under favorable growing conditions are in the first 4 km (28–32) of its upstream limit.

Literature information indicates that *V. americana* growth steadily declines with increasing salinity until it ceases at approximately 8–9 ppt, but it can tolerate salinity (survive) up to 11–13 ppt (Day et al.

Chamberlain, Doering

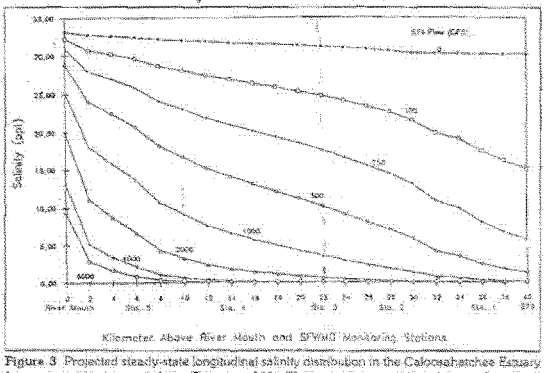


Figure 3. Projected steady-state longitudinal salinity distribution in the Caloosahatchee Estuary for a range of freshwater inflows (Bierman 1993). The x-axis corresponds to distance from Shell Point (km).

1989, Twilley and Barko 1990). The qualitative information assembled from observations in the CE (Figure 4) is consistent with these limits and indicates that density declines where salinity is above 10 ppt. A similar plot of biomass vs. temperature reveals no trend, suggesting little influence of temperature on *V. americana* distribution in this system.

Employing the results of the model by Bierman (1993; Figure 3), it appears that at least a 300 cfs mean monthly discharge from S-79 is required to maintain *V. americana* in the system. Analysis of historical S-79 discharges determined that attaining the 300 cfs minimum inflow will be a concern only during the November–May dry season. Therefore augmentation of flow should be considered during this time. Discharges that approach 400–500 cfs will provide salinity conditions of <10 ppt within the portion of the estuary that support most of the total *V. americana* coverage. To provide salinity conducive for *V. americana* throughout its entire 18 km range will require mean monthly discharges of approximately 800 cfs.

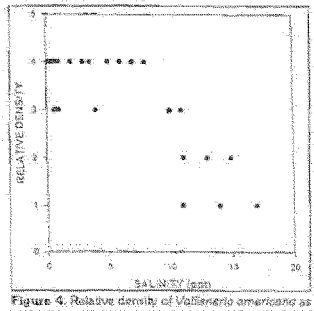


Figure 4. Relative density of *Vallisneria americana* as a function of salinity in the Caloosahatchee Estuary. Density ranks equate to following: 1 = absent; 2 = absent to sparse; 3 = moderately dense; 4 = dense. Each circle corresponds to one observation (Phillips and Springer 1960; Gunter and Hall 1962; Hoffacker 1994; SFWMD).

H. wrightii is the only seagrass species consistently found around station 5, upstream of Shell Point, until it mixes downstream with *T. testudinum* in San Carlos Bay (Figures 5a and b). *H. wrightii* has a much smaller distribution upstream of Shell Point than *V. americana*. It ranges only from 2–10 km upstream of Shell Pt., with the greatest coverage per 2-km segment within the 4-6 km area.

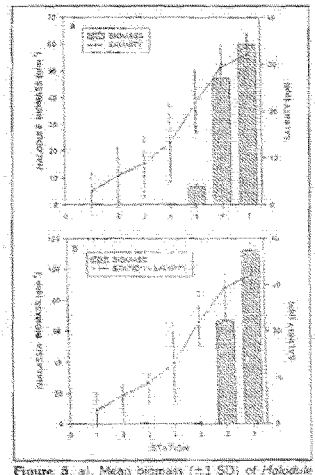


Figure 5. a). Mean biomass (±1 SD) of *Halodule wrightii* (dry weight) and salinity (±1 SD) at each sampling station for all seasons combined, and (b) mean biomass (±1 SD) of *Thalassia testudinum* (dry weight).

H. wrightii is reported to have a wide salinity tolerance by McMahan (1968). It does not survive below 3.5 ppt and prefers salinity as high as 44 ppt. This wide tolerance is probably why it is the only true seagrass species encountered inside the CE at station 5, although high discharges probably limit its productivity. The lowest biomass occurs inside the estuary where salinity is also lowest and most variable. Graphically and statistically, biomass of *H. wrightii* is greater when salinity is above 20 ppt (Figure 6). Statistically, the greatest biomass occurs when salinity is >28 ppt.

Literature summarized by Zieman and Zieman (1989) indicates that the optimum salinity range for *T. testudinum* is 24–35 ppt, with maximum photosynthetic activity occurring at 35 ppt and decreasing linearly with declining salinity. *T. testudinum* does not normally grow in areas where salinity is below 17 ppt. These literature values are consistent with preliminary monitoring results for the CE (Figure 5b). *T. testudinum* does not exist inside the estuary (in Iona Cove: area 5), where salinity during sampling was more variable, with a standard deviation that extended below 20 ppt due to long periods below 10 ppt. Like *H. wrightii*, the biomass of *T. testudinum* is statistically greater when salinity is above 20 ppt, regardless of season.

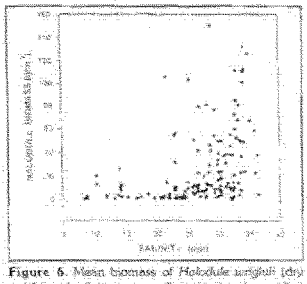


Figure 6. Mean biomass of *Halodule wrightii* (dry weight) and salinity per sampling trip at each sampling station for all seasons combined.

According to the Bierman model and statistical analysis, the 400–600 cfs needed to support over 80% of the *V. americana*, will not lower salinity below that preferred by *H. wrightii* (>20 ppt) anywhere in its current range. Salinity begins to approach the reported mortality limit of *H. wrightii* (3.5 ppt) in area 5 when average discharges approach 3,000 cfs for more than a month. Both *H. wrightii* and *T. testudinum* biomass are statistically greatest throughout their respective distributions when mean monthly inflow is less than about 800 cfs for more than two months. In San Carlos Bay, mean monthly inflows >4,500 for two or more months are statistically associated with the least biomass for both species.

Finfish

At least 75% of Florida's recreational fishes depend on estuaries for at least a portion of their life. The most important role of estuarine systems is as a nursery area for juvenile stages (Seaman 1988). In the upper CE, Gunter and Hall (1962) reported the greatest catches in seines consisted of juveniles, during midwinter inflows that reduced salinity in the inner estuary to 1–5 ppt (station 2 area). Seine catches in the outside water (San Carlos Bay area) were greatest when salinity was high. Therefore, establishment of a minimum inflow for *V. americana* should generally benefit the finfish of the estuary by providing a salinity gradient that includes desired low salinity conditions upstream for juveniles. Maintenance of this minimum flow is apparently most critical during the winter dry season. However, year round high maximum inflow limits that maintain salinity downstream of Shell Point also appear beneficial.

Bay anchovy (*Anchoa mitchilli*) juveniles and adults were the third most abundant fish collected by Gunter and Hall (1962), with 94% of the fish caught upstream of Shell Point. Most of the juveniles they caught were from near zero salinity water at stations close to *V. americana* beds at Beautiful Island and the Ft. Myers bridges. This is consistent with Jones et al. (1978), who reported that juveniles often ascend rivers above brackish waters. Therefore, inflows within the optimum range for SAV (300–800 cfs) should not adversely impact bay anchovies, and should provide better conditions for their development and food production.

Redfish (*Sciaenops ocellata*) are an important game fish in Florida. Spawning occurs seaward of estuary passes during late summer and fall. Seaman (1988) reported that seagrass meadows are primary habitat for young redfish. Once in the estuary, juveniles feed on benthic organisms from October to February and later on small fish and shrimp. Collections of redfish in the CE (Phillips and Springer 1960; Gunter and Hall 1962) were almost exclusively inside the estuary with salinity ranging from 0.2–14 ppt. Therefore, promoting dry season inflows conducive for SAV also will provide salinity and habitat for redfish recruitment and development.

Ichthyoplankton

Anchoa spp. comprised 76% of the SFWMD ichthyoplankton samples during 1986–1989 (unpublished data). The greatest density occurred during April–July, followed by the period of December through March. During the dry season, when inflows will need to be augmented for *V. americana*, high inflows >2,500 cfs were associated with the lowest mean ichthyoplankton density, regardless of location in the estuary. Mean density within the flow category of 300–600 cfs were at least the second highest at all stations, and therefore represented the optimum overall flow category.

The presence of developing fish eggs provides a good indication of the spawning location and recruitment success of fish in an

estuary. Statistical analysis of eggs within ichthyoplankton samples during the dry season found significant differences existed among inflow categories: inflows in the range of 150–600 cfs were associated with the highest mean egg density at stations 1–4; and density decreased as inflows increased above this category. In fact, no eggs were ever collected during this season at stations 1–5 when inflows were >2,500 cfs and substantially fewer eggs were collected at station 6. Reduced egg density during high inflows are assumed to be related to a 'flush-out' effect, so similar impacts probably exist during the wet season.

Zooplankton

Zooplankton provide a crucial link in the estuarine food web when they consume free-floating microscopic plants (phytoplankton) and transfer plant energy to higher trophic levels. Dominant forage fishes such as bay anchovy, as well as juvenile stages of most estuarine fish species, depend on zooplankton as a food source.

Within each season, mean zooplankton density increased with increasing salinity and distance from S-79. In general, zooplankton density was greatest during April–July. Collections during this time period appeared sensitive to high flows. Inflows greater than 1,500 cfs resulted in the lowest mean density at all stations. Evaluation of dry season inflow (November–May) revealed significant lower density with flows >1,200 cfs. Zooplankton mean density associated with inflows between 300–600 cfs were consistently among the greatest encountered at each station.

Invertebrates

In the Little Manatee River (southwest Florida), Peebles and Flannery (1992) reported that transfer of the estuary's food source to juvenile fish appeared to occur largely through their feeding on benthic organic material. Therefore, the density of benthic organisms can strongly influence the survival of many higher trophic species. The SFWMD benthic macroinvertebrate survey (unpublished data) found that the CE supports a large number of species (519). The majority of these are sessile and can't relocate to a more favorable location when water quality deteriorates. CE inflows within the optimum range for *V. americana* appear conducive for supporting a wide range of benthic infauna. Statistical analysis of dry season data indicate that peak benthic macroinvertebrate density at stations 1–4 was associated with inflows (150–600 cfs) that establish salinity in approximately the mesohaline range (5–18 ppt). This same preliminary analysis also indicated that mean monthly discharges >3,000 cfs are associated with the lowest densities at stations 1–4.

Penaeid shrimp probably represent the most economically important fishery in Florida (Seaman 1988). Mating and spawning occurs offshore and the postlarvae migrate into the estuary and seek shallow areas with vegetation and/or abundance of organic detritus. The loss of SAV directly reduces fishery yields (Seaman 1988). Gunter and Hall (1962) indicated pink shrimp (*Penaeus duorarum*) were common in seine and net samples in the CE. Haunert (1987) reported pink shrimp abundance increased after inflows increased in the St. Lucie Estuary, but decreased when inflows caused salinity to decline to oligohaline conditions (<5 ppt), which are not tolerated well by pink shrimp (McFarland and Lee 1963; Gunter et al. 1964). Therefore, in the CE, minimum and maximum inflows that promote SAV at both the inner estuary and the Iona Cove–San Carlos Bay regions should provide ideal salinity for pink shrimp and support bottom vegetation habitat important for postlarvae development.

The CE supports a year-round commercial

Chamberlain, Doering

and sport fishery for blue crabs (*Callinectes sapidus*). This species also is an important source of food for many fish. The first development stages are planktonic, which prefer 30 ppt and will perish if exposed to salinity <20 ppt (Millikin and Williams 1984). After settling out of the plankton, each subsequent juvenile phase of both sexes is concentrated in progressively lower salinity because of their continuing migration up the estuary (Millikin and Williams 1984). Juvenile and adult blue crabs also occur in much

Table 1. Provisional recommended inflows (cubic feet/second) for promoting the health of selected taxa in the Caloosahatchee Estuary.

SPECIES	LOWER INFLOW LIMIT (LIL)	PREFERRED INFLOW RANGE (PIR)	UPPER INFLOW LIMIT (UIL)	IMPORTANT MONTHS
Vallisneria	300	>400		dry season (Nov–May) LIL, PIR
Halodule, *Thalassia*		<800	3,000 *Halodule* 4,500 *Thalassia*	all year — UIL
Fish (general)	300	300–1,300	3,000	dry season — PIR; all year — UIL
Bay anchovy	300	300–800	3,000	dry season — PIR; all year (esp. spring) — UIL
Silver perch	300	300–800	3,000	dry season — PIR; all year (esp. Jan–early summer) — UIL
Redfish	300	300–800	3,000	dry season (esp. Nov–Mar) — PIR; all year (esp. Jul–Dec) — UIL
Snook	300	300–1,500	3,000	late dry season — PIR; all year (esp. late dry season) — UIL
Larval fish		300–600	2,500	dry season (esp. spring–early summer)
Fish eggs		150–600	2,500	all year
Pink shrimp	300	300–800	3,000	all year
Blue crabs	300	300–800	3,000	all year (esp. Feb–Jul)
Zooplankton		300–600; <1,500	2,500	all year
Shrimp and crab larvae		<1,300	2,500	all year (esp. spring–Jul)
Benthic macro-invertebrates		300–800	3,000	all year
Oysters		300–800	3,000	all year

-128-

higher densities in areas covered by vegetation. Therefore, inflows in the range of 300–800 will be beneficial for blue crabs because of their salinity requirements throughout the CE, as well as the SAV habitat that these flows promote in both the inner and outer estuary.

ESTIMATE OF OPTIMUM INFLOW

Table 1 recommends provisional inflow ranges and timing for maintaining the health of the important taxa discussed above and others. The preliminary analysis suggests that a minimum inflow of 300 cfs for *V. americana* during the dry season will not be harmful, but inflows greater than about 2,500–3,000 cfs may be detrimental to other biota anytime of the year. Therefore, a distribution of inflows that has the greatest frequency range from 300 to <1,500 cfs, with a peak of 300–800 cfs, should be generally beneficial to all the biota evaluated.

Beyond identifying the optimal timing and distribution of inflow, we also must consider that freshwater inflow varies naturally as a function of rainfall. Inclusion of this natural variation is important to insuring a diverse composition of estuarine biota. Ultimately, this will mean a defined percent of violations should be allowed for both the high and low discharge limits. As a first attempt to define this environmentally sensitive distribution of S-79 discharges, a optimization program (computer model) was employed (Labadie 1995; Otaro et al. 1995). The program utilized historic watershed runoff data during 1966–1990 (without Lake Okeechobee releases). The desired inflow ranges (limits for the biota) are input variables to the model, along with the natural periodicity of violations of the upper and lower limits (estimated from the 1966–1990 historic data). For the Caloosahatchee Estuary, 20.5% violation of the lower limit and 5.5% violations of the upper limit created inflows that emulated the natural variability established from rainfall during 1966–1990. In addition to natural variation, the resulting frequency distribution generated by the model (Table 2) reveals that: (1) the appropriate inflow limits were attained (300–2,800 cfs); and (2) the greatest frequency of inflows were within the range from 300–1300 cfs, with a peak of inflows between 300–800 cfs.

Table 2. Proposed frequency distribution of freshwater inflows to the Caloosahatchee Estuary for 1966–1990 generated by the optimization model.

FREQUENCY OF OCCURRENCE (%)	DISCHARGE RANGE (from S-79; cfs)
20.5	0–300
44.3	301–800
15.7	801–1300
5.5	1301–1800
4.8	1801–2300
3.9	2301–2800
5.5	>2801

The above-recommended optimum flow distribution is provisional, based on the data currently evaluated, preliminary model results, and our best professional judgement. A final distribution will be established after a better understanding of the salinity tolerances of seagrass and other species is determined. This will be accomplished by conducting a more detailed evaluation of the field data than provided in this summary, and by completing field and lab experiments, which have already begun.

ACKNOWLEDGMENTS

The resource-based strategy was based on peer reviewed guidelines developed by Mote Marine Laboratory for SFWMD estuarine research, and applied in the St. Lucie Estuary. Mote Marine Laboratory also identified and enumerated the organisms contained in the Caloosahatchee samples. The field work, sample processing, and data management depended on the effort of many SFWMD staff, most notably Dan Crean and Kathy Haunert.

LITERATURE CITED

Berman, V. 1993. Performance Report for the

Caloosahatchee Estuary salinity modeling. SFWMD expert assistance contract deliverable from Limno-Tech, Inc.

Day, J.W., C.A.S. Hall, W.M. Kemp and A. Yanez-Arancibia. 1989. Estuary Ecology. John Wiley and Sons, Inc. 558 pp.

Gunter, G., J.Y. Christmas and R. Killebrew. 1964. Some relations of salinity to population distributions of motile estuarine organisms with special reference to penaeid shrimp. Ecology 45:181–185.

Gunter, G. and G.E. Hall. 1962. Biological investigation of the Caloosahatchee Estuary in connection with Lake Okeechobee discharges through the Caloosahatchee River. Consultant report to the U.S. Corps of Engineers, Jacksonville District. Serial No. 25. 59 pp.

Haunert, D.E. 1987. A proposed supplemental water management strategy to enhance fisheries in the St. Lucie Estuary, Florida. SFWMD Draft Report.

Hoffacker, V.A. 1994. Caloosahatchee River submerged grass observations. W. Dexter Bender and Associates, Inc. Letter-report and map to Chip Merriam, SFWMD.

Jones, P.W., F.D. Martin and J.D. Hardy, Jr. 1978. Development of fishes of the Mid-Atlantic Bight, vol. 1. Acipenseridae through Ictaluridae. U.S. Dept. Interior, Fish and Wildl. Serv. 366 pp.

Labadie, P.W. 1995. Optimization of managed runoff to the St. Lucie Estuary. Final contract report for SFWMD, P.O. No. PC P60517. 38 pp.

McFarland, W.N., and B.D. Lee. 1963. Osmotic and ionic concentrations of penaeidean shrimps of the Texas coast. Bull. Mar. Sci. Gulf Caribb. 13:391–417.

McMahan, C.A. 1968. Biomass and salinity tolerance of shoal grass and manatee grass in Lower Laguna Madre, Texas. J. Wildl. Manage. 33:501–506.

Millikin, M.R. and A.B. Williams. 1984. Synopsis of biological data on the blue crab, Callinectes sapidus Rathbun. NOAA Tech. Rep. NMFS 1, FAO Fisheries Synopsis No. 138, 39 pp.

Otero, J.M., J.W. Labadie, D.E. Haunert and M.S. Danon. 1995. Optimization of managed runoff to the St. Lucie Estuary. In: Water Resources Engineering, Volume 2. W.H. Espey, Jr. and P.G. Cobbs, (ed): Proceedings of First Intern. Conf., Water Resources Engineering and Amer. Soc. Civil Engineers (ASCE), pages 1506–1510.

Peebles, E.B. and M.S. Flannery. 1992. Fish nursery use of the Little Manatee River estuary (Florida): relationships with freshwater discharge. Final Rep. for Southwest Florida Water Management District. 91 pp.

Phillips, R.C. and V.G. Springer. 1960. A report on the hydrography, marine plants, and fishes of the Caloosahatchee River area, Lee County, Florida. Fla., State Bd. Conserv., Marine Lab. Special Science Report. No 5. 34 pp.

Seaman, W., Jr. (ed). 1988. Florida aquatic habitat and fishery resources. Florida Chapter, American Fisheries Society, 543 pp.

Twilley, R.R. and J.W. Barko. 1990. The growth of submerged macrophytes under experimental salinity and light conditions. Estuaries 13: 311–321.

Zieman, J.C. and R.T. Zieman. 1989. The ecology of the seagrass meadows of the west coast of Florida: a community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85(7.25). 155 pp.

C.14 EXISTING LEGAL SOURCES OF WATER FOR THE CALOOSAHATCHEE ESTUARY

Existing Legal Sources for the Caloosahatchee Estuary At the Franklin Lock and Dam (S-79)

Coastal Ecosystems Division

Southern Restoration Department

May 2003

1

Introduction:

The Water Resources Development Act of 2000 (WRDA 2000) assures the protection of existing legal sources of water as of the date of enactment, December 2000. CERP projects cannot eliminate or transfer an existing legal source of water unless a new source of water supply of comparable quantity and quality is available to replace water lost as a result of the Plan.

Legal sources are defined as follows:

> *The quantity of water available from all locations of which there was a dependence as of December 2000, consistent with federal and State law for: 1) urban and agricultural existing legal uses, including those uses exempt from permitting requirements; 2) non-consumptive uses, including regional surface water deliveries and groundwater seepage for resource protection; 3) meeting the entitlement rights of the Seminole tribe of Florida; 4) the Miccosukee Tribe; 5) federal and state requirements for Everglades National Park; and 6) protection of fish and wildlife.*

It is proposed to spatially separate the major regions or user basins of the C&SF project to properly determine the dependence of each basin on existing legal sources. Within this context, estuaries may be viewed as "user basins" that have existing legal sources of freshwater for the protection of fish and wildlife. The task at hand is to quantify the volume of water currently delivered to estuaries that is beneficial (=protects) to fish and wildlife and sustains healthy populations.

Beneficial Discharges to Estuaries:

No standard methods exist to quantify the beneficial discharge of freshwater to an estuary. Freshwater discharge affects many aspects of the estuarine environment including circulation, water chemistry, salinity, residence time, and biological

2

productivity. In turn changes in any of these parameters can affect estuarine fish and wildlife. Thus, the "benefits" to fish and wildlife of a particular discharge event may be defined in terms of any of these parameters. In general, the approach used here has been to examine the effects of freshwater discharge on salinity and in turn the effects of salinity on selected estuarine organisms. A discharge is beneficial if it produces a salinity regime that allows estuarine organisms to successfully reproduce and survive. A salinity-based definition was chosen because historically, salinity has been identified as the environmental variable that primarily controls the performance, composition, distribution and abundance of estuarine flora and fauna (Bulger et al. 1993, Emery et al. 1957, Gunter 1961).

Another important aspect of freshwater discharge to estuaries is that it varies. The natural component of this variability in discharge is primarily a function of temperature and rainfall. Although there are exceptions, freshwater discharge accounts for much of the variation in estuarine salinity at seasonal and inter-annual time scales (Peterson et al. 1995). This kind of natural variability can cause dramatic changes in the composition and distribution of estuarine biota (Tyler 1986, Nichols, 1985). Despite the noticeable effects that it may have, beneficial discharges should allow for natural variability. Ideally, a beneficial discharge rate should not be viewed as a single constant value but as a long-term average derived from a time-series that follows a natural periodicity.

In order to quantify this beneficial volume or discharge, two pieces of information are required. First, we need to know the quantity of water delivered as of Dec. 2000. Output from the South Florida Water Management Model (SFWMM) 2000 will serve as an estimate of "current water delivery". Second, a "beneficial discharge target" must be defined and quantified. In the best case, both the "current water delivery" and the "beneficial discharge target" will be defined as a climate driven time-series of daily flows. Once the two are known, the "beneficial deliveries" as of Dec 2000 can be calculated by a straightforward subtraction of the "current water delivery" from the "beneficial discharge target".

3

South Florida Water Management Model:

The South Florida Water Management Model (SFWMM) is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7600 square miles using a mesh of 2 mile x 2 mile cells. In addition, the model includes inflows from Kissimmee River, and runoff and demands in the Caloosahatchee River and St. Lucie canal basins. The model simulates the major components of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal-groundwater seepage, levee seepage and groundwater pumping. It incorporates current or proposed water management control structures and current or proposed operational rules. The ability to simulate water shortage policies affecting urban, agricultural, and environmental water uses in South Florida is a major strength of this model. The SFWMM simulates hydrology on a daily basis using climatic data for the 1965-2000 period which includes many droughts and wet periods. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. The 2000 Base run, which serves as an estimate of current water delivery, simulates the 36-year period from 1965 – 2000 on a daily basis, assuming land uses as they were in 2000. The "beneficial discharge target" also will simulate the same period on a daily basis.

Since the literature concerning beneficial discharges to estuaries is not well developed, there are no accepted methods for quantification. Several possible approaches are described below.

Flow Range Approach:

In general, the South Florida Water Management District has applied a resource-based approach to water management issues in estuaries. Water quantity issues (e.g. minimum, maximum, and optimum flows) have been addressed by (1) identifying important resources and their location in an estuarine system (e.g. oysters, Submerged Aquatic Vegetation), (2) determining the salinity tolerances of these resources, (3) determining

the relationship between freshwater inflow and the distribution of salinity within in the estuary and (4) determining the freshwater discharge that produces overlap between a resource and its tolerable salinity. The salinity tolerance information can be used to identify a salinity envelope (with an upper bound and lower bound) within which these keystone resources can successfully complete their entire life cycle. The relationship between salinity and fresh water discharge can in turn be used to identify a range of freshwater inflows (with a lower bound and an upper bound) that maintains salinity within the prescribed envelope at appropriate locations in the estuary. These flows are beneficial and protect fish and wildlife. In general, the salinities employed in these envelopes are those which can be tolerated by indicator organisms for about a month or longer. The flows associated with these envelopes are therefore mean monthly flows.

In the simplest application, an upper limit to beneficial flows is identified such that higher flows are not considered beneficial. Flows in the output from the SFWMM model that fall below this critical level are considered beneficial. Because they fall below minimum flows, excessively low flows, while not harmful, provide essentially no ecological benefit. The counter argument, employed in this method is that some flow, however small, is more beneficial than none at all. The procedure is illustrated in Figure 1.

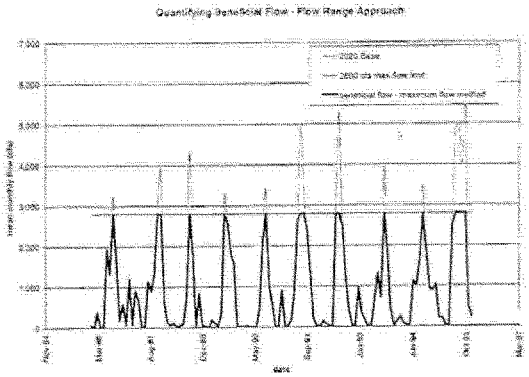


Figure 1. Beneficial Flow based on maximum acceptable flow

Flow Distribution Approach:

The flow distribution is an extension of the flow range approach described above. The salinity or flow envelope approach specifies a range of acceptable flows and limits that can be used to define a "beneficial volume". However, these limits are constant, containing no signature of natural variability. Runoff events outside the norm occur with some frequency. While it is not known precisely what frequencies are beneficial or harmful to an estuary, it is generally accepted that elimination of naturally occurring "extreme" events would be detrimental. Therefore, a distribution with most flows occurring inside the envelope and higher or lower flows occurring outside the envelope with some lower frequency is more natural and desirable.

The problem is to identify the shape of the "beneficial" frequency distribution. A flow frequency distribution is composed of a number of contiguous flow ranges and a frequency of occurrence for each. A contiguous series of flow intervals can be defined by the different levels of physiological or demographic performance that occur at different levels of flow or salinity. A qualitative impression of the relative frequency of each interval can be based on the number and quality of physiological or demographic functions supported by each interval (Figure 2). For example, in Figure 2, the frequencies of flows in the 500 to 700 cfs and 700 – 900 cfs intervals are highest because these support the best adult survival, growth and reproduction and the highest population abundances and instances of occurrence.

The resulting distribution is a qualitative representation of a hydropattern that is ecologically favorable for biota in the Caloosahatchee estuary. Climate driven hydrologic modeling is then used to create a hydrologic pattern that is both consistent with the species driven hydropattern and the statistical characteristics of river discharge to an estuary (log-normal mean monthly flows). The final hydropattern is a 36 year (1965 – 2000) time series of daily discharge for S-79 that produces a frequency distribution of mean monthly flows that is log-normal and includes natural variability.

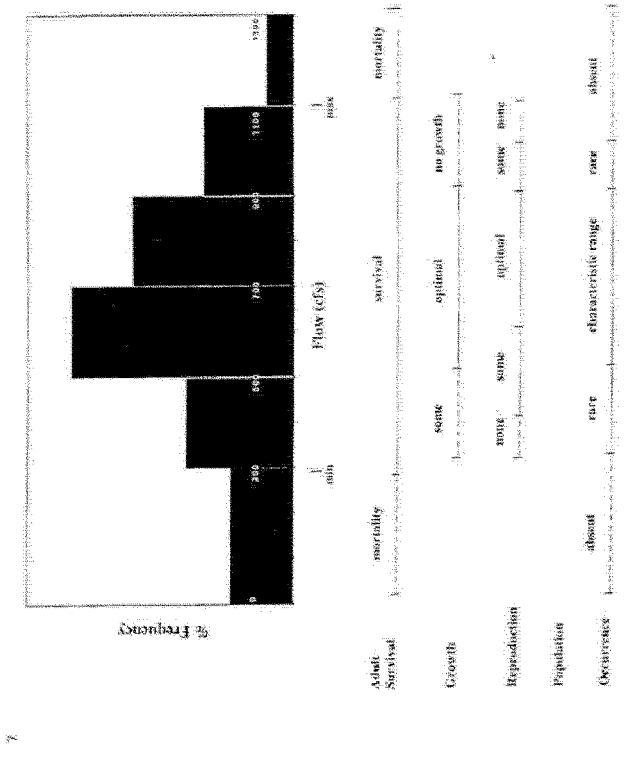


Figure 2. Conceptual derivation of an ecologically based distribution of freshwater inflow

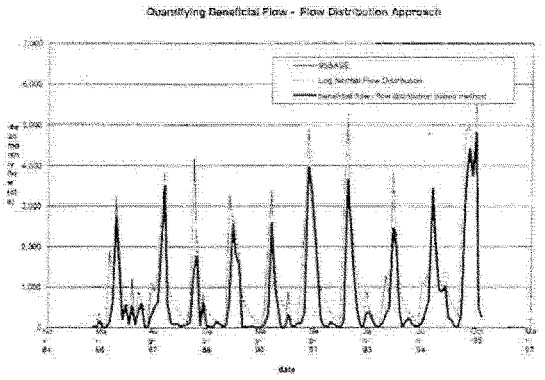


Figure 3. Beneficial Flow based on flow distributions.

Pre-Development Flow Approach:

For some estuarine systems it may not be possible to use the resource-based approach described above. This may occur because important resources have not been identified or their salinity tolerances are unknown. This may also occur because other water quality parameters (aside from salinity) may be better indicators of beneficial or detrimental water volumes (e.g. nutrients). An analysis of natural inflows provides an alternative approach. This method assumes that the pattern and magnitude of natural freshwater inputs are "good" for estuarine receiving waters. Estimates of "natural" inflows can be derived from historic measurements that occurred before the system was impaired or from models such as a natural systems model.

The Caloosahatchee Estuary:

Study Area:

The Caloosahatchee River and Estuary are located on the southwest coast of Florida (Figure 4). The Caloosahatchee River runs from Lake Okeechobee to the Franklin Lock and Dam (S-79) where it empties into the estuary which is some 40 kilometers long and terminates at Shell Point. The Caloosahatchee River is the major source of freshwater to the estuary. Enough water enters the estuary at S-79 to fill its volume over 8 times per year (Doering and Chamberlain 1999).

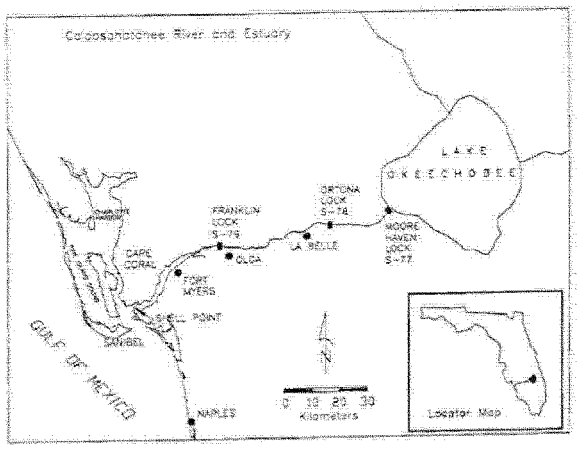
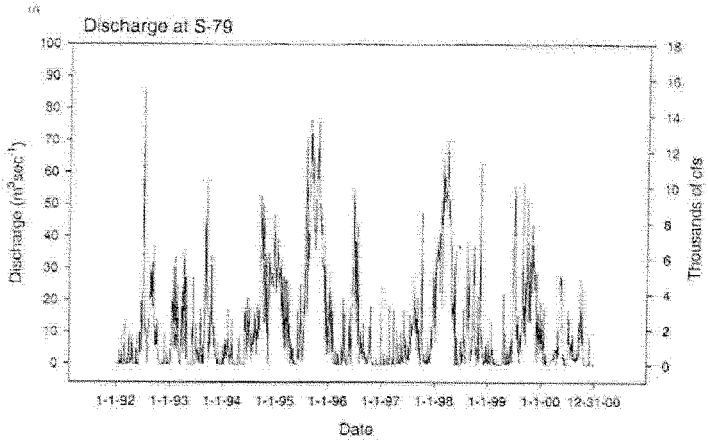


Figure 4. The location of the Caloosahatchee estuarine system



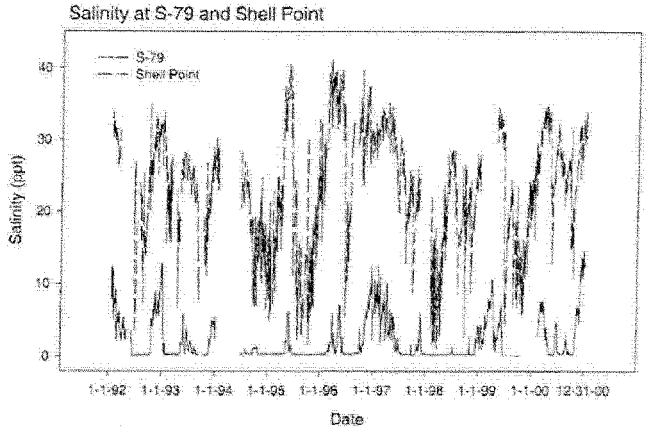


Figure 5. Daily freshwater discharge at S-79 and corresponding salinity at S-79 and Shell Point

The hydrology of the Caloosahatchee system has been altered over time. The river has been permanently connected to Lake Okeechobee and about 20% of the water entering the estuary now comes from the Lake mainly as regulatory releases to maintain the Lake at a prescribed water level. The river has also been straightened, deepened and three water control structures have been added. The last, Structure S-79, was completed in 1966 to act, in part, as a salinity barrier (Flaig and Capece, 1993). The result is that freshwater delivery has been altered and the salinity gradient is variable and often truncated. Long-term records of salinity at the head (S-79) and mouth (Shell Point) illustrate this high variability and truncation of the salinity gradient (Figure 5). During periods of low freshwater discharge, salt water regularly intrudes all the way to the structure, often exceeding 10 ‰. By contrast, high freshwater discharge can cause salinity to drop below 5 ‰ at the mouth. The transition between the two states can be rapid, sometimes requiring less than a week. The fluctuations observed at the head and mouth of the estuary exceed the salinity tolerances of oligohaline and marine species.

Figure 5. Daily freshwater discharge at S-79 and corresponding daily average salinity at S-79 at the head of the estuary and at Shell Point near its mouth.

Ecological Basis for Beneficial Deliveries to the Caloosahatchee:

The South Florida Water Management District recognized the need to identify a range of discharges from S-79 that will protect the system and began a research program in 1985 (Chamberlain and Doering 1998a). The research program included field sampling to establish relationships between major ecosystem components (seagrass, zooplankton, fish larvae, benthic macroinfauna) and inflow at S-79 (Chamberlain and Doering 1998b). An extensive literature review was conducted to summarize salinity tolerance information for other organisms found in the Caloosahatchee but not sampled by the District. The District began a series of laboratory experiments in 1995 to establish cause and effect salinity tolerances of submerged aquatic angiosperms (SAV) found in the Caloosahatchee (Doering et al. 1999, Doering and Chamberlain 2000, Doering et al. 2001). More recently, the District has funded research on the relationship between flow, salinity and autecology of the oyster (Volety and Tolley 2003).

12

The results of this research form the basis of our understanding of the ecological response of the Caloosahatchee to freshwater discharge at S-79. In the next section the derivation of the flow envelope is presented first, followed by the derivation of the flow distribution.

Derivation of a Flow Range for the Caloosahatchee:

A combination of the Valued Ecosystem Component Approach (USEPA, 1987) and the habitat overlap concept of Browder and Moore (1981) was used to establish minimum and maximum inflow estimates. Conceptually, flows below the minimum are considered too low to support an adequate biotic structure and function of the low salinity zone in an estuary. Inflows above the maximum cause loss of biotic structure and functionality in areas of higher salinity. Inflow estimates and their derivation have been published in the peer-reviewed literature (Chamberlain and Doering 1998b; Doering et al. 2002). A brief description of the approach is given here.

The Valued Ecosystem Component Approach (VEC) is the general name given to a method developed by the U.S. Environmental Protection Agency (USEPA, 1987) to guide monitoring programs in the National Estuary Program. The approach has been modified to focus on providing critical estuarine habitat. In some cases that habitat might be physical, such as an open water oligohaline zone. In other cases the habitat is biological and typified by one or more prominent species (e.g. an oyster bar). For the Caloosahatchee, beds of submerged angiosperm grasses (SAV) have been identified as a VEC.

The overlap concept of Browder and Moore (1981) forms the basis for relating freshwater discharge to VEC or other estuarine resources (Sklar and Browder, 1998). The concept of static and dynamic habitat overlap (Browder and Moore, 1981) is based on the ideas of Gunter (1961) that (a) estuaries serve a nursery function and (b) salinity determines the distribution of species within an estuary, and indeed different life stages of the same species. In addition, the concept recognizes the importance of the appropriate physical or static habitat to the nursery function and

15

ability of the estuary to support diverse and abundant biotic populations. Freshwater inflow positions favorable salinities relative to important stationary habitat factors such as shoreline, water depth, and bottom type (Browder and Moore, 1981). In the present application, ecologically supportive freshwater inflows produce a temporal and spatial overlap between grass beds and physiologically tolerable salinity (Figure 6).

In order to estimate minimum and maximum flows, using the overlap approach, the relationship between the spatial distribution of salinity in the estuary and discharge at S-79 must be known. Statistical regression and steady state numerical modeling were used for this purpose (Doering et al. 2002). The location of overlap of tolerable salinity and SAV in the estuary must also be known.

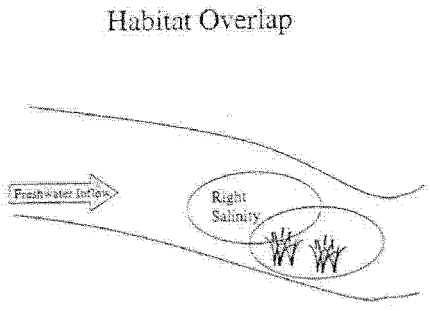


Figure 6. Illustration of the habitat overlap concept. Freshwater inflow positions favorable salinity over grass bed.

The distribution of SAV in the Caloosahatchee is given in Figure 7. The salt tolerant freshwater species *Vallisneria americana* is found at the head of the estuary. Under good growing conditions, *V. americana* can cover about 405 hectares (1000 acres), primarily along the shore. Appreciable densities of plants begin about 32 km upstream of Shell Point and extended to about 12 km upstream of Shell Point. About 60 % of the total area that can be covered by *V. americana* is located between 24 km and 32 km, upstream of the Ft. Myers Bridges (Figure 2). *Halodule wrightii* is the only seagrass found upstream of Shell Point. Further downstream in San Carlos Bay mixed beds of *Thalassia testudinum* and *H. wrightii* occur. Under good growing conditions, some 121 hectares (300 acres) of *H. wrightii* can be found between 2 km and 10 km upstream of Shell Point. About 75% of this area is located between km 2 and km 6 (Chamberlain and Doering 1998b).

15

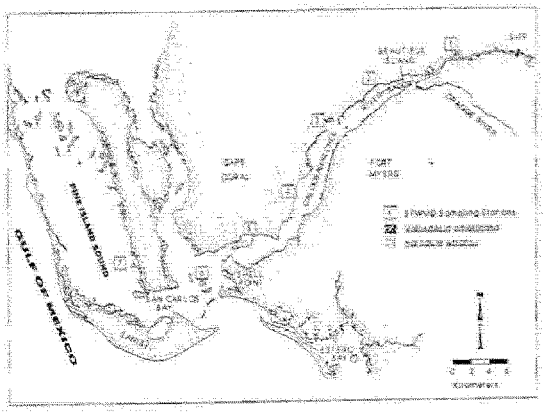


Figure 7. Distribution of submerged aquatic vegetation in the Caloosahatchee Estuary. Numbers refer to areas sampled for zooplankton, ichthyoplankton and other biota.

Although *V. americana* is considered a freshwater species, it is salt tolerant. Salinity tolerances of *V. americana* reported in the literature vary (Doering et al. 1999). Bourn (1932; 1934) found that growth declined with increasing salinity until it ceased at 8.4 ‰. Haller et al. (1974) reported growth at 3.33 ‰ , no growth at 6.66 ‰ or 10 ‰ and death at 13.3 ‰ . After 5 weeks, Twilley and Barko (1990) found no effect of salinity on growth over the range 0 ‰ to 12 ‰. Our laboratory results suggest that for *V. americana* from the Caloosahatchee, growth is low or nil in the 10 ‰ - 15 ‰ range with mortality occurring at salinities greater that 15 ‰ (Doering et al. 1999; Doering et al. 2002). This agrees well with transplant experiments conducted in the Caloosahatchee that indicated mortality at salinities greater than 15 ‰ (Kraemer et al. 1999). Adair et al. (1994) found the distribution of *V. americana* in Trinity Bay,

16

Texas limited to salinities less than 10 $^{o}/_{oo}$. In outdoor mesocosm experiments, French (2001) observed minimal growth of Vallisneria from the Chesapeake Bay at 10 $^{o}/_{oo}$ and 15 $^{o}/_{oo}$. The combination of results from field monitoring and laboratory experiments conducted by District and other investigators agree that 10 $^{o}/_{oo}$ is a critical threshold salinity for growth.

Halodule wrightii apparently tolerates a wide range of salinity. Upper survival limits range from 52.5 $^{o}/_{oo}$ to 80 $^{o}/_{oo}$ (McMillan and Moseley 1967; MacMahon 1968; McMillan 1974). Estimates of the lower bound for survival also vary. MacMahon (1968) observed death at 0 $^{o}/_{oo}$ and 3.5 $^{o}/_{oo}$ and survival at 9 $^{o}/_{oo}$ after 3 weeks exposure. McMillan (1974) observed green tissue at 0 $^{o}/_{oo}$ and 5 $^{o}/_{oo}$ after two weeks exposure. Zimmerman and Livingston (1976) reported a characteristic salinity range of 17 $^{o}/_{oo}$ – 36 $^{o}/_{oo}$ for *H. wrightii* in Florida estuaries, with a lower limit of 6 $^{o}/_{oo}$.

Both our field density data and our laboratory growth results agree with the characteristic salinity range reported by Zimmerman and Livingston (1976). Although variable, our laboratory results indicate that growth declines at salinities less than 18 $^{o}/_{oo}$ and mortality can begin at 6 $^{o}/_{oo}$ (Doering et al. 2002).

The minimum flow estimate (mean monthly flow at S-79 of about 300cfs) is based on maintaining a tolerable salinity (<10 ppt) for *Vallisneria americana* upstream of Km 24 as measured from Shell Point. This location is consistent with the recently established Minimum Flow and Level for the Caloosahatchee Estuary. The maximum inflow estimate of 2800 cfs is based on avoiding mortality of *Halodule wrightii* at low salinity (< 6 ppt) downstream of Km 6 as measured from Shell Point (see Doering et al. 2002, Appendix 1).

Ecologically Based Flow Distribution:

So far a flow envelope for the Caloosahatchee Estuary down to Shell Point has been identified. The overlap concept can be extended to seagrasses located further down stream in San Carlos Bay. The concept also can be extended to other organisms in the Caloosahatchee: identifying the

17

flows associated with maximum abundances in different areas of the system. This analysis begins to identify optimal or preferred ranges of flow within the flow envelope and quantifies preferred and maximum flows for the more marine portion of the system located in San Carlos Bay.

Table 1. Flow tolerances for biota in the Caloosahatchee Estuary. Flows refer to mean monthly discharge at S-79. * for locations see Figure 7.

SPECIES	General Area	Locations*	Preferred Flow Range (cfs)	Upper Inflow Limit (cfs)
Fish (general)	Estuary	2 - 5	300 – 2800	3,000
Bay Anchovy	Upper Estuary	2 - 4	300 - 800	3,000
Silver Perch	Upper Estuary	2 - 4	300 - 800	3,000
Redfish	Estuary	2 - 5	300 - 800	3,000
Snook	Estuary	2 - 5	300 – 1,500	3,000
Wild Celery	Upper Estuary	2-3	300 - 800	None
Zooplankton	Estuary	2 – 3	150 – 600	2,500
Shrimp/Crab Larvae	Iona Cove	5	1,200 – 1,500	>1,500
	San Carlos Bay	6	2,500 – 3,000	>3,000
Ichthyoplankton	Upper Estuary	2 - 4	< 600	2,500
	Iona Cove	5	600 - 800	2,500
Benthic Macro - Invertebrates	Upper Estuary	1 - 4	150 - 600	3,000
Oysters	Lower Estuary San Carlos Bay	4 - 6	500 – 2000	> 2000
Blue Crabs	Estuary-San Carlos	1 - 6	300 - 800	> 3000
Seagrass				
Halodule	Iona Cove	5	< 800	2,800
Halodule/Thalassia	San Carlos Bay	6	< 2,500	< 4,500

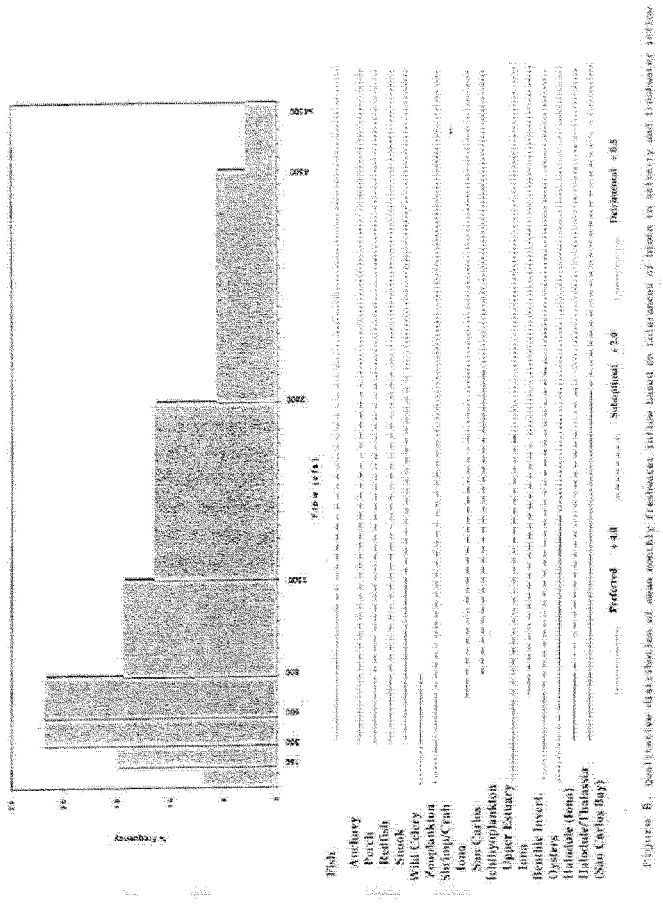
Table 1 summarizes statistical analyses of the effects of freshwater discharge at S-79 on the abundances of various organisms found in the Caloosahatchee (Chamberlain and Doering

18

1998b). Details of the statistical analyses may be found in Chamberlain et al. (1995), SFWMD 2003 (MFL update appendix) and Volety and Tolley 2003. From this summary a qualitative flow distribution was derived.

For each organism or group of organisms, preferred, suboptimal and detrimental ranges of flow were identified (Figure 8). Initial flow ranges for the frequency distribution were selected based on the clustering of preferred, suboptimal and detrimental flows within specific ranges. Most preferred flows, associated with high abundance, occurred in the 150 – 800 cfs ranges, most suboptimal in the 800 – 2000 cfs range and most detrimental at flows greater than 3000 cfs. These gross flow ranges were further subdivided to provide more detail in the distribution.

A score was derived for each flow range based on the number of organisms for which that flow range was preferred, suboptimal or detrimental. In derivation of the score, the number of organisms that preferred the range were given highest weight (4), while the number for which the flow range was detrimental were given the least (0.5). The number for which the flow range was suboptimal was given an intermediate weight (2). Weighted numbers were summed for each flow range and normalized to the total number of organisms used to calculate the score. Normalized scores were expressed as a percentage of the sum of normalized scores. For example, the total score for the 300 – 500 cfs interval was 46 based on 12 organisms. The normalized score was 3.8 which was 22 % of the sum of normalized scores. The resulting qualitative frequency distribution (Figure 8) has a peak in the 300 – 800 cfs range. This is consistent with the conclusions of Chamberlain and Doering (1998b).


Fish
Anchovy
Perch
Redfish
Snook
Wild Celery
Zooplankton
Shrimp/Crab
Ibis
Star Carlos
Ichthyoplankton
Upper Estuary
Ibis
Benthic Invert.
Oysters
Haloladie (Ibis)
Haloladie/Thalassia
(San Carlos Bay)
Preferred +4.0
Suboptimal +2.0
Detrimental +0.5

21

Beneficial Deliveries to the Caloosahatchee:

This section of the report describes the development of Beneficial Delivery Targets for the Caloosahatchee Estuary. Since the tidal watershed (downstream of S-79) is unmonitored and outside of the SFWMD management area, environmental deliveries are only defined for the freshwater portion of the Caloosahatchee Watershed, the area upstream of S-79. Furthermore, regulatory discharges from Lake Okeechobee are not considered in this analysis, which deals only with runoff from the Caloosahatchee watershed delivered to the estuary at S-79.

Owing to development in the watershed, the Caloosahatchee Estuary suffers from stresses associated with inflows that are too high at times and inflows that are too low at times. Restoration targets were developed during the Caloosahatchee Water Management Plan and the RESTUDY. These targets were long-term monthly flow distributions. Two distributions were created during that process (EST01, EST02) and a third (EST05) was created especially for this project. EST01 was based on a redistribution of existing water deliveries at S-79; EST02 was based on minimal deliveries at S-79; EST05 was similar to EST02 except that mean monthly inflow at S-79 was never allowed to fall below 300 cfs. EST02, the minimal delivery time-series, was intended to be equivalent to deliveries from the pre-development watershed. The base flow of 300 cfs in EST05 was added to protect fish and wildlife from the detrimental effects of low flow, which is consistent with the Minimum Flow and Level for the Caloosahatchee. All three distributions have a peak in the 300 – 800 cfs range and are thus commensurate with the qualitative, species driven flow distribution derived earlier. These distributions are shown in Table 2.

Table 2. Monthly Flow Distributions at S-79

Flow Range	2020 Base	Est01	Est02	Est05
0 to 150 cfs	25%	0%	0%	0%
150 to 300 cfs	6%	14%	7%	0%
300 to 500 cfs	6%	24%	38%	43%
500 to 800 cfs	8%	24%	30%	32%
800 to 1500 cfs	13%	21%	19%	19%
1500 to 2800 cfs	11%	12%	6%	6%
2800 to 4500 cfs	9%	4%	1%	1%
>4500 cfs	23%	1%	0%	0%

22

Each distribution has a long-term average flow. Table 3 shows the average annual flows corresponding to the distributions of Table 2. Note that EST01 has about the same runoff (688,000 acre-feet) as current conditions (668,000 acre-feet). Runoff for EST02 (496,000 acre-feet) is almost 200,000 acre-feet less than current conditions. This difference in runoff relates to the decrease in evaporation that occurred when the watershed was drained and land use shifted away from hydric vegetation. Addition of a base flow (300 cfs) in EST05 adds 30,000 acre-feet to EST02.

Table 3. Average Annual Flows (acre-foot per year) at S-79

2000 Base	Est01	Est02	Est05
668,186	687,963	493,672	524,849

In order to calculate Existing Legal Sources, a time series with a daily time step, consistent with the SFWMM is required. A linear reservoir model (LINRES) was selected for this effort. Linear reservoir models are an old form of watershed model that includes HSPF and the Stanford Watershed models. This type of model is process driven, requires few parameters, and can be easily fitted to the flow distribution pattern of EST02. Like other CERP hydrologic models it is continuous and long-term and operates on a daily time step using spatially distributed rainfall and potential evapotranspiration (See Appendix 2).

Evaluation of Beneficial Deliveries:

Three Beneficial Delivery times series or Targets have been developed for use in calculation of Existing Legal Sources: EST01, EST02 and EST05. Undoubtedly, there are numerous ways to quantify and compare the "benefit" afforded to the Caloosahatchee Estuary by each of these flow distributions. We have examined the salinity produced in the estuary by each of these 35-year daily discharge scenarios. Specifically, we have examined the ability of each scenario to meet salinity requirements of the MFL in the upper estuary and salinity requirements of maximum inflows in the lower estuary.

Regression models, based on output from a numerical, hydrodynamic model have been used to estimate salinity in the estuary (Appendix 3). EST01, EST02 and EST05 define

33

beneficial freshwater deliveries at S-79. Freshwater also enters the estuary downstream (or west) of S-79. In modeling salinity in the estuary, these downstream inflows also have been considered (Appendix 2).

Comparison of EST01, EST02, and EST05:

Table 4. Frequency analysis of 30-day moving average salinity for EST01 and EST02 at various locations in the Caloosahatchee Estuary. The 30-day moving average salinity is used because it is an MFL performance measure.

30-day moving average salinity (ppt)	Ft. Myers			Shell Point		
	EST01	EST02	EST05	EST01	EST02	EST05
	% of days	% of days	% of days	% of days	% of days	% of days
0-5	34	27	28	0	0	0
5-10	29	33	41	0	0	0
10-13	23	32	32	2	1	1
13-15	13	9	0	2	2	2
15-20	1	0	0	10	6	6
20-25	0	0	0	17	14	14
25-30	0	0	0	59	70	77
30-35	0	0	0	11	7	6

The volume of water in EST01 exceeds that in EST02 by some 200,000 acre-feet annually (Table 3). Yet, the distribution of salinities produced in the estuary differ only slightly (Table 4.) Minimum flow criteria (≤ 10 ppt at Ft. Myers) are exceeded 37 % of the time in EST01 and 41 % of the time in EST02. Adding a 300 cfs base flow to EST02, as in EST05, produces slightly lower salinity at Ft. Myers but still exceeds MFL criteria at a frequency (32 %) comparable to the other two flow distributions (Table 4). Neither of the three time series causes salinity to drop below 6 ppt in the lower estuary. EST02 is preferred over EST01 as a Beneficial Delivery Target since it is our best approximation of predevelopment conditions and since the extra water required by EST01 does not achieve any further benefit within the estuary according to the criteria

24

employed. EST05 provides a slightly higher level of protection (lower salinity) in the upper estuary than the other two time series.

While EST02 and EST05 yield similar results, they are fundamentally different and the decision to use one or the other in the calculation of an Existing Legal Source for the Caloosahatchee must be a matter of policy. As stated earlier, EST02 is our best available estimate of pre-development delivery of freshwater to the Caloosahatchee. Using EST02 in the calculation assumes that flows equivalent to those entering the system before it was modified are adequate to protect fish and wildlife under current conditions. However, since permanent alteration has occurred, this assumption may be unreasonable. Addition of a base flow in EST05 recognizes that the estuary has been modified, especially by installation of S-79 which truncates the salinity gradient, preventing upstream migration of low salinity water during the dry season and hence eliminating the oligohaline zone that historically existed. EST05 is consistent with the 300 cfs minimum flow established for the Caloosahatchee Estuary at S-79 (Doering et al. 2002). The definition of "beneficial" underlying EST05 views inflows below a 300 cfs threshold as being just as detrimental as no flow at all because in either case, there is no oligohaline zone in the estuary. EST02 assumes that any flow, even if below the 300 cfs threshold, is better than no flow at all.

Figure 9 shows the average position in the estuary of the 10 ppt isohaline during the dry season under the EST02 and EST05. The mean position of this critical isohaline under EST05 occurs at Ft. Myers. Thus, on average, EST05 provides a level of protection commensurate with the Caloosahatchee Estuary MFL. It should be noted however, that given the error involved in prediction of isohaline position, the mean position of the 10 ppt isohaline could also occur at Ft. Myers under EST02.

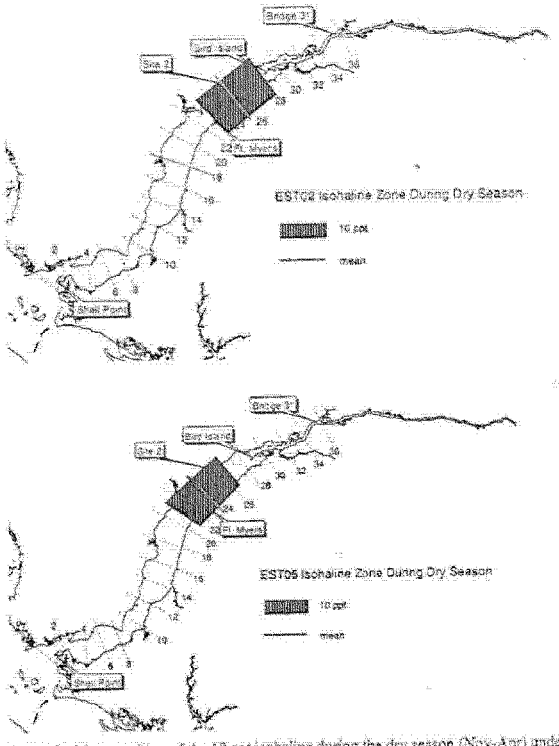


Figure 9. Mean position of the 10 ppt isohaline during the dry season (Nov-Apr) under EST02 and EST05. Box indicates error in estimate of isohaline position.

26

Existing Legal Sources for the Caloosahatchee Estuary:

Existing Legal Sources can be calculated by comparing a particular hydrology against the Beneficial Delivery Target hydrology. The Beneficial Delivery Target describes a hydrology that protects fish and wildlife in the estuary. Since it is a target, it exists in theory only. Existing Legal Source Deliveries are a subset of beneficial deliveries; they are the beneficial deliveries occurring today. They are calculated by comparing "2000 Base" hydrology against the Beneficial Delivery Target hydrology.

Table 5 shows how Existing Legal Sources for 2000 Base change when based on different Beneficial Delivery Targets. Existing Legal Sources are calculated using two methods – one based on daily flows and the other based on monthly flows. The daily definition shows current deliveries to be about 45,000 acre-feet per year less than the monthly definition.

Not surprisingly, the choice of a Beneficial Delivery Target has a significant effect on Existing Legal Sources. Using EST01 instead of EST02 would result in a difference of 160,000 acre-feet per year. EST02 is preferred over EST01 as a Target since it is our best approximation of pre-development conditions and since the extra water required by EST01 does not achieve any known benefit within the estuary.

Using EST02 as the Target, only 250,000 acre-feet of the total 668,000 acre-feet of "2000 Base" runoff is delivered at a time that is beneficial to the estuary. Including a base flow of 300 cfs in the Beneficial Delivery Target (EST05) does not significantly change the total volume of the Existing Legal Source Delivery.

27

Table 3: Average Annual Existing Legal Source Deliveries (acre-foot per year) at S-79 for 2000 Base - based on different Beneficial Delivery Targets

	Ex01	Ex02	Ex03
Defined daily	441,704	280,199	283,397
Defined monthly	493,658	326,038	328,829

Literature Cited:

Bourn, W.S. 1932. Ecological and physiological studies on certain aquatic angiosperms. Contributions From Boyce Thompson Institute 4: 425 - 496.

Bourn, W.S. 1934. Sea-water tolerance of *Vallisneria spiralis* L. and *Potomogeton foliosus* Raf. Contributions From Boyce Thompson Institute 6: 303 - 308.

Browder, J.A. and D. Moore 1981. A new approach to determining the quantitative relationship between fishery production and the flow of fresh water to estuaries. Pp 403-430 in Cross, R.D. and D.L. Williams (eds) Proceedings of the national symposium on freshwater inflow to estuaries Volume I.U.S. Fish and Wildlife Service, U.S. Dept. of Interior. FWS/OBS-81/04.

Bulger, A. J., B.P. Hayden, M.E. Monaco, D.M. Nelson, M.G. McCormick-Ray. 1993. Biologically-based estuarine salinity zones derived from multivariate analysis. Estuaries 16: 311-322.

Chamberlain, R.H., D.E. Haunert, P.H. Doering, K. Haunert and J. Otero 1995. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary, Florida. White Paper. South Florida Water Management District.

Camberlain, R.H. and P.H. Doering. 1998a. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation. Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16; Punta Gorda, FL. Charlotte Harbor National Estuary Program Technical Report No. 98-02. 274 p.

Chamberlain, R.H. and P.H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach. Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16; Punta Gorda, FL. Charlotte Harbor National Estuary Program Technical Report No. 98-02. 274 p.

28

Doering, P.H. and R.H. Chamberlain 1999. Water quality and the source of freshwater discharge to the Caloosahatchee Estuary, FL. Water Resources Bulletin 35: 793-806.

Doering, P.H., R.H. Chamberlain, K.M. Donohue, and A.D. Steinman 1999. Effect of salinity on the growth of *Vallisneria americana* Michx. from the Caloosahatchee Estuary, Florida. Florida Scientist 62(2): 89-105.

Doering, P.H., R.H. Chamberlain, and J. M. McMunigal 2001. Effects of simulated saltwater intrusions on the growth and survival of Wild Celery, Vallisneria americana, from the Caloosahatchee Estuary (South Florida). Estuaries 24: 894-903.

Doering, P.H., R.H. Chamberlain, and D. E. Haunert 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. Estuaries 25(6B): 1343-1354.

Doering, P.H. and R.H. Chamberlain 2000. Experimental studies on the salinity tolerance of turtle grass *Thalassia testudinum*. Ch 6. pp 81-97, In S.A. Bortone (ed), Seagrass: Monitoring ecology, physiology, and management. CRC Press (Boca Raton, FL) 318 pp.

Emery, K.O., R.E. Stevenson, and J.W. Hedgepeth 1957. Estuaries and Lagoons. Ch. 23 in:Treatise on Marine Ecology and Paleoecolgy. Geol. Soc. Amer. Memoir 67: 673-750.

Flaig, E. G. and J. Capece 1998. Water use and runoff in the Caloosahatchee watershed. pp 73- 80 in: Proceedings of the Charlotte Harbor Public Conference and Technical Symposium; 1997 March 15-16; Punta Gorda, FL. Charlotte Harbor National Estuary Program Technical Report No. 98-02. 274 p.

French, G. T. 2001 Effects of light and salinity stress on Vallisneria americana (wild Celery). Master of Science Thesis, School of Marine Science, College of William and Mary in Virginia. 137pp.

Gunter, G. 1961. Some relations of estuarine organisms to salinity. Limnol. and Oceanogr. 6: 182-190.

Haller, W.T., D. L. Sutton, and W. C. Barlowe. 1974. Effects of salinity on growth of several aquatic macrophytes. Ecology 55: 891-894

Kraemer, G. P., R. H. Chamberlain, P. H. Doering, A. D. Steinman, and M. D. Hanisak. 1999. Physiological response of transplants of the freshwater angiosperm Vallisneria

C.15 FINAL CALOOSAHATCHEE RIVER (C-43) BASIN ECOLOGICAL PERFORMANCE MEASURES

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

Summary Form (4 pages)

C-43 Basin Storage Reservoir Project - Caloosahatchee Estuary Hydrologic Evaluation Performance Measures

Name of Performance Measures Document : S-79, Shell Point, and San Carlos Bay Freshwater Inflow

Status: Date this 4 page summary created/revised – 28 June 2005
For 6/28/05 DRAFT of full Performance Measures Document (attached). Previous Draft 5/12/05

Category: Hydrologic – (Water Levels, **Flow Volumes**)

Justification: The Caloosahatchee River is the major source of freshwater for the Caloosahatchee Estuary and southern Charlotte Harbor aquatic environment. The river bisects its watershed and now functions as a primary canal (C-43) that conveys both runoff from the Caloosahatchee watershed and regulatory releases from Lake Okeechobee. The C-43 has undergone numerous physical changes to facilitate increased freshwater discharge for flood protection and meet water supply demands. Together, these physical changes and alterations of the natural freshwater inflow to the Caloosahatchee Estuary have caused unnatural large scale fluctuations in the salinity and water quality within the area above Shell Point, as well as reduction in environmental stability for the San Carlos Bay area. The area's biotic richness and significant economic value are threatened by long-term shifts in water quantity and quality.

Description of Performance Measure: Reduce the high variability in freshwater inflow to the Caloosahatchee Estuary, thereby restoring the full range of salinity along its longitudinal axis required to support naturally occurring conditions for estuarine biota. This can be accomplished by: (1) reduction of wet season high flow from the watershed, capturing and storing this water, and then releasing it during the dry season in a more environmentally sensitive and beneficial manner to estuarine resources; and (2) reducing discharges from Lake Okeechobee to the Caloosahatchee Estuary.

SWFFS/CERP Targets & Current Condition:
Ecological Performance targets
1. (a) Maintain a 30-day moving average salinity ≤ 10 ppt during the dry season at the Ft. Myers continuous salinity sensor (near the surface at the Ft. Myers Yacht Basin), such that *Vallisneria americana* (tape grass) in the Beautiful Island area does not decrease below 20% coverage and blade length is ≥ 10 cm (values are provisional and may be adjusted after current research (MML 2004 and 2007 reports) are evaluated); (b) Daily average salinity shall not exceed 20 ppt at Ft. Myers more than once every two years, and neither shall the 30-day moving average salinity of 10 ppt (MFL Rule: SFWMD 2000); (c) Limit the occurrence of average monthly salinity <15 ppt at the Cape Coral Bridge sensor, so salinity ≥ 20 ppt is promoted in Iona Cove (Bierman 1993), which is supportive of minimum seagrass density (coverage ≥ 30% at 1 meter water depth and average blade length ≥ 10 cm - values are provisional and may be adjusted upon further research); and (d) Maintain daily salinity at Piney Point > 5 ppt, so that minimum conditions are provided for the recruitment, survival, and growth of juvenile oysters upstream of Shell Point during March – October (juvenile oyster growth ≥ 2.5 mm a month; recruitment ≥ 3 spats per substrate shell a month; and mortality < 20% per month - values are based on information interpreted from Volety et al. 2003).
2) Maintain an average monthly salinity ≥ 25 ppt, as measured at the Sanibel Causeway Bridge near surface continuous sensor, so that historical seagrass density and coverage in the San Carlos Bay area (as determined from previous surveys, hydroacoustic monitoring, and aerial photography) is protected and restored to a previous condition (at least circa Harris et al. 1983) that includes reestablishment of continuous coverage at deeper depths in the San Carlos Bay area between Shell Point and the Sanibel Causeway.

Hydrologic performance targets to achieve the Ecological targets
1a) For each alternative, compare the number of times that the combined mean monthly inflows from the Caloosahatchee watershed and Lake Okeechobee fall below a low-flow limit of **450** cfs, measured at S-79, during October to July . The alternative with the fewest number of times that monthly average flows fall below **450 cfs** will be considered better for protecting aquatic vegetation, oysters, and fish communities.

1

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

1b). For each alternative, compare the frequency that the combined mean monthly low-flow limit of **450** cfs through S-79 was not met for just one month (not followed by another month below the this low-flow limit), as well as the frequency for 2, 3, 4... etc. consecutive months. The water management alternative with the fewest number of consecutive months below the **450** cfs will be considered better for protecting estuarine aquatic resources.
1c). For each alternative, compare the frequency that the combined mean monthly low-flow limit of **450** cfs through S-79 from the watershed and Lake Okeechobee was not met for just one year (not followed by another year with months below **450** cfs), as well as the frequency for 2, 3, 4... etc. consecutive years. The water management alternative with the fewest number of years and consecutive years with average monthly flow occurrences below **450** cfs will be considered better for protecting estuarine aquatic resources.

2a). For each management alternative, compare the number of times that the combined mean monthly inflow from the watershed and Lake Okeechobee exceeds 2,800 cfs at S-79. The alternative with the fewest number of times that this criterion is exceeded at any time of year will be considered better for protecting both SAV and juvenile oysters at Shell Point and upstream. Additionally, a better ranking will be given to the alternative with the least number of discharges above this limit during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival.
2b). For each alternative, compare the frequency that the combined mean monthly inflow from the watershed and Lake, measured at S-79, exceeds 2,800 cfs for just one month (not followed by another month above this limit), as well as the frequency for 2, 3, 4... etc. consecutive months. The alternative with the fewest consecutive months that violate this criterion throughout the year will be considered better for protecting estuarine resources, including juvenile oyster recruitment and survival. Additionally, a better ranking will be given to the alternative with the least number of discharges above this limit during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival

3a). For each alternative, compare the number of times that the combined mean monthly inflow from the watershed and Lake Okeechobee exceed 4,500 cfs at S-79. The alternative with the least number of times flows exceed these limits will be considered better for protecting the estuarine resources, including those downstream in the San Carlos Bay region. Additionally, a better ranking will be given to the alternative with the least number of discharges above this limit during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival.
3b). For each alternative, compare the frequency that the combined mean monthly inflows from the watershed and Lake, measured at S-79, exceeds 4,500 cfs for just one month (not followed by another month above this limit), as well as the frequency for 2, 3, 4... etc. consecutive months. The alternative with the fewest number of consecutive months that violate this criterion will be considered better for protecting aquatic resources, including juvenile oysters. Additionally, a better ranking will be given to the alternative with the least number of consecutive discharge periods above this limit during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival.

4). For the C-43 BSR Project, in combination with other CERP infrastructure alternatives, compare the number of days that regulatory discharges from Lake Okeechobee are made to the Caloosahatchee River. The management alternative with the least daily discharge volume, the fewest number of total days of discharge, and the fewest number of consecutive days will be preferred. Special consideration will be provided for pulse releases that may benefit the estuary.

5). For each alternative, compare the frequency distribution of the combined monthly average freshwater inflows through S-79 from the watershed and Lake Okeechobee for the entire period of record being evaluated. The alternative with the frequency distribution of inflows that best approaches the range defined in the main Performance Measures Document will be considered better for protecting estuarine resources, while further promoting biotic diversity. Specifically, the alternative that maximizes up to 75% of flows

2

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

from S-79 in the **450 to 800** cfs and almost all the remaining flows in the 800-2800 cfs range will be considered the most desirable. The preferred flow distribution may change as more information is provided regarding: predevelopment flow and salinity conditions; natural variation; what salinity conditions were naturally (historically) associated with droughts and flood events; and what flows are needed to protect and restore the biotic features in the current and future developed system.
Rationale: The Caloosahatchee River is the major source of freshwater for the Caloosahatchee Estuary and southern Charlotte Harbor aquatic environment. The Caloosahatchee Estuary and downstream region supports a wide diversity of estuarine organism of environmental and commercial value. Alteration to the natural freshwater inflow to the estuary have caused unnatural large scale fluctuations in the salinity and water quality within the area above Shell Point, as well as reduction in environmental stability for the San Carlos Bay area. The resulting impacts to seagrass, oysters, benthic invertebrates, and fishes can be dramatic and long lasting. It is the goal of the C-43 BSR and CERP to reduce the high variability in freshwater inflow to the Caloosahatchee Estuary, so to restore a full range of salinity along its longitudinal axis that is supportive of naturally occurring estuarine biota. This goal can be accomplished by: (1) reducing high flows during the wet season, capturing and storing this water, then releasing it in a more environmentally sensitive manner that is beneficial to estuarine resources during the dry season; and (2) minimizing regulatory (non discretionary) discharges form Lake Okeechobee to the Caloosahatchee Estuary.
Modeling Evaluation Protocol: Regional and subregional models will be used to simulate historical (base) conditions and predicted flows to the estuary with and without CERP project features for each alternative considered. Natural system flows to the Caloosahatchee Estuary from its watershed and tidal basins may also be considered in order to compare flows associated with the developed basins. Output (flows) from the above model runs will be used to evaluate the level that hydrologic targets are achieved for each alternative and base condition. Model output will be used as input for the estuarine salinity model to further assess changes in salinity. To help evaluate if ecological goals will be met, the estimated salinity will be used to assess the impact on key biota by employing habitat suitability indices related to salinity.
Monitoring Assessment Protocol: 1). Define and assess appropriate attributes (specific species and/or community values) to ascertain if this project's ecological goals are attained and there is a discernable positive impact on the estuary, specifically including SAV, oyster, and fish as follows: a). Routinely (at seasonally important intervals) monitor SAV coverage, density, and canopy height to at least 1.5-2.0 m depth at key species locations. b). Routinely monitor (at seasonally important intervals) oyster survival and recruitment at key locations. c). Routinely monitor (seasonally) water quality, including temperature, D.O., salinity, nutrients, chlorophyll, suspended solids, and water clarity along the longitudinal axis of the estuary (S-79 - Sanibel Causeway and into lower Pine Island Sound and Matlacha Pass). d). Monitor routinely (at appropriate seasonal intervals) species and biotic groups of concern as separately defined in performance measure documents and the CE conceptual model. At a minimum, insure the Monitoring Assessment Plan (MAP) effort within RECOVER is being fulfilled. 2). Scientifically assess and publicly agree what constitutes desirable natural variability (predevelopment conditions) related to salinity and causal freshwater inflow from S-79 and the tidal basin. 3). Install and monitor flow gages in downstream tidal tributaries to begin assembling a long term data set to: verify model predictions of flows; determine actual amount and timing of tidal tributary flows related to MFL requirements for achieving the salinity criteria; and to help assess flow impacts on biota being monitored for CERP (RECOVER). 4). Monitor S-79 and S-77discharges for adherence to the selected alternative flow distribution. 5). Continue to maintain and monitor existing 7 salinity recorders and other permanent sensors in the Caloosahatchee Estuary. Install new sensors to monitor salinity and other water quality parameters of concern at key locations for VEC. Suggest additional sensors be located in western San Carlos Bay, lower Pine Island Sound, and Matlacha Pass. 6). Assess limits of SAV morphology for providing suitable habitat as a VEC and its relationship to flow, salinity, and water quality conditions. 7). Finish development of the: tape grass model; Caloosahatchee Hydrodynamic/Salinity Model; a water quality model component; habitat suitability models; and a seagrass model for the lower estuary.

3

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

S-79, SHELL POINT, AND SAN CARLOS BAY
FRESHWATER INFLOW PERFORMANCE MEASURES

INTRODUCTION

BACKGROUND

The Caloosahatchee River is the major source of freshwater for the Caloosahatchee Estuary and southern Charlotte Harbor aquatic environment. The river bisects its watershed and now functions as a primary canal (C-43) that conveys both runoff from the Caloosahatchee watershed and regulatory releases from Lake Okeechobee. The canal has undergone a number of alterations to facilitate this increased freshwater discharge and flood protection. These alterations include: channel enlargement; bank stabilization; the development of an intricate network of canals within the watershed; and the addition of three lock and dams. The final downstream structure, Franklin Lock and Dam (S-79), demarcates the beginning of the estuary, and acts as a barrier to salinity and tidal action, which historically extended to nearly the LaBelle area.

ISSUES

The above alterations to the Caloosahatchee River and watershed have resulted in a drastic change in freshwater inflow to the downstream ecosystem. The resulting large fluctuation of salinity and water quality can adversely impact estuarine biota (Chamberlain and Doering 1998a; Sklar and Browder 1998).

An important upper estuarine feature is the freshwater-brackish submerged grass, *Vallisneria americana* (tape grass), which when present is located near the shoreline in the upper estuary to a depth of about 1.0 m (Figure 1). Its greatest coverage occurs from Beautiful Island to just past the Ft. Myers bridges (Hoffacker et al. 1994; Chamberlain and Doering 1998b). During times of extended low inflow conditions, when salinity is too high, this grass becomes very sparse and can disappear completely (Chamberlain et al. 1995; Doering et al. 2002; SFWMD 2000)

Downstream, sparse beds of the seagrass *Halodule wrightii* (shoal grass) extend up from San Carlos Bay to nearly the Cape Coral Bridge (Hoffacker et al. 1994; Chamberlain and Doering 1998b). Like tape grass, it is restricted to the shoreline margins (Figure 1) and historically represented a valued ecosystem component of the estuary. Oysters also exist near the mouth at Shell Point and historical accounts of the river indicate that oysters were once a more prominent feature in the area upstream (Sackett 1888). Both shoal grass and oysters in this area of the estuary are sensitive to high freshwater inflows from S-79 (Chamberlain and Doering 1998b; Doering et al. 2002; Volety et al. 2003).

The dominant biological features in the San Carlos Bay area are its numerous mangrove islands and many kilometers of mangrove shoreline, which are often closely associated with oysters and large meadows of seagrass (Figure 1). Because of its biotic richness and aesthetic appeal, San Carlos Bay supports a wide variety of recreational and fishery activities with significant economic value. The natural resources of this area are also impacted by large freshwater

releases and are threatened by long-term shifts in water quantity and quality (Chamberlain and Doering 1998b; Doering et al. 2002; Volety et al. 2003).

Recent environmental investigations in the Caloosahatchee Estuary (CE) have resulted in an estimate of the optimum quantity of water needed by the Caloosahatchee Estuary to protect key biota. These species, or Valued Ecosystem Components (VECs), help sustain the ecological structure and function of the estuary by providing food, living space, and foraging sites for other naturally occurring estuarine species. Oysters and submerged aquatic vegetation (SAV) represent VECs in the Caloosahatchee Estuary. Limits on water quantity and related water quality, such as salinity, will protect these species and should lead to a healthy and diverse estuarine ecosystem.

Research results reported by Chamberlain et al. 1995, Doering et al. 1999 and 2001, Doering and Chamberlain 2000, and Kraemer et al. 1999 were used to determine optimum salinity (envelope) for SAV in the Caloosahatchee Estuary. A steady-state salinity model (Scarlatos 1988; Bierman 1993 Figure 2) and a statistical model of salinity (SFWMD 2000) were used to estimate mean monthly flows from S-79 that will establish a desirable salinity range in the geographic locations of SAV, without adverse impacts to benthic invertebrates, ichthyoplankton, and zooplankton (Chamberlain et al. 1995, 1999, 2001; Chamberlain and Doering 1998b; Doering et al. 2002; SFWMD 2000 and 2002). An upgraded, fully hydrodynamic model has been developed and is under refinement. An early version of this model (Figure 3) has been used to verify and improve estimates of inflow requirements based on model prediction of salinity distribution in the estuary. For the CE, a mean monthly inflow of at least 300 ft^3/sec (cfs) is needed from S-79 to ensure that the average monthly salinity at Ft. Myers (Yacht Basin) is $\leq$ 10 ppt (target maximum salinity for tape grass) and daily average salinity does not exceed 20 ppt more than once in two consecutive years. This estimated minimum flow level (MFL) depends on about 200 cfs of additional flow from the downstream tidal basin between S-79 and Ft. Myers. However, violations of the salinity criteria commonly occurs during dryer than normal periods in the dry season when the combined tidal tributary flows are < 200 cfs. Therefore, a minimum flow of 300 from S-79 is not enough. A greater frequency of flows are needed from S-79 that approaches 500 cfs in order to achieve the intended salinity goals associated with the MFL and prevent MFL salinity violations during these very dry conditions.

At the other extreme, mean monthly flows that exceed 2,800 cfs should be minimized, because greater flows cause more than half the estuary upstream of Shell Point to become freshwater and salinity near Shell Point drops to levels that threaten many of the species in this region. Mean monthly inflows greater than 4,500 cfs from S-79 causes: salinity and other water quality parameters in San Carlos Bay to decline below desired levels; and the entire estuary upstream of Shell Point to approach freshwater conditions.

Research results reported by Volety et al. (2003) further demonstrated the importance of oysters as a VEC. They found that a greater abundance of decopds and fishes were associated with clusters of live oyster compared to dead-articulated clusters, while the structure provided by both living and dead

oysters shells supported a greater abundance than no shells. Species richness and dominance were higher for samples with oyster clusters (dead or live) compared to controls with no oyster shell. This study points out that, "perhaps the real significance of living oysters to habitat value lies not only in creating a three-dimensional structure, but also in maintaining this structure of clusters through time." Individual oysters may die, leaving empty compartments for reef residents, but "mass mortality within a cluster results in the disarticulation of the oysters shell."

Volety et al. (2003) in their field and lab research evaluated the survival of oyster adults and juveniles, as well as oyster health, the prevalence and intensity of disease, and oyster recruitment success. The results were compared to environmental factors, including salinity and freshwater flow from S-79. Oysters grow best at a salinity of 14 to 28 parts per thousand (ppt). Infection by the oyster pathogen, *Perkinsus marinus*, increases during higher salinity and temperature. Field studies during this research determined that the prevalence of infection was high, but disease intensity was low, because temperature and salinity act antagonistically (i.e., high summer temperature occurs during the wet season and lower salinity). Therefore, freshwater releases to diminish *Perkinsus marinus* are generally not advised during warm summer months because of the potential threat to oyster populations from further lowering salinity.

The greatest oyster growth and recruitment occurs during the wet season, but slower growth, poor spat production, and excessive valve closure occurs at salinities below 14 ppt. During their study, salinity conditions were best suited for oyster growth just upstream of Shell Point. However, this upstream area is also the most vulnerable to high mortality when large releases cause salinity to fall below threshold tolerance, sometimes for prolonged periods. The Volety et al (2003) report suggests, "that while adult oysters are tolerant, salinities of 5 ppt or lower will result in > 95% mortality of juvenile oysters." High juvenile mortality can occur when exposed to this salinity for just a week. Experimental results indicate that adults are able to tolerate salinities as low as 5 ppt up to 8 weeks, but can not tolerate salinities lower than 3 ppt, which can occur upstream of Shell Point when S-79 discharges exceed 4,000 cfs. Therefore, high discharges can limit population survival and abundance in this region where they were historically present. As a restoration note, Volety et al. (2003) indicated that because of high spat recruitment at intermediate salinities, along with good growth rates and low disease, it is very feasible to develop oyster reefs upstream of Shell Point by strategically placing oyster clutch in suitable areas, if provided the ability to control current [high] freshwater inflows.

Oysters in southwest Florida spawn continuously, with peak recruitment (spat settlement) occurring during May to November. Recruitment near Shell Point and possibly upstream begins to peak in March, a full 3 months earlier than in San Carlos Bay, thus making these newly settled juveniles vulnerable to large releases from S-79, which have often occurred during this period to regulate Lake Okeechobee water level for flood protection. Large freshwater flows at this time and during the summer also expose oyster larvae to lethal low salinities, or

flush the larvae to more downstream locations where there may not be suitable substrate for settlement.

In their conclusions, Volety et al. (2003) recommended freshwater inflows for the protection and enhancement of oyster recruitment and survival around Shell Point and San Carlos Bay, which are consistent with the flows outlined above for SAV. "Flows between 500 and 2000 cfs would result in salinities of 16-28 ppt at all stations, conditions that are favorable to sustain and enhance oyster populations in the Caloosahatchee Estuary." Under current water management practices, oysters in the Caloosahatchee are not stressed by low flows of < 300 cfs from S-79. However, complete cessation of discharges during the winter will increase salinities in areas normally associated with lower salinity, and result in the migration of marine predators and pests. They further speculate that oyster spat that recruit to downstream areas also will be exposed to higher salinity and heavy predation pressure resulting in very little survival. However, the greatest threat to oysters under current water management practices is due to high flows that exceed 3,000 cfs for extended periods (2-4 weeks). This is especially true for summer months during peak spawning, juvenile recruitment, and oyster growth. Volety et al. (2003) recommends that when freshwater releases are necessary, repeated pulses of < 1 week duration during winter months be made instead of sustained releases of freshwater during summer or winter months. Interpretation of these results also indicates that such pulses would be least damaging during December through February, before increased spawning and recruitment begins at upstream locations.

PERFORMANCE MEASURES

Physical changes to the estuary in combination with alteration of the natural freshwater inflow to the estuary have caused unnatural large scale fluctuations in the salinity and water quality within the area above Shell Point, as well as reduction in environmental stability for the San Carlos Bay area. The resulting impacts to seagrass, oysters, benthic invertebrates, and fishes can be dramatic and long lasting. It is the goal of the C-43 Basin Storage Reservoir (BSR) Project and Comprehensive Everglades Restoration Plan (CERP) to reduce the high variability in freshwater inflow to the Caloosahatchee Estuary, so to provide a full range of salinity along its longitudinal axis that is supportive of naturally occurring estuarine biota. This goal can be accomplished by: (1) reducing high flows from the watershed during the wet season, capturing and storing this water, then releasing it in a more environmentally sensitive manner that is beneficial to estuarine resources during the dry season; and (2) minimizing (non discretionary) regulatory discharges form Lake Okeechobee to the Caloosahatchee Estuary.

ECOLOGICAL PERFORMANCE TARGETS:

ET 1. (a) Maintain a 30-day moving average salinity ≤ 10 ppt during the dry season at the Ft. Myer's continuous salinity sensor (at 20% of water

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

depth), such that salinity in the Beautiful Island area remains <10 ppt, tape grass in this area does not decrease below 20% coverage, and blade length is ≥ 10 cm (values are provisional and may be adjusted after current and planned research (MML 2004 and 2007 reports) are evaluated); (b) Daily average salinity shall not exceed 20 ppt at Ft. Myers more than once every two years, and neither shall the 30-day moving average salinity of 10 ppt (MFL Rule: SFWMD 2000); (c) Limit the occurrence of average monthly salinity <15 ppt at the Cape Coral Bridge sensor, so salinity ≥20 ppt is promoted in Iona Cove (Bierman 1993), which is supportive of restoring at least continuous minimum seagrass density in the Iona Cove area (coverage ≥ 30% at 1 meter water depth and average blade length ≥ 10 cm – values are provisional and may be adjusted upon further research); and (d) Maintain daily salinity at Piney Point > 5 ppt, so that minimum conditions are provided for the recruitment, survival, and growth of juvenile oysters upstream of Shell Point during March – October (juvenile oyster growth ≥ 2.5 mm a month; recruitment 3 spats per substrate shell a month; and mortality < 20% per month – values are based on information interpreted from Volety et al. 2003).

ET 2. Maintain an average monthly salinity ≥ 25 ppt, as measured at the Sanibel Causeway near surface continuous sensor, so that historical seagrass density and coverage in the San Carlos Bay area is protected (as determined from previous surveys and areal photography) and restored to a previous condition (at least circa Harris et al. 1983), which includes reestablishment of continuous coverage at deeper depths in the San Carlos Bay area between Shell Point and the Sanibel Causeway.

HYDROLOGIC PERFORMANCE TARGETS TO ACHIEVE THE ECOLOGICAL TARGETS

Freshwater inflow:

HT 1a. For each alternative, compare the number of times that the combined mean monthly inflows from the Caloosahatchee watershed and Lake Okeechobee fall below a low-flow limit of **450** cfs at S-79 during October to July. The alternative with the fewest number of times that flows fall below **450** cfs will be considered better for protecting aquatic vegetation, oysters, and fish communities.

HT 1b. For each alternative, compare the frequency that the combined mean monthly low-flow limit of **450** cfs through S-79 was not met for just one month (not followed by another month below **450** cfs), as well as the frequency for 2, 3, 4…etc. consecutive months. The water management alternative with the fewest number of consecutive months with average flows below **450** cfs will be considered better for protecting estuarine aquatic resources.

HT 1c. For each alternative, compare the frequency that the combined mean monthly low-flow limit of **450** cfs through S-79 from the watershed

8

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

and Lake Okeechobee was not met for just one year (not followed by another year with months below **450** cfs), as well as the frequency for 2, 3, 4...etc. consecutive years. The water management alternative with the fewest number years and consecutive years with average monthly flow occurrences below **450** cfs will be considered better for protecting estuarine aquatic resources

HT 2a. For each management alternative, compare the number of times that the combined mean monthly inflow from the watershed and Lake Okeechobee exceed 2,800 cfs at S-79. The alternative with the fewest number of times that this criterion is exceeded at any time of year will be considered better for protecting both SAV and juvenile oysters at Shell Point and upstream. Additionally, a better ranking will be given to the alternative with the least number of discharges above this limit during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival.

HT 2b. For each alternative, compare the frequency that the mean the combined monthly inflow from the watershed and Lake, measured at S-79, exceeds 2,800 cfs for just one month (not followed by another month above this limit), as well as the frequency for 2, 3, 4... etc. consecutive months. The alternative with the fewest consecutive months that violate this criterion throughout the year will be considered better for protecting estuarine resources, including juvenile oyster recruitment and survival. Additionally, a better ranking will be given to the alternative with the least number of discharges above this limit during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival.

HT 3a. For each alternative, compare the number of times that the combined mean monthly inflows from the watershed and Lake Okeechobee exceed 4,500 cfs at S-79. The alternative with the least number of times flows exceed this limit will be considered better for protecting the estuarine resources, including those downstream in the San Carlos Bay region. Additionally, a better ranking will be given to the alternative with the least number of discharges above this limit during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival.

9

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

> ***HT 3b***. For each alternative, compare the frequency that the combined mean monthly inflows from the watershed and Lake, measured at S-79, exceeds 4,500 cfs for just one month (not followed by another month above this limit), as well as the frequency for 2, 3, 4...etc. consecutive months. The alternative with the fewest number of consecutive months that violate this criterion will be considered better for protecting aquatic resources, including juvenile oysters. Additionally, a better ranking will be given to the alternative with the least number of consecutive discharge periods above these limits during March through October, in order to limit critically low salinity conditions from occurring both upstream and downstream of Shell Point, which threatens estuarine resources, including SAV and juvenile oyster recruitment and survival.

As part of the South Florida Restudy, water management alternatives were evaluated that incorporated a range of infrastructure changes. The adopted plan (CERP) when built is predicted to reduce drastically the number of regulatory discharges from Lake Okeechobee that elevates freshwater inflow to the CE.

> ***HT 4***. For the C-43BSR Project, in combination with other CERP infrastructure alternatives, compare the number of days that regulatory discharges from Lake Okeechobee are made to the Caloosahatchee River. The management alternative with the least daily discharge volume, the fewest number of total days of discharge, and the fewest number of consecutive days will be preferred. Special consideration will be provided for pulse releases that may benefit the estuary

The optimum range and timing of freshwater discharges is best achieved by identifying a frequency distribution of desirable inflows, which also considers that freshwater inflows vary naturally as a function of rainfall. An optimum inflow range that includes natural variation in salinity is important to insuring a diverse composition of estuarine biota (Sklar and Browder 1998). As a first attempt to define this environmentally sensitive distribution of S-79 discharges, an optimization model was employed (Labadie 1995; Otero et al. 1995). The model utilized historic watershed runoff data during 1966-1990 (without regulatory Lake Okeechobee discharges). The desired inflow ranges were input variables to the model, along with the natural periodicity of violations based on rainfall cycles. However, this initial distribution and allowable violations did not fully account for: the physical changes in the Caloosahatchee Estuary, such as the truncating effect of installing S-79; and the adverse biotic impacts from the violations that cause unnatural salinity conditions and extremes within this physically changed environment. Therefore, the initial distribution frequencies (Chamberlain et al. 1995; Chamberlain and Doering 1998b) were further refined during the Restudy to consider MFL requirements for achieving estuarine resource protection. Most recently, estimates of tidal tributary inflows were added to better assess total estuarine inflows related to salinity distribution targets, which lead to the selection of EST05 as the preferred distribution.

10

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

The current proposed frequency distribution of mean monthly inflows to the CE from S-79 (estuary demand time series EST05: Caloosahatchee Freshwater Watershed delivery volume to the estuary ~ 524,000 af/yr) was chosen from several CERP options because it best meets the range of flows from S-79 that are needed for achieving estuarine protection and restoration goals by: providing flows that do not fall below the limit that achieves the MFL salinity based rules; reducing mean monthly flows greater than 2,800 cfs; and maintaining a full estuarine salinity gradient that is not unnaturally compressed. Most importantly, a flow distribution that provides S-79 flows below the 450 cfs EST05 low-flow limit will not achieve the protection defined in the MFL rule (SFWMD 2000 and 2002).

The frequency distribution of flows from S-79 associated with EST05 (without tidal basin contribution) are identified in the following table.

Discharge Range (cfs) From S-79	Percent Distribution Of Flows From S-79
0 to 450	0%
450 to 500	42.8%
500 to 800	31.7%
800 to1500	19.2%
1500 to 2800	5.6%
2800 to 4500	0.7%
>4500	0%

HT 5. For each alternative, compare the frequency distribution of the combined monthly average freshwater inflows through S-79 from the watershed and Lake Okeechobee for the entire period of record being evaluated. The alternative with the frequency distribution of inflows that best approaches the range defined in the above table will be considered better for protecting and restoring estuarine resources, while further promoting biotic diversity. Specifically, the alternative that maximizes, up to 75% of the flows from S-79 in the **450-800** cfs range and almost all the remaining inflow in the 800 to 2800 cfs range will be considered the most desirable.

In order to better achieve the CERP project and MFL restoration goals, the EST05 distribution provides no allowances of monthly average discharges from S-79 that are less than **450** cfs. However, salinity violations are allowed under the MFL rule once every two years for the moving monthly average and daily salinity criteria. Therefore, the C-43 BSR Project can still achieve estuarine protection and restoration success if the final selected alternative has flow occurrences beyond the distribution limits, including those below 450 cfs. The degree of achievement will be in part demonstrated by comparing performance measure targets and habitat units between base conditions and the alternative.

11

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

As discussed earlier, the preferred flow distributions have changed periodically during the course of this project. The proposed EST05 flow distribution may also change as more information is provided regarding: predevelopment flow and salinity conditions; natural variation; what salinity conditions were naturally (historically) associated with droughts and flood events; and what flows are needed to protect and restore the biotic features in the current and future developed system. This is consistent with the adaptive management strategy adopted for this project.

INFORMATION NEEDS AND RECOMMENDED ASSESSMENT STUDIES

1. Define and assess appropriate attributes (specific species and/or community values) to ascertain if this project's ecological goals are attained and there is a discernable positive impact on the estuary, specifically including SAV, oyster, and fish as follows:
   (a) Routinely (at seasonally important intervals) monitor SAV coverage, density, and canopy height to at least 1.5-2.0 m depth at key species locations.
   (b) Routinely monitor (at seasonally important intervals) oyster survival and recruitment at key locations.
   (c) Routinely monitor (seasonally) water quality, including temperature, D.O., salinity, nutrients, chlorophyll, suspended solids, and water clarity along the longitudinal axis of the estuary (S-79 – Sanibel Causeway and into lower Pine Island Sound and Matlacha Pass).
   (d) Monitor routinely (at appropriate seasonal intervals) species and biotic groups of concern as separately defined in performance measure documents and the CE conceptual model. At a minimum, insure the Monitoring Assessment Plan (MAP) effort within RECOVER is being fulfilled.
2. Scientifically assess and publicly agree what constitutes desirable natural variability (predevelopment conditions) related to salinity and causal freshwater inflow from S-79 and the tidal basin.
3. Install and monitor flow gages in downstream tidal tributaries to begin assembling a long term data set to: verify model predictions of flows; determine actual amount and timing of tidal tributary flows related to MFL requirements for achieving the salinity criteria; and to help assess flow impacts on biota being monitored for CERP (RECOVER).
4. Monitor S-79 and S-77discharges for adherence to the selected alternative flow distribution.
5. Continue to maintain and monitor existing 7 salinity recorders and other permanent sensors in the Caloosahatchee Estuary. Install new sensors to monitor salinity and other water quality parameters of concern at key locations for VEC. Suggest additional sensors be

12

located in western San Carlos Bay, lower Pine Island Sound, and Matlacha Pass.

6. Assess limits of SAV morphology for providing suitable habitat as a VEC and its relationship to flow, salinity, and water quality conditions.
7. Finish development of the: tape grass model; Caloosahatchee Hydrodynamic/Salinity Model; a water quality model component; habitat suitability models; and a seagrass model for the lower estuary.

LITERATURE CITED

Bierman, V. 1993. Performance report for the Caloosahatchee Estuary salinity modeling. South Florida Water Management District expert assistance contract deliverable. Limno-Tech, Inc.

Chamberlain, R. H. and P.H. Doering. 1998a. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation, p. 81-90. *In* S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington, D.C.

Chamberlain, R. H. and P.H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach, p. 121-130. *In* S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington, D.C.

Chamberlain, R.H., P.H. Doering, K.M. Haunert, and D. Crean. 2001. Distribution of ichthyoplankton and recommended freshwater inflow to the Caloosahatchee Estuary, FL. Poster presentation, 16th Biennial Conference of the Estuarine Research Federation.

Chamberlain, R.H., P.H. Doering, K.M. Haunert, and D. Crean. 1999. Distribution of zooplankton and recommended freshwater inflow to the Caloosahatchee Estuary, FL. Poster presentation, 15th Biennial Conference of the Estuarine Research Federation.

Chamberlain, R.H., D.E. Haunert, P.H. Doering, K.M. Haunert, and J.M. Otero. 1995. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary, Florida. Technical report, South Florida Water Management District, West Palm Beach, Florida.

Doering, P.H. and R.H. Chamberlain. 2000. Experimental studies on the salinity tolerance of Turtle Grass, *Thalassia testudinum*, p. 81-98. *In* S.A. Bortone (ed.), Seagrasses: Monitoring, ecology, physiology, and management. CRC Press LLC, Boca Raton, Florida, 318 pp.

Doering, P.H., R.H. Chamberlain, K.M. Donohue, and A.D. Steinman. 1999. Effect of salinity on the growth of *Vallisneria americana* Michx. From the Caloosahatchee Estuary, Florida. *Florida Scientist* 62(2): 89-105.

Doering, P.H., R.H. Chamberlain, and D.E. Haunert. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. *Estuaries* 25 (1343-1354).

Doering, P.H., R.H. Chamberlain, and J.M. McMunigal. 2001. Effects of simulated saltwater intrusion on the growth and survival of Wild Celery, *Vallisneria americana*, from the Caloosahatchee Estuary (South Florida). *Estuaries* 24(6A): 894-903.

Harris, B.A., K.D. Haddad, K.A. Steidinger, and J.A. Huff. 1983. Assessment of Fisheries Habitat: Charlotte Harbor and Lake Worth, Florida. Florida Department of Natural Resources, Bureau of Marine Research, St. Petersburg, Florida. 211 pp.

Hoffacker, V.A. 1994. Caloosahatchee River submerged grass observation during 1993. W. Dexter Bender and Associates, Inc. Letter-report and map to Chip Meriam, SFWMD.

Kraemer, G.P., R.H. Chamberlain, P.H. Doering, A.D. Steinman, and M.D. Hanisak. 1999. Physiological response of transplants of the freshwater angiosperm *Vallisneria americana* along a salinity gradient in the Caloosahatchee estuary (SW Florida). *Estuaries* 22: 138-148.

Labadie. P.W. 1995. Optimization of management runoff to the St. Lucie Estuary. Final Contract report for SFWMD, P.O. No. PC P60617. 38 pp.

Mote Marine Laboratory (MML). 2004. Final report: Habitat Use of *Vallisneria americana* beds in the Caloosahatchee River. Contract C-12836 between Mote Marine Laboratory and the SFWMD.

Mote Marine Laboratory (MML). 2007 Final report: Habitat Use of *Vallisneria americana* beds in the Caloosahatchee River. New follow-up contract begins in FY2005 with MML and final report expected in 2007.

Otero, J.M., P.W. Labadie, D.E. Haunert, and M.S. Daron. 1995. Optimization of managed runoff to the St. Lucie Estuary, p. 1506-1510. *In* W.H. Espey, Jr. and

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

P.G. Cobbs (eds.), Proceedings of the First International Conference: Water Resources Engineering and American Society of Civil Engineers, Volume 2.

Sackett. J.W. 1888. Survey of the Caloosahatchee River, Florida. Report to Captain of the U.S. Engineering Office, St. Augustine, Florida.

Scarlotos, P.D. 1988. Caloosahatchee Estuary hydrodynamics. South Florida Water Management District, Technical Publication No. 88-7. 39 pp.

SFWMD. 2000. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary. South Florida Water Management District, Florida.

SFWMD. 2002. Technical documentation to support development of minimum flows and levels for the Caloosahatchee River and Estuary: Draft 2002 Status Update Report. South Florida Water Management District, Florida.

Sklar, F.H. and J.A. Browder. 1998. Coastal environmental impacts brought about by alteration to freshwater flow in the Gulf of Mexico. *Environmental Management* 22 (4): 547-562.

Volety, A.K., S.G. Tolley, and J.T. Winstead. 2003. Effects of seasonal and water quality parameters on oysters (*Crassostrea virginica*) and associated fish populations in the Caloosahatchee River: Final contract report (C-12412) to the South Florida Water Management District. Florida Gulf Coast University, Ft. Myers, Florida.

15

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

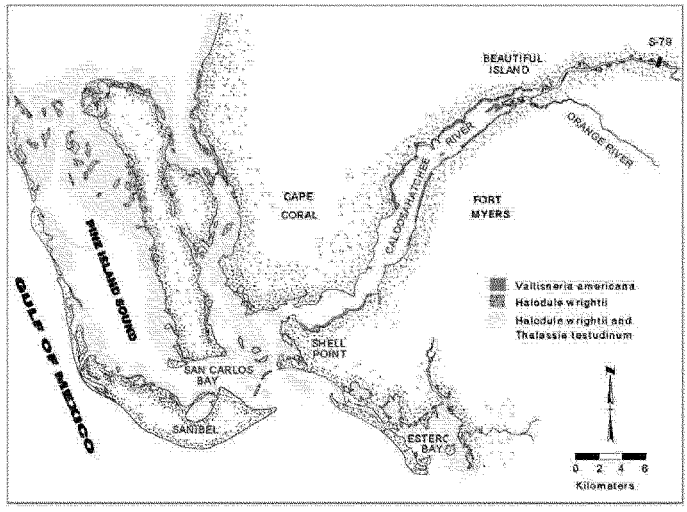


Figure 1. Caloosahatchee Estuary and surrounding area. The general historic range of dominant submerged aquatic vegetation species are indicated, when condition are good for maximum distribution (*V. americana* farthest upstream and *H. wrightii* near the downstream mouth, Shell Point).

16

6/28/05 SWFFS DRAFT C
Text: Bob Chamberlain (rchamber@sfwmd.gov)

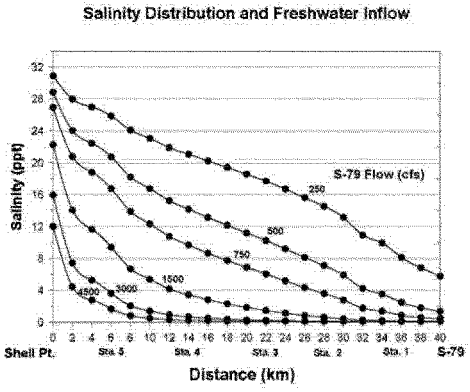


Figure 2. Steady-state salinity model results (Bierman 1993). Sta. 1 -5 are locations (km from Shell Point) of biological sampling stations. Other key locations include: (1) Piney Point oyster area near 4 km; (2) Iona Cove seagrass area near 4-6 km; (3) Cape Coral Bridge near 11-12 km; (4) Ft. Myers Bridges and Yacht Basin salinity recorder near 23.5 km; (5) Beautiful Island tape grass area near 28-30 km; and (5) Orange River near 31-32 km.

17

5/12/05 Draft (C-43 BSR)
Text: Bob Chamberlain (rchamber@sfwmd.gov)

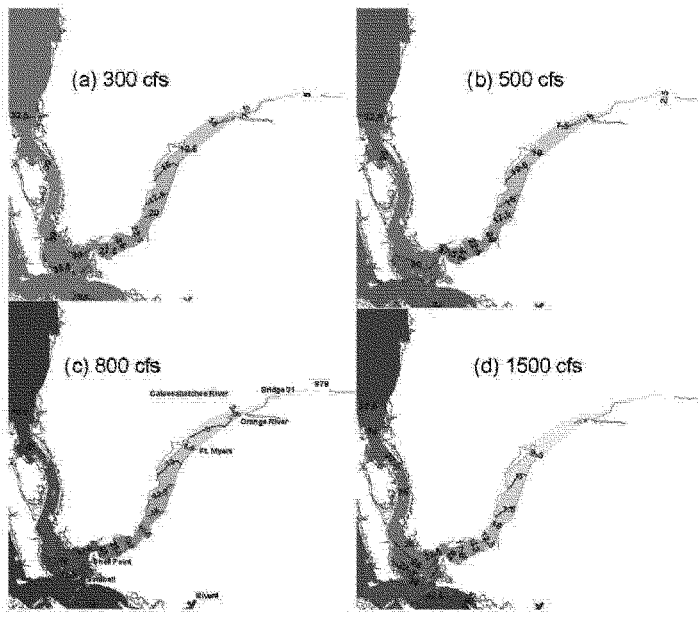
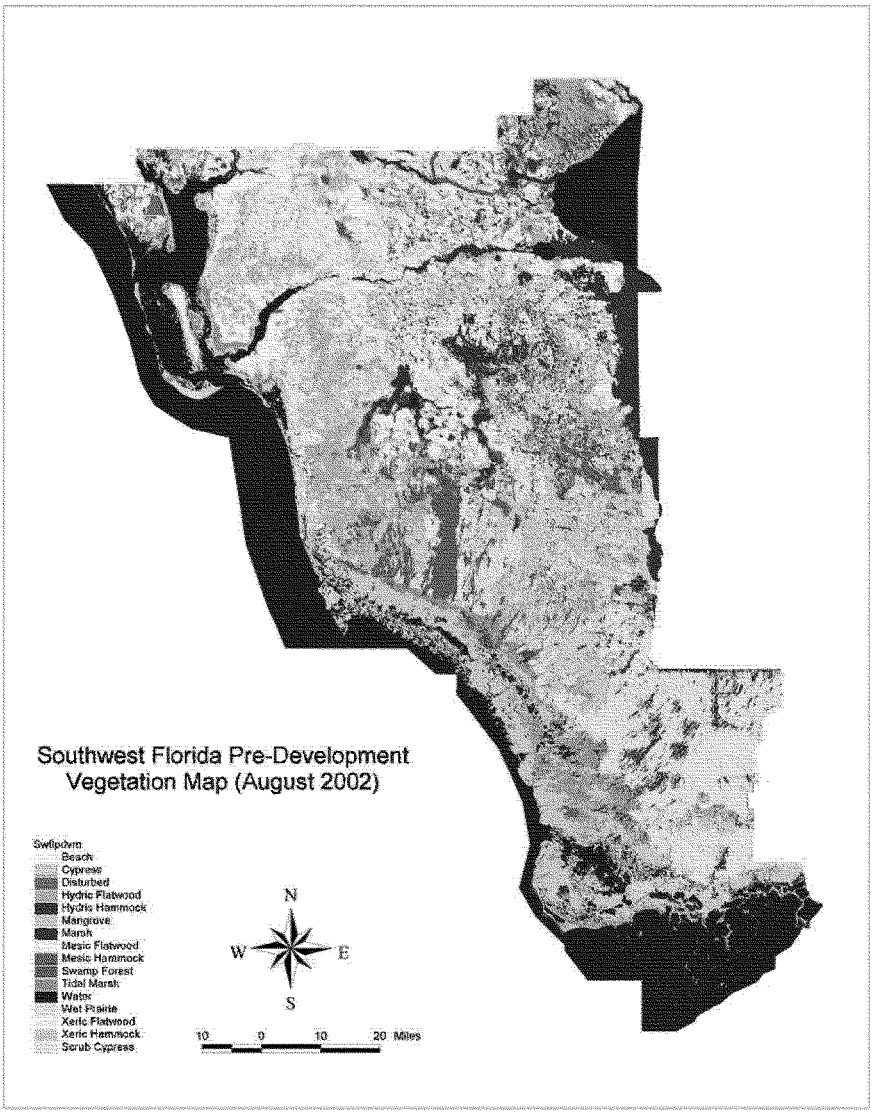


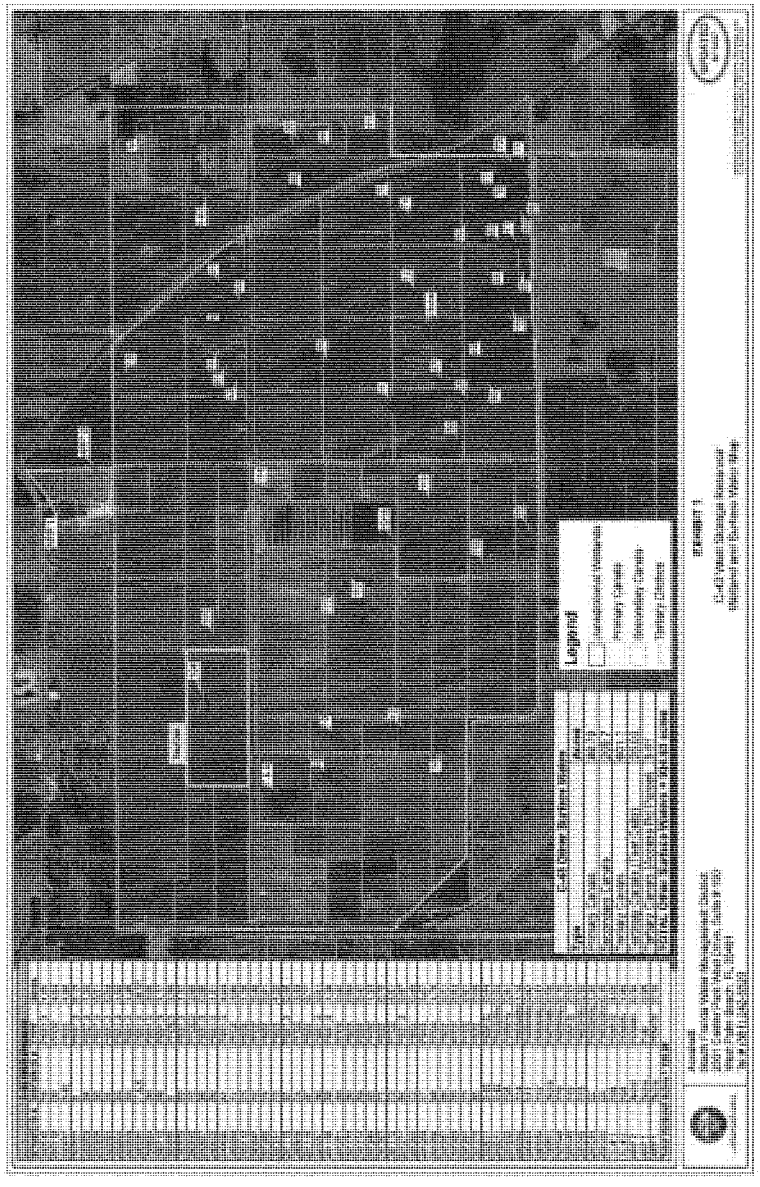
Figure 3. Hydrodynamic-salinity model results depicting salinity (ppt) contours for selected flow levels from S-79

18

C.16 SOUTHWEST FLORIDA FEASIBILITY STUDY PRE-DEVELOPMENT VEGETATION MAP



C.17 JURISDICTIONAL WETLANDS ON SITE



C.18 SUMMARY OF THE SEAGRASS HSI



Final Report for Technical Assistance for an Ecological Evaluation of the Southwest Florida Feasibility Study

STRESSOR RESPONSE MODEL FOR THE SEAGRASSES, *Halodule wrightii* and *Thalassia testudinum*

By Frank J. Mazzotti, Leonard G. Pearlstine, Robert Chamberlain, Tomma Barnes, Kevin Chartier, and Donald DeAngelis

Joint Ecosystem Modeling Laboratory

Technical Report

FINAL REPORT
for

Technical Assistance for an Ecological Evaluation of the

Southwest Florida Feasibility Study

STRESSOR RESPONSE MODELS FOR THE SEAGRASSES, *Halodule wrightii* and *Thalassia testudinum*

Prepared By:
Frank J. Mazzotti[1], Leonard G. Pearlstine[1], Robert Chamberlain [2], Tomma Barnes[3], Kevin Chartier[1], and Donald DeAngelis[4]

[1]University of Florida
Ft. Lauderdale Research and Education Center
3205 College Ave
Davie, FL 33314
(954) 577-6304

[2]South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

[3]Post, Buckley, Schuh and Jernigan
3501 North Causeway Blvd., Suite 725
Metairie, LA 70001
(504) 862-1481

[4]United States Geological Survey
University of Miami, Dept. of Biology
1301 Memorial Dr. RM 215
Coral Gables, FL 33146

Prepared For:
South Florida Water Management District
Fort Myers Service Center
2301 McGregor Blvd.
Fort Myers, FL 33901

United States Geological Survey
1301 Memorial Dr. RM 215
Coral Gables, FL 33146
(305) 284-3974

May 2007

University of Florida

This report should be cited as:

Mazzotti, F.J., Pearlstine, L.G., Chamberlain, R., Barnes, T., Chartier, K., and DeAngelis, D. 2007, Stressor response models for Seagrasses, *Halodule wrightii* and *Thalassia testudnium*. JEM Technical Report. Final report to the South Florida Water Management District and the U.S..Geological Survey. University of Florida, Florida Lauderdale Research and Education Center, Fort Lauderdale, Florida, 19 pages.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the University of Florida.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted material contained within this report.

Contents

Introduction....1
Southwest Florida Feasibility Study....1
C43 West Reservoir....1
Forcasting Models....1
Habitat Suitability Indices....2
Ecology of the Seagrass....2
HSI for Seagrass....9
References Cited....17

Figures

Figure 1. Caloosahatchee Estuary SAV monitoring stations....4
Figure 2. Time series density of seagrass....5
Figure 3. Seagrass coverage at two locations in San Carlos Bay....6
Figure 4. HSI value for seagrass response to salinity....10
Figure 5. HSI value for seagrass response to light....11
Figure 6. Average Monthly Photosynthetic Active Radiation (PAR)....12
Figure 7. Light attenuation vs. Salinity in seagrass areas....13
Figure 8. Light attenuation regions....18
Figure 9. HSI value for Seagrass response to temperature....14
Figure10. Estimated water temperature in the Caloosahatchee Estuary....15

Tables

Table 1. Habitat requirements for the seagrass, *Halodule* and *Thalassia*....7
Table 2. Changes to the HSI model's spatial boundaries and post-processing routines....9

STRESSOR RESPONSE MODEL FOR THE SEAGRASSES, *Halodule wrightii* and *Thalassia testudinum*

By Frank J. Mazzotti, Leonard G. Pearlstine, Robert Chamberlain, Tomma Barnes, Kevin Chartier, and Donald DeAngelis

Introduction

A key component in adaptive m anagement of Comprehensive Everglad es Restoration Plan (CERP) projects is evaluating alternative management plans. Regional hydrological and ecological models will be applie d to evalua te resto ration alte rnatives and the re sults will b e applied to modify management actions.

Southwest Florida Feasibility Study

The Southwest Florida Feasibility Study (SW FFS) is a com ponent of the Co mprehensive Everglades Restoratio n Plan (CERP). The SWFFS is an independent but integrate d implementation plan f or CERP projects and wa s initia ted in recog nition tha t there wer e additional w ater resource issues (needs, problem s, and opportunitie s) within Southwest Florida that were not being addressed directly by CERP. The SWFFS identifies, evaluates, and compares alternatives that address those additional water resource issues in Southwest Florida. An adaptive assessment strategy is being deve loped tha t w ill cre ate a syst em-wide m onitoring program to measure and interpret ecosystem responses. T he SWFFS provides an esse ntial fram ework to address the health and s ustainability of aquatic s ystems. This includes a focus on water quantity and quality, flood protection, and ecological integrity.

C43 West Reservoir

The purpose of the C43 Basin Storage Reservoir project is to im prove the tim ing, quantity, and quality of fr eshwater flows to the Caloosahatch ee River estuary. The project includes an above-ground reservoir with a total stor age capacity of approxim ately (170,000 acre-feet) and will be located in the C-43 Basin in Hendr y, Glades, or Lee Counties. The initial design of the reservoir assumed 8094 hectares (20,000 acres) with water levels fluctuati ng up to 2.4 m eters (8 feet) above grade. The final size, depth and configura tion of this facility wi ll be determ ined through more detailed planning and design.

Forecasting Models

Forecasting models brin g togeth er research and monitoring to ecosystems of Southwest Flo rida and place th em into an adaptive m anagement framework for the evaluation of altern ative plans. There are two princip le ways to structure adap tive m anagement: (1) *passive,* by which policy

decisions are made based on a forecasting model and the model is revised as monitoring data become available, and (2) *active,* by which management activities are implemented through statistically valid experimental design to better understand how and why natural systems respond to management (Wilhere 2002).

In an integrated approach that includes both passive and active-adaptive management, a forecasting model simulates system response and is validated by monitoring programs to measure actual system response. Monitoring can then provide information for passive-adaptive management for recalibration of the forecasting model. Directed research, driven by model uncertainties, is an active-adaptive management strategy for learning and the reduction of uncertainties in the model.

The forecasting models for the C-43 West Reservoir Project and the Southwest Florida Feasibility Study consist of a set of stressor response (habitat suitability) models for individual species. These stressor response models have been developed principally with literature, expert knowledge, and currently available field data.

Habitat Suitability Indices

Habitat Suitability Indices (HSI) models were developed with each stressor variable portrayed spatially and temporally across systems of the study area at scales appropriate to the organism or community being portrayed. The HSI models have been incorporated into a GIS to portray responses spatially and temporally to facilitate policy decisions. That is, the model describes a response surface of habitat suitability values that vary spatially according to stressor levels throughout the estuary and temporally according to temporal patterns in stressor variables. Much of the temporal variation is a result of temporal cycling of important stressor inputs, such as water temperature and salinity. Temporal change for other important variables may not be cyclical, such as rising sea level and increasing land use and fresh water demands in the region. Areas predicted to be suitable and those predicted to be less suitable or disturbed should be targeted for additional sampling as part of the model validation and adaptive management process.

Species selected for modeling (focal species) are ecologically, recreationally or economically important and have a well established linkage to stressors of management interest. They may also make good focal species because they engage the public in caring about the outcome of restoration projects. The habitat suitability models (HSI) were developed by choosing specific life stages of each species with the most limited, restricted, or tightest range of suitable conditions, to capture the highest sensitivities of the organisms to the environmental changes associated with the planned restoration activities. Values used in the models are listed in Table 1.

The models calculate habitat suitability monthly as the weighted geometric mean of the environmental variables identified as important for each model. Because the geometric mean is derived from the product of the variables rather than the sum (as in the arithmetic mean) and has the appropriate property that if any of the individual variables are unsuitable for species success (i.e., the value of the variable is zero) then the entire index goes to zero.

Ecology of Seagrasses

Beds of submerged aquatic vegetation (SAV) are important to the ecology of shallow estuarine and marine environments. These beds provide habitat for many benthic and pelagic organisms,

function as nurseries for juveniles and other early life stages, stabilize sediments, improve water quality, and can form the basis of a detrital food web (Kemp et al. 1984; Fonseca and Fisher 1986; Carter et al. 1988; Killgore et al. 1989; Lubber et al. 1990). Because of the importance of these beds, estuarine restoration initiatives often focus on SAV (Batiuk et al. 1992; Johansson and Greening 2000; Virnstein and Morris 2000). SAV are commonly monitored to gauge the health of estuarine systems, (Tomasko et al. 1996) and their environmental requirements can form the basis for water quality goals (Dennison et al. 1993; Stevenson et al. 1993).

In the Caloosahatchee Estuary, field and laboratory research has been conducted by the South Florida Water Management District (SFWMD, associated contractors, and non-government organizations over a wide range of flows and salinities. This information, along with the results from researchers in other systems, is used to estimate maximum freshwater inflow limits and associated water quality requirements to protect and restore *Halodule wrightii* (shoal grass) and *Thalassia testudinum* (turtle grass).

McNulty et al. (1972) and Harris et al. (1983) mapped SAV in the lower estuary upstream of Shell Point, as well as throughout the outer embayments. *Halodule* is the only seagrass species consistently located upstream of Shell Point (Figure 1: Stations 5 and 6) until it mixes downstream with *Thalassia* and other less common species in San Carlos Bay (Stations 7 and 8) and Pine Island Sound (Stations 9 and 10). *Halodule* has a wide salinity tolerance (McMahan 1968). It does not survive below 3.5 ppt and prefers salinity as high as 44 ppt (Zieman and Zieman 1989). This wide tolerance is probably why it is the only true seagrass species encountered upstream of Shell Point. Monitoring results (Figure 2a) indicate that, of all areas where *Halodule* is present, the lowest biomass is found upstream, where salinity is more diluted and most variable (Chamberlain et al 1995, Chamberlain and Doering 1998b, Doering et al. 2002). The greatest biomass occurs when salinity is above 20 ppt. Figure 2a also depicts seasonal growth patterns that can be influenced by high freshwater inflow that cause decreasing salinity (as occurred in the Water Year 2006) due to tropical storms during 2004 and 2005.

Literature summarized by Zieman and Zieman (1989) indicates that the optimum salinity range for *Thalassia* is 24-35 ppt. The maximum photosynthetic activity of *Thalassia* occurs in euhaline seawater and decreases proportionately with decreasing salinity. *Thalassia* does not grow in areas with salinity normally below 17 ppt and will suffer significant leaf loss when exposed to lower salinity. *Thalassia* does not exist upstream of Shell Point where salinity during the SFWMD study was more variable. Recent monitoring results (Figure 2b) also depict a declining density below normal at the end of WY 2006 from discharge related to tropical storms during 2004 and 2005.

Comparison of map coverage by Harris et al. (1983) determined substantial loss in seagrass during the mid-later 20th century. This loss was in part due to changes in freshwater flow patterns (salinity variability), physical alteration in the estuary and watershed, as well as changes in water management practices (Chamberlain and Doering 1998a). Harris et al. (1983) reported that the greatest loss appeared to be from deeper beds, which indicates that a change in water clarity has occurred, in part probably due to the increased freshwater inflow reaching the downstream beds and associated decreased water quality (i.e., increased water color).

In general, as flows increase, the water quality constituents (primarily color) that inhibit light penetration also increase. Therefore, as light attenuation increases, the depth at which the seagrass can survive decreases. SFWMD monitoring data indicates that average monthly flows

from S-79 that exceed 4,000 cfs are associated with light penetration below that necessary to support plants at 1 m depth in San Carlos Bay. Lower mean monthly discharges that approach 3,000 cfs are associated with the same problem for *Halodule* upstream of Shell Point. At deeper depths (e.g., 1.5m) plant coverage is considerably more sensitive to the freshwater inflow (Figure 3).

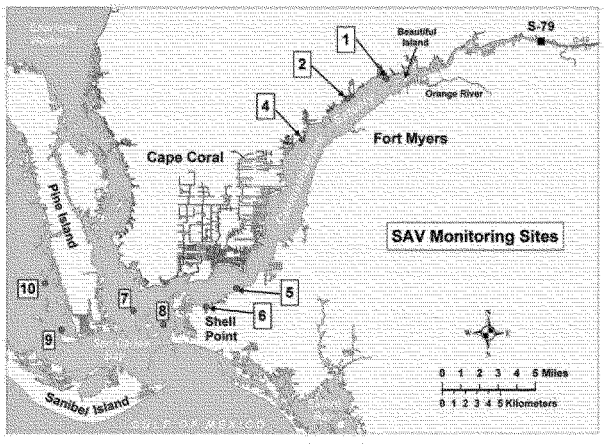


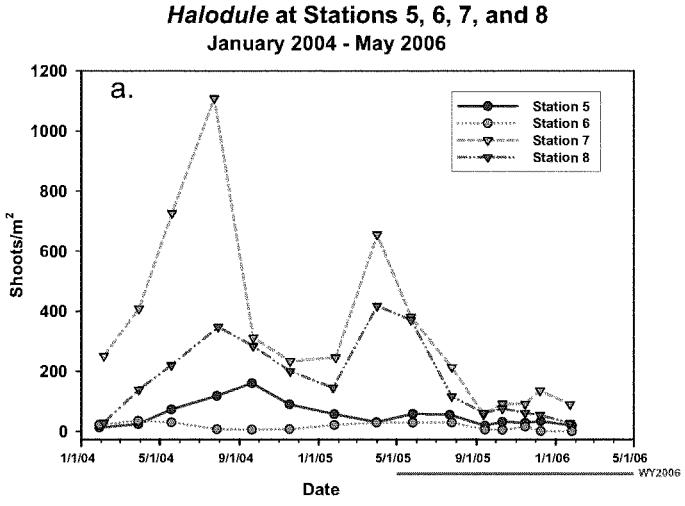
Figure 1. Caloosahatchee Estuary SAV monitoring stations for *Vallisneria americana* is found at stations 1-3, *Halodule wrightii* at stations 5-10, *Thalassia testudinum* at stations 8-10.

Based on the literature identified in Table 1, along with SFWMD laboratory and field research, the HSI curve in Figure 4 was formulated to represent relative *Halodule* and *Thalassia* response to salinity values generated during model runs.

Although there are species-specific variations, generally speaking, SAV distributions are limited by four environmental factors: light, salinity, temperature, and nutrients (Dennison et al. 1993, Kemp et al. 2004). In the Caloosahatchee, as indicated above, studies have documented that SAV distribution and subsequently its functionality, is strongly related to limits on their physiological response to salinity and light. Except at the distribution margins, plant location in the estuary generally depends on salinity, while growth characteristics controlling plant height and depth strongly relates to light attenuation within salinity tolerant zones.

The average daily bottom light (ADBL) required by SAV, which helps determine the depth to which plants exist, is measured in the photosynthetic active radiation (PAR) spectrum of 400-700 nanometers during the entire 24 hour day (not just daylight or peak light periods). ADBL for shoal grass can be divided into stressed environments like in Iona Cove, and more desirable areas as in San Carlos Bay (as evidenced in the results of Dunton 1994 and 1996 from Texas). Dunton and Tomasko (1991) and Dunton (1996) also determined light requirements during winter and summer seasons. Based primarily on their results, the minimum range of ADBL in Iona Cove is estimated to be about 50-60 micro-Einsteins (uE = micromoles/m^2/sec) and saturation is 220-

300uE, depending on the season . In San Carlos Bay, the m inimum and saturation levels of ADBL equates to about, 75-100uE, and 225-325uE, respectively.



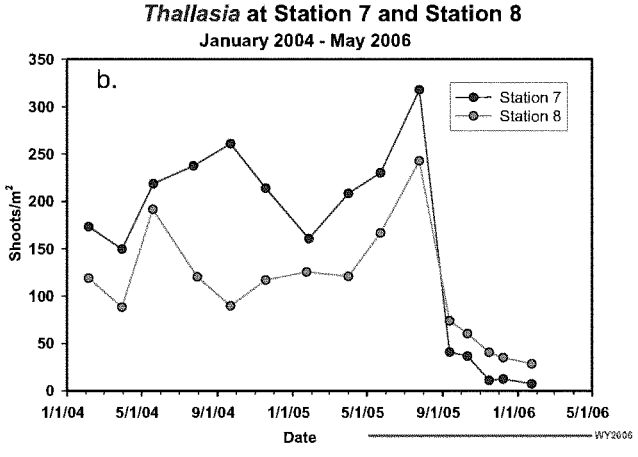


Figure 2. Time series density of seagrass: (a.) *Halodule wrightii;* and (b) *Thalassia testudinum* (turtle grass) in the Caloosahatchee Estuary and San Carlos Bay, with the time period of a Water Year indicated (WY: May 1 –April 30). Data collected by the Sanibel-Captiva Conservation Foundation.

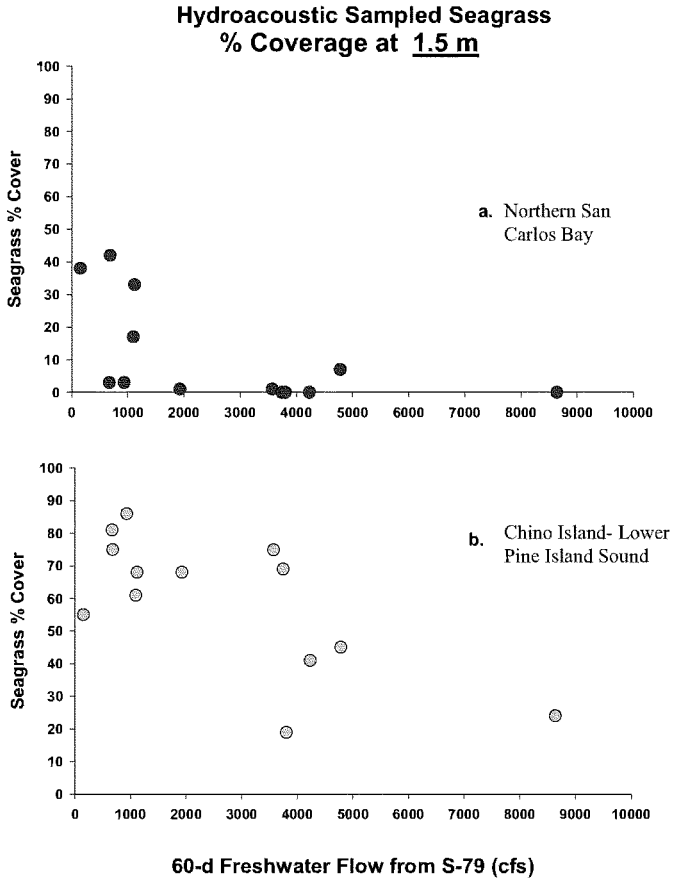


Figure 3. Seagrass coverage at two locations downstream of the Caloosahatchee River (a. Site 7; and b. Site 9-in Figure 1) compared to 60-day average freshwater inflow from S-79 prior to sampling.

These estimates can be put on a relative HSI scale from 0 to 1 as reflected in Figure 5. However, this scale better reflects the qua lity of habitat (e.g. plant growth potential and health), not the amount of c overage (acres), which is one of the HSI modeling objectives. For exa mple, a HSI =1.0 or 0.5 both represent an area with plant cove rage that is sustaina ble between months. To address this issue, a "50% Approach" was a dopted, whereby a single linear line from the minimum ADBL during the winter in Iona C ove to the PAR level of 150uE is used that represents 50% of saturation during the summer growing season in San Carlos Bay (Figure 5).

Table 1. Habitat Requirements for the Seagrasses, *Halodule* and *Thalassia*. The following table summarizes S-79 inflow criteria (mean monthly cubic feet per second), important salinity ranges, and water quality requirements for the protection and support of *Halodule* and *Thalassia* in the Caloosahatchee Estuary.

Variable	Estuary Area	Value	Source
Halodule and *Thalassia*	Throughout their range	Light to 1m: 1) Min. 20-25% of Subsurface irradiance 2) Minimum attenuation Coef -1.5 3) Most important during warm growing season 4) Recovery goal: Deeper, 2m? 5) Optimal Productivity at 300 mE	Kenworthy and Haunert 1991 Tomasko and Hall 1999 Dixon and Leverone 1995 Herzka and Dunton 1997 Fong et al. 1997
Halodule	Throughout its range	Salinity: 1) 3.5ppt - minimum tolerance; duration of tolerance 1-2 months; Recovery 1 year (following winter and spring) of preferred salinity 2) Prefers > 20ppt, below which productivity declines 3) Optimum, seawater ~ 35ppt 4) Location requirements – long term average salinity >20ppt, std. dev. < 10ppt	Zieman and Zieman 1989 McMahan 1968 Chamberlain and Doering 1998b Chamberlain (Pers. field/lab obs) 2004
		Temperature: 1) Greatest productivity during March – September (Possibly a magnitude more biomass in shallow areas of Area 6) 2) Optimum 22-26°C	Chamberlain (Pers. field/lab obs/analysis) 2004 Fong et al. 1997
Area	5	Flow (to achieve above salinity and light limits): 1) Max < 3,000 cfs 2) Preferred < 1000 cfs 3) Optimum < 500 cfs	Chamberlain and Doering 1998b Doering et al. 2002
Thalassia	Throughout its range	Salinity: 1) ~ 6ppt - minimum tolerance; duration tolerance 1-2 months; Recovery 1 year (following winter and spring) of preferred salinity;	Chamberlain and Doering 1998b Doering and Chamberlain 2000 Doering et al. 2002 Zieman and Zieman 1989 Zieman et al 1999 Chamberlain (Pers. field/lab obs/analysis) 2004

		Mortality when 0 ppt for ≥ 3 weeks – no recovery 2) Prefers > 20ppt, < 17ppt productivity declines 3) Optimum, 24-35ppt 4) Location requirements – long term average salinity >20-25ppt, std. dev. ≤ 5ppt	
		Temperature: 1) Greatest productivity during March – September 2) Optimum when ~ 30°C 3) Decreased productivity @ < 20 °C 4) Stressful when water temp < 15 °C (winter) 5) Mortality - month>36°C	Chamberlain (Pers. field/lab obs/analysis) 2004 Dawes et al. 1997 Koch and Erskine 2001 Miller 2000
Halodule and Thalassia	Area 6	Flow (to achieve above salinity and light limits): 1) Max 4,500 efs 2) Preferred < 2,500 cfs 3) Optimum < 1,000 cfs	Chamberlain and Doering 1998b Chamberlain 1995 Doering et al. 2002

The for mula for calculating ADBL is based on the Lambert-Beer equa tion, which requires knowing: (1) surface incident light in the PAR sp ectral range; (2) water co lumn light attenuation (K); and (3) depth. Average monthly incident PAR for the Caloosahatchee is depicted in Figure 6 and was calculated from a daily average PAR da taset, recorded by a continuous sensor during 1998-2004, located in the nearby Estero Bay W atershed. Light attenuation was calculated based on the curv ilinear rela tionships of salin ity and simultaneous light atte nuations m easurements (Figure 7) at stations upstream and downstream of Shell Point (Figure 8). Depth was determ ined from bathymetry surveys of the Caloosahatchee Estuary and the resulting information supplied in a GIS data file that matched the grid cell points of the model.

Seasonal patterns are an indicati on of the influence and im portance of temperature o n seagrass, with th e be st gr owth o ccurring between the 22 and 30 °C range. In addition, tem perature will affect photosynthesis by altering th e rate of biochem ical reactions of photosynthesis. Therefore, ecological models of seagrass in clude tem perature as a variab le governing seagrass growth predictions (Fong et al. (1887). Based on these literature results and those identified in Table 1, a HSI temperature curve was developed (Figure 9) that indicates th e relative importance and input value to the HSI model, as per the estimated daily average (ambient) temperature (Figure 10).

HSI for the Seagrass, *Halodule wrightii* and *Thalassia testudinum*

HSI Variables and Summary Formula

Habitat suitability for the combined grasses *Halodule wrightii* and *Thalassia testudinum* is calculated monthly as a geometric mean:

HSI = (Previous^{w} * Salinity^{w} * Temperature^{w} * LightAvailability^{w})

Where w = the weight for each variable and the sum of $w = 1$. In the accepted model, each of the variables has been weighed equally, so $w = 0.25$.

Previous
"Previous" variable included because current month's HSI score should depend on the how well the grass was doing last month (previous score). In the model application, Previous = previous_month_HSI score + 0.05, (not to exceed 1.0), in order to allow for growth from month to month, if other conditions are suitable.

Table 2. Changes to HSI model's spatial boundaries (A and B) and post-processing routines (C) for adjusting the final HSI ecological model scores to better reflect long-term impacts of severe reduction in seagrass coverage due to low HSI scores of environmental variables (salinity, light and temperature in above model formula).

Routine	Model output criteria	Model score adjustment
A.	Apply new masks for the three areas of the estuary (Pine Island, San Carlos Bay, and Iona Cove	Consider them separately and evaluate the spread across them
B.	Establish a lower depth threshold of 5 ft and 7ft in San Carlos Bay and Pine Island Sound	Model areas > depth thresholds are not scored
C.	If HSI score $\leq$ 0.1 for one month,	Than HSI = 0.1 for remainder of season

Adjustments were agreed to by ecological benefits sub-team (6/14/06)

HSI Curves and Application (for determining HSI variable input values)

Salinity

HSI Calculation – Values based on the literature identified in Table 1, along with SFWMD laboratory and field research, which resulted in the curvilinear relationship between HSI values and salinity depicted below in Figure 4.

Data Source - Freshwater inflows are estimated for S-79 and from the tidal basin using hydrologic models. Flows are generated for each base-case and proposed alternative.

These flows are input for the CH3D hydrodynamic salinity model and associated regression routine, which calculates salinity at fixed locations in the estuary. Using a spatial interpolation program, salinity is then calculated throughout the estuary at each GIS cell point where a HSI value is determined.

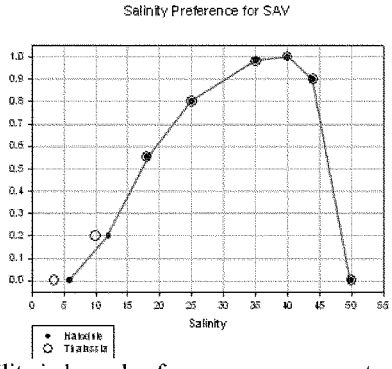


Figure 4. Habitat suitability index value for seagrass response to salinity.

Available light at Depth (based on *Halodule wrightii* requirements)

HSI Calculation – Literature provided estimates of the light needed by *Halodule*, ranging from the minimum requirements to the maximum a plant can utilize. Since this project is interested in estimating the area of coverage and not the density, a 50% line was used to estimate HSI related to potential for presence (Figure 5).

Data Source

a) Depth - Recent bathymetry data provided in GIS format to match HSI cells.
b) Available incident light at the surface (surface irradiance = SI)) - Daily average value estimated from a continuous sensor (7 year period of record, 1998-2004: Figure 6).
c) Light attenuation (K) - Amount of Photosynthetic Active Radiation (PAR) lost with increasing water depth. Field measured values were correlated with simultaneous field measurements of salinity from upstream of Shell Point (Iona Cove area) and downstream (San Carlos Bay and Pine Island Sound) using non-linear regression (Figures 7 and 8).
d) Amount of light at depth (ADBL) for each HSI cell – Determined using the Lambert-Beer equation ($[(0.9*SI)*e^{-K*depth}]$) , which requires input of the incident light just below the water surface (.90(SI)), the attenuation coefficient (K), and depth of each GIS cell.

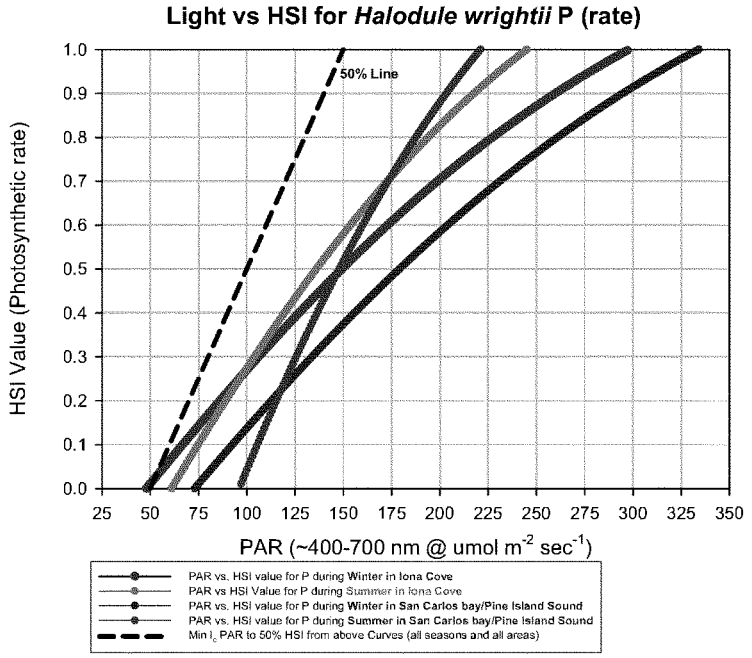


Figure 5. Habitat suitability index value for seagrass response to light. HSI values represent the relative amount of average daily light required by *Halodule wrightii*. The 50% line was used in the model to indicate relative light vs. plant's need to maintain presence

Available Light at the Surface

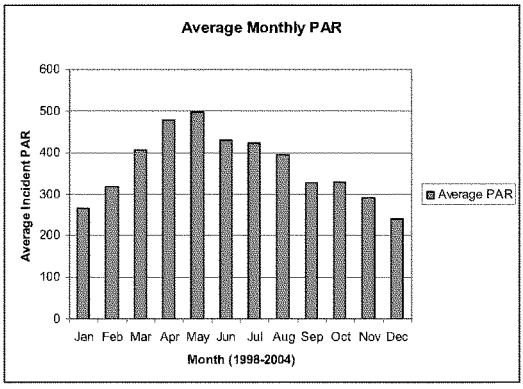


Figure 6. Average Monthly Photosynthetic Active Radiation (PAR)

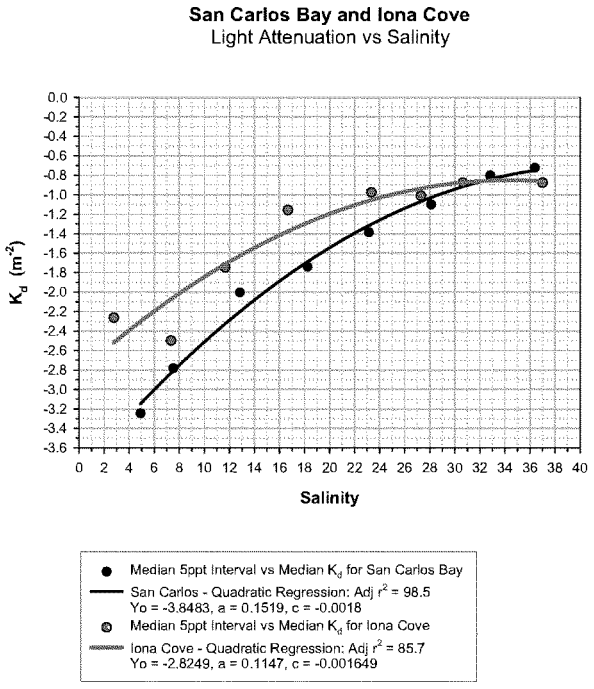


Figure 7. Light attenuation vs. Salinity in seagrass areas.

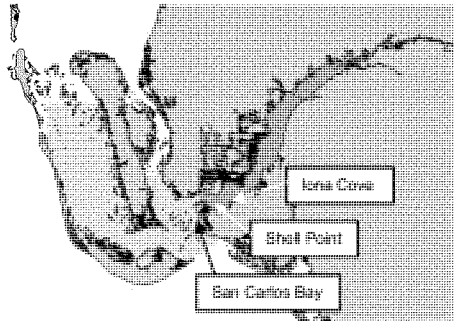


Figure 8. Light attenuation regions. The m odel uses Iona Cove light attenuation relationships for areas east of S hell Po int and San Carlos Bay light attenuation relationships for areas west of Shell Point.

Temperature

HSI Calculation – Preferred temperature range of seagrass (Figure 9) based on literature values (Dawes et al. 1997, Koch and Erskine 2001, Miller 2000).

Data Source – HSI uses a monthly average estimated water temperature. The single monthly value is estimated by fitting a non-linear regression line to daily temperature vs. day of the year (Period of record beginning in 1993), so each day has about 13 temperature values (Figure 10).

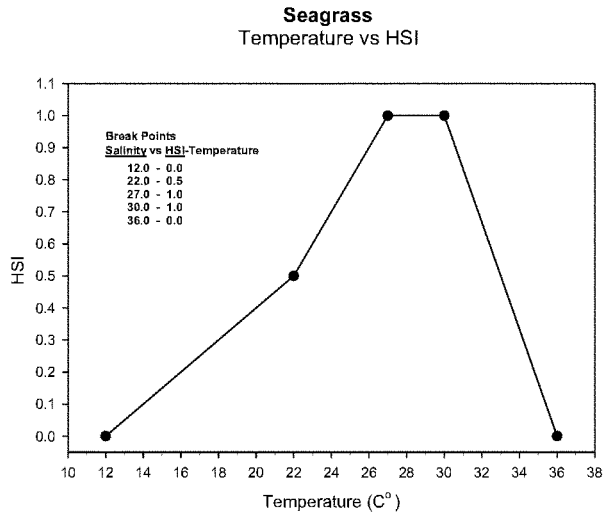


Figure 9. Habitat suitability index value for seagrass response to temperature.

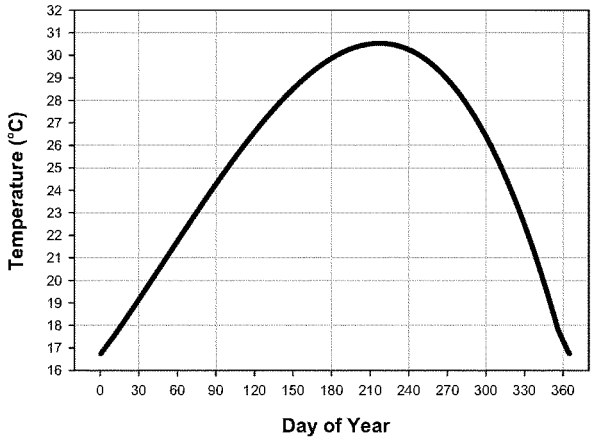


Figure 10. Estimated water temperature in the Caloosahatchee Estuary adjacent to seagrass area.

References Cited

Batiuk, R.A., R.J. Orth, K.A. Moore, W.C. Dennison, J.C. Stevenson, L.W. Staver, V. Carter, N.B. Rybicki, R.E. Hickman, S. Kollar, S. Bieber, and P. Heasly 1992. Chesapeake Bay submerged aquatic vegetation habitat requirements and restoration targets: A technical synthesis. Chesapeake Bay Program CBP/TRS 83/92 186 pp.

Bulthuis, D.A. 1987. Effects of temperature on photosynthesis and growth of seagrass. *Aquatic Botany* 27: 27-40

Carter, V., J.W. Barko, G.L. Godshalk, and N.B. Rybicki. 1988. Effects of submerged macrophytes on water quality in tidal Potomic River. *Maryland. Journal of Freshwater Ecology* 4:493-501.

Chamberlain (Pers. field/lab obs/analysis) 2004

Chamberlain, R.H., D.E. Haunert, P.H. Doering, K.M. Haunert, and J.M. Otero. 1995. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary, Florida. Technical report, South Florida Water Management District, West Palm Beach, Florida.

Chamberlain, R. H. 1995. Impacts from freshwater inflow on seagrass in the Caloosahatchee Estuary. Poster Presentation, 13th Biennial Conference of the Estuarine Research Federation.

Chamberlain, R. H. and P.H. Doering. 1998a. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation, p. 81-90. *In* S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington, D.C.

Chamberlain, R. H. and P.H. Doering. 1998b. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: A resource-based approach, p. 121-130. *In* S.F. Treat (ed.), Proceedings of the 1997 Charlotte Harbor Public Conference and Technical Symposium. South Florida Water Management District and Charlotte Harbor National Estuary Program, Technical Report No. 98-02. Washington, D.C.

Dennison, W.C., R.J. Orth, K.A. Moore, J.C. Stevenson, V. Carter, S. Kollar, P. W. Bergstrom and R.A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation. *Bioscience* 43(2):86-94.

Doering, P.H. and R.H. Chamberlain. 2000. Experimental studies on the salinity tolerance of Turtle Grass, *Thalassia testudinum*, p. 81-98. *In* S.A. Bortone (ed.), Seagrasses: Monitoring, Ecology, Physiology, and Management. CRC Press LLC, Boca Raton, Florida, 318 pp.

Doering, P. H., R. H. Chamberlain, and D.E. Haunert. 2002. Using submerged aquatic vegetation to establish minimum and maximum freshwater inflows to the Caloosahatchee Estuary, Florida. *Estuaries* 25 (1343-1354).

Dixon, L.K. and J.R. Leverone. 1995. Light requirements of *Thalassia testudinum* in Tampa Bay, Florida. Final report to the Surface Water Improvement and Management Department, Southwest Florida Water Management District, Tampa.

Dunton, K. H. 1994. Seasonal growth and biomass of the subtropical seagrass *Halodule wrightii* in relation to continuous measurements of underwater irradiance. *Marine Biology* 120:479-489.

Dunton, K. H. 1996. Photosynthetic production and biomass of the subtropical seagrass *Halodule wrightii* along an estuarine gradient. *Estuaries* 19-2B:436-447.

Dunton, K. H., and D. A. Tomasko. 1991. The seasonal variation in the photosynthetic performance of *Halodule wrightii* measured in situ in Laguna Madre Texas. *In* W. J. Kenworthy and D.E. Haunert (eds.), The Light Requirements of Seagrass: Proceedings of a Workshop to Examine the Capability of Water Quality Criteria, Standards and Monitoring Programs to Protect Seagrasses, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFC-287. Beaufort, North Carolina.

Fong, P., M.E. Jacobson, M. C. Mescher, D. Lirman, and M. C. Harwell. 1997. Investigating the management potential of a seagrass model through sensitivity analysis and experiments. *Ecol. App.* 7: 300-315.

Fonseca, M.S. and J.S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass and with reference to their ecology and restoration. *Marine Ecological Progress Series* 29: 15-22.

Harris, B.A., K.D. Haddad, K.A. Steidinger, and J.A. Huff. 1983. Assessm ent of Fisheries Habitat: Charlotte Harbor and Lake W orth, Flor ida. Florida Departm ent of Natural Resources, Bureau of Marine Research, St. Petersburg, Florida. 211 pp.

Herzka, S.Z. and K.H. Dunton. 1997. Seasonal photosynthetic patterns of the seagrass *Thalassia testuninum* in the western Gulf of Mexico. *Marine Ecological Process Series* 152: 103-117.

Johansson, J.O.R. and H.S. Greening. 2000. Seagrass restoration in Tampa Bay: A resource based approach to estuarine management, p 279-294. *In* S.A. Bortone (ed.). Seagrasses: Monitoring, Ecology, Physiology, and Management. CRC Press, Boca Raton, Florida.

Kenworthy, W. J. and D.E. Haunert. 1991. The light requirements of seagrass: Proceedings of a workshop to examine the capability of water quality criteria, standards and monitoring programs to protect seagrasses. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFC-287. Beaufort, North Carolina.

Kemp, W.M., W.R. Boynton, R.R. Twilley, J.C. Stevenson, and L.G. Ward. 1984. Influence of submersed vascular plants on ecological processes in upper Chesapeake Bay, p. 367-394. *In* V.S. Kennedy (ed.). The Estuary as a Filter. Academic Press, New York.

Kemp, W.M., R. Batiyk, R. Bartleson, P. Bergstrom, V. Carter, C. Gallegos, W. Hunley, L. Karrh, E.W. Koch, J.M. Landwehr, K.A. More, L. Murrey, M. Naylor, N.B. Rybicki, J.C. Stevenson, and D.J. Wilcox. 2004. Habitat requirements for submerged aquatic vegetation in Chesapeake Bay: Water quality, light regime, and physical-chemical factors. Estuaries 27: 363-377.

Killgore, K.J., R.P. Morgan, II, and N.B. Rybicki.1989. Distribution and abundance of fishes associated with submersed aquatic plants in the Potomic River. North *American Journal of Fisheries Management* 9:101-111.

Koch, M. S. and J.M. Erskine. 2001. Sulfide as a phytotoxin to the tropical seagrass, *Thalassia testudinum* with high salinity and temperature. *Journal of Experimental Marine Biology and Ecology* 266: 81-95.

Lubbers, L., W.R. Boynton, and W.M. Kemp. 1990. Variations in structure of estuarine fish communities in relation to abundance of submersed vascular plants. *Marine Ecological Progress Series* 65: 1-14.

McNulty, J.K., W.N. Lindall, J.E. Sykes. 1972. Cooperative Gulf of Mexico estuarine inventory and study, Florida: Phase 1, area description. NOAA Technical Rep. NMFS Circ-368.

McMahan, C.A. 1968. Biomass and salinity tolerance of shoal-grass and manatee grass on lower Laguna Madre, Texas. *Journal of Wildlife Management* 32: 501-506.

Stevenson, J.C., L.W. Staver, and K.W.Staver.1993. Water quality associated with survival of submersed aquatic vegetation along an estuarine gradient. *Estuaries* 16: 346-361.

Tomasko, D.A., C.J. Dawes, and M.O. Hall. 1996. The effects of anthropogenic enrichment on turtle grass (*Thalassia testudinum*) in Sarasota Bay, Florida. *Estuaries* 19: 448-456.

Tomasko, D.A. and M.O. Hall. 1999. Productivity and biomass of the seagrass Thalassia testudinum along a gradient of freshwater influence in Charlotte harbor, Florida. *Estuaries* 22 (3A): 592-602.

Virnstein, R.W. and L.J. Morris.2000. Setting seagrass targets for the Indian River Lagoon, Florida, p. 211-218. *In* S.A. Bortone (ed.). Seagrasses: Monitoring, Ecology, Physiology, and Management. CRC Press, Boca Raton, Florida.

Wilhere, G.F. 2002. Adaptive m anagement in habitat conservation plans. *Conservation Biol.* 16(1): 20-29.

Zieman, J.C. and R.T. Zieman 1989. The ecology of the seagrass meadows of the west coast of Florida: a community profile. U.S. Fish and Wildl. Serv. Biol. Rep. 85(7.25). 155 pp.

Zieman, J.C., J.W. Fourqurean, and T.A. Frankovich. 1999. Seagrass die-off in Florida Bay: Long-term trends in abundance and growth of turtle grass, *Thalassia testudinum*. *Estuaries* 22:460-470.

APPENDIX D
REAL ESTATE

This page intentionally left blank

TABLE OF CONTENTS

D.0 REAL ESTATE D-3
D.1 STATEMENT OF PURPOSE OF THE REAL ESTATE PLAN (REP) D-3
D.2 DESCRIPTION OF PRIOR REP PREPARED FOR THE PROJECT D-3
D.3 PROJECT AUTHORIZATION D-3
D.4 PROJECT PURPOSE D-6
D.5 PROJECT LOCATION AND DESCRIPTION D-7
D.5.1 Project Location D-7
D.5.2 Project Description – Selected Alternative Plan (Alt 3B) D-9
D.5.3 Project Features D-10
D.5.3.1 Reservoir Impoundment D-10
D.5.3.2 Canals D-11
D.5.3.3 Em bankments D-12
D.5.3.4 C43CS-1 and C43CS-2 Crest Spillway Structures D-12
D.5.3.5 Pumping Station C43PS-1 ..... D-12
D.5.3.6 Pumping Station C43PS-4 ..... D-13
D.5.3.7 Gated Culvert Structure C43S-3 ..... D-13
D.5.3.8 Culvert Structure C43S-7 ..... D-13
D.5.3.9 Culvert Structure C43S-9 ..... D-13
D.5.3.10 Gated Spillway Structure C43S-10 ..... D-14
D.5.3.11 Gated Spillway Structure C43S-11 ..... D-14
D.5.3.12 C43S-1 and C43S-8 - Gated Outlet Structures D-14
D.5.3.13 Balancing Outlet Structure C43S-12 ..... D-14
D.5.3.14 Culvert Structure C43S-14 ..... D-14
D.5.3.15 Culvert Structure C43S-15 ..... D-14
D.6 ANALYSIS OF ESTATES REQUIRED FOR PROJECT D-15
D.6.1 Estates Required for CERP Projects D-15
D.6.1.1 Determine the Rights that Are Required to Construct and Perform Operation, Maintenance, Repair, Rehabilitation, And Replacement (OMRR&R) for the Project: D-16
D.6.1.2 Other Factors to be Considered: D-16
D.6.2 Estates for Components D-16
D.6.2.1 Reservoir and Embankments D-17
D.6.2.2 Pum p Stations D-17
D.6.2.3 Perim eter Canals D-18
D.6.2.4 Main Access Road D-18
D.6.2.5 Perimeter Access and Buffer Area D-18
D.6.2.6 Tem porary Work/Stockpile/Staging Areas D-19
D.6.3 Facility, Utility Relocations D-19
D.6.3.1 Florida Power and Light Company (FP&L) D-19
D.6.4 TEMPORARY WORK AREAS D-20
D.6.5 BORROW AND DISPOSAL SITES D-20
D.6.5.1 Borrow D-20
D.6.5.2 Disposal D-20
D.6.6 RECREATI ON FEATURES D-21

D.6.7 ACCESS TO THE PROJECT AREA D-22
D.7 EXISTING FEDERAL PROJECTS D-22
D.8 FEDERALLY OWNED LANDS D-22
D.9 NON-FEDERAL SPONSOR OWNED LANDS AND CREDITING D-23
D.9.1 Crediting Considerations D-27
D.9.2 Department of Interior Grant Number LWCF-1, Addendum 3, Land and Water Conservation Act Funds D-27
D.9.2.1 Certification and Crediting for Actual and Incidental Costs Acquired under the Department of Interior Grants D-28
D.10 UNIFORM RELOCATION ASSISTANCE ACT, PL 91-646 ..... D-29
D.11 NAVIGATIONAL SERVITUDE AND OTHER LANDS D-29
D.12 INDUCE D FLOODING D-30
D.13 MINERAL AND TIMBER ACTIVITIES D-31
D.14 NON-FEDERAL AUTHORITY TO PARTICIPATE IN THE PROJECT D-31
D.15 PROPOSED ESTATES D-31
D.15.1 Standard Estates D-31
D.15.1.1 Standard Estate – Fee D-31
D.15.1.2 Channel Improvement Easement D-31
D.15.1.3 Temporary Work Area and/or Disposal Area Easement D-32
D.16 ZONING ORDINANCES D-32
D.17 ACQUISITION SCHEDULES D-32
D.18 HAZARDOUS, TOXIC OR RADIOLOGICAL WASTE (HTRW) D-32
D.19 PROJECT SUPPORT D-34
D.20 BASELINE COST ESTIMATES AND MCACES COST ESTIMATES D-34
D.21 BASELINE COST ESTIMATES AND MCACES COST ESTIMATES D-34
D.22 REAL ESTATE MAPS D-37
D.23 EXHIBITS D-39

LIST OF TABLES

Table D-1: Main Project features D-11
Table D-2: Acreage and Interest Owned by SFWMD D-26
Table D-3: Baseline Cost Estimate D-35
Table D-4: MCACES Project Real estate Costs D-36

LIST OF FIGURES

Figure D-1: Location map D-8
Figure D-2: Caloosahatchee River (C-43) West Basin Storage Reservoir Site Plan D-15
Figure D-3: Caloosahatchee River (C-43) West Basin Storage Reservoir Recreation Features D-22
Figure D-4: SFWMD Parcel Acquisition Map D-25
Figure D-5: Environmental Lands Map D-30
Figure D-6: Real Estate Planning Map D-38

D.0 REAL ESTATE

D.1 STATEMENT OF PURPOSE OF THE REAL ESTATE PLAN (REP)

The purpose of this Real Estate Plan (REP) is to present the overall real estate requirements, costs, acquisition schedules, and other real estate requirements necessary and in support of the Final Project Implementation Report (FPIR) for the Central and Southern Florida, Comprehensive Everglades Restoration Plan, Caloosahatchee River (C-43) West Basin Storage Reservoir project. This Real Estate Plan is tentative in nature and both the final real property acquisition lines and estimates of value are subject to change after approval of the decision document to which this Plan is appended.

D.2 DESCRIPTION OF PRIOR REP PREPARED FOR THE PROJECT

The Caloosahatchee River (C-43) West Basin Storage project was discussed in the Central and Southern Florida Project, Comprehensive Review Study (Restudy), Appendix "F," Real Estate Plan; dated April 1999, page F-32.

D.3 PROJECT AUTHORIZATION

Along with the Central and Southern Florida Comprehensive Review Study, and the Water Resources Development Act of 2000, Section 601the C-43 West Basin Storage Reservoir Project PIR is authorized by Section 309(l) of the Water Resources Development Act of 1992 (Public Law 102-580) which states:

"(1) CENTRAL AND SOUTHERN FLORIDA. -- The Chief of Engineers shall review the report of the Chief of Engineers on central and southern Florida, published as House Document 643; 80th Congress, 2nd Session, and other pertinent reports, with a view to determining whether modifications to the existing project are advisable at the present time due to significantly changed physical, biological, demographic, or economic conditions, with particular reference to modifying the project or its operation for improving the quality of the environment, improving protection of the aquifer, and improving the integrity, capability, and conservation of urban water supplies affected by the project or its operation."

This study is also authorized by two resolutions of the Committee on Transportation and Infrastructure, United States House of Representatives, dated September 24, 1992. The first resolution states:

"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications

of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes."

The second resolution states:

"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors, is requested to review the report of the Chief of Engineers on Central and Southern Florida, published as House Document 643, Eightieth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of environmental quality, water supply and other purposes for Florida Bay, including a comprehensive, coordinated ecosystem study with hydrodynamic modeling of Florida Bay and its connections to the Everglades, the Gulf of Mexico, and the Florida Keys Coral Reef ecosystem."

The Water Resources Development Act of 1996 was enacted on October 12, 1996. Section 528 of the Act (Public Law 104-303) entitled "Everglades and South Florida Ecosystem Restoration" authorizes a number of ecosystem restoration activities and also provides specific direction and guidance for the CERP.

(b) RESTORATION ACTIVITIES-
(1) COMPREHENSIVE PLAN-
(A) DEVELOPMENT-
(i) PURPOSE- The Secretary shall develop, as expeditiously as practicable, a proposed Comprehensive Plan for the purpose of restoring, preserving, and protecting the South Florida ecosystem. The Comprehensive Plan shall provide for the protection of water quality in, and the reduction of the loss of fresh water from, the Everglades. The Comprehensive Plan shall include such features as are necessary to provide for the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the Central and Southern Florida Project.
(ii) CONSIDERATIONS- The Comprehensive Plan shall—
(I) Be developed by the Secretary in cooperation with the non-Federal project sponsor and in consultation with the Task Force; and
(II) Consider the conceptual framework specified in the report titled "Conceptual Plan for the Central and Southern Florida Project Restudy," published by the Commission and approved by the Governor.
(B) SUBMISSION- Not later than July 1, 1999, the Secretary shall—
(i) Complete the feasibility phase of the Central and Southern Florida Project comprehensive review study as authorized by section 309(l) of the Water Resources Development Act of 1992 (106 Statue. 4844), and by two resolutions of the Committee on Public Works and Transportation of the House of Representatives, dated September 24, 1992; and

(ii) Submit to Congress the plan developed under subparagraph (A)(i) consisting of a feasibility report and a programmatic environmental impact statement covering the proposed Federal action set forth in the plan.
(C) ADDITIONAL STUDIES AND ANALYSES- Notwithstanding the completion of the feasibility report under subparagraph (B), the Secretary shall continue to conduct such studies and analyses as are necessary, consistent with subparagraph (A)(i).

A design agreement to perform project engineering and design (PED) activities including adaptive assessment and monitoring in support of CERP was executed on May 12, 2000 between the U.S. Army Corps of Engineers (Corps) and South Florida Water Management District (SFWMD). This agreement provides for the SFWMD to receive in-kind credit for design work. A Master Program Management Plan (MPMP) for the CERP was executed on August 24, 2000, outlining the protocols and procedures by which project management plans for all projects included in the agreement would be completed. This document conforms to the guidance provided within the MPMP.

In Section 601 of the Water Resources Development Act of 2000 (PL 106-541), Congress approved the Central and Southern Florida (C&SF) Project Comprehensive Review Study Integrated Feasibility Report and Programmatic Environmental Impact Statement (known as the "Yellow Book"), which describes and outlines the Comprehensive Everglades Restoration Plan (CERP):

(b) Comprehensive Everglades Restoration Plan –
(1) Approval -
(A) IN GENERAL. —Except as modified by this section, the Plan is approved as a framework for modifications and operational changes to the Central and Southern Florida Project that are needed to restore, preserve, and protect the South Florida ecosystem while providing for other water-related needs of the region, including water supply and flood protection. The Plan shall be implemented to ensure the protection of water quality in, the reduction of the loss of fresh water from, and the improvement of the environment of the South Florida ecosystem and to achieve and maintain the benefits to the natural system and human environment described in the Plan, and required pursuant to this section, for as long as the project is authorized.
A Project Implem entation Report must be co mpleted for C-43 Basin Storage Reservoir project, as set forth in Section 601(b)(2)(D) of WRDA 2000.

(i)PROJECT IMPLEMENTATION REPORTS.—Before implementation of a project described in any of clauses (i) through (x) of subparagraph (C), the Secretary shall review and approve for the project a project implementation report prepared in accordance with subsections (f) and (h).
(ii) SUBMISSION OF REPORT. —The Secretary shall submit to the Committee on Transportation and Infra-structure of the House of Representatives and the

Committee on Environment and Public Works of the Senate the project implementation report required by sub-sections (f) and (h) for each project under this paragraph (including all relevant data and information on all costs).
(iii) FUNDING CONTINGENT ON APPROVAL. —No appropriation shall be made to construct any project under this paragraph if the project implementation report for the project has not been approved by resolutions adopted by the Committee on Transportation and Infrastructure of the House of Representatives and the Committee on Environment and Public Works of the Senate.

Finally, Section 601(h)(4) of WRDA 2000 further requires that PIRs document:

(4) PROJECT-SPECIFIC ASSURANCES-
(A) PROJECT IMPLEMENTATION REPORTS-
(i) IN GENERAL- The Secretary and the non-Federal sponsor shall develop project implementation reports in accordance with section 10.3.1 of the Plan.
(ii) COORDINATION- In developing a project implementation report, the Secretary and the non-Federal sponsor shall coordinate with appropriate Federal, State, tribal, and local governments.
(iii) REQUIREMENTS- A project implementation report shall--
(I) be consistent with the Plan and the programmatic regulations promulgated under paragraph (3);
(II) describe how each of the requirements stated in paragraph (3)(B) is satisfied;
(III) comply with the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.);
(IV) identify the appropriate quantity, timing, and distribution of water dedicated and managed for the natural system;
(V) identify the amount of water to be reserved or allocated for the natural system necessary to implement, under State law, subclauses (IV) and (VI);
(VI) comply with applicable water quality standards and applicable water quality permitting requirements under subsection (b)(2)(A)(ii);
(VII) be based on the best available science; and
(VIII) include an analysis concerning the cost-effectiveness and engineering feasibility of the project.

D.4 PROJECT PURPOSE

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to address the declining health of the Caloosahatchee River and estuarine ecosystem by improving water deliveries to the estuary. The project will increase availability of water for the estuarine system during the dry season, while reducing excessive high flows during the wet season. This will result in providing a downstream salinity range suitable for a healthy ecosystem that promotes estuarine habitat, increased fish and wildlife and biological diversity. Once the demands of the estuary are met, additional water resource benefits could be achieved by providing supplemental water resources for

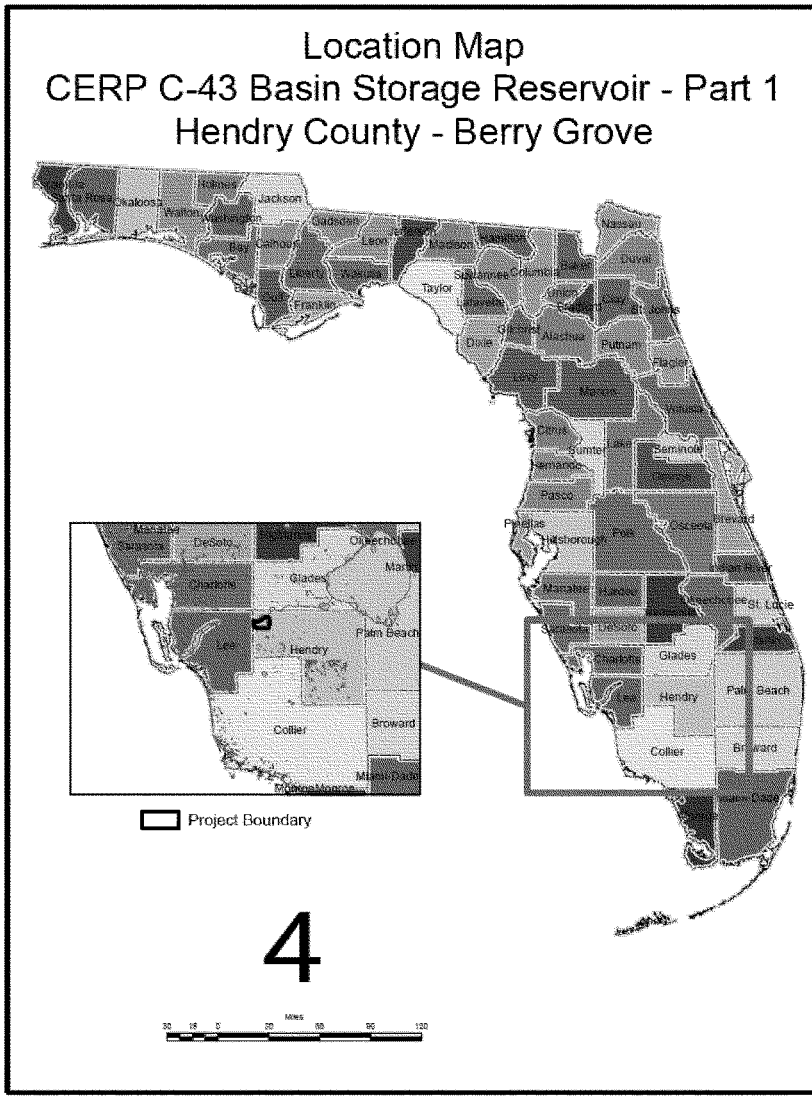
agriculture and urban users resulting in a reduction of demands placed on existing surface and ground water resources such as the Caloosahatchee River (C-43 Canal) and Lake Okeechobee.

D.5 PROJECT LOCATION AND DESCRIPTION

D.5.1 Project Location

The Caloosahatchee River (C-43) West Basin Storage Reservoir project area encompasses approximately 10,700 acres consisting of approximately 10,480 acres in fee, approximately 20 acres of perpetual channel easement, and 200 acres in temporary easement that lie within approximately 12,430 acres owned or being acquired by SFWMD. The lands are located in northwestern portion of Hendry County, Florida within Township 43 South, Range 28 East in Sections 30, 31, 32, 33, 34, 35 and 36; in Township 44 South, Range 28 East in Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12; in a portion of Section 31, Township 43 South, Range 29 East; and in a portion of Section 6, Township 44 South, Range 29 East. Reservoir access from State Road 80 will be located in Section 27, Township 43 South, Range 28 East. Portions of Sections 25, 26, 27 28, 29 and 30, Township 43 South, Range 28 East will be used as staging areas. The (C-43) West Basin Storage Reservoir project is situated approximately 36 miles west of the city of Clewiston and approximately 6 mile west from the Hendry County seat of LaBelle, Florida. It parallels State Road 80 (SR80) which lies to the North. To the Northeast and east the Project adjoins the Bob Paul (Bob Paul) property. To the south and southeast the Project adjoins the A. Duda and Sons, Inc. property (Duda). The East side adjoins State Road 29 (SR 29). On the west side of the Project is the Townsend Canal. See ***Figure D-1*** below.

FIGURE D-1: LOCATION MAP



The Reservoir currently under consideration will be constructed on property formerly owned by J&H Grove Holdings, L.C. (Berry Groves), the Griffin Family Limited Partnership, the MG Enterprises, L.L.C and the Bryan Paul Citrus.. All these lands are currently owned in fee by the SFWMD except the Bryan Paul

Citrus parcel that will be an exchange of 541.31 acres of SFMWD ownership in exchange for 600.17 acres of the Bryan Paul Citrus property.

Agricultural lands are prevalent in Hendry County; pastureland and crops (primarily citrus but also sugarcane and others) comprise the majority of the agricultural industry. Remaining natural areas include pine flatwoods (upland communities dominated by pine and saw palmetto) and a variety of wetland communities. Land use within the project boundary reflects the land use of the surrounding county.

The Duda pump station, located at the "bend" in the Townsend Canal west of the southwest corner of the Griffin property, lifts water from the Townsend Canal into the Townsend Canal south of the pump station and feeds a series of canals within the Duda property.

In addition to the Townsend canal, other water systems that exist within the vicinity of the project include the Northeast Rim Ditch, the Roberts Canal, the Crawford Canal, the Banana Branch, and the Fort Simmons Branch. Such water systems including canals, streams, and ponds are common and serve as watershed conveyance systems and tributaries to the Caloosahatchee River (C-43 Canal).

Prior to site preparation by SFWMD, Berry Groves' citrus plant was situated north of the project footprint along SR 80. The Duda citrus plant is east of the project footprint along SR 29. A large FP&L transmission line is located parallel and borders the entire northern boundary of the project footprint. This FP&L transmission line will not be impacted by the project.

D.5.2 Project Description – Selected Alternative Plan (Alt 3B)

The Selected Alternative Plan (SAP) consists of a two-cell impoundment with a "normal pool" storage capacity of 170,000 acre-feet. This SAP comes closest to approximating the Restudy C-43 Reservoir recommended volume of approximately 160,000 acre-feet of storage and is the size evaluated and currently being designed by the SFWMD under their Acceler8 program. The project footprint for the SAP encompasses approximately 10,480-acres in fee, approximately 20 acres of perpetual channel easement, and 200 acres in temporary easement for total project footprint of 10,700 acres. It consists of major features and components to include a two-cell reservoir with armoring, cutoff walls, and embankments. Other features are Pump Stations, spillways with emergency overflow and vertical lifts, drawdown structures, culverts, canals, earthwork artificial habitat creation, and recreational features. The reservoir design includes a pump station with 1,500 cfs capacity to pump water from the Townsend Canal to fill the Reservoir.

Each cell is designed to discharge independently through separate discharge structures. Cell 1 will discharge via the S-1 structure into the Townsend Canal. Cell 2 will discharge via S-8 structure into the Perimeter Canal. These structures will be designed for incremental operation allowing required flows to be released to the Caloosahatchee River (C-43 Canal) during periods of low flow. These structures could also serve as design storm control structures for releases prior to and during a storm event. The storm releases must be balanced with the targeted maximum flow allowed over S-79, which is 4,500 cfs. An emergency spillway with a crest elevation based on retaining the 25-year, 72-hour storm event is to be provided within each cell's discharge structure. The 25-year, 72-hour storm captured in the reservoir would be a "control release" after the storm event in order to restore the water surface to the normal pool elevation while not exceeding the maximum flow of 4,500 cfs at S-79.

D.5.3 Project Features

A discussion of the project features and major components along with the acreage, and estate follows. See Table D-1 "Main Project Features and ***Figure D-2***: "Caloosahatchee River (C-43) West Basin Storage Reservoir Site Plan." below.

D.5.3.1 Reservoir Impoundment

The Reservoir is an earthen impoundment consisting of approximately 9,220 acres of interior storage that is to be constructed above the existing ground. It will consist of an approximate 170,000 acre-feet two-cell reservoir. Water will be pumped from the Caloosahatchee River (C-43 Canal) and into the Reservoir by utilizing the existing Townsend Canal and a new pump station (C43PS-1) located in the northwest corner of the project. See ***Figure D-2*** below.

Water will be discharged from the Reservoir through gravity discharge structures in each cell that discharge into a Perimeter Canal. Both flows into and out of the Reservoir will be controlled by monitoring flows at S-79.

TABLE D-1: MAIN PROJECT FEATURES

Project Features/Components	Approximate Acreage Rounded	Proposed Estate (SAP)	Total Acres for SAP
Reservoir (interior)	9220	Fee	
Seepage Canals	244	Fee	
Reservoir Embankment	774	Fee	
Pump Structures PS-1 and PS-4	17	Fee	
Townsend Canal	106	Fee	
Access Road from State Road 80	4	Fee	
Perimeter Access and Buffer Area	115	Fee	10,480®
Townsend Canal (Northern and Middle Canal)	20	Perpetual Channel Easement	
Temporary W ork Area/Stockpile and Staging	200	Temporary Easement	
Relocation	0		
Recreation	0		
Borrow/Disposal	0		
Total Project LERRD Proposed			10,700®

D.5.3.2 Canals

The existing Townsend Canal, located along the west perimeter of the Reservoir, would serve as the west Perimeter Canal. The existing spoil piles along the east side of the Townsend Canal would be removed as part of the project. Drainage improvements are proposed outside of the project boundary and would include new or replacement culverts in the header canal east of the project. Improvements to or the relocation of the existing weir structure located at the mouth of the Townsend canal are included.

The Perimeter Canal is a man-made canal that collects seepage from Cells 1 and 2 of the Reservoir, re-routes and conveys flow from the Roberts Canal to the Banana Branch Canal and conveys irrigation flows, cell discharge flows, and flood routing. The Perimeter Canal is vital in assisting with the regulation and stabilization of stormwater runoff, regulatory releases from Lake Okeechobee and improving the salinity balance for the Caloosahatchee estuary. The Perimeter Canal also provides flow releases to the downstream portions of the Roberts Canal (Banana Branch), Fort Simmons Branch and the Townsend Canal. The Perimeter Canal has three discharge structures that help facilitate with the flow control measures described above identified as C43S-3, C43S-10, and C43S-11. The Perimeter Canal design includes littoral shelves along the exterior slope that are intended to promote wetland vegetation, fisheries and recreation activities.

D.5.3.3 Embankments

The perimeter embankment would have an external geometry that includes a 12-foot wide crest (14 foot Crest Width including the soil cement protection) and 3 horizontal to 1 vertical side slopes. Crest elevations have been established at +55 and +54 feet NAVD for Cell 1 and Cell 2, respectively. The embankment would be constructed largely of random fill, but would also include a low permeability soil-bentonite (SB) wall, an internal drain, and upstream slope protection. The SB wall would extend from an elevation 5 feet above the normal pool elevation to 5 feet below the top of a clay layer which underlies the project site at depths generally in the range of 10 to 25 feet below existing surface grades.

A few structures pass through the perimeter embankment. At these locations, the above ground portion of the SB wall would be replaced with select fill. In addition, a roughly 100-foot wide bench with a 24-foot access road would be constructed above the existing ground surface immediately downstream of the perimeter embankment. A Perimeter Canal would be located on the outside of the bench.

The Interior Dam between Cells 1 and 2 would be a homogenous embankment with a crest elevation of +50 feet NAVD. It would not include any SB wall or internal drain. The side slopes of the separator dam would be covered on both sides with soil-cement. Typical Sections of the proposed embankments are provided on Plates C-2 through C-4.

D.5.3.4 C43CS-1 and C43CS-2 Crest Spillway Structures

C43CS-1 is located on the west side of Cell 1 and discharges to the Townsend Canal. C43CS-2 is located just east of C43S-8 in the northwest corner of Cell 2 and discharges to the Perimeter Canal. The design objective of the crest spillway structures is to minimize the surcharge storage of the reservoir without exceeding the allowable discharge. Each cell of the reservoir has an uncontrolled crest spillway structure to manage flood flows.

D.5.3.5 Pumping Station C43PS-1

Pump Station C43PS-1 will consist of a 1500 cfs pump station 252' long and 84' wide with intake located on the Townsend Canal and an over-the embankment arrangement for discharge to the Reservoir. The facility will house four main pumps. Two pumps will be 500 cfs capacity each, and two will be 250 cfs capacity each. The pump station building will consist of an operating floor at El 25.0 for the placement of most pump station machinery and a two-story steel structure above El 25.0 housing the control room, break room and workshop.

D.5.3.6 Pumping Station C43PS-4

The purpose of the C43PS-4 pump station is for water supply to the neighboring landowners and maintenance of stage in the Perimeter Canal for seepage control. The station site is situated at the Southwest corner of the Reservoir at the southern limit of the District's property. The. pump station will be designed to pump water from the Townsend Canal into the Perimeter Canal at a maximum 150 cfs rated capacity. The station discharge will be conveyed to the Perimeter Canal a distance of 1500 to 2000 feet via a conveyance canal paralleling the toe of slope of the Reservoir embankment.

The Townsend Canal provides flood conveyance for the citrus operations south of the Reservoir and irrigation water during the dry season. The normal canal stage upstream of the existing pump station is maintained for the farm operations at 23.5 feet NAVD. The Townsend Canal stage varies with the Caloosahatchee River.

D.5.3.7 Gated Culvert Structure C43S-3

C43S-3 consists of a Double Barrel 10'x10' Box Culvert. Each barrel will have an independent intake structure, consisting of a 10'x10' sluice gate and a 10'x10' weir gate with allowance for a 5 foot high weir opening Should there be a demand for irrigation by the Bob Paul Grove, C43PS-4 will introduce 150 cfs into the Perimeter Canal. This flow will ultimately be conveyed through the Perimeter Canal to C43S-3 at which time it will be pumped into the LPDD Canal and used for irrigation for the Bob Paul Grove.

D.5.3.8 Culvert Structure C43S-7

Structure C43S-7 is located at the intersection of the upstream end of the Banana Branch Canal and the Perimeter Canal. The structure will provide a hydraulic connection between the perimeter canal and the Banana Branch Canal. It consists of a double 10'W x 10' H box culvert with one (1) sluice gate and one (1) weir gate. The reservoir bisects the Roberts/Banana Branch Canal thus flow from the Roberts Canal is re-routed through the Perimeter Canal and discharged to the Banana Branch Canal via Structure C43S-7.

D.5.3.9 Culvert Structure C43S-9

Structure C43S-9 is a double 6'W x 6'H box culvert that conveys flow from the Perimeter Canal through to the Fort Simmons Branch Canal which discharges into the Caloosahatchee River.

D.5.3.10 Gated Spillway Structure C43S-10

Structure C43S-10 consists of one 14'x10' Vertical Roller Gate and two (2) 10'x10' weir gates. The structure will consist of a reinforced concrete spillway with one (1) Vertical Roller Gate and two (2) Weir Gates to control flow through the Perimeter Canal. Design flow received by the Perimeter Canal from the Roberts Canal would be conveyed and discharged into the Banana Branch Canal prior to C43S-10. The flow from the Roberts Canal will be bypassed through the project site using the Perimeter Canal and outlet to the Banana Branch Canal

D.5.3.11 Gated Spillway Structure C43S-11

C43S-11 is the largest of the Perimeter Canal structures which consists of a reinforced concrete spillway with two (2) 14'W x 8' H Vertical Roller Gates and two (2) 10'W x 8'H weir gates to control flow through the Perimeter Canal ultimately to the Townsend Canal.

D.5.3.12 C43S-1 and C43S-8 - Gated Outlet Structures

C43S-1 and C43S-8 are the main outlets for Cell 1 and Cell 2 respectively. Both outlets discharge into the north Perimeter Canal with C43S-1 discharging four feet lower than C43S-8.

D.5.3.13 Balancing Outlet Structure C43S-12

C43S-12 is located on the interior dam between Cells 1 and 2 of the reservoir. The primary function of the structure is to convey water between the cells and allow the cells to operate independently if needed. If one of the cells needs to be dewatered for maintenance C43S-12 may be closed to isolate the cells.

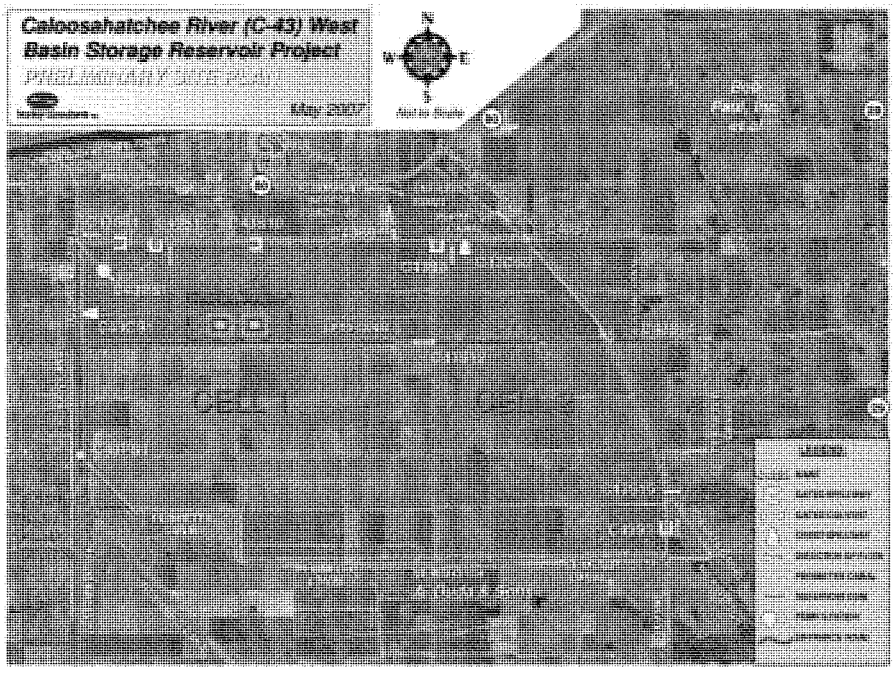
D.5.3.14 Culvert Structure C43S-14

Structure C43S-14 is a 10'Wx6'H box culvert that connects the Header Canal to the Perimeter Canal. This structure will convey water from the Perimeter Canal, into the Header Canal. This culvert structure will provide a hydraulic connection between the perimeter canal and the Header Canal.

D.5.3.15 Culvert Structure C43S-15

This culvert structure will provide a hydraulic connection between the perimeter canal and the Roberts Canal. The Roberts Canal discharges into the Perimeter Canal located downstream of Structure C43S-3. Flow from the Roberts Canal is conveyed through Structure C43S-15. The structure, which consists of a double 10'x8' box culvert with an independently operated sluice gate and weir gate.

FIGURE D-2: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR SITE PLAN



D.6 ANALYSIS OF ESTATES REQUIRED FOR PROJECT

The Programmatic Regulations for the CERP, 33 CFR 385, Part 385.5, require the development of Six Program-Wide Guidance Memorandum. The April 2005 draft in Section 1.9.3 and the November 2006 draft in Section 1.10.3 of the Six Program-Wide Guidance Memoranda provide that an analysis to determine the estates required for implementation of a project should be determined using the following guidelines.

D.6.1 Estates Required for CERP Projects

For all lands determined to be required for CERP Projects, the interests required for implementation generally will be fee simple, based on assumptions that all or a significant portion of the rights in the land will be required for project purposes. Although fee acquisition should be the standard estate for CERP projects, lesser estates such as flowage or conservation easements should be considered, as appropriate, if the benefits of the project can still be achieved with the lesser estate. The PIR should provide the rationale for such lesser estates.

To verify the appropriateness of fee simple acquisition or less than fee acquisition, the PIR must include the following analysis and the conclusions must be reflected in the appropriate report sections. The level of detail required for the analysis will vary depending on the project feature involved.

D.6.1.1 Determine the Rights that Are Required to Construct and Perform Operation, Maintenance, Repair, Rehabilitation, And Replacement (OMRR&R) for the Project:

- *Identify the affirmative rights on the land that are required to implement the project.*
- *In addition to affirmative rights that may be required, identify restrictions on use (restrictive covenants) by the fee owner that are required so as not to interfere with project purposes and outputs.*
- *Identify the length of time that the affirmative rights or restrictive covenants are needed for the project.*
- *Determine whether constructed project features may need to be modified over time due to uncertainties in science, formulation, or design (adaptive management).*
- *Determine whether project land, or portions thereof, will be open for public use (either active or passive uses).*

D.6.1.2 Other Factors to be Considered:

- *Compare the cost/value of specific types of easements to fee value.*
- *Assess potential for severance damages from fee acquisition.*
- *Determine whether public owners have legal capability to convey fee.*
- *Assess stewardship/OMRR&R considerations regarding the risk and consequences of encroachment on project land by adjacent owners; the risk and consequences of violation of easement terms by fee owners; and monitoring and enforcement capabilities of Sponsor.*
- *Assess negative perception by public of private benefits or gain due to landowner reservations where easements are selected.*
- *Assess whether State Marketable Title Act requires re-recording of easement instruments.*

D.6.2 Estates for Components

For the analysis, the estates for each of the three project components were determined independently utilizing not only the factors set forth above but Engineering Regulation 405-1-12, Chapter 12, paragraph 12-9 because of the nature of the components. The Caloosahatchee River (C-43) West Basin Storage Reservoir project includes approximately 10,
700 acres, with approximately 9,220 acres of interior storage area, approximately 244 acres required for the north, south and east seepage canals,

approximately 774 acres of embankment, approximately 106 acres required for the Townsend Canal approximately 17 acres required for the two pump stations, approximately 4 acres required for the access road from State Road 80 to the project site, approximately 115 acres required for the perimeter road and berm area on the north, south and east sides of the project, and approximately 200 acres for temporary construction area staging and stock pile area. All of the lands are owned in fee or will be acquired in fee by the SFWMD, except for approximately 20 acres within the Townsend Canal over which SFWMD has an easement sufficient for project purposes.

D.6.2.1 Reservoir and Embankments

The Reservoir embankments comprising approximately 774 acres have been determined to be a dam with the embankments on all four sides having to meet dam safety criteria. Chapter 12, paragraph 12-9 of ER 405-1-12 requires fee title for dam sites. While a standard estate such as a flowage easement (permanent flooding) for the interior areas of the Reservoir might be sufficient, the estimated value of the easement over this approximately 9,220 acres would exceed 95 percent of the fee value of the property. Access to the interior of the Reservoir must also be restricted. The following activities will have to be prohibited:

a) commercial or industrial activities;
b) construction of any kind within the reservoir;
c) dumping of refuse, wastes, sewage, or other debris;
d) harvesting wood products;
e) commercial recreational activities;
f) activities detrimental to flood damage reduction, water management, conservation, environmental restoration, water storage, erosion control, soil conservation, reclamation, fish and wildlife habitat preservation, and allied purposes,
g) any mining or alteration of the surface of the land, including any substance that must be quarried or removed by methods that will consume or deplete the surface, including, but not limited to, the removal of topsoil, sand, gravel, rock, and peat; any use or activity that causes or is likely to cause significant pollution of any surface, and
h) prohibition of all agricultural activity.

Leaving rights outstanding in third parties would also inhibit future operational changes in the Reservoir and the other facilities associated with the Reservoir. All these lands for construction of the Reservoir are required in fee.

D.6.2.2 Pump Stations

The lands required for the pump stations (permanent structures) approximately 17 acres would be required in fee.

D.6.2.3 Perimeter Canals

For the land required for the perimeter canals and structures in and around perimeter canals (south, north and east side) comprised approximately 244 acres and the Townsend Canal (west side) comprised of approximately 126 acres, a permanent canal easement could be the estate required for these lands. However, the estimated value of this easement would exceed 90 percent of the fee value of the property. Therefore fee title is the recommended estate for the lands required for the Townsend Canal, except for approximately 20 acres located adjacent to and running just south of the Caloosahatchee River (C-43 Canal) over which SFWMD has acquired a perpetual canal easement, which contains language identical to the standard perpetual channel easement, which is sufficient for project purposes.

D.6.2.4 Main Access Road

An access road will run from SR80 to the Project site to provide ingress and egress for both project operation and maintenance and the general public for recreation purposes at the site. The standard road easement could be the estate required for these lands, comprised of approximately 4 acres. However, the estimated value of this easement would exceed 80 percent of the fee value of the property. Therefore fee title is the recommended estate.

D.6.2.5 Perimeter Access and Buffer Area

There are approximately 115 acres located between the exterior edge of the perimeter canals on which permanent maintenance access roads will be constructed and maintained. These roads will provide access not only for project operation and maintenance but for public access for recreation purposes. While a modified standard estate such as a modified road easement might be sufficient, the estimated value of the easement over this land would exceed 80 percent of the fee value of the property. In addition, the following activities will have to be prohibited:

a) commercial or industrial activities;
b) construction of any kind within this area;
c) dumping of refuse, wastes, sewage, or other debris;
d) harvesting wood products;
e) commercial recreational activities;
f) activities detrimental to flood damage reduction, water management, conservation, environmental restoration, water storage, erosion control, soil conservation, reclamation, fish and wildlife habitat preservation, and allied purposes,
g) any mining or alteration of the surface of the land, including any substance that must be quarried or removed by methods that will

consume or deplete the surface, including, but not limited to, the removal of topsoil, sand, gravel, rock, and peat; any use or activity that causes or is likely to cause significant pollution of any surface, and

h) prohibition of all agricultural activity.

All these lands are required in fee.

D.6.2.6 Temporary Work/Stockpile/Staging Areas

During the construction of the Reservoir Project, the contractor may need approximately 200 acres for temporary work areas, temporary stockpile areas and temporary staging areas. A temporary easement for the period of construction will be required over this approximately 200 acres. SFWMD owns fee title to lands directly to the north of the Reservoir project which will be used for these temporary work/stockpile/staging areas.

D.6.3 Facility, Utility Relocations

Preliminary Attorney's Opinions of Compensability have been completed and used for the purpose of completing the study. Final Attorney's Opinions of Compensability and final relocation determinations will be completed as required by Engineering Regulation (ER) 405-1-12, chapter 12, paragraph 12-22 prior to completion of the PCA or 100% design of the reservoir by SFWMD.

D.6.3.1 Florida Power and Light Company (FP&L)

FP&L owns a limited right of way easement 140 feet in width that runs through the East ½ of Section 31 and into Sections 32, 33, 34, 35 and 36, Township 43 South, Range 28 East for construction of electric transmission and distribution power lines and towers recorded in ORB 4 page 14 of the records of Hendry County. These power lines will not be impacted by the project. Therefore no relocation of this line will be necessary for the project.

FP&L owns an easement 15 foot wide in Sections 7 and 8, Township 44 South, Range 28 East for construction of overhead and underground electric utility facilities (including wires, poles, guys, cables, conduits and appurtenant equipment) recorded in Official Record Book 428 page 870 of the records of Hendry County. As modified and superseded by an easement 15 foot wide in Sections 5, 7 and 8, Township 44 South, Range 28 East for construction of overhead and underground electric utility facilities (including wires, poles, guys, cables, conduits and appurtenant equipment) recorded in Official Record Book 460 page 37 of the records of Hendry County. This powerline easement runs along side the LPDD drainage canal and will be relocated to the north of the project area. It was determined that FP&L has a compensable interest in this area.

FP&L owns an easement 10 foot wide in Sections 30, 31, 32, 33, 34, 35 and 36, Township 43 South, Range 28 East and Sections 31, 32 and 33, Township 43 South, Range 29 East for construction of overhead and underground electric utility facilities (including wires, poles, guys, cables, conduits and appurtenant equipment) recorded in Official Record Book79 Page 231 of the records of Hendry County. Some of this easement is within the right of way of the Townsend Canal. It is anticipated that only one power pole will have to be relocated. Other minor utility lines run throughout the project area and will be abandoned or removed by the utility company. It was determined that FP&L has a compensable interest in this area.

"ANY CONCLUSION OR CATEGORIZATION CONTAI NED IN THIS REPORT THAT AN ITEM IS A UTILI TY OR FACILITY RE LOCATION TO BE PERFORMED BY THE NON-FEDERAL SP ONSOR AS PART OF ITS LE RRD RES PONSIBILITIES IS PRELIMINARY ONLY. THE GOVE RNMENT W ILL MAKE A FINAL DETERMINATION OF THE RELOCA TIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAI NTENANCE OF T HE PROJE CT AFTE R FURTHER ANALYSIS AND COMPL ETION AND APP ROVAL OF FINAL ATTORNEY'S OPINIONS OF C OMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES."

Final Attorney's Opinions of Compensability and final relocation determinations will later occur as required by Engineering Regulation (ER) 405-1-12, chapter 12, paragraph 12-22.

D.6.4 TEMPORARY WORK AREAS

Preliminary analysis indicates that all required temporary staging and stockpile areas will occur within the lands and right of way owned or controlled by SFWMD. Therefore, no additional LER is anticipated to be required for such purposes.

D.6.5 BORROW AND DISPOSAL SITES

D.6.5.1 Borrow

Based on the Geotechnical analysis, it was determined that sufficient quantities of suitable borrow material, within the project footprint, will be made available for construction of the embankment and for other purposes. (See Engineering Appendix). Therefore, no off-site borrow or disposal sites will be required.

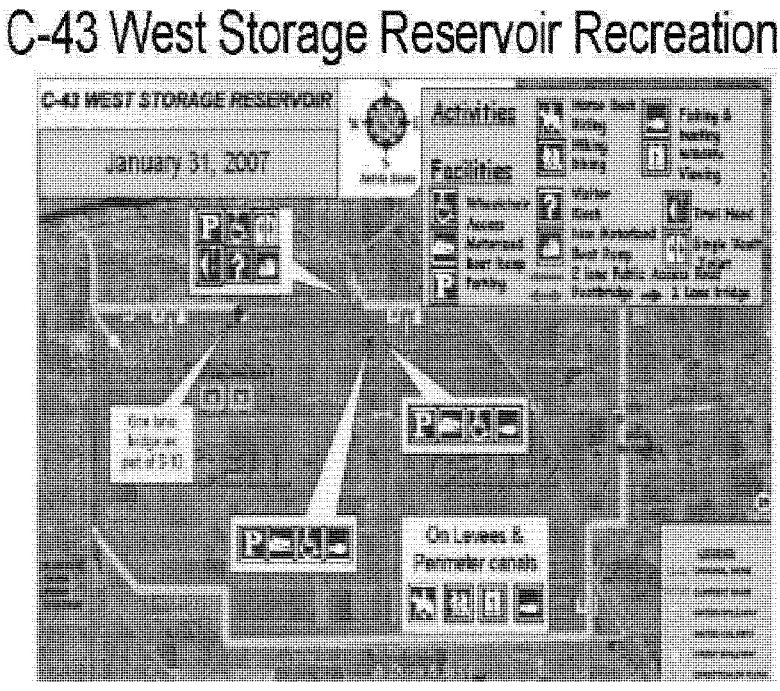
D.6.5.2 Disposal

It is proposed that excavated material from the construction site will be utilized for borrow material; therefore, no additional disposal material or borrow site will be required.

D.6.6 RECREATION FEATURES

Recreational features being considered for construction lie within the approximately 10,480 acres to be provided in fee and will be constructed within the footprint of the project. Therefore, no addition LER is required for recreational purposes. The recreational features being proposed may include a nature study, multi-use trail atop the embankment, equestrian use, boat and bank fishing, canoeing/kayaking, motor boating and hunting which will fit with the project purposes as managed by the SFWMD. A major recreation attraction of the Caloosahatchee River (C-43) West Basin Storage Reservoir will be an approximately 12-mile multi-purpose trail loop atop the embankment constructed as part of the project. Recreation facilities proposed include parking and toilet facilities (clivas multrum waterless vault toilets), information kiosk, canoe/kayak launch facility, a shade structure, traffic-control fencing and a pedestrian footbridge bridge over the perimeter canal to provide public access to the reservoir. Two handicapped accessible, double-lane public boat ramps would be provided. Vehicle access will be over the single-lane bridge over C43S-10. The ramps are proposed within the reservoirs on the north embankment. A paved two-lane public road will provide vehicular access to a one-lane bridge across the perimeter canal. A two-lane crushed shell road up the embankment and to the ramps is proposed. Boat traffic control buoys would keep boaters clear of the reservoir structures. Signage would post warnings. The canoe/kayak launch facility would be on the perimeter canal. Littoral areas are proposed at the corners of the seepage canal as part of the project and would provide ideal bank fishing locations outside the levee perimeter. The Florida Fish & Wildlife Conservation Commission (FWC) has endorsed the littoral shelf concept for habitat benefit and potential water quality benefits. Shades trees are proposed on the outside area of the north rim canal adjacent to parking areas. Ample public parking will be developed outside of the north levee and perimeter canal in the general area of the construction staging location. See ***Figure D-3*** and the Appendix H - Recreation of this report for further discussion.

FIGURE D-3: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR RECREATION FEATURES



D.6.7 ACCESS TO THE PROJECT AREA

Access to the site would be from State Road 80 along the existing access road to the Field Office. Other access roads would be added as required for both construction and operation and maintenance activities. Therefore, ingress and egress will be via Federal, State, municipal, county roads, and roads and rights of way available to the non-Federal sponsor for project purposes. No additional LER are required.

D.7 EXISTING FEDERAL PROJECTS

There are no known Federal projects that lie fully or partially within the LER required for the project.

D.8 FEDERALLY OWNED LANDS

There are no known federally owned lands within the project area.

D.9 NON-FEDERAL SPONSOR OWNED LANDS AND CREDITING

The SFWMD records indicate that they currently own approximately 12,352 acres in fee and approximately 20 acres in easement for a total of 12,372 acres (***Figure D-4*** entitled "SFWMD Parcel Acquisition Map, and, ***Table D-2*** entitled "Acreage and Interest Owned by SFWMD). The approximately 20 acres of easement is situated at the northwest corner of SFWMD's fee ownership, and it connects the Townsend Canal to the Caloosahatchee River. A review of the SFWMD easements indicated that they currently have sufficient interest for the construction, maintenance, repair, replacement and operation for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. The estate proposed for this approximately 20 acres of Townsend Canal is the standard channel improvement easement for the project. SFWMD is currently in negotiation to exchange 541.31 acres within its ownership for 600.17 acres owned by Bryan Paul Citrus and identified on the map and table as GX100-008 and GX100-009 respectively. Such an exchange would add an additional approximately 58 acres for a estimated total of 12,430 acres for SFWMD ownership in fee and easement that would be available and sufficient interest for project purposes. Within the approximately 12,372 acres presently owned by SFWMD, approximately 9,003 acres were acquired from J&H Grove Holdings, Inc. (area referred to as the Berry Groves) with both Federal (DOI) and State funds. Only approximately 7,080 acres of this approximately 9,003 acres acquired with both Federal and State funds will be used for the Project. The remainder of the approximately 3,620 acres required for the project was acquired with State funds.

A breakdown of the acreages and costs are as follows:

- SFWMD's total land acquisition consists of approximately 12,372 acres including approximately 20 acres of easement.
- SFWMD will exchange approximately 541 of these acres for approximately 600 acres owned by Bryan Paul Citrus for a new total of approximately 12,340 acres.
- Total project footprint for LER requirements is estimated at approximately 10,700 acres that consists of approximately 10,480 acres in fee, approximately 20 acres in perpetual easement, and approximately 200 acres in temporary easements.
- Federal (DOI) and State funds contribution for acquiring 9,003 acres of J&H Grove Holdings L.C.(Berry Grove) property consist of *$32,800,000 of Federal funds and $38,668,403 of State funds for a total of *$71,500,000®. Such figures are based on information provided by SFWMD.
- Land acquired with Federal and State funds to be used for project purposes is approximately 7,080 acres.

- Federal Fund contribution for approximately 7.080 acres is estimated at $27,502,294 for land cost and $64,375 for acquisition cost for an estimated total of $27,566,669.
- Federal administrative costs for 10,700 acres is an estimated amount of $424,219® with 25% contingency.
- Total estimated Federal cost share *$27,930,000.
- State funds contribution for both the 7,080 acres as well as the remaining 3,620 acres is an estimated amount of $50,990,270 for land cost and an estimated amount of $1,504,585® for acquisition cost with 7% contingency included.
- Total estimated real estate costs for the 10,700 acres required for the project are the sum of $27,502,294 Federal + $424,219 Federal + $50,990,270 non-Federal + $1,504,585 non-Federal which amounts to *$80,420,000.00 (Rounded Down).

*Note costs in $x1000

The amount of the Federal share may be increased or decreased based on a more detailed analysis which will occur during the crediting review process after approval of the Project, execution of a Project Cooperation Agreement, and certification of the land by SFWMD. See ***Figure D-4*** entitled "SFWMD Parcel Acquisition", ***Table D-2*** entitled "Acreage and Interest Owned by SFWMD", and ***Table D-3*** entitled "Summary of Baseline Cost Estimate".

FIGURE D-4: SFWMD PARCEL ACQUISITION MAP

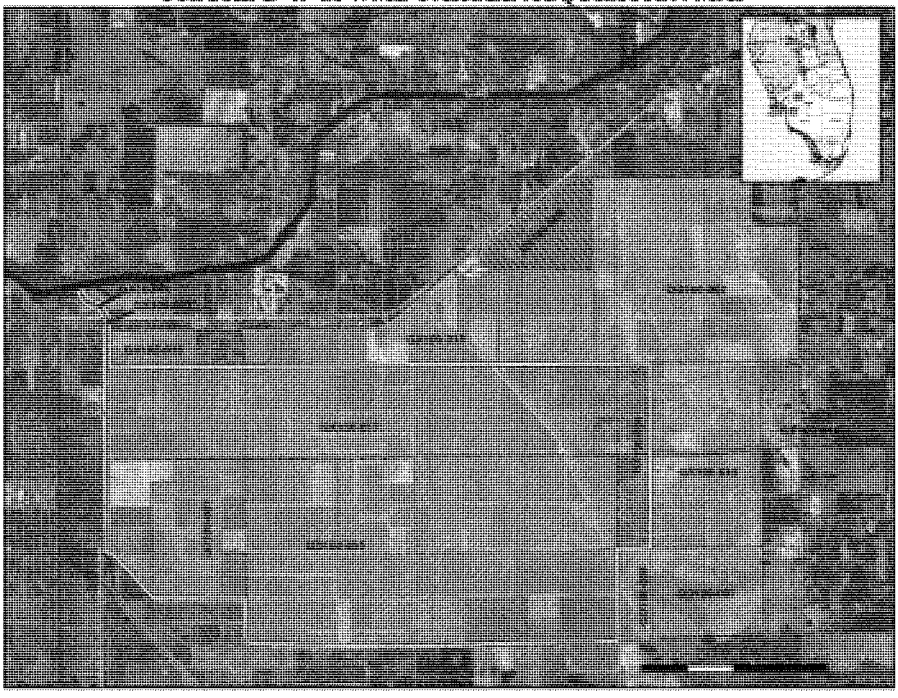


TABLE D-2: ACREAGE AND INTEREST OWNED BY SFWMD

Landowner Name	Acres Acquired	Land Purchase Price	Land Associated Costs	Total Acquisition Costs	District/State Funded	Locally Funded	Federally Funded
Berry, Paul & Duda (GX 100-002) easement	10.28	$0.00	$4,940.04	$4,940.04	$4,940.04	$0.00	$0.00
Berry Groves (GX100-003) easement	5.99	$0.00	$5,946.87	$5,946.87	$5,946.87	$0.00	$0.00
SFWMD (GX100-008*) fee	541.31	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
J&H Grove Holdings, L.C. (GX100-001) fee	8,121.52	$63,010,622	$854,434.62	$63,865,056.62	$32,359,745.62	$0.00	$31,505,311
J&H Grove Holdings, L.C. (GX100-004) fee	338.98	$7,510,988	$80,358.67	$7,591,346.67	$6,296,657.67	$0.00	$1,294,689
Griffin Family LMTD Partnership (QD 100-001) fee	954.89	$4,620,000	$105,588.50	$4,725,588.50	$4,725,588.50	$0.00	$0.00
MG Enterprises LLC (QD 100-005) fee	2,399.11	$13,875,000	$58,995.28	$13,933,995.28	$13,933,995.28	$0.00	$0.00
Sub-Total Acres currently acquired	12,372.08	$89,016,610	$1,099,377.07	$90,115,987.07	$57,315,987.07	$0.00	**$32,800,000
SFWMD (GX100-008*) fee to be conveyed to Bryan Paul Citrus	541.31	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Sub total after conveyance to Bryan Paul	11,830.77						
Bryan Paul Citrus (GX100-009) fee to be acquired by SFWMD in exchange for GX100-008	600.17			$0.00	$0.00	$0.00	$0.00
FINAL TOTAL ACRES OWNED BY SFWMD	**12,430.94**						

* Note GX-100-008 (Cerp Id=04) was exchanged for GX-100-009 (Cerp Id=04A); no dollar impact
** Note these figures had not yet been verified but will be verified during crediting and certification of lands.

D.9.1 Crediting Considerations

This report takes into consideration for crediting purposes the Congressional Authority, the Programmatic Regulations, Six Program-Wide Guidance Memoranda, dated February 2006, and the DOI and SFWMD Grant Agreement entitled Everglades Watershed Restoration-Grant Number LWCF-1.

The CERP Congressional Authority - the CERP Congressional Authority which reads, in part, as follows: "Regardless of the date of acquisition, the value of lands or interests in land acquired by non-Federal interests for any activity described in subsection (b) shall be included in the total cost of the activity and credited against the non-Federal share of the cost of the activity. Such value shall be determined by the Secretary."

"IN GENERAL- Notwithstanding section 528(e)(4) of the Water Resources Development Act of 1996 (110 Stat. 3770) and regardless of the date of acquisition, the value of lands or interests in lands and incidental costs for land acquired by a non-Federal sponsor in accordance with a project implementation report for any project included in the Plan and authorized by Congress shall be-- (i) included in the total cost of the project; and (ii) credited toward the non-Federal share of the cost of the project.

Draft Programmatic Regulations, Six Program-Wide Guidance Memoranda, dated February 2006 - States that credit will be afforded to the Sponsor based on the actual cost of the land needed for a project instead of what the land is worth at the time of a Project Cooperation Agreement signing. Consequently, the Project Delivery Team (PDT) should use actual acquisition costs in plan formulation, cost estimating, and crediting, subject to those costs being reasonable, allocable, and allowable." Therefore, credit for LERRD provided by SFWMD will be based on actual cost of the land, the administrative cost to purchase the lands, and the incidental cost for acquiring the LERRD for the project.

D.9.2 Department of Interior Grant Number LWCF-1, Addendum 3, Land and Water Conservation Act Funds

In June 1999, the DOI and SFWMD executed a Grant Agreement entitled Everglades Watershed Restoration-Grant Number LWCF-1, in which DOI provided $38,900,000 in Federal funds to the SFWMD for the acquisition of land in the East Coast Buffer/WPA and Southern Corkscrew Regional Ecosystem Watershed Project. SFWMD matched the Federal share with a State share of $38,900,000, making the total expenditures on land acquisition at $77,800,000. This Grant contained language to allow SFWMD to manage these acquired lands during an Interim Period defined as "...the period of time: 1) commencing a) with respect to Grant Lands, the date of purchase or date of possession under

condemnation, as appropriate, and b) with respect to Match Lands, the effective date of the Grant Agreement as defined below, and 2) ending a) sixty (60) days prior to the issuance of a notice to proceed with construction of the respective phase of the District/Corps Project, at which time the Grant Land or Match Land is deemed to be 'Incorporated into a District/Corps Project', or b) on the date of receipt by Interior of written notice from the Corps or the District that the particular Grant Land or Match Land is not to be included within a District/Corps Project, or c) such other date agreed to by Interior and the District." .... "Upon incorporation of each Grant Land or Match Land into a District/Corps Project, such Grant Land or Match Land shall be managed in accordance with Corps approved water management and control plans and operation and maintenance manuals for the project so long as the project remains authorized."

This Grant was amended December 1999 to add an additional $13,900,000 from each of the parties bringing the total to $105,600,000. The Grant was amended again in April 2000 to add an additional $18,900,000 from each of the parties bringing the total to $143,000,000. This additional $37,800,000 was to be used to purchase the Berry Groves property (Caloosahatchee River (C-43) West Basin Storage Reservoir project). The DOI's additional $18,900,000 in funding came from Land and Water Conservation Funds provided to the DOI by Congress. The last amendment to this Grant was executed in June 2001 with each party contributing an additional $5,974,000 bringing the total State and Federal funding under the Grant to $155,348,000. Not all the lands covered in this Grant Agreement are within the footprint of the Caloosahatchee River (C-43) West Basin Storage Reservoir project.

D.9.2.1 Certification and Crediting for Actual and Incidental Costs Acquired under the Department of Interior Grants

Pursuant to the terms and conditions of the Department of Interior Grant Agreement, SFWMD submitted and Department of Interior reviewed and approved the actual acquisition costs and SFWMD's administrative/incidental costs, (excluding SFWMD's staff costs) for the acquisition of J&H Grove Holdings, L.C. (Berry Grove) properties consisting of approximately 9,003 acres in the amount of $71,500,000®, of which $32,800,000 were Federal funds. Of the approximately 7,080 acres of the approximately 9,003 acres required for the project, the Federal share would be approximately $27,566,670® as shown in ***Table D-2***, ***Table D-3***, and ***Table D-4***. These figures may be increased or decreased based on a more detailed analysis during the crediting review process after approval of the Project, execution of a Project Cooperation Agreement and certification of the land.

The sum of $27,566,670 will be credited towards the Federal share of total project cost. This would avoid the review of the same information by two

Federal Agencies and would be consistent with the terms of the Framework Agreement as stated above. The value of real estate acquired pursuant to this Article will be the actual acquisition cost of such real property for credit purposes under applicable cost-sharing principles." This proposal would also reduce future administrative costs.

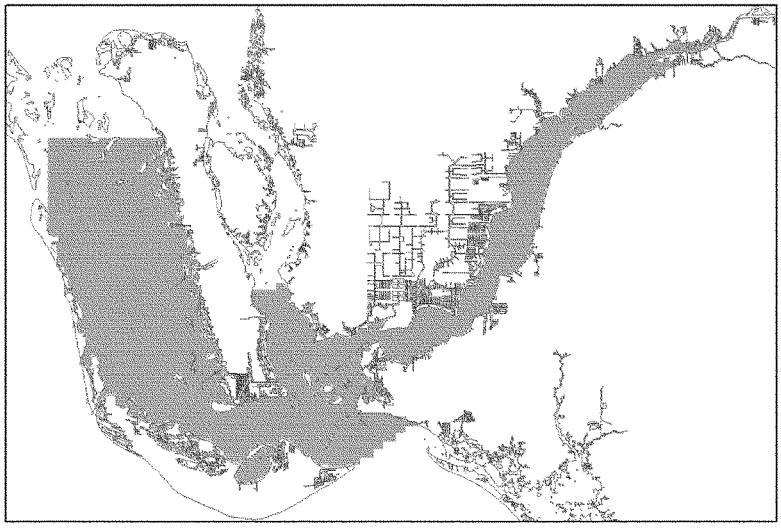
D.10 UNIFORM RELOCATION ASSISTANCE ACT, PL 91-646

Information provided by SFWMD indicates that there were no persons displaced from acquisition of the project lands by SFWMD. SFWMD's purchase contracts indicated that PL 91-646 was considered, but as part of the acquisition, the landowners waived their rights to relocation claims in the negotiated contracts. SFWMD will be required to provide proof of such waiver prior too or provide such proof as part of the crediting package for LERRD crediting.

D.11 NAVIGATIONAL SERVITUDE AND OTHER LANDS

Approximately 71,000 acres of the Caloosahatchee River and Caloosahatchee estuary from the tidal Caloosahatchee River (i.e., downstream of S-79 to Shell Point) to San Carlos Bay (Shell Point to Pine Island Sound), and areas within Pine Island Sound and Matlacha Pass will be available for use for the environmental benefits for the project. These acres are within the navigable waters of the United States and within the navigation servitude of the Untied States. See ***Figure D-5*** below. See Environmental Appendix for further discussion on the subject matter.

FIGURE D-5: ENVIRONMENTAL LANDS MAP



D.12 INDUCED FLOODING

An analysis will be completed to address the Savings Clause Provisions established by the Water Resources Development Act of 2000 (WRDA 2000) that was signed into law by the President of the United States (Public Law No. 106-541, of the 106th Congress). Section 601(h)(5) contains a Savings Clause that provides protection for existing legal sources of water that will be eliminated or transferred due to project implementation and for no significant and adverse reduction in the level of service for flood protection that was in existence on the date of enactment and in accordance with applicable law. The Programmatic Regulations for the Everglades (33 CFR §§ 385.5 and 385.35-37) require a programmatic guidance memorandum on existing legal sources of water, and a determination of the pre-CERP baseline conditions and direction about what constitutes "levels of service for flood protection ... in accordance with applicable law" existing on date of enactment of WRDA 2000.

To ensure the levels of service of flood protection will not be diminished by this project, hydrologic and hydraulic analyses are being performed using surface water and groundwater modeling. The results of the analyses indicate that the project is not expected to result in stage increase in canal systems adjacent to the project site. The modeling analysis indicates that no flooding will occur outside the project due to the construction or the operation and maintenance of the project. The analysis also indicates that any seepage from the reservoir will be captured in the seepage canals; however, additional analyses will be

undertaken after project construction to ensure that the level of service of flood protection in areas adjacent to the project site is maintained.

D.13 MINERAL AND TIMBER ACTIVITIES

Preliminary investigations indicate that there are no known present or anticipated mineral activities in the vicinity of the proposed project that may affect construction, operation, or maintenance of the project.

D.14 NON-FEDERAL AUTHORITY TO PARTICIPATE IN THE PROJECT

The SFWMD was created by virtue of Florida Statutes, Chapter 373, Section .069 to further the State policy of flood damage prevention, preserve natural resources of the State including fish and wildlife and to assist in maintaining the navigability of rivers and harbors. (There are other enumerated purposes but they are not directly applicable to this project). See Exhibit "C".

D.15 PROPOSED ESTATES

Based on the analysis set forth in paragraph D.1.7.1 above, the following estates will be required:

D.15.1 Standard Estates

D.15.1.1 Standard Estate – Fee

The fee simple title to (the land described in Schedule A), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

D.15.1.2 Channel Improvement Easement

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A) for the purposes as authorized by the Act of Congress approved (ADD APPROPRIATE WRDA AUTHORIZATION), including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions there from; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

D.15.1.3 Temporary Work Area and/or Disposal Area Easement

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A), for a period not to exceed ADD APPROPRIATE TERM OF YEARS AREA IS REQUIRED FOR CONSTRUCTION PURPOSES) _____, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

D.16 ZONING ORDINANCES

Preliminary investigation indicates that no enactments of zoning ordinances are proposed in lieu of, or to facilitate, acquisition in connection with the project.

D.17 ACQUISITION SCHEDULES

It is anticipated that SFWMD currently owns, or will own or control the lands required for construction, operations, and maintenance of the project. Following execution of the Project Cooperation Agreement (PCA), the Federal Government will provide SFWMD with general written descriptions, including maps as appropriate, of the LER and the facility/utility relocations that the Government has determined the non-Federal sponsor must provide and perform for the construction, operation, and maintenance of the project. The LER descriptions will include the required estate, acreage, location, and schedule requirements in detail sufficient to enable the SFWMD to fulfill its obligations to provide the LER in a timely fashion. If relocation is required then the descriptions will include sufficient detail so as to enable the non-Federal sponsor to perform its relocation responsibilities in a timely fashion. In addition, a written notice to proceed with acquisition of such additional LER will be provided to SFWMD.

D.18 HAZARDOUS, TOXIC OR RADIOLOGICAL WASTE (HTRW)

The existing conditions portion of the HTRW document includes a summary of the Phase I/II Environmental Site Assessment (ESA) studies done on the four

properties acquired for the reservoir project. In the course of these studies, over 50 point source sites with potential HTRW contamination were identified. At this time, most if not all of these potential contamination sites have been either remediated or further investigated to characterize the sites and prepare remediation plans. The project sponsor, the SFWMD has made a commitment to the Corps and FWS that after it takes control of the properties from the present lessees and begins construction of the reservoir, all of the outstanding point source remediation efforts will be completed. In addition to the point source contamination sites, the SFWMD also identified distributed soil contamination in portions of the cultivated areas on all of the acquired properties. The remediation of the cultivated soil sites involves the placement of these soils into the core of the reservoir dam. This will isolate the contaminated soils from benthic organisms that serve as food for higher level organisms and thus reduce the potential for bioaccumulation of contaminants by fish and wildlife.

The FWS service has reviewed all of the SFWMD's remediation plans and indicated that they believe that the efforts will sufficiently reduce the risk of harm to fish and wildlife in those areas where the remediation will be performed. The FWS has also stated that moderate levels of copper and other contamination of the cultivated areas are believe to not pose a direct threat to species of concern; however, they believe that an indirect effect may occur since widespread low-level soil contamination may reduce the population of benthic organisms upon which the species of concern normally feed.

Despite the diligent work performed by the SFWMD and FWS to reduce the risk to environmental resources, it is possible that once the reservoir is built, bioaccumulation of soil contaminants does result in harm to one or more species of interest. If this does happen, additional remediation efforts, such as more extensive removal of the reservoir bottom sediments could be done to further reduce the exposure of benthic organisms to nearsurface soil contamination. The cost of additional remediation, if necessary, would be the responsibility of the non-federal sponsor. If such remediation is necessary, the reservoir would be at least partially out of service for several months while the work is conducted.

Most of the contamination at the point source sites has been delineated and much of it remediated. The remaining sites are expected to be remediated prior to certification of the lands and are not likely to cause a project delay. See main body of report for a full discussion of the HTRW.

The non-Federal sponsor shall be responsible for ensuring that the development and execution of Federal, State, and/or locally required HTRW response actions area accomplished at 100 percent non-project cost. No cost sharing credit will be given for the cost of response actions.

D.19 PROJECT SUPPORT

No real estate issues relevant to planning, designing or implementing are anticipated. No real estate issues that may impact the project schedules, budgets, PCA, or quality of the deliveries are anticipated since these lands are currently owned by SFWMD.

There is no known or anticipated opposition to the project by landowners in the project area or any known or anticipated ownership concerns that could impact the project since SFWMD already owns, controls, or will control the lands that are required for project purposes.

D.20 BASELINE COST ESTIMATES AND MCACES COST ESTIMATES

The actual acquisition costs and administrative costs provided by SFWMD were considered in the final computation. SFWMD cost towards the land and incidental cost is estimated at $52,400,056.39 without contingency and $52,494,855.94 with contingency. A seven percent contingency was added to the Sponsor's estimated administrative/incidental costs due to risk and uncertainty. The federal cost amounted to $27,926,512.75, which includes the Federal share of the land costs as well as future federal administrative costs. The total real estate cost with contingency is estimated at $80,421,000. These figures are subject to modification and verification during the crediting review process.

D.21 BASELINE COST ESTIMATES AND MCACES COST ESTIMATES

The actual acquisition costs and administrative costs provided by SFWMD were considered in the final computation. SFWMD cost towards the land and incidental cost is estimated at $52,494,855.94. A seven percent contingency was added to the Sponsor's estimated costs due to risk and uncertainty. The Federal cost amounted to $27,930,000®. The total real estate cost with contingency is estimated at $80,420,000 (Rounded Down). (***Table D-3***)

TABLE D-3: BASELINE COST ESTIMATE

TABLE D-3: SUMMARY OF BASELINE COST ESTIMATE

PROJECT: Caloosahatchee River (C-43) West Basin Storage Reservoir
DATE: 13 Jun 2007

ESTATE	Approximate Acres	PRORATED	Non-Federal Amounts - Actual Cost	Federal Amounts	Federal & Non_Federal Amounts	
FEE	10,480.00					
Non-Federal Funds			$50,240,270.00			
Land Payments by LS - Direct Acquisition with FederalL-LWCF1 Funds				$27,502,294.00	$77,742,564.00	
EASEMENT - PERMANENT CHANNEL	20		$0.00			
Work Area – Temporary Easement	200.00	$3,750.00	$750,000.00			
SUBTOTAL	10,700		$50,990,270.00			
Improvements	0.00		$0.00			
Severance			$0.00			
Minerals	$0.00		$0.00			
SUBTOTAL			$50,990,270.00	$27,502,294.00		
TOTAL LANDS AND DAMAGES (RD)	10,700				$78,492,564.00	
ACQ/ADMIN						
Fed				$275,000.00		
Federal - LWCF1 Funds				$64,375.00		
Non-Fed			$1,406,155.08			
PL 91-646 Contingency (RD) -Federal 25%			$0.00	$84,843.75		
Contiengency (RD) - Non-Federal 7%			$98,430.86			
SUBTOTAL (W/O Contingency)			$1,406,155.08	$339,375.00		
SUBTOTAL (With Contingency)			$1,504,585.94	$424,218.75		
TOTAL Estimated RE COSTS (RD)	10,700.00					*$80,421,000

*The Total Estimated RE Cost of $80,421,000 was rounded down to $80,420,000.

TABLE D-4: MCACES PROJECT REAL ESTATE COSTS

TABLE D-4 : MCACES PROJECT REAL ESTATE COSTS

PROJECT: Caloosahatchee River (C-43) West Basin Storage Reservoir

DATE: 6/13/2007

01	LANDS AND DAMAGES	Federal Cost	Non-Federal Cost
01AA	PROJECT PLANNING	$100,000.00	
01B--	ACQUISITIONS		
01B20	By LS (State funds)		$1,250,763.83
01B20	BY FED -LWCF1 (Funds)	$64,375.00	
01B40	Review of LS	$50,000.00	
01C--	CONDEMNATIONS		
01C20	By LS	$0.00	$0.00
01C40	Review of LS	$5,000.00	
01E--	APPRAISALS		
01E30	By LS		$145,391.25
01E50	Review of LS	$90,000.00	
01F--	PL 91-646 ASSISTANCE		
01F20	BY LS	$0.00	$0.00
01F40	Review of LS	$5,000.00	
01G--	TEMPORARY PERMITS LICENSES RIGHTS-OF-ENTRY		
01G20	By LS - Future		$10,000.00
01G40	Review of LS	$20,000.00	
01G60	Damage Claims	$0.00	
01M00	PROJECT RELATED ADMINISTRATION		
	Real Estate Review of PCA	$5,000.00	
01R--	REAL ESTATE PAYMENTS		
01R1	Land Payments by LS		**$50,990,270.00**
01R1B	Land Payments By LS - Direct Acquisition with Federal-LWCF1 Funds	**$27,502,294.00**	
01R2	PL 91-646 Assistance Payment		
01R2B	By LS	$0.00	$0.00
Total Real Estate Cost Excluding Contigency (RD)		$27,841,669.00	$52,396,422.08
Contingency Federal	**25%**	$84,843.75	
Contingency -Non-Federal	**7%**		$98,430.86
TOTAL PROJECT REAL ESTATE COST (RD)			****$80,420,000**

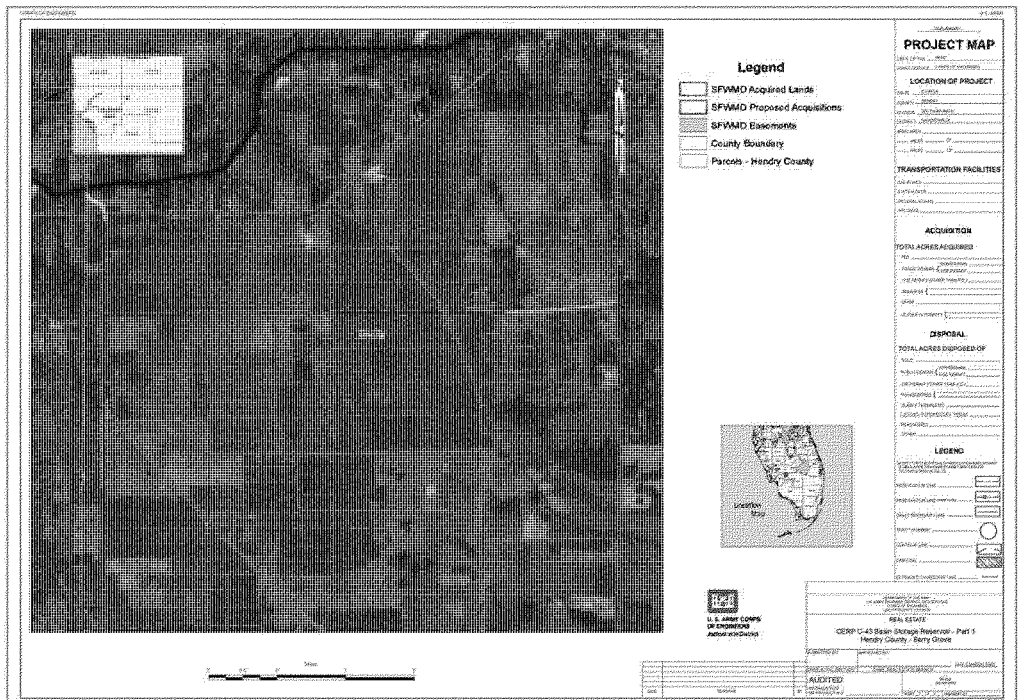
*The percentages are based on incidental and administrative cost (Land cost not considered in the Contingency Cost)

**The Total Estimated real estate cost of $80, 421,000 was rounded down to $80,420,000.

D.22 REAL ESTATE MAPS

The Real Estate Planning Map (***Figure D-6***) depicts the project area and location, project footprint, project features, and ownerships.

FIGURE D-6: REAL ESTATE PLANNING MAP



2604

D.23 EXHIBITS

EXHIBIT "A"
SEC. 390. EVERGLADES ECOSYSTEM RESTORATION

(a) IN GENERAL.--On July 1, 1996, out of any funds in the Treasury not otherwise appropriated, the Secretary of the Treasury shall provide $200,000,000 to the Secretary of the Interior to carry out this section.

(b) ENTITLEMENT.--The Secretary of the Interior (referred to in this section as the "Secretary")--

(1) shall be entitled to receive the funds made available under subsection (a);

(2) shall accept the funds; and

(3) shall use the funds to--

(A) conduct restoration activities in the Everglades ecosystem in South Florida, which shall include the acquisition of real property and interests in real property located within the Everglades ecosystem; and

(B) fund resource protection and resource maintenance activities in the Everglades ecosystem.

(c) SAVINGS PROVISION.--Nothing in this subsection precludes the Secretary from transferring funds to the Army Corps of Engineers, the State of Florida, or the South Florida Water Management District to carry out subsection (b)(3).

(d) DEADLINE.--The Secretary shall use the funds made available under subsection (a) for restoration activities referred to in subsection (b)(3) not later than December 31, 1999.

(e) REPORT TO CONGRESS.--For each of calendar years 1996 through 1999, the Secretary shall submit an annual report to Congress describing all activities carried out under subsection (b)(3).

(f) SEPARATE AND ADDITIONAL EVERGLADES RESTORATION ACCOUNT.--

(1) ESTABLISHMENT.--There is established in the Treasury a special account (to be known as the "Everglades Restoration Account"), which shall consist of such funds as may be deposited in the account under paragraph (2). The account shall be separate, and in addition to, funds deposited in the Treasury under subsection (a).

(2) SOURCE OF FUNDS FOR ACCOUNT.--

(A) PROCEEDS FROM SURPLUS PROPERTY.--

(i) IN GENERAL.--Subject to subparagraph (B), the Administrator shall deposit in the special account all funds received by the Administrator, on or after the date of enactment of this Act, from the disposal pursuant to the Federal Property and Administrative Services Act of 1949 (40 U.S.C. 471 et seq.) of surplus real property located in the State of Florida.

ii) AVAILABILITY AND DISPOSITION OF FEDERAL LAND.--

(I) IDENTIFICATION.--Any Federal real property located in the State of Florida (excluding lands under the administrative jurisdiction of the Secretary that are set aside for conservation purposes) shall be identified for disposal or exchange under this subsection and shall be presumed available for purposes of this

subsection unless the head of the agency controlling the property determines that there is a compelling program need for any property identified by the Secretary.
(II) AVAILABILITY.--Property identified by the Secretary for which there is no demonstrated compelling program need shall, not later than 90 days after a request by the Secretary, be reported to the Administrator and shall be made available to the Administrator who shall consider the property to be surplus property for purposes of the Federal Property and Administrative Services Act of 1949 (40 U.S.C. 471 et seq.).
(III) PRIORITIZATION OF DISPOSITION.—The Administrator may prioritize the disposition of property made available under this subparagraph to permit the property to be sold as quickly as practicable in a manner that is consistent with the best interests of the Federal Government.
(B) LIMIT ON TOTAL AMOUNT OF DEPOSITS.--The total amount of funds deposited in the special account under subparagraph (A) shall not exceed $100,000,000.
(C) EFFECT ON CLOSURE OF MILITARY INSTALLATIONS.--Nothing in this section alters the disposition of any proceeds arising from the disposal of real property pursuant to a base closure law.
(3) USE OF SPECIAL ACCOUNT.--Funds in the special account shall be available to the Secretary until expended under this paragraph. The Secretary shall use funds in the special account to assist in the restoration of the Everglades ecosystem in South Florida through--
(A) subject to paragraph (4), the acquisition of real property and interests in real property located within the Everglades ecosystem; and
(B) the funding of resource protection and resource maintenance activities in the Everglades ecosystem.
(4) STATE CONTRIBUTION.--The Secretary may not expend any funds from the special account to acquire a parcel of real property, or an interest in a parcel of real property, under paragraph (3)(A) unless the Secretary obtains, or has previously obtained, a contribution from the State of Florida in an amount equal to not less than 50 percent of the appraised value of the parcel or interest to be acquired, as determined by the Secretary.
(5) DEFINITIONS.--In this subsection:
(A) ADMINISTRATOR.--The term "Administrator" means the Administrator of General Services.
(B) BASE CLOSURE LAW.--The term "base closure law" means each of the following:
(i) The Defense Base Closure and Realignment Act of 1990 (part A of title XXIX of Public Law 101-510; 10 U.S.C. 2687 note).
(ii) Title II of the Defense Authorization Amendments and Base Closure and Realignment Act (Public Law 100-526; 10 U.S.C. 2687 note).
(iii) Section 2687 of title 10, United States Code.
(iv) Any other similar law enacted after the date of enactment of this Act.

(C) EVERGLADES ECOSYSTEM.--The term "Everglades ecosystem" means the Florida Everglades Restoration area that extends from the Kissimmee River basin to Florida Bay.
(D) EXCESS PROPERTY.--The term "excess property" has the meaning provided in section 3 of the Federal Property and Administrative Services Act of 1949 (40 U.S.C. 472).
(E) EXECUTIVE AGENCY.--The term "executive agency" has the meaning provided in section 3 of the Federal Property and Administrative Services Act of 1949 (40 U.S.C. 472).
(F) SPECIAL ACCOUNT.--The term "special account" means the Everglades Restoration Account established under paragraph (1).
(G) SURPLUS PROPERTY.--The term "surplus property" has the meaning provided in section 3 of the Federal Property and Administrative Services Act of 1949 (40 U.S.C. 472).
(g) REPORT TO DETERMINE THE FEASIBILITY OF ADDITIONAL LAND ACQUISITION AND RESTORATION ACTIVITIES.--
*(1) IN GENERAL.--The Secretary shall conduct an investigation to determine what, if any, unreserved and unappropriated Federal lands (or mineral interests in any such lands) under the administrative jurisdiction of the Secretary are suitable *1025 for disposal or exchange for the purpose of conducting restoration activities in the Everglades region.*
(2) CONSERVATION LANDS.--No lands under the administrative jurisdiction of the Secretary that are set aside for conservation purposes shall be identified for disposal or exchange under this subsection.
(3) FLORIDA.--In carrying out this subsection, the Secretary shall, to the maximum extent practicable, determine which lands and mineral interests located within the State of Florida are suitable for disposal or exchange before making the determination for eligible lands or interests in other States.
(4) PUBLIC ACCESS.--In carrying out this subsection, the Secretary shall consider that in disposing of lands, the Secretary shall retain such interest in the lands as may be necessary to ensure that the general public is not precluded from reasonable access to the lands for purposes of fishing, hunting, or other recreational uses.
(5) REPORT.--Not later than 1 year after the date of enactment of this Act, the Secretary shall submit a report to the Committee on Resources of the House of Representatives and the Committee on Energy and Natural Resources of the Senate describing the results of the investigation conducted under this subsection. The report shall describe the specific parcels identified under this subsection, establish the priorities for disposal or exchange among the parcels, and estimate the values of the parcels.

Exhibit "B"
SECTION 601 (E)(3) OF THE WATER RESOURCES DEVELOPMENT ACT OF 2000, (PL 106-541)
(e) COST SHARING.
(3) FEDERAL ASSISTANCE.
(A) IN GENERAL.--The non-Federal sponsor with respect to a project authorized by subsection (b), (c), or (d) may use Federal funds for the purchase of any land, easement, rights-of-way, or relocation that is necessary to carry out the project if any funds so used are credited toward the Federal share of the cost of the project.
(B) AGRICULTURE FUNDS.--Funds provided to the non-Federal sponsor under the Conservation Restoration and Enhancement Program (CREP) and the Wetlands Reserve Program (WRP) for projects in the Plan shall be credited toward the non-Federal share of the cost of the Plan if the Secretary of Agriculture certifies that the funds provided may be used for that purpose. Funds to be credited do not include funds provided under section 390 of the Federal Agriculture Improvement and Reform Act of 1996 (110 Stat.1022).

Exhibit "C"
FLORIDA STATUTES
TITLE XXVIII. NATURAL RESOURCES; CONSERVATION, RECLAMATION, AND USE CHAPTER 373. WATER RESOURCES
PART I. STATE WATER RESOURCE PLAN
373.1501. South Florida Water Management District as local sponsor
(1) As used in this section and s. 373.026(8), the term:
(b) "Department" means the Department of Environmental Protection.
(c) "District" means the South Florida Water Management District.
(f) "Project" means the Central and Southern Florida Project.
(g) "Project Component" means any structural or operational change, resulting from the restudy, to the Central and Southern Florida Project as it existed and was operated as of January 1, 1999.
(h) "Restudy" means the Comprehensive Review Study of the Central and Southern Florida Project, for which federal participation was authorized by the federal Water Resources Development Acts of 1992 and 1996 together with related Congressional resolutions and for which participation by the South Florida Water Management District is authorized by this section. The term includes all actions undertaken pursuant to the aforementioned authorizations which will result in recommendations for modifications or additions to the Central and Southern Florida Project.
(2) The Legislature finds that the restudy is important for restoring the Everglades ecosystem and sustaining the environment, economy, and social wellbeing of South Florida. It is the intent of the Legislature to facilitate and support the restudy through a process concurrent with Federal Government review and Congressional authorization. Nothing in this section is intended in any way to limit federal agencies or Congress in the exercise of their duties and

responsibilities. It is further the intent of the Legislature that all project components be implemented through the appropriate processes of this chapter and be consistent with the balanced policies and purposes of this chapter, specifically s. 373.016.
(4) The district is authorized to act as local sponsor of the project for those project features within the district as provided in this subsection and subject to the oversight of the department as further provided in s. 373.026. The district may:
(a) Act as local sponsor for all project features previously authorized by Congress;
(b) Continue data gathering, analysis, research, and design of project components, participate in preconstruction engineering and design documents for project components, and further refine the Comprehensive Plan of the restudy as a guide and framework for identifying other project components;
(c) Construct pilot projects that will assist in determining the feasibility of technology included in the Comprehensive Plan of the restudy; and
(d) Act as local sponsor for project components.
(5) In its role as local sponsor for the project, the district shall comply with its responsibilities under this chapter and implement project components through appropriate provisions of this chapter. In the development of project components, the district shall:
(a) Analyze and evaluate all needs to be met in a comprehensive manner and consider all applicable water resource issues, including water supply, water quality, flood protection, threatened and endangered species, and other natural system and habitat needs;
(b) Determine with reasonable certainty that all project components are feasible based upon standard engineering practices and technologies and are the most efficient and cost-effective of feasible alternatives or combination of alternatives, consistent with restudy purposes, implementation of project components, and operation of the project; (c) Determine with reasonable certainty that all project components are consistent with applicable law and regulations, and can be permitted and operated as proposed. For purposes of such determination:
1. The district shall convene a pre-application conference with all state and federal agencies with applicable regulatory jurisdiction;
2. State agencies with applicable regulatory jurisdiction shall participate in the pre-application conference and provide information necessary for the district's determination; and
3. The district shall request that federal agencies with applicable regulatory jurisdiction participate in the pre-application conference and provide information necessary for the district's determination;
(d) Consistent with this chapter, the purposes for the restudy provided in the Water Resources Development Act of 1996, and other applicable federal law, provide reasonable assurances that the quantity of water available to existing legal users shall not be diminished by implementation of project components so as to adversely impact existing legal users, that existing levels of service for flood protection will not be diminished outside the geographic area of the project

component, and that water management practices will continue to adapt to meet the needs of the restored natural environment.
(e) Ensure that implementation of project components is coordinated with existing utilities and public infrastructure and that impacts to and relocation of existing utility or public infrastructure are minimized.
(6) The department and the district shall expeditiously pursue implementation of project modifications previously authorized by Congress or the Legislature, including the Everglades Construction Project. Project components should complement and should not delay project modifications previously authorized.
(7) Notwithstanding any provision of this section, nothing herein shall be construed to modify or supplant the authority of the district or the department to prevent harm to the water resources as provided in this chapter.
(8) Final agency action with regard to any project component subject to s. 373.026(8)(b) shall be taken by the department. Actions taken by the district pursuant to subsection (5) shall not be considered final agency action. Any petition for formal proceedings filed pursuant to ss. 120.569 and 120.57 shall require a hearing under the summary hearing provisions of s. 120.574, which shall be mandatory. The final hearing under this section shall be held within 30 days after receipt of the petition by the Division of Administrative Hearings.

APPENDIX E
AGENCY AND PUBLIC COORDINATION

This page intentionally left blank

TABLE OF CONTENTS

E.0 AGENCY/PUBLIC COORDINATION E-1
E.1 PUBLIC INVOLVEMENT PROGRAM E-1
E.2 SCOPING FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT E-1
E.3 OTHER REQUIRED COORDINATION E-2
E.3.1 U.S. Fish and Wildlife Service E-2
E.3.2 National Marine Fisheries Service E-2
E.3.3 Florida Fish and Wildlife Conservation Commission E-3
E.3.4 Florida State Historic Officer E-3
E.4 ENVIRONMENTAL JUSTICE E-3
E.5 REVIEW OF THE DRAFT AND FINAL PIR/EIS E-4
E.5.1 Comments Received and Responses E-4

This page intentionally left blank

E.0 AGENCY/PUBLIC COORDINATION

Public outreach efforts for the Caloosahatchee River (C-43) West Basin Storage Reservoir project began early in the project formulation process. Due to the intense public, political, and media interest in restoration of the south Florida ecosystem, public participation has been a critical component of the development of this Project Implementation Report (PIR).

E.1 PUBLIC INVOLVEMENT PROGRAM

Public involvement is a process by which interested and affected individuals, organizations, agencies, and governmental entities are consulted and participate in the decision-making. Public involvement in the Caloosahatchee River (C-43) West Basin Storage Reservoir project has two main functions: to inform the public about what the project team is planning and to generate input on key issues and concerns critical to resolving the challenges involved in the planning effort.

This project has been developed with strong cooperation from the US Fish and Wildlife Service (USFWS), US Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), US Environmental Protection Agency (USEPA), National Oceanic and Atmospheric Administration (NOAA), US Geologic Survey (USGS), Florida Fish and Wildlife Conservation Commission (FFWCC), and Florida Department of Environmental Protection (FDEP), as well as Hendry and Lee counties. The South Florida Water Management District (SFWMD) is a cost-sharing partner in the study and had been a fully active participant in the formulation of this project and creation of the project report. USEPA, USFWS, and USGS have staffers located in the Planning sections of U.S. Army Corps of Engineers (USACE), Jacksonville District; these staffers aid in interagency coordination for Comprehensive Everglades Restoration Plan (CERP) projects. There has also been local participation in the project from Lee and Hendry counties.

E.2 SCOPING FOR THE CALOOSAHATCH EE RI VER (C-43) WEST BASIN STORAGE RESERVOIR PROJECT

A Notice of Intent (NOI) to produce an integrated Caloosahatchee River (C-43) West Basin Storage Reservoir Draft PIR and Environmental Impact Statement (EIS) was published in the Federal Register in March 2003. A Scoping Letter asking for agency and public comment on the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir PIR was sent out March 18, 2003

An official letter inviting USFWS, USEPA, Everglades National Park (ENP), FFWCC and FDEP to be cooperating agencies (as defined by the National Environmental Policy Act or NEPA) was sent in September 2006. These

agencies were chosen because of their special expertise on the area. The selection of these agencies to be invited as cooperating agencies does not exclude any other agencies from full participation in the project. Although none of these agencies accepted the invitation, their input will continue to be valued and solicited for the project.

E.3 OTHER REQUIRED COORDINATION

In addition to the scoping required by the NEPA, coordination required by other Federal laws and regulations has been conducted with the following agencies:

E.3.1 U.S. Fish and Wildlife Service

Two Planning Aid Letters, dated August 13, 2003 and March 29, 2005 were received from the USFWS as part of the process for developing alternative plans. A Draft Fish and Wildlife Coordination Act Report (DCAR) report was issued in March 2007. A Final CAR was issued on July 13, 2007. The letters and report can be reviewed in ***Annex A***. This information has been incorporated by the project team into the Caloosahatchee River (C-43) West Basin Storage Reservoir PIR plan formulation process. The USFWS is a member of the project team.

The USFWS also identified critical fish and wildlife habitat and threatened and endangered species in a letter dated April 11, 2002, and provided scoping comments in a letter dated June 10, 2003 (see ***Annex A***). The USACE asked for formal consultation with the USFWS due to potential adverse impacts to the endangered Florida panther (*Felis concolor coryi*), threatened Audubon's crested caracara (*Polyborus plancus audubonii*), and threatened eastern indigo snake (*Drymarchon corais couperi*). This letter was sent by the USACE on January 10, 2007. The USFWS concurred with the Corps determinations and completed the formal consultation by a BO dated 20 July 2007.

E.3.2 National Marine Fisheries Service

Public law 104-208 reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of Essential Fish Habitat (EFH). Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the National Marine Fisheries Service (NMFS) regarding potential effects of their actions on EFH and Federally managed fisheries. This PIR/EIS served as an EFH assessment and was coordinated with NMFS. NMFS has also completed their consultation for Section 7 of the Endangered Species Act (ESA) by concurring with the "may affect but not likely to adversely affect" determination for sea turtles and smalltooth sawfish by letter dated March 28, 2007. NMFS reviewed the draft EIS and stated in an email dated 30 May 2007 that "NOAA's National Marine Fisheries Service, Southeast Region, Habitat Conservation Division, has

reviewed the Department of the Army permit application listed below. We anticipate that any adverse effects that might occur on marine and anadromous fishery resources would be minimal and, therefore, do not object to issuance of the permit." The permit application referred to used this draft EIS as the NEPA document, and therefore NMFS agreed with the Corps determination of beneficial effects to EFH and fishery resources.

E.3.3 Florida Fish and Wildlife Conservation Commission

No Planning Aid Letters have been received from the Florida Fish and Wildlife Conservation Commission (FWC), though FWC has participated in the project team. FWC submitted comments dated 8 June 2007 on the draft PIR/EIS through the Florida Clearinghouse. Those comments along with the Corps' response are summarized in the draft PIR comment matrix in Annex A.

E.3.4 Florida State Historic Officer

Coordination with the State Historic Preservation Officer (SHPO) in accordance with the procedure of the Advisory Council on Historic Preservation is complete. An archaeological and historical survey of the project area revealed one site potentially eligible for listing in the National Register of Historic Places. It was the opinion of Janus Research, contractor to the SFWMD, that the site would not be adversely impact by project activities. Janus recommended no further archaeological or historical investigations in the project area. The SHPO concurred with Janus' opinion and recommendation by a letter sent October 5, 2006.

E.4 ENVIRONMENTAL JUSTICE

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires the Federal government to achieve environmental justice by identifying and addressing disproportionately high adverse effects of its activities on minority and low-income populations. It requires the analysis of information such as the race, national origin, and income level for areas expected to be impacted by environmental actions. It also requires Federal agencies to identify the need to ensure the protection of populations relying on subsistence consumption of fish and wildlife, through analysis of information on such consumption patterns and communication to the public of associated risk. Environmental justice analysis is included in this report in the environmental impacts section as well as the agency coordination section.

E.5 REVIEW OF THE DRAFT AND FINAL PIR/EIS

A Notice of Availability was published in the Federal Register on 27 April 2007 when this document was released for public and agency review. Comments received were addressed and are included in Annex B.

A Notice of Availability of the Final PIR/EIS will be published in the Federal Register, and the final report will be sent to numerous local, state and Federal agencies, private interest groups and interested public for review and comment in accordance with the Council on Environmental Quality's NEPA regulations and related USACE guidance. Comments received during the review will be considered in preparing the final study documents and by subsequent reviewers and decision-makers in the Washington-level Federal review process. The agencies, groups and individuals listed in Annex B will be sent copies of the Final PIR.

E.5.1 Comments Received and Responses

The Final PIR will be made available to the public and other agencies. After the 30-day review period, comments received from state, Federal and local agencies, Native American Tribes, non-governmental organizations and concerned individuals will be reviewed. The comment letters received will be on file in the USACE, Jacksonville District at the address shown on the cover page of this document.

APPENDIX F
PLAN FORMULATION

This page intentionally left blank

TABLE OF CONTENTS

F.0 PLAN FORMULATION F-1
F.1 PLAN FORMULATION AND ALTERNATIVE EVALUATION F-1
F.1.1 Background and Introduction F-1
F.1.2 Plan Formulation and Evaluation Process F-4
F.1.3 System -Wide Perspective F-4
F.1.4 Local Perspective F-5
F.1.5 Development of Alternative Plans F-5
F.1.6 Formulation of Alternative Plans F-5
F.1.7 Com ponents/Management Measures Considered by Alternative Development Sub-team F-6
F.1.7.1 Reservoir Storage Areas F-6
F.1.7.2 Restoration of Natural Storage Areas F-7
F.1.7.3 Stormwater Treatment Areas F-8
F.1.7.4 Aquifer Storage and Recovery F-9
F.1.7.5 Backpumping with Stormwater Treatment F-10
F.1.7.6 Oxbow Restoration F-11
F.1.7.7 Operation of Reservoirs F-11
F.1.7.8 Best Management Practices (BMPs) F-11
F.2 PROJECT SITING ANALYSIS F-12
F.2.1 Development and Application of Project Siting Criteria F-12
F.2.2 List of Potential Sites F-13
F.3 SCREENING F-30
F.3.1 Gate Criteria F-30
F.3.2 General Criteria F-30
F.3.3 Results of Application of Screening Criteria F-30
F.3.4 Level 1 Gate Criteria F-37
F.3.5 Level 2 General Screening Criteria F-43

LIST OF TABLES

Table F-1: List of Siting Information for Project locations F-15
Table F-2: Potential Sites Based on Storage Capacity F-31
Table F-3: Potential Sites Based on Restoration Potential F-32
Table F-4: Caloosahatchee River (C43) west Basin storage reservoir Site Screening Scores–Storage Summary F-33
Table F-5: Caloosahatchee River (C-43) West Basin Storage Reservoir Site Screening Scores – Restoration Summary F-34
Table F-6: Site Screening Matrix - Storage F-77
Table F-7: Site Screening Matrix – Restoration F-80
Table F-8: Siting Methodology Summary F-83

LIST OF FIGURES

Figure F-1: Locations of Potential Sites F-29
Figure F-2: Locations map of Caloosahatchee Bain showing locations of parcels that have passed Site Screening Criteria F-36

F.0 PLAN FORMULATION

F.1 PLAN FORMULATION AND ALTERNATIVE EVALUATION

F.1.1 Background and Introduction

Extreme changes in salinity in the Caloosahatchee Estuary due to either excessive or little to no freshwater discharges over the Franklin Lock & Dam (S-79) have resulted in an ecosystem in decline. Ecological and water quality problems will continue into the future unless restorative actions are taken. Large regulatory releases from Lake Okeechobee along with discharges of substantial amounts of excess stormwater runoff from the basin during the wet season have had negative impacts on the Caloosahatchee River & estuary. Since rainfall cannot be controlled, it is necessary to store the excess stormwater to prevent its rapid conveyance to the estuary. Historically in South Florida, storage was achieved through extensive wetland systems that once dominated the landscape, and provided for the attenuation and filtering of the stormwater runoff resulting from rainfall events.

The purpose of the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to improve water deliveries to the estuary, provide for dry season flows, restore downstream salinity levels to those supportive of key estuarine species, and ensure the availability of water for the natural system needs of the Caloosahatchee estuarine system. Improvements in the distribution of water should result in improvements to the timing, quality and quantity of water deliveries to the inland ecosystems. Additional water resource benefits could provide supplemental water resources for agriculture and urban users resulting in a reduction of demands placed on existing surface and ground water resources such as the Caloosahatchee Rive (C-43 Canal) and Lake Okeechobee.

The Restudy provided the initial scope of the project as determined during the creation of CERP. The screening and evaluation of plan components proposed in the Restudy made the determination that above ground water storage provided the most cost effective alternative for freshwater attenuation (CERP, Volume 1, Section 7.2). The CERP project scope included a description of the project as follows:

"This feature includes above-ground reservoir(s) with a total storage capacity of approximately 160,000 acre-feet located in the Caloosahatchee River (C-43) Basin in Hendry, Glades, or Lee Counties. The initial design of the reservoir(s) assumed 20,000 acres with water levels fluctuating up to 8 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design."

Reservoir storage became a starting point of the Caloosahatchee River (C-43) West Basin Storage Reservoir study. Improvements in the timing, distribution, and magnitude of water deliveries to the estuary should result from improvements in the distribution of surface storage. Further improvements from additional in-basin storage, other potential recommendations to supplement water uses in the study area, and provide dry season flows to the estuarine systems are anticipated benefits.

In 1997, significant amendments were made to the Florida Water Resources Act of 1972 (Chapter 373, Florida Statutes) regarding regional water supply planning. These changes required the SFWMD to prepare a District-wide Water Supply Assessment (DWSA) and to prepare water supply plans for regions that were anticipated to have the potential of demand outstripping available supply by the year 2020. The SFWMD in 1998 had undertaken a water supply planning initiative to ensure prudent management of South Florida's water resources. As a result of this initiative, the SFWMD released in 2000 the Caloosahatchee Water Management Plan (CWMP). The CWMP analysis determined that the projected surface water needs of the Caloosahatchee River and Estuary can be met during a 1-in-10 drought condition with the development of water management and storage infrastructure that effectively captures and stores surface water flows in the basin. The CWMP determined that improved management for surface water through storage could increase freshwater availability in the region and reduce potential impacts resulting from water use.

Both the Restudy and the CWMP therefore arrived at a similar conclusion: above ground water storage areas were the most cost affective and appropriate method for attenuation of freshwater runoff and capture of Lake Okeechobee inflows in the Caloosahatchee River (C-43) West Basin Storage Reservoir project area.

During completion of the CERP Master Program Management Plan (MPMP) in August of 2000, the project was divided into two parts, Part I: The Caloosahatchee River (C-43) Basin Storage Reservoir Project (C-43 BSRP), and Part II: The Caloosahatchee River (C-43) Basin ASR Project. The projects were separated to accommodate the inclusion of the findings of the Caloosahatchee ASR Pilot Project into the full ASR project without delaying the implementation of the reservoir aspect of the project. The Caloosahatchee River (C-43) Basin Storage Reservoir Project (Part I) was subsequently divided into two separate PIRs, with the first PIR being known as Caloosahatchee River (C-43) West Basin Storage Reservoir.

The Caloosahatchee River (C-43) West Basin Storage Reservoir PIR addresses formulation, evaluation, and justification of a separable reservoir project by

reaffirming that a reservoir in the West Caloosahatchee River (lower) basin will achieve the benefits of the Restudy for the Caloosahatchee River (C-43) Basin in a cost-effective manner, demonstrate that a reservoir has been optimized, and acknowledge that the project is part of a more comprehensive plan for the Caloosahatchee River (C-43) Basin. Since the Caloosahatchee River (C-43) West Basin Storage Reservoir project is located in the lower portion of the West Caloosahatchee River (C-43) Basin, the PIR is focused on estuary restoration and has limited capability to provide additional water to meet water supply demands in the East Caloosahatchee River (upper) basin. A subsequent second PIR will address the water supply needs and water quality issues of the East Caloosahatchee River (upper) basin and will also address any additional restoration needs and demands in the West Caloosahatchee River (lower) basin not met by the Caloosahatchee River (C-43) West Basin Storage Reservoir project.

Storage of water within the Caloosahatchee River (C-43) Basin had been established as one of the primary management measures contributing to the goals and purposes of the Restudy. Based on these findings, the SFWMD acquired approximately 12,372 acres using State and Federal funds appropriated to the Department of Interior under the authority of the 1996 Farm Bill (Federal Agriculture Improvement and Reform Act of 1996, Public Law 104-127, 110 Stat. 1022). As the PIR development process was initiated, there was an effort to identify early opportunities to obtain system-wide benefits by utilizing readily available lands. One of these opportunities was the Caloosahatchee River (C-43) West Basin Storage Reservoir evaluating a potential reservoir in the western Caloosahatchee River Basin on lands acquired by SFWMD with DOI Farm Bill and SFWMD funds.

Draft Programmatic Regulations Guidance Memoranda # 1 and #2 instruct project teams to affirm and optimize the component identified in the Restudy unless conditions or planning objectives have changed, or if the component no longer meets the purposes outlined in the Restudy, to formulate new alternatives. Additionally, for projects where the non-Federal sponsor has already acquired lands, formulation of alternative plans using other sites will be minimized if the intended project purposes can be achieved and no more cost-effective sites are identified during formulation. Additional management measures to address the new circumstances should be developed and screening should occur based on the project's evaluation criteria and performance measures. As stated in CERP Guidance Memorandum 2:

Reaffirmation: If the project as described in the Plan is reaffirmed, then the Project Delivery Team's efforts will focus on development of design alternatives and optimization of the project features, cost-effectiveness, satisfaction of programmatic regulations requirements for PIRs, Micro-Computer Aided Cost

Engineering System (MCACES) cost estimates, and the integrated National Environmental Policy Act (NEPA) documentation to supplement the information contained in the Programmatic Environmental Impact Statement for the Plan, in accordance with the concept of tiering under NEPA.

Reformulation: When the project described in the Plan no longer achieves the benefits of the project as described in the Plan, additional formulation will be required prior to initiating detailed design of the selected alternative plan. However, the formulation completed and described in the Plan will provide the foundation for the Project Delivery Team to formulate additional alternatives. The new or changed circumstances requiring additional formulation should be documented.

The plan formulation for this project focuses on reaffirming that above-ground storage reservoirs in the Caloosahatchee River (C-43) Basin continue to meet the goals, objectives, and purposes for the project as described in the Restudy. Accordingly, in reviewing the findings of the Restudy, the team has determined that based on the current conditions, the project as described in the Restudy still achieves the benefits of the project in a cost-effective manner. As a result, the team has determined that the plan formulation process entails optimization of the project described in the Restudy.

F.1.2 Plan Formulation and Evaluation Process

The Caloosahatchee River (C-43) West Basin Storage Reservoir project has developed evaluation criteria and performance measures consistent with planning objectives that were used during the formulation process. More specifically, performance measures were utilized during for plan formulation, and a full suite of evaluation criteria were utilized for comparison of alternative plans and selection of the recommended plan. Benefit and impact analyses conducted for this study will be accomplished at both the local and system-wide scale consistent with the CERP draft guidance memorandum on Plan Formulation and Evaluations Procedures.

F.1.3 System-Wide Perspective

The Caloosahatchee River (C-43) West Basin Storage Reservoir project is related to the balance of CERP through the Caloosahatchee River (C-43 Canal), which connects the Caloosahatchee Estuary to Lake Okeechobee and its watershed. From a system-wide perspective, freshwater releases made through the Caloosahatchee River (C-43 Canal) to the Caloosahatchee estuary are based on management of Lake Okeechobee for the benefit of the entire Central and Southern Florida Project system, which includes providing flood protection and water supply for natural, urban and agricultural areas. These management decisions have not traditionally been made on the basis of maintaining a healthy

ecosystem within the Caloosahatchee estuary system as their primary objective. However, they have resulted in significant adverse effects, such as oyster die-off and seagrass bed deterioration, in the receiving water bodies when discharges are made for extended periods of time at high rates of flow. The Restudy analysis recognized this effect and sought means to reduce the high flow events from Lake Okeechobee through the Caloosahatchee River (C-43 Canal). CERP includes various storage projects around the lake to reduce the need to make such damaging discharges into the Caloosahatchee River (C-43 Canal). The combination of storage options reduces the volume stored in Lake Okeechobee that contributes to higher lake levels, therefore reducing the potential future discharge to the estuary.

F.1.4 Local Perspective

The primary C&SF canal (C-43) along with the secondary and agricultural canal systems which drain into the primary canal (C-43) provide the conveyance for freshwater and nutrients to the receiving water bodies in the Caloosahatchee estuary as well as promote drainage of historic watershed wetlands. Therefore, solutions that address these specific problems will be formulated and evaluated within the Caloosahatchee River (C-43) Basin.

F.1.5 Development of Alternative Plans

The following sections describe the methodology used to develop the Caloosahatchee River (C-43) West Basin Storage Reservoir project alternative plans; locate appropriate sites for the various components; and describe the details of each alternative developed.

The CERP identified a conceptual project that served as a starting point of 160,000 acre-feet of above ground storage for environmental restoration for the Caloosahatchee River and estuary. This storage amount was established through various previously completed modeling techniques. Under the CERP analysis of the sub-region, an acceptable salinity range for the estuarine ecosystem was established that translated to mean monthly freshwater inflows of 300 cfs to 2800 cfs at S-79. This included the need for low flow augmentation and minimizing high flow discharge events to improve estuarine water quality and to protect and restore estuarine habitat and biota. This flow target at S-79 helped produce modeling results indicating the most efficient size for determining the storage capacity of reservoirs to capture local basin and Lake Okeechobee inflows.

F.1.6 Formulation of Alternative Plans

Alternative plans were formulated to identify specific ways to achieve planning objectives within constraints, so as to solve the problems and realize the

opportunities that were identified in the first steps of the planning process. An alternative plan consists of a system of structural and /or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified study planning objectives subject to the planning constraints. A management measure is a feature or an activity that can be implemented at a specific geographic site to address one or more planning objectives. Management measures are the building blocks of alternative plans and are categorized as structural and nonstructural. An alternative plan is a set of one or more management measures functioning together to address one or more objectives.

F.1.7 Components/Management Measures Considered by Alternative Development Sub-team

As described in the above section, the plan formulation process begins with a group of ideas that are developed and refined by the team to address specific planning goals and objectives of the project. These ideas become the building blocks of the components that will eventually be combined to form the different alternative plans. The following section provides a description of each component type considered by the team for use in further plan formulation activities, how it could meet planning objectives, and reasons for its retention or exclusion from the plan formulation process. The components described are reservoirs, stormwater treatment areas, natural storage and water quality treatment areas, oxbow restoration, operations of reservoirs, and Best Management Practices (BMPs).

F.1.7.1 Reservoir Storage Areas

The CERP Restudy project scope included a description of the Caloosahatchee River (C-43) West Basin Storage Reservoir project as follows: "This feature includes above-ground reservoir(s) with a total storage capacity of approximately 160,000 acre-feet located in the Caloosahatchee River (C-43) Basin in Hendry, Glades, or Lee Counties." As previously stated, reservoir storage became the starting point of the Caloosahatchee River (C-43) West Basin Storage Reservoir study. Draft Programmatic Regulations Guidance Memoranda # 1 and #2 instruct PDT's to optimize the component identified in the Comprehensive Plan, unless conditions have changed, planning objectives have changed, or the component no longer meets the purposes outlined in the Restudy. The PDT's focus was therefore to formulate using surface storage reservoirs to the extent practicable to meet planning objectives, but to consider other management measures as needed if reservoirs did not meet the full suite of planning objectives in a cost effective manner.

Above ground reservoirs were considered and evaluated as a means for capturing, confining and storing excess stormwater runoff generated by the drainage basin. These reservoirs will essentially be large water storage areas

surrounded by perimeter levees constructed from excavating soil from the interior of the reservoir adjacent to the levee locations. Deeper reservoirs will require extended side slopes to provide structural stability and seepage control. Excess soil excavated as a result of the increase in depth will be compacted into thin layers to form the levees and extended side slopes. The maximum sustained depth of water in the reservoir is usually less than 15 feet above the existing ground surface, with the maximum levee height (top of levee) being above that of the operating pool of stored water. This is to protect the levee against wind or rain driven overtopping.

Water will be pumped from adjacent canals into the reservoirs when the flow rates in the canals begin to contribute excess deliveries of water to the Caloosahatchee River. To improve water quality, water stored in the reservoirs may be conveyed through a stormwater treatment cell before it is released to the Caloosahatchee River. Water may also be released back to the adjacent source canals when required for maintenance purposes or when it is advantageous to supplement water supply. Water surface levels within the reservoirs will vary over a large range. In general, it is expected that water levels will gradually increase during the rainy season, approaching maximum levels near the beginning of the dry season. As the dry season's end approaches, water levels in the reservoir may drop to near the existing ground surface (as a result of evapotranspiration and water withdrawals).

The reservoir will not be specifically designed to provide in situ habitat or be considered a habitat due to the expected seasonal fluctuations in water levels. However it is probable that fish colonization will occur in the reservoirs. To allow for the survival of fish populations during times when water levels are low, it may prove practical to excavate deeper regions within reservoirs that can act as fish refugia. Any habitat function derived from the reservoirs is incidental. Reservoirs will be sited on already cultivated agricultural lands.

F.1.7.2 Restoration of Natural Storage Areas

Reservoir storage was identified in the Restudy as the key component for the restoration of the Caloosahatchee River and estuary. The Restudy did not explore the use of natural areas as an alternative to reservoir storage. However, some natural areas were considered by the PDT as management measures that could contribute to the goal of reducing the amount of stormwater reaching the canal systems, river, and estuary through the natural retention of stormwater runoff.

The Alternative Development Sub-team looked at lands where the retention of stormwater was both practical and possible. These lands were then identified and considered as possible sites for restoration because of their ability in providing additional water storage within the Caloosahatchee River (C-43)

Basin. Those sites that did not contribute to addressing problems in the Caloosahatchee estuary (i.e., stand alone or hydrologically separate sites) but were ideal candidates for restoration, were to be considered through the planning process for the Southwest Florida Feasibility Study (SWFFS). Information on other restoration sites within the Caloosahatchee River (C-43) Basin will be transferred to the SWFFS project delivery team for evaluation and potential implementation. Specifically, Lake Hicpochee, Telegraph Swamp, Lake Flirt and Graham Marsh were all evaluated. From this original list, it was determined that Graham Marsh fell outside of the West Basin Storage Reservoir study boundary, so that site was dropped. Telegraph Swamp was also dropped from consideration, due to threatened and endangered species issues, which could be adversely effected by potential restoration efforts. Lake Hicpochee and Lake Flirt are still being considered as alternative sites for natural area restoration in this study.

Finally, incorporation of the use of natural areas as a storage option introduces an opportunity to re-hydrate and restore historic wetland and lacustrine areas and upland areas that have been altered due to urban and agricultural encroachments. This would address the "enhance ecological values" objective of the potential alternative plan by, in addition to improving habitat quality in the estuary through storage of basin runoff, also increasing the spatial extent of watershed wetlands and lake habitats through restoration.

F.1.7.3 Stormwater Treatment Areas

Stormwater Treatment Area or STAs are designed and built to capture and treat stormwater runoff from the drainage basin, then release it back to the receiving water body. Their primary function is to reduce nutrient loadings and remove suspended sediments dissolved in the water column. STAs are usually shallow water bodies created by constructing small levees six to seven feet in height above the surrounding ground surface. The depth of water flowing through the STAs will usually range from one to three feet in depth. The general design of STAs is to divide it into a number of cells in which the water depth and rate of flow can be controlled. Water enters the STA through a distribution canal in a controlled manner to induce shallow and slow flow over a surface that is covered with dense vegetation. The vegetated cells are designed to uptake nutrients and remove suspended sediments from the water column. Discharge from an STA will usually be directed toward the primary receiving water body such as the Caloosahatchee River.

More than 75% of the nitrogen and phosphorus load sent to the Caloosahatchee Estuary comes from sources upstream of S-79. Within the estuary, the impact of the S-79 pollutant load is evident from tidal river water body segments downstream of S-79 that are impaired for chlorophyll-a and/or biological integrity. FDEP examined the potential nutrient impairment problems in the

estuary. Their study used regression equations to describe the relationships between chlorophyll-a concentration and nitrogen loading, and between chlorophyll-a concentration and phosphorus loading. Their findings indicated that due to the naturally occurring high levels of phosphorus in the watershed, nitrogen, rather than phosphorus, was the limiting nutrient, and high nitrogen loads were responsible for the elevated chlorophyll-a concentrations in the Caloosahatchee estuary. Vegetated STAs are designed to remove at least 80% of the incoming phosphorus load in water captured by the reservoirs. STAs recently constructed in South Florida have been designed to optimize phosphorus removal, but are not as effective at the removal of nitrogen. The long-term efficacy of total nitrogen removal in South Florida STAs awaits further empirical evaluation. Because STA's are more effective at removing phosphorus than nitrogen and because the excess nutrient problem in the Caloosahatchee estuary is related to nitrogen, the need for STA's as part of the project was questioned by the PDT. The PDT decided to consider STA's not as stand-alone management measures, but as potential treatment cells within storage reservoirs. Furthermore, the design and operation of reservoirs themselves would be examined as a promising means of reducing nitrogen loads to the estuary.

F.1.7.4 Aquifer Storage and Recovery

The CERP Restudy project scope included a description of the 44 Aquifer Storage and Recovery (ASRs) wells within the Caloosahatchee Basin, each having an injection or withdrawal capacity of five million gallons per day with chlorination for pre-treatment and aeration for post-treatment. The ASR wells will be located at the reservoirs locations and are to be either adjacent to or connected to the surface reservoir. When the reservoirs are filled to capacity, water is to be pumped into the ASR well for storage (at a specific capacity). When water levels are low in the reservoir, water is then pumped from the ASR well back into the reservoir. It was assumed for the Restudy that the recovery efficiency would be 70% of water injected.

The ASR wells are proposed in order to maximize the benefits associated with the Caloosahatchee Basin storage reservoirs. For example, due to high ET rates in the study area, it would be difficult to store enough water in surface reservoirs to provide minimum dry season flows to the estuary over more than one dry season. Since water storage in the aquifer is protected from the high ET rates, ASR's are an attractive management measure for storing water to meet minimum downstream flows over multiple years and during drought events. However, a pilot project for ASR wells is necessary to identify the most suitable sites of the ASR wells in the vicinity of the reservoirs and to determine the optimum configuration of those wells. The pilot project will provide information regarding the characteristics of the aquifer system within the Caloosahatchee River Basin as well as determine the hydrogeological and geotechnical

characteristics of the upper Floridan Aquifer. The pilot project will also determine the specific water quality characteristics of water to be injected, the specific water quality characteristics and the amount of water recovered from the aquifer, and the water quality characteristics of water within the receiving aquifer. The level and extent of treatment and the number of ASRs wells needed may be modified based upon the finding s from the ASR pilot project.

While the Caloosahatchee River Basin ASR pilot project is under way, the findings are not yet available for use. Recognizing that more information regarding the feasibility and performance of ASR's was necessary from the pilot projects before ASR's could be designed and implemented in the Caloosahatchee Basin, in 2000 the Master Program Management Plan (MPMP) for CERP separated the Caloosahatchee River (C-43) Basin Storage Reservoir and Aquifer Storage and Recovery Projects as described in the Restudy into Part 1 (Caloosahatchee River (C-43) Basin Storage Reservoir Project) and Part 2 (Caloosahatchee River (C-43) Basin ASR Project). The projects were separated to accommodate the inclusion of the findings of the Caloosahatchee ASR Pilot Project without delaying the implementation of the reservoir. Therefore this PIR focuses only on the storage reservoir portion, while a subsequent PIR focusing on implementation of the ASR project will be undertaken between 2015-2020, according to the current Master Implementation Sequencing Plan (MISP).

F.1.7.5 Backpumping with Stormwater Treatment

Backpumping with Stormwater Treatment was identified in the CERP Restudy project scope as a feature to capture excess Caloosahatchee River (C-43) Basin runoff, which would then be used to augment the regional system water supply.

This feature includes pump stations and a stormwater treatment area with a total capacity of approximately 20,000 acre-feet located in the Caloosahatchee River (C-43) Basin in Glades and Hendry Counties. The initial design of the stormwater treatment area assumed 5000 acres with the water level fluctuating up to 4 feet above grade. The final size, depth and configuration of this facility will be determined through more detailed planning and design. This feature operates after the estuary and agricultural/urban demands have been met in the basin and when water levels in the storage reservoir exceed 6.5 feet above grade. Lake Okeechobee must also be considered to have available storage. When these conditions are met, a series of pump stations will backpump excess water from the reservoir and the Caloosahatchee River (C-43) Basin to Lake Okeechobee after treatment through a stormwater treatment area.

While this feature was included in the Restudy, subsequent analyses from the 2000 Caloosahatchee Water Management Plan (SFWMD 2000) determined that the Caloosahatchee River (C-43) Basin, even with the Restudy's 160,000 acre-feet of additional storage, has insufficient water supply to meet all future

environmental, agricultural, and urban demands. Backpumping water from the Caloosahatchee River (C-43) Basin to Lake Okeechobee therefore does not make sense. The study area has a water shortage, not a water surplus to be exported to other basins.

F.1.7.6 Oxbow Restoration

As a result of natural changes to the course of the Caloosahatchee River over the years, a number of oxbows have formed along the banks of the Caloosahatchee River. An oxbow is a crescent shape lake that forms when the course of the river changes at a bend in the river and over a period of time, sedimentation builds up and closes the bend off from the river. There are approximately 35 of these oxbows located along the Caloosahatchee River from the S-79 structure to the City of LaBelle. Some of these oxbows have connections to the river with some water flowing through them. Water quality is poor in all of the oxbows; all have dissolved oxygen problems due to decaying vegetation and sediment buildup. Oxbows offer little storage value, but could provide habitat within the river. Currently, restoration of the Caloosahatchee River Oxbows is being addressed under the Army Corps of Engineers' Section 206 Continuing Authorities program for small ecosystem restoration projects.

F.1.7.7 Operation of Reservoirs

Nutrient loading and suspended sedimentation have been identified as secondary issues affecting the health of the Caloosahatchee River and Estuary. The Caloosahatchee River (C-43) West Basin Storage Reservoir project alternatives will focus on the capture and release of basin runoff through the use of reservoirs that will alter the timing and quantity of nutrients delivered to the estuary through S-79 Structure. This will have an effect on other water quality parameters such as dissolved oxygen and Chlorophyll-a. A nutrient loading analysis of reservoir operations conducted by FDEP determined that with an available storage of 228,000 acre-feet of storage, the project would capture approximately 500 tons/year of TN. Depending upon the design and operation of the reservoir system, settling and some biological uptake will remove between 20% and 30% of the TN load captured by the reservoirs. With ASR, the total load of nitrogen removed from the system would increase by 50% to approximately 150 to 200 tons/year. This is approximately 6% to 9% of the present annual nitrogen load (roughly 3,000 tons per year) to the estuary.

F.1.7.8 Best Management Practices (BMPs)

The Florida Watershed Restoration Act provided for FDACS to develop water quality BMPs for agricultural non-point sources. The FDACS BMP program adopts BMPs developed by growers through workshops as the most effective and practicable on-location means to improve water quality from agricultural

discharges. The focus of the BMP effort is to reduce the nutrient and pollutant content of runoff from all major agricultural commodity groups (i.e., citrus, sugarcane, cattle, and row crops). The status and likely effects of agricultural BMP implementation will be taken into account in the assessment of water quality conditions. Participation is self-implementing in that a grower chooses to participate. Benefits of participation include a mechanism for "presumption of compliance" with state water quality standards and a waiver of liability.

All agricultural sectors within the Caloosahatchee Basin have joined to develop a Caloosahatchee BMP Manual for adoption by FDACS for their BMP Program in 2005. The program also includes cost-share funds for growers to implement BMPs as part of the Florida Forever Act Amendments. FDEP acts as a partner in the monitoring of the FDACS BMP program as part of the TMDL Program. A watershed is considered successful once 80 percent of the agricultural acres in the watershed are enrolled in the FDACS BMP program. For the purpose of this study, the study team will develop conservative estimates for future BMPs based on input from USDA and other local governments responsible for monitoring the program.

SFWMD will expand its Urban BMP Program into the urban areas within the next year. The concept behind the BMP program is to identify and establish effective measures to prevent polluted stormwater from entering the receiving water bodies. The program includes education for homeowners and landscape professionals.

Many of the local governments in the Caloosahatchee Basin, including Lee County have implemented and funded stormwater management programs. Cities such as Ft. Myers have similar programs. These cities and counties have similar goals that strive to ultimately improve urban drainage problems, while at the same time providing a means to clean surface water runoff from entering in the Caloosahatchee River/estuary.

The BMP programs described above are considered as part of the future without project conditions for the Caloosahatchee River (C-43) West Basin Storage Reservoir project and will not be considered as management measures in the formulation of Caloosahatchee River (C-43) West Basin Storage Reservoir project's alternative plans.

F.2 PROJECT SITING ANALYSIS

F.2.1 Development and Application of Project Siting Criteria

When the Alternative Development Group started the process of evaluating potential site locations in the Caloosahatchee River (C-43) Basin, all suggestions were recognized and included in the site screening analysis. The first step of the

process was to determine potential site locations for project components. Potential sites locations had been identified earlier during the development of the CERP Restudy and in the Caloosahatchee Water Management Plan, which became the starting point for the Alternative Development Group. Additional potential sites locations were also identified early on in PDT meetings, with input from the public and stakeholders providing additional information on potential site locations.

In sorting through the long list of potential site locations, the Alternative Development Group quickly realized the need to develop a process that could rate parcels of land against a variety of criteria and screen for suitability for use in this project. In October 2002, an Alternative Development/Site Screening Sub-Team began development of a screening criteria and application process for use in conducting a preliminary site screening of these potential sites for the project. The purpose of the Site Screening process is to screen a site for its potential use in the development of alternative plan management measures to meet the goals of the project. If the list of potential sites included locations that are inappropriate for use as management measures, the screening process is an early and efficient method to identify and eliminate these inappropriate sites. Some of the factors that went into developing the criteria were:

- Land use and land cover
- Proximity to primary canal or existing canal conveyance networks
- Soils suitability and recharge potential
- Potential contributions to the watershed
- Potential storage capacity
- Potential restoration value
- Hydrologic network distance from the estuary
- Land elevations

Once screened, the more suitable land parcels will be further evaluated for those land parcels which best fits into the overall plan for the project. This will save time and resources by avoiding detailed planning and early engineering activities on sites that are incompatible with the project purpose. The following sections contain a description of the project siting process evaluation criteria, and conclusions derived during the project component siting effort.

F.2.2 List of Potential Sites

Information on potential sites locations were compiled and organized for the project. This information included the names of the land parcel(s), description (including current land use and conditions of the site that were compatible with the project), land parcel(s) size, county, sub-basin, and the rationale for choosing the site. From this information, a site/basin map was then developed that clearly identifies each site. (***Table F-1***and ***Figure F-1***).

The original list of potential site locations for this project included several natural areas that could potentially be restored as well as provide additional water storage within the Caloosahatchee River (C-43) drainage basin. The intent was to identify natural areas that specifically contributed to or had an effect on the health of the estuary through hydrologic connections.

The identified land parcel(s) were evaluated for their potential suitability for use in the development of alternative plan management measures. Potential sites were scored for two sets of objectives:

1. Meeting the storage requirements of the project
2. Potential incorporation into a restoration plan.

The siting criteria were divided into two categories:

1. Gate Criteria
2. General Criteria

The Gate Criteria are the first look at the suitability of a potential land parcel for the project. Once a potential land parcel(s) is screened and has passed the Gate Criteria, a second screening application is applied to the site. The General Criteria are applied to the more suitable land parcel(s) for further evaluation to determine those land parcels which best fits into the overall plan for the project. A more detail explanation of the Gate and General Criteria is provided in the subsequent paragraphs below. All of the Screening Criteria included a name and number assignment, a screening level and category designation. The criterion sheets included a criteria description, Storage and Restoration Scoring Rationale, Methodology (identifying the tools to be used to score the sites), and any applicable comments that included the author's name and date the criteria was accepted by the sub-team (Appendix F).

TABLE F-1: LIST OF SITING INFORMATION FOR PROJECT LOCATIONS

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P1	Berry Grove	The Berry Groves parcel has been used as a citrus grove since the early 1960' s. Its' location in the basin is at a point along the Caloosahatchee River (Caloosahatchee Riv er (C-43 Canal)) that approx. 83% of basin runoff could be captured. In addition, its' proximity to the rive r as well as its' current in frastructure (Townsend Canal connection to C-43, Header Canal for internal distribution, Roberts Canal for inflows from southeast), were strong indicators in the determination to ac quire th e property. Other considerations included th e size as well as the number of owners.	8640 acres	Hendry	WCB	Site was analyzed during the Restudy and the CWMP and subsequently acquired for use in the Caloosahatchee River (C-43) W est Basin Storage Reservoir Project.

2637

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P1+A	Berry Gro ve + Griffin	The Berry Groves is generally described in P1 above. The additional parcel, Griffin, has been used as a citrus grove as well since the early 1960' s. In c onjunction with Berry Groves its' location, proximity to water source and current infrastructure is conducive to storage. The addition of the Griffin parcel would not significantly increas e th e tim e and resources required for the analysis and potentially the design and construction of a reservoir on this combined site. Other considerations in cluded the s ize as well as the number of owners.	9594 acres	Hendry	WCB	Site was analyzed during the Restudy and the CWMP and has recently been acquired for use in the Caloosahatch ee River (C-43) W est Basin Storage Reservoir Project. Site adds 954 acres.

2638

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P1+A+B	Berry Gro ve + Griffin + Metlife	The Berry Groves and Griffin parcels are generally described in P1 and P1+A above. The additional parcel, Metlife, has been used as a citrus grove as well sinee the early 1960' s. In c onjunction with Berry Groves and Griffin, its' location, proximity to water source and current infrastructure is conducive to storage. T he addition of the Metlife parcel would improve the regularity of the site (minimize the num ber of parcel corners and obtuse an gle sizes) while not s ignificantly increas ing the time and resources required for the ana lysis and pote ntially th e design and construction of a reservoir o n this com bined site. Other considerations included the size as we ll as the num ber of owners.	11,954 acres	Hendry	WCB	Site was analyzed during the Restudy and the CWMP and has recently been acquired for use in the Caloosahatchee River (C-43) Basin Storage R eservoir Project. Site adds 2360 acres.
A	Griffin	Griffin, has been used as a citrus grove as well since the early 1960's. Its' location, proxim ity to water so urce and curren t infrastructure is conducive to storage.	954 acres	Hendry	WCB	

2639

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
B	Metlife	Metlife, has been used as a citrus grove as well since the early 1960's. Its' location, proximity to water source and current infrastructure is conducive to storage.	2360 acres	Hendry	WCB	
P2	Lake Hicpochee	Lake Hicpochee was historically a lake and wetland system that had no sustained connection to Lake Okeechobee. Lake Hicpochee was bisected when the Caloosahatchee River was channelized and has been over drained and greatly impacted by invasive plant species since then. The Florida Fish and Wildlife Conservation Commission has developed restoration plans for Lake Hicpochee in the past, but due to funding they have not been implemented. Although, the two halves of Lake Hicpochee could never be re-connected due to navigational requirements for the C-43, the lake could be surrounded by low leves and the water level could be restored.	4600 acres	Glades	ECB	Site was suggested by Graham Story and supported by multiple environmental agencies for low-level storage and restoration. The State of Florida (TIITF) owns the majority of the historical footprint of Lake Hicpochee.

2640

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P2+C	Lake Hicpochee + River Groves	See Lake Hicpochee in P2 above. River Grov es is curren tly p lanted in citrus an d has a co nnection at the northe astern corn er to Lake Hicpochee. It is s ituated in Glade s County, and is adjacent to the C-43.	7,160 acres	Glades	ECB	Current landowners presented the site as an option for deeper storage to be used in the restoration of Lake Hicpochee and the Caloosahatchee. Site adds 2560 acres.
P2+D	Lakc Hicpochee + Duda Farms	See Lake Hicpochee in P2 above. Duda is curren tly planted in sugarcane and has a connection at the on the east sid e to the C-19 Canal which connects to Lake Hicpochee, which flows into the C-43. It is situated in Glades County. Duda = 2880 acres, Peeples = 2080 acres and Bronson = 960 acres	10,520 acres	Glades	ECB	Current landowners presented the site as an option for deeper storage to be used in the restoration of Lake Hicpochee and the Caloosahatchee. Sites add 5920 acres.
P2+C+D	Lake Hicpoehee + River Gro ves + Duda Farms	See P2, P2+C and P2+D above.	17,680 acres	Glades	ECB	See the comments from P2, P2+C and P2+D above.
C	River Groves	River Groves is curren tly p lanted in citrus an d has a co nnection at the northe astern corn er to Lake Hicpochee. It is s ituated in Glade s County, and is adjacent to the C-43.	2,560 acres	Glades	ECB	

2641

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
D	Duda Farms	Duda is currently planted in sugarcane and has a connection at the on the east side to the C-19 Canal which connects to Lake Hicpochee, which flows into the C-43. It is situated in Glades County. Duda = 2880 acres	2,880 acres	Glades	ECB	
P2E		The site is located to the east of Lake Hicpochee between Duda and River Groves. See P2, P2+C and P2+D above.	2,830 acres	Glades	ECB	See the comments from P2, P2+C and P2+D above.
P3	Central Distributed Reservoir (Baron WCD Canal No. 1)	Two different approaches for the distributed reservoir concept have been presented to the Caloosahatchee River (C-43) Basin Storage Reservoir Team, 1, utilizes an existing canal, which is controlled at the downstream end, widened and used as storage, 2, utilizes an existing agricultural retention/irrigation storage area to reduce agricultural reliance on the C-43. This site falls under the first category. It is located near the river along a major Drainage/Irrigation Canal that has the potential for modifications to would provide storage.	1,650 acres	Glades	WCB	This approach was suggested by Bruce Boler of EPA and the area was identified by looking at the existing drainage/irrigation infrastructure for potential application.

2642

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P3E	Eastern Distributed Reservoir (Flagpole Canal)	Two differe nt approaches for the distributed reservoir concept have been presented to the Caloosahatchee River (C-43) Basin Storage Reservoir Team, 1, utilizes an existin g canal, which is controlled at the downstream end, widened and used as storage, 2, utilizes an existing agricu ltural retention/irrigation s torage area to reduce ag ricultural re liance on the C-43. This site falls under the firs t category, as well, and is located in the cas tern basin alon g a m ajor Drainage/Irrigation Canal that has the potential for m odifications to would provide storage.	5,120 acres	Hendry	ECB	This approach was suggested by Bruce Boler of EPA and the area was identified by looking at the existing drainage/irrigation infrastructure f or potential application.

2643

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
PWC-4	Western Dispersed Reservoir Four Corners	Two distinct approaches for the dispersed reservoir concept have been presented in the Caloosahatchee River (C-43) Basin Storage Reservoir Feasibility Study. 1. utilizes an existing canal which is controlled at the downstream end, widened and used as storage. 2. utilizes an existing agricultural retention/detention storage area to reduce agricultural acreage on the C-43. This site falls under the first category as well and is located in the western basin along the Prairie Drainage/Irrigation Canal that has the potential for on site retention as it would provide storage. In addition, the Four Corners intersection of Charlotte, Glades, Hendry, and Lee Counties had been identified as an area in need of an upland water management system to	23,040 acres	Glades	WCB	This suggestion came from the problems and opportunities development of this project as well as the Southwest Florida Feasibility Study.

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
F5	Campaign Security Road Site	This site was identified by Jacobs as a potential for providing flow attenuation for the Cumberland Reservoir. It is located on the Chattahoochee River, just downstream of the Cobb County Water Treatment Plant.	2,000	Cobb	Upper Chattahoochee	This site was not carried forward because it is a duplicate of site F6.
F6	Lower Powers Ferry Road Site	This site was identified by Jacobs as a potential for providing flow attenuation for the Cumberland Reservoir. It is located on the Chattahoochee River, just downstream of the Cobb County Water Treatment Plant.	2,000	Cobb	Upper Chattahoochee	This site was not carried forward because it is a duplicate of site F5.
F7	Lower Roswell Road Site	This site was identified by Jacobs as a potential for providing flow attenuation for the Cumberland Reservoir. It is located on the Chattahoochee River, just downstream of the Cobb County Water Treatment Plant.	2,000	Cobb	Upper Chattahoochee	This site was not carried forward because it is a duplicate of site F5.
F8	Lower Roswell Road Site	This site was identified by Jacobs as a potential for providing flow attenuation for the Cumberland Reservoir. It is located on the Chattahoochee River, just downstream of the Cobb County Water Treatment Plant.	2,000	Cobb	Upper Chattahoochee	This site was not carried forward because it is a duplicate of site F5.
F9	Lower Roswell Road Site	This site was identified by Jacobs as a potential for providing flow attenuation for the Cumberland Reservoir. It is located on the Chattahoochee River, just downstream of the Cobb County Water Treatment Plant.	2,000	Cobb	Upper Chattahoochee	This site was not carried forward because it is a duplicate of site F5.
F10	Lower Roswell Road Site	This site was identified by Jacobs as a potential for providing flow attenuation for the Cumberland Reservoir. It is located on the Chattahoochee River, just downstream of the Cobb County Water Treatment Plant.	2,000	Cobb	Upper Chattahoochee	This site was not carried forward because it is a duplicate of site F5.

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P7	Graham Marsh	Graham Marsh is located just south of the northeastern basin boundary. Graham Marsh is an undisturbed significant wetland. Currently used as an paved pasture/prime area. May fall outside of the Caloosahatchee River (C-43) Watershed as specified from Graham Marsh provides water to system. Is also a 4 cells. Has minimal infrastructure and great distance for use in the Caloosahatchee River (C-43)	24,320 acres	Hendry	N/A	Location contributed by Hugh English as having potential for control storage to managed by current use. Assessed by Bob Hercamp as well.
P8	Alico Devil's Garden	Description: Located south of the Alico Devil's Garden is for used outside the Caloosahatchee River (C-43) Watershed along CR833 in eastern Hendry. Currently used as improved pasture/current area.	6,000 acres	Hendry	N/A	Location contributed by Hugh English
P9	Montura Ranch Estates Reservoir	Currently used as reservoir retention for the Montura Ranch Estates development in eastern Hendry County. Basin improves subareas that lie east of the hills outside the Caloosahatchee River (C-43) Watershed.	2,560 acres	Hendry	N/A	Location contributed by "Buck" Abergonis, Hendry County Engineer

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P104	SR29 Infrastructure Changes	Infrastructure changes along SR29 as part of alleviating flooding south of Labelle, while enabling the diversion of flows to a reservoir site.	n/a	Hendry	WCD	Location contributed by "Rock" Aboagnale, Hendry County Engineer
P105	Felda Infrastructure Changes	Infrastructure changes in north of Felda as part of alleviating flooding in Felda, while enabling the diversion of flows to a reservoir site.	n/a	Hendry	WCD	Location contributed by "Rock" Aboagnale, Hendry County Engineer
P106	Railroad Grade Infrastructure Changes	Infrastructure changes: Canal 1 at Labelle to be used in alleviating flooding south and east of Labelle, while enabling the diversion of flows to the Caloosahatchee River (C-43) for capture in a reservoir.	n/a	Hendry	WCD	Location contributed by "Rock" Aboagnale, Hendry County Engineer
P107	Hendry or Dog Canal Infrastructure Changes	Infrastructure changes along the Townsend Dog Canal in Hendry County to be used in alleviating flooding in Lehigh Acres, while enabling the diversion of flows to a reservoir site.	n/a	Lee	WCD	Location contributed by "Rock" Aboagnale, Hendry County Engineer, Lee County Water Control District, Craig Benscoter, local stakeholder
P108	S-79 / G-Lock	Construction of a new lock at the western end of the Franklin Lake Flow-through. The water by-passed in the Caloosahatchee River (C-43) could be cleaned as it makes its way from S-78 to S-79. [7]	2,500 acres	Glades	WCD	Location developed during the CWMP, and suggested by Graham Stacy

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P11	Osteen Lykes Brothers	This parcel is located directly north of Osteen. The site currently includes planted pine and unimproved pasture as well as a natural system with flows to the C-32. In addition, site contains an existing sand track pit.	11,200 acres	Glades	WCD 55-01	Location is identified as the Collins or Lykes Brothers tract on sort at a Project Delivery Team Meeting as a site for consideration as a public private partnership.
P12	Nocatee Slough	Nocatee Slough is located south of Fisheating Creek and the Herbert Hoover Dike and adjacent to the SFWMD owned Nocatee or Slough Recreation Area. The site contains the remnants of the slough and is used for improved pasture.	14,200 acres	Glades	FCD	Location is identified as the Collins or Lykes Brothers tract on sort at a Project Delivery Team Meeting as a site for consideration as a public private partnership.

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P13	South-Central	This site is located south of the C-43, east of LaBelle, and is bounded by two major drainage canals on the east and west. The site may be divided into two sections due to the number of landowners located on the northern half. The existing land use includes citrus and improved pasture.	9,700 acres	Hendry	WCB/ECB	During the completion of the site screening criteria, the Project Delivery Team initiated a basin wide review for any potential additions to the list of sites already under consideration. This site was identified as having potential for storage due to its' size, location in the basin as regards runoff, no known significant existing wetlands, current land use, proximity to source and threatened and endangered species sightings. P13A (north) = 9600 acres, P13B (south) = 15360 acres, P13B1 (south and east of Canal No. 2) = 9700 acres
F	Paul	This site is located immediately east of P1 (Berry Groves) and could contribute to the placement of a significant portion of the required storage in one contiguous reservoir. The existing use includes citrus and although there are several owners, they are all from the same family. Review the discussions in P1, P1+A, P1+B, and P1+A+B above.	5,120 acres	Hendry	WCB	Recently suggested by staff at SFWMD as having potential.

2649

Site Id. Number	Site Name	General Description	Size	County	Sub-Basin	Rational
P14	Berry Grov es + Griffin + Metlif e + Paul	This site is com posed of site P1 (Berry Gro ves), A (Griffin), B (Metlife) an d site F (P aul). The existing use includes citrus.	17,074 acres	Hendry	WCB	Recently suggested by staff at SFWMD as having potential.
P15	Telegraph Swamp East	This site is located to the eas t of Telegraph Swa mp. The existing use includes agricultural.	3,475 acres	Lee	WCB	Site exis ts to the eas t of P5 (which did not pass GO).

Shaded sites were screened from further consideration.

Sub Basins: ECB = East Caloosahatchee Basin
WCB = West Caloosahatchee Basin
TSB = Telegraph Swamp Basin

2650

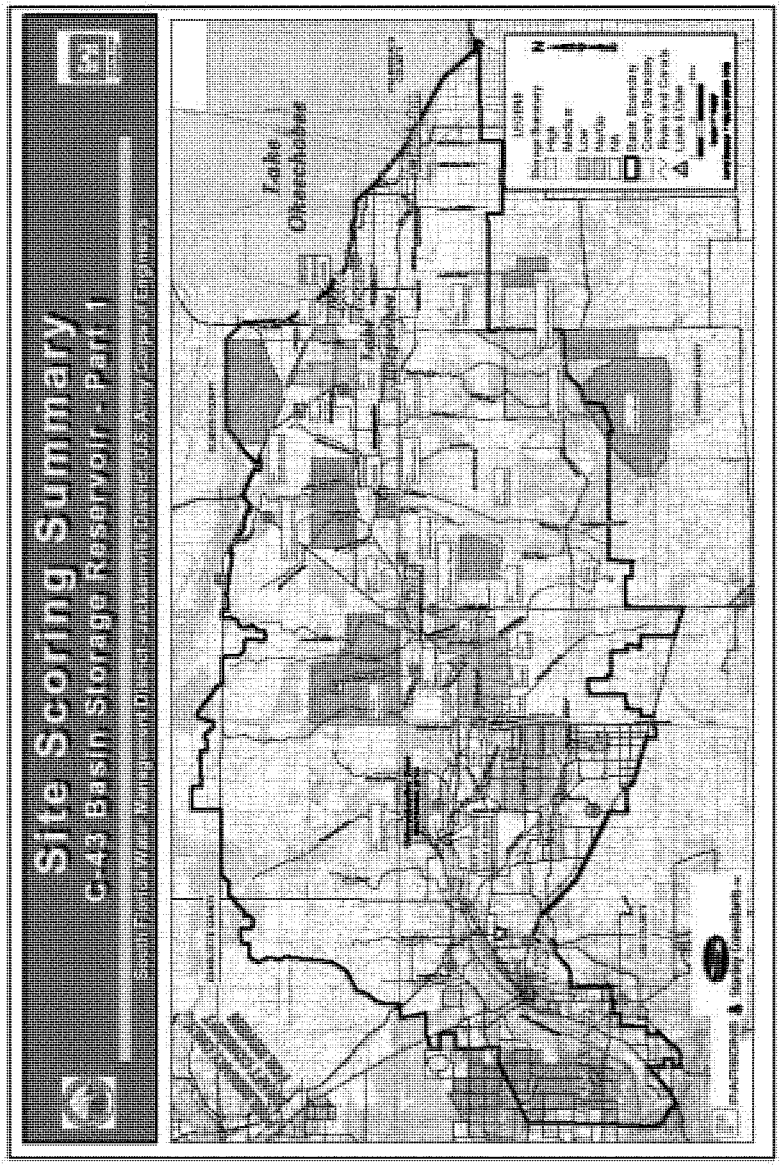


FIGURE F-1: LOCATIONS OF POTENTIAL SITES

F.3 SCREENING

F.3.1 Gate Criteria

As stated in the above paragraph, the Gate Criteria is the first look at the suitability of a potential land parcel for the project. The Gate Criteria consist of six criteria. The first six criteria included:

- Threatened and Endangered Species/Habitat
- Significant Wetlands
- Known Significant Cultural Resources
- Known Superfund Sites
- Safety Impacts
- Basin Location

Rating of the land parcel(s) was based on a simple rating of either Go or No Go. A site that was known to violate one or more of these criteria received a "No Go" rating and would not be considered for further analysis.

F.3.2 General Criteria

Once a site has passed the Gate Criteria, a second further screening application is applied to evaluate the potential suitability of the land parcel. The additional sitting criteria followed six general categories. They are:

- Utilities
- Use and Density Factors
- Regulatory or Legal Factors
- Transportation Impacts
- Land Condition
- Other Considerations (Environmental Justice and Recreation)

From these six general categories, 33 criteria were developed to rate the suitability of the site using a simple rating system of –1, 0, or +1. These sites were then rated for each of the 33 criteria, resulting in a -1, 0, or +1 score being assigned to the site for the specific criteria. These scores would then be tallied, with a total overall score being determined for each site. Each site's total score would give an indication of its' relative strength or weakness for use as a management measure in the development of alternative plans.

F.3.3 Results of Application of Screening Criteria

Approximately twenty land parcels were identified as potential sites for the location of future project components. These twenty sites were screened using both the Gate and General Criteria to evaluate their suitability as potential site locations for future project components (reservoirs, etc.). The Gate Criteria were first applied to the twenty sites, as the first screen to determine which sites

would be suitable for the location of project components. Using the Gate Criteria, potential sites were rated for storage capabilities (able to be best utilized for placement of storage reservoirs) and for restoration potential. The storage rational was based on the fact that the site used as a storage facility, did not have an adverse impact on the Gate Criteria. The restoration rational was base on whether the site implements recovery plan goals or the site either alone or combined with other sites resulted in restoration goals being met (as defined by the project goals and objectives) without having a negative impact on the Gate Criteria. ***Table F-2*** shows those sites that did not pass the Gate Criteria for storage capacity. Next, again using the Gate Criteria, the twenty sites were evaluated for their restoration potential.

Table F-3 shows those sites that did not pass the Gate Criteria for the sites' restoration potential. It should be noted that when some of the sites which passed the Gate Criteria for restoration potential but did not pass the Gate Criteria for storage capacity, were combined with adjacent sites, these sites then did received a passing grade for storage capacity. Therefore, those sites (P2-Lake Hicpochee) then were passed on along with the other passing sites to be screened using the site screening criteria. Although P3-WCD Canal No. 1 did not pass one of the Gate Criteria, further review of the site determined that with some redesign of the storage component, the site was still a viable option and was therefore passed on to be screened further.

TABLE F-2: POTENTIAL SITES BASED ON STORAGE CAPACITY

Gate Criteria GO / NO GO	Potential Sites Based on Storage Capacity								
	P2	P3	P5	P6	P7	P8	P9	P11	P12
T&E Species/ Habitat	No Go	No Go	No Go	No Go	No Go			No Go	No Go
Significant Wetlands	No Go	Go	Go	No Go	No Go			Go	Go
Known Significant Cultural Resources	Go	Go	Go	Go				Go	Go
Known Superfund Sites	Go	Go	Go					Go	Go
Safety Impacts	Go	Go	Go					Go	Go
Basin Location	Go	Go	Go	Go	No Go	No Go	No Go	Go	Go

TABLE F-3: POTENTIAL SITES BASED ON RESTORATION POTENTIAL

Gate Criteria GO / NO GO	Potential Sites Based on Restoration Potential		
	P****	P****	P&P**
T&E Species / Habitat	Go	Go	Go
Significant Wetlands	Go	Go	Go
Known Significant Cultural Resources			
Known Superfund Sites		Go	Go
Safety Impacts		Go	Go
Basin Location	No Go	No Go	No Go

After passing the Gate Criteria, each site or combination of sites were rated using the site screening criteria to further narrow down the selection of potential sites locations. Again these sites were rated for both storage capacity and restoration potential based on the site screening criteria. As stated in the previous section, these sites were given a rating of +1, 0, or –1 depending on how it was scored for each individual screening category. These scores were then added up to determine an overall score for the site based on both storage capacity and restoration potential. Each sites or group of sites individual scores were then added up for both storage capacity and restoration potential. The potential maximum score that a site could receive was a score of 33 points, assuming that a site scored a +1 for each of the 33 individual site screening criteria. Those sites that had a score of +12 or above were selected as locations to place storage components (***Table F-4*** and ***Table F-5***). Additionally, the following sites were rejected for the following reasons even though some of these sites received a favorable rating:

P3W/P4	Land was unavailable
P5	Land was unavailable
P6	Site was located in a known panther corridor
P7	Not located in the Caloosahatchee River (C-43) Basin
P8	Not located in the Caloosahatchee River (C-43) Basin
P9	Not located in the Caloosahatchee River (C-43) Basin
P10A-D	Canal improvements, provided no storage or restoration value
10E	Lake Flirt Lock (cost prohibited)
P11	Land was not available
P12	Significant Cultural Impacts from storage use
F-Paul	Traded for MetLife property on Berry Grove Site

From a list of twenty potential sites, eleven sites were identified as suitable locations for project components (See Appendix F, Siting Criteria).

TABLE F-4: CALOOSAHATCHEE RIVER (C43) WEST BASIN STORAGE RESERVOIR SITE SCREENING SCORES–STORAGE SUMMARY

Site	Score (33 max)	Comment
High Scores (18+)		
P1	20	
A	19	
B	21	
P1+A+B	21	
C (River Groves)	18	
D (Duda)	20	
D (Peeples)	19	
D (Bronson)	19	
P10E (Flirt)	20	
F (Paul)	21	
P14 (P1+A+B+F)	21	
P15	19	
Medium Scores (12-17)		
P2+C	15	
P2+C+D	14	
P2+D	15	
P2E	16	
P3E	14	
P13 South	15	
Low Scores (6-11)		
P3W-4	4	
No Go		
P2 (Hilgendorf)	12	No Go T&E, Significant Wetlands
P3	12	No Go T&E
P4	6	Combined with P3W-4
P5	11	No Go T&E
P6	8	Combined with P10C
P7	9	Not located in C-43 Basin
P8	9	Not located in C-43 Basin
P9	8	Not located in C-43 Basin
P11	10	No Go T&E
P12	9	No Go T&E, No Go Significant Cult. Resources

TABLE F-5: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR SITE SCREENING SCORES – RESTORATION SUMMARY

Site	Score (33 max)	Comment
High Scores (18+)		
P2 (Hilpochee)	21	
P2+C	20	
P2+D	18	
Medium Scores (12-17)		
C (River Groves)	14	
D (Duda)	14	
D (Peeples)	12	
D (Bronson)	13	
P2+C+D	17	
P2E	14	
P3	12	
P5	17	
P10E (Flirt)	16	
P11	12	
P15	14	
Low Scores (0-11)		
P1	8	
A	10	
B	11	
P1+A+B	11	
P3W-4	9	
P3E	7	
F (Paul)	10	
P14 (P1+A+B+F)	9	
No Go:		
P4	0	Combined with P3W-4
P6	0	Combined with P10C
P7	0	Not located in C-43 Basin
P8	0	Not located in C-43 Basin
P9	0	Not located in C-43 Basin
P12	0	No Go Significant Cult. Resources

Each of the parcels shown on ***Figure F-2*** met the requirements of the site screening criteria for selections to various degrees. When the siting criteria were prioritized and weighted (high, medium and low) out of the approximately twenty parcels screened, eleven sites met the requirements of the screening

criteria for storage and restoration. The follow sites will be used for developing preliminary design for reservoirs:

- P1 Berry Grove
- A Griffin Parcel
- B Metlife Parcel
- P2 Lake Hicpochee
- P2E Parcel on west side of Lake Hicpochee
- C River Grove Parcel
- D-Duda Duda Parcel
- D-Peeples Peeples Parcel
- D-Bronson Bronson Parcel
- P3 WCD Canal No. 1
- P3E Flagpole Canal
- P13 South Central Parcel
- P15 Parcel located on southwest corner of Four Corners (Intersection of Lee, Hendry, Charlotte and Glades County)

Further analysis on each of these sites for their use as locations of project component will be conducted when preliminary designs of reservoirs are developed which look at utilize the site to its fullest potential.

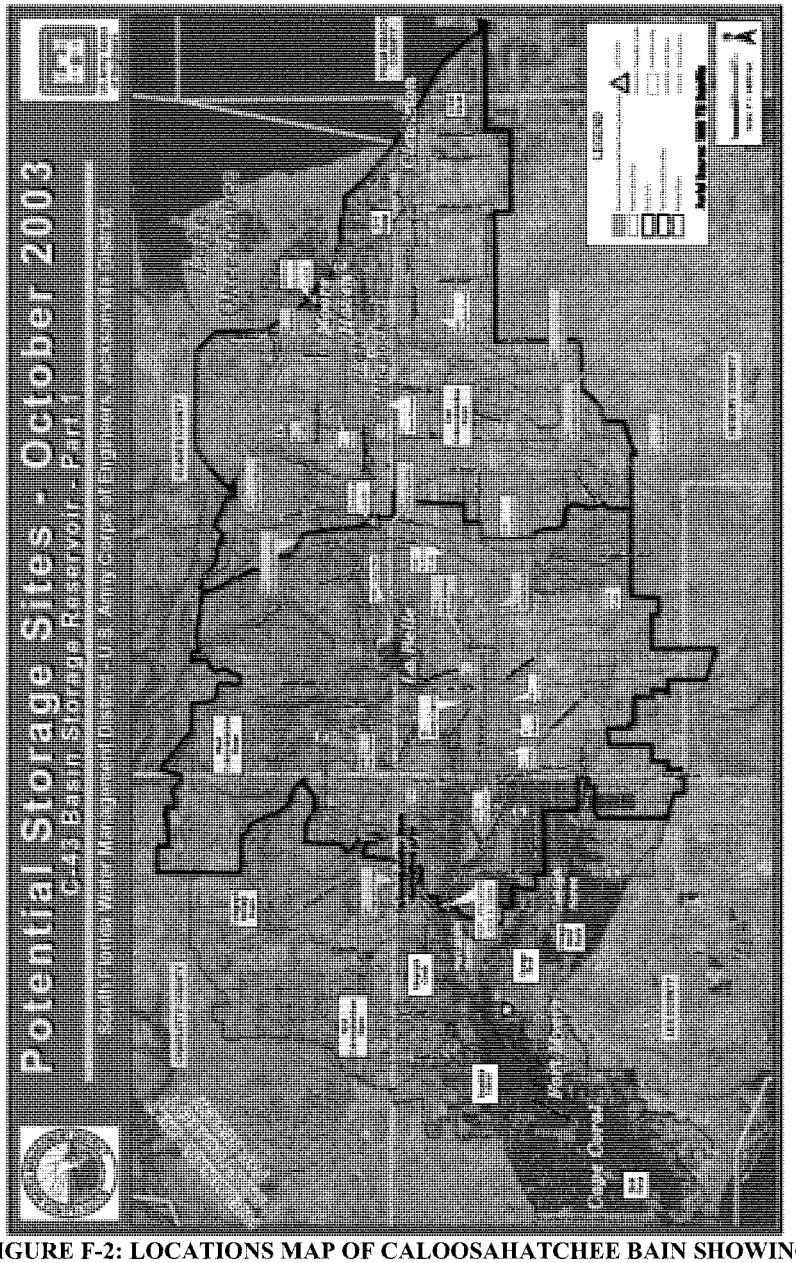


FIGURE F-2: LOCATIONS MAP OF CALOOSAHATCHEE BAIN SHOWING LOCATIONS OF PARCELS THAT HAVE PASSED SITE SCREENING CRITERIA

F.3.4 Level 1 Gate Criteria

Caloosahatchee River (C43) West Basin Storage Reservoir Site Screening Criteria

Criterion Name: THREATENED AND ENDANGERED SPECIES / HABITAT	SSG –1.0.1
Level:	**1 - Gate Criteria**
Category:	**Not Applicable**

Description:
Endangered and Threatened Species – those animal and plant species defined by federal and/or state regulations to be endangered or threatened.

Habitats of Endangered and Threatened Species – defined as areas indicated on geographic information system maps of the USFWS and the FWC that contain habitats of endangered and threatened species including the zones established in the Florida Panther protection and Recovery Plan.

Storage Rationale:	**Restoration Rationale:**
GO: Not likely to adversely effect threatened or endangered species or their habitat. **NO GO :** Likely to adversely effect threatened or endangered species or their habitat	**GO:** Site implements recovery plan goals OR Site (either alone or when combined with other sites) results in the restoration goals being met (as defined in the projects "Goals and Objectives") **NO GO:** Site (either alone or in rational combination with other sites) does not reasonably aid in meeting the project's restoration goals or is contrary to species recovery plan goals.
Storage Methodology: Direct impacts – GIS analysis Secondary impacts – GIS analysis Native habitats shall be avoided as well as known nesting areas for these species on sites under consideration for storage.	**Restoration Methodology:** Direct impacts – GIS analysis Secondary impacts – GIS analysis Additional source material – South Florida Multi-species Recovery Plan, other adopted recovery plans and guidelines. Using a site that has been identified as habitat for threatened and endangered species for restoration would result in a Go rating.

Comments:
There are several threatened and endangered species found in the Caloosahatchee Basin, including the Florida panther (*Felis concolor coryi*), wood stork (*Mycteria americana*), Florida grasshopper sparrow (*Ammodramus savannarum floridanus*), West Indian manatee (*Trichechus manatus*), red-cockaded woodpecker (*Picoides borealis*), Florida scrub-jay (*Aphelocoma coerulescens*), Everglade snail kite (*Rostrhamus sociabilis plumbeus*), Audubon's crested caracara (*Polyborus plancus audubonii*), Bald eagle (*Haliaeetus leucocephalus*), Okeechobee gourd (*Cucurbita okeechobeensis*), Beautiful pawpaw (*Deeringothamnus pulchellus*). In addition, the Everglades snail kite has designated critical habitat.

GIS materials include layers provided by USFWS and FWC associated with South Florida Multi-Species Recovery Plan, Southwest Florida Regional Wildlife Habitat Plan, and Closing the Gaps in Florida's Wildlife Habitat Conservation System.

Accepted by Project Delivery Team.

Author(s): Jim Beever / FWC, beever@fwc.state.fl.us, and Stephanie Brady USFWS, Stephanie_Brady@fws.gov

Criterion Name: SIGNIFICANT WETLANDS	SSG –1.0.2
Level: 1 – Gate Criteria	
Category: **Not Applicable**	

Description:

Wetlands – those areas defined by federal and/or state regulations to be wetlands, in accordance with the regulation-prescribed hydrology, vegetation and soils criteria.

Significant Wetlands – defined as one or a combination of the following:
Wetlands of regional or state importance as defined by FAC 62-302. Wetlands, which also constitute headwaters. Wetlands, which if affected (positively or negatively), would result in substantial secondary impacts (which may also be positive or negative). Wetlands, which if negatively affected, could not be mitigated.

Storage Rationale:	**Restoration Rationale:**
GO: Site results in no to minimal negative wetland impacts to significant wetlands.	**GO:** Site allows for wetland restoration benefits to target wetland types and an approximation of the original wetland function (either alone or when combined with other sites) results in some of the restoration goals being met (as defined in the projects "Goals and Objectives")
NO GO: Site results in more than minimal impacts to significant wetlands.	**NO GO:** Site, alone or in ratio nal combination with other sites, does not reasonably aid in meeting the project's restoration goals.
Storage Methodology: Direct impacts – GIS analysis of NWI data Direct = within footprint	**Restoration Methodology:** Direct impacts – GIS analysis of NWI data

Comments:

GIS layers include EPA/FWC Wetlands of Significance to Listed Species and the Regionally Significant Wetlands Maps Developed in the Southwest Florida EIS and the LWCWSP (J. Beever 11/8/02). Secondary impacts will be considered in screening criteria.
Further detailed screening will occur during Alternatives evaluation.

Accepted by Project Delivery Team.

Author(s): Sandy Scheda / SEA-Project Consultant / sscheda@scheda.com

Criterion Name: KNOWN SIGNIFICANT CULTURAL RESOURCES	SSG –1.0.3
Level:	**1 – Gate Criteria**
Category:	**Not Applicable**

Description:
Cultural resources – any prehistoric or historic district, site, building, structure, or object found in, or eligible for inclusion in the National Register of Historic Places (NRHP) (as defined by the National Historic Preservation Act of 1966-as amended).

Storage Rationale:	**Restoration Rationale:**
GO: Site results in no negative impacts to significant resources, or impacts, which can be practicably mitigated. **NO GO:** Site results in negative impacts to significant resources, which cannot be practicably mitigated.	**GO:** Site results in no negative impacts to significant resources, or impacts, which can be practicably mitigated. **NO GO:** Site results in negative impacts to significant resources, which cannot be practicably mitigated.
Storage Methodology: Utilizing existing and publicly available information.	**Restoration Methodology:** Same

Comments:
More detailed analysis will occur in future phases.

Site results in area being rehydrated to its historic aesthetic appearance, OR site results in the preservation of known wooden or other organic artifacts whose condition has been degraded by dehydration.

Accepted by Project Delivery Team.

Author(s): Sandy Scheda & Bill Burger / SEA-Consultant, sscheda@scheda.com

Criterion Name: KNOWN SUPERFUND SITES		SSG –1.0.4
Level:	**1 - Gate Criteria**	
Category:	**Not Applicable**	
Description: This criterion is based on whether or not a site is known to be on the USEPA Superfund hazardous waste sites list.		
Storage Rationale: **GO:** Site is not listed as a Superfund site. **NO GO:** Site is listed as a Superfund Site.	**Restoration Rationale:** **GO:** Site is not listed as a Superfund site. **NO GO:** Site is listed as a Superfund Site.	
Storage Methodology: Compare the list of proposed sites to the list of sites on the Superfund cleanup list. (Note: There are no Superfund listed sites in Glades or Hendry Counties.	**Restoration Methodology:** Compare the list of proposed sites to the list of sites on the Superfund cleanup lis t. (Note: T here a re no Superfund listed sites in Glades or Hendry Counties	
Comments: There are no superfund sites in Glades or Hendry counties. Accepted by Project Delivery Team.		
Author(s): Gordon Romeis, FDEP, Gordon.romeis@dep.state.fl.us		

Criterion Name: SAFETY IMPACTS	**SSG –1.0.5**
Level:	**1 – Gate Criteria**
Category:	**Not Applicable**
Description: Initial review of the measures that will have to be taken to avoid or prevent the risks to human life, health, and safety by utilizing the site under review.	
Storage Rationale: **NO GO:** The site violates the criteria for dam/levee design currently utilized by the US ACOE standards or higher state standards. **GO:** The facility at the site can be designed to comply with the criteria for dam/levee design currently utilized by the US ACOE standards or higher state standards.	**Restoration Rationale:** N/A
Storage Methodology: GIS Assessment that identifies inhabited areas, and general topographic relief, with sites overlaid. Distance to habited sites, and topographic assessment, can be evaluated. Utilizing the design criteria identified above to perform an initial evaluation of suitability.	**Restoration Methodology:** N/A
Comments: General JPEG File provided by SWFRPC. Sites identified as having a probability for loss of life enter intensive screening for Mitigation requirements; should such requirements not be able to be met, the site becomes removed from further consideration. Federal law PL 91-646 will be followed in the event of displacement of landowners. It is a requirement of CERP to maintain the existing level of flood protection in accordance with WRDA 2000 and applicable State regulations. **It is recogniz ed that the projec t will be designed to USACE standards or higher state standards for public safety or the criteria being specifically adopted for the Comprehensive Everglades Restoration Plan, the more stringent of the criteria.** This Gate Criterion relates to the following Screening Criterion: Buffers/Setbacks; and the Land Condition subgroup criteria of Current Land Use, Soils, Topographic Relief, and Configuration Complexity. Accepted by Project Delivery Team.	
Author(s): Wayne Daltry, Lee County BOCC, wdaltry@leegov.com	

Criterion Name: BASIN LOCATION	**SSG –1.0.6**
Level: 1 – Gate Criteria	
Category: **Not Applicable**	
Description: This criterion is based on whether or not a site is known to be in the contributing watershed for the Caloosahatchee River (C-43) Basin.	
Storage Rationale: **GO :** Site is in the Caloosahatchee River (C-43) Basin **NO GO :** Site is not in the Caloosahatchee River (C-43) Basin	**Restoration Rationale:** Same
Storage Methodology: Compare the location of the proposed sites to the Caloosahatchee River (C-43) Basin Map.	**Restoration Methodology:** Same
Comments: To be accepted by the PDT	
Author(s): Shawn Waldeck, Stanley Consultants, waldeckshawn@stanleygroup.com	

F.3.5 Level 2 General Screening Criteria

Caloosahatchee River (C43) West Basin Storage Reservoir Site Screening Criteria

Criterion Name: UTILITY IMPACTS		SSC –2.1.1
Level:	**2 - General Screening Criteria**	
Category:	**Utility**	

Description:

Utility Impacts include existing, authorized, and potential utility facilities and/or corridors that are/may be located within, across, and/or adjacent to a proposed project site. Utilities include above ground and underground electric power, telephone, cable, fiber optic cable, water, sewer, and similar lines and related facilities such as sub stations, switching stations, etc. Authorized facilities include those that have been permitted, but are not yet constructed and/or operational. Potential facilities/corridors include those for which land has been acquired by easement and/or fee but which have not yet been permitted for a specific use.

Storage Rationale:

Positive (+ 1): No existing utility lines, facilities, easements or fee corridors within or immediately adjacent to the proposed project site that would need to be relocated and/or incorporated into the project design. Local power distribution lines available to provide power during construction and for operational purposes upon project implementation without major relocation or connection costs.

Neutral (0): Existing utility lines, facilities, easements, etc. can be avoided and/or incorporated into the proposed project design with minimal impacts to the existing utility lines, facilities, easements, etc. and/or the project design or timetable and/or relocated at a minimal cost.

Negative (-1): Existing utility lines, facilities, easements, etc. cannot be incorporated into the proposed project design and must be relocated at a significant cost in order to locate the project on the proposed site, including project construction and operational needs for power. This value may also be impacted by the number and type of utility lines, facilities, etc. that may need to be relocated.

Restoration Rationale:

Positive (+ 1): No existing utility lines, facilities, easements or fee corridors within or immediately adjacent to the proposed project site that would need to be relocated and/or incorporated into the project design. Local power distribution lines available to provide power during construction and for operational purposes upon project implementation without major relocation or connection costs.

Neutral (0): Existing utility lines, facilities, easements, etc. can be avoided and/or incorporated into the proposed project design with minimal impacts to the existing utility lines, facilities, easements, etc. and/or the project design or timetable and/or relocated at a minimal cost.

Negative (-1): Existing utility lines, facilities, easements, etc. cannot be incorporated into the proposed project design and must be relocated at a significant cost in order to locate the project on the proposed site, including project construction and operational needs for power. This value may also be impacted by the number and type of utility lines, facilities, etc. that may need to be relocated.

Methodology:

Use a combination of existing land use information, GIS mapping information, utility information, Sunshine State Utility Locator Service, planning documents, and on-site visits to identify existing, permitted, and proposed utility lines, facilities, and corridors and specific information about each including the size of the line and/or facility, whether it is a local or regional type line and/or facility, etc.

The number and type (local versus regional service) of existing, permitted, and proposed lines and/or facilities will be evaluated to determine whether a positive, neutral or negative valne will be assigned.

Comments:

Existing or proposed utility lines and/or other utility facilities on and/or adjacent to a proposed project site may impact the design and/or implementation of the proposed project. In some cases, depending on the type of project proposed and the type of existing or proposed lines and/or facilities, it is possible to design the project in such a way that it avoids or minimizes impacts to the existing and/or proposed lines and/or facilities. In other cases, it may not

be possible to build the project without relocating and/or modifying the lines and/or facilities. Power needs during construction and/or operation of the proposed project may also be a consideration depending on the location, size and type of proposed project. Depending on the type of lines and/or facilities involved, the relocation and/or modification costs could significantly impact the cost of the project and the time required to complete the project. An additional consideration for utilities that have acquired lands by easement or fee for future lines and/or facilities, but have not yet applied for or received permits for those lines and/or facilities, is the extent to which those lands are part of their overall network for providing service within their service area and how that would impact their ability to meet their service requirements in the future. A related consideration is maintenance of access to these facilities during as well as post construction of the proposed project.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Susan Coughanour, SFWMD, scoughanour@sfwmd.gov

Criterion Name: WETLAND HABITAT	SSC -2.2.1
Level: 2	- General Screening Criteria
Category:	Use & Density Factors

Description:
Wetlands – those areas defined by federal and/or state regulations to be wetlands, in accordance with the regulation-prescribed hydrology, vegetation and soils criteria.

"Wetlands" means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands are generally classified as hydric or alluvial, and possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions described above. These species, due to morphological, physiological, or reproductive adaptation, have the ability to grow, reproduce, or persist in aquatic environments or anaerobic soil conditions. Florida wetlands generally include swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps, and other similar areas. Florida wetlands generally do not include longleaf or slash pine flatwoods, with an understory dominated by saw palmetto.

(Taken from FAC Chapter 40E-4.021, Definitions)

Storage Rationale:	Restoration Rationale:
Positive (+1): Potential site use results in no or low level negative wetland impacts, impacts are to lower quality wetland, impacts are mitigatable. **Neutral (0)**: Potential site use results in a low to moderate level of negative wetland), impacts may also be to average quality wetlands, impacts are mitigatable. **Negative (-1)**: Potential site use results in high level of negative wetland impacts, impacts may also be to high quality wetland, impacts are difficult to mitigate.	**Positive (+ 1)**: Site attains designated wetland restoration benefits Site potentially may increase the spatial extent of functional wetlands. **Neutral (0)**: Site (either alone or when combined with other sites) results in some of the restoration goals being met (as defined in the projects "Goals and Objectives"). **Negative (-1)**: Site does not reasonably aid in meeting the project's restoration goals.
Storage Methodology: Direct impacts – GIS analysis Secondary impacts – GIS analysis Uses other appropriate mapping resources such as smaller scale aerials to complete preliminary review of accuracy of GIS databases	**Restoration Methodology:** Same

Comments:
Best professional analysis by team members with ecological expertise that identifies both isolated and interconnected systems that impact the site or are impacted by the site. Adjacent lands that can contribute to the restoration of or preservation of wetlands.

The screening for this item takes this into further detail than gate criteria.

Author(s): Sandy Scheda, SEA-Project Consultant, sscheda@scheda.com

Criterion Name: PROTECTED SPECIES/WILDLIFE/HABITAT	SSC –2.2.2
Level: 2 - General Screening Criteria	
Category: **Use & Density Factors**	

Description:
Protected Species. Those animal and plant species defined by federal and state regulations to be endangered, threatened, or species of special concern.

Habitats of Protected Species and Wildlife. These areas are defined and maintained in geographic information system by both the USFWS and the FWC. These databases contain habitats of these species.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Site location results in no adverse impacts to protected species, other wildlife, or their habitats. **Neutral (0):** Site location results in a slight adverse impact to protected species, other wildlife, or their habitats. **Negative (-1):** Site location results in low to high level of adverse impacts to protected species, other wildlife, or their habitats, or site would require a review for potential take.	**Positive (+1):** Restoration site implements goals to recover or restore protected species, wildlife, and their habitats **Neutral (0):** Restoration site (either alone or when combined with other sites) results in the restoration goals being met. **Negative (-1):** Restoration site (either alone or in rational combination with other sites) is contrary to the recovery or restoration of protected species, wildlife or their habitats.
Storage Methodology: Direct impacts - GIS analysis Secondary impacts - GIS analysis	**Restoration Methodology:** Direct impacts - GIS analysis Secondary impacts - GIS analysis Additional source material - South Florida Multi-species Recovery Plan, other adopted recovery plans and guidclines.

Comments:
GIS materials inclnde layers provided by USFWS and FWC associated with South Florida Multi-Species Recovery Plan, Southwest Florida Regional Wildlife Habitat Plan, and Closing the Gaps in Florida's Wildlife Habitat Conservation System

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Jim Beever, FWC, james.beever@fwc.state.fl.us, and Stephanie Brady, USFWS, Stephanie_Brady@fws.gov

Criterion Name: CULTURAL RESOURCES	SSC –2.2.3
Level:	**2 - General Screening Criteria**
Category:	**Use & Density Factors**

Description:
Cultural resources – any prehistoric or historic district, site, building, structure, or object found in, or eligible for inclusion in the National Register of Historic Places (NRHP) (as defined by the National Historic Preservation Act of 1966-as amended)

Storage Rationale:	Restoration Rationale:
Positive (+1): Site con sists of less t han 10 % high probability area o r kno wu cultural reso urce sites, which can be mitigated. **Neutral (0):** Si te co nsists o f 10-20% hi gh probability area o r con tains one to three rep orted cultural reso urces, wh ich can b e mitigated cost-effectively. **Negative (-1):** Site consists of 20% or greater h igh probability areas or co ntains m ore th an three reported cultu ral resou rces or any cultural resource listed o n or determined elig ible for th e National Register of Hi storic Places, whi ch cannot be mitigated cost-effectively.	**Positive (+1):** Site results in no adverse effect or p rovides a beneficial effect to eligible historic properties. **Neutral (0):** Site resu lts in n egative im pacts to Natio nal Register Listed /Eligible resou rces, wh ich can b e m itigated cost-effectively. **Negative (-1):** Site resu lts in negative imp acts to National Register Listed/Eligible resources, which cannot be mitigated cost-effectively.
Storage Methodology:	**Restoration Methodology:**
Analysis wo uld be conducted usi ng the re sults of Probability M apping for belo wground resou rces. Considers location o f k nown above-ground resources	Same

Comments:
High Probability Areas are areas lo cated by the confluence of creeks and larger bodies of water, and high areas in marshy areas.

In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, all adverse affects to cultural resources will be avoided or mitigated in consultation with the State Historic Preservation Officer.

Author(s): Grady Caulk, Corps, Sandy Scheda & Bill Burger, SEA-Consultant, sscheda@scheda.com

Criterion Name: CONSERVATION LANDS	SSC –2.2.4
Level:	**2 - General Screening Criteria**
Category:	**Not Applicable**

Description:

Conservation Lands – those lands and waters in conservation and preservation protection defined by federal, state, regional local government or private conservation ownership, including conservation easements.

Proposed Conservation Lands – those lands and waters in conservation and preservation protection defined by federal, state, regional local government or private conservation ownership, including conservation easements that are on official listings or documents for acquisition in fee or less-than-fee.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Site results in no negative impacts to conservation lands or proposed conservation lands. **Neutral (0)**: Site results have the potential to secondarily negatively impact the acquisition of proposed conservation lands either by physical or appraisal effects. **Negative (-1)**: Site results in negative impacts to existing conservation lands or proposed conservation lands by direct effects in preventing conservation uses or preventing acquisition for conservation purposes.	**Positive (+1):** Site implements conservation use or acquisition goals **Neutral (0):** Site (either alone or when combined with other Sites) results in some of the restoration goals being met (as defined in the projects "Goals and Objectives") **Negative (-1):** Site (either alone or in rational combination with other Sites) does not reasonably aid in meeting the project's restoration goals or is contrary to conservation goals on existing and proposed lands.
Storage Methodology: Direct impacts – GIS analysis Secondary impacts – GIS analysis Additional material- official land acquisition proposal lists and documents	**Restoration Methodology:** Direct impacts – GIS analysis Secondary impacts – GIS analysis Additional material Conservation Lands Management Plans, other adopted restoration plans and guidelines.

Comments:

There are several conservation lands and on-going conservation lands acquisition projects in the Caloosahatchee Basin, including the Florida panther Ecoscape project.

The screening criteria shall prohibit the selection of sites that will not contribute to the protection of existing conservation lands or interfere with on-going conservation land acquisition in-fee or less-than-fee simple.

GIS materials include layers provided by USFWS, FWC, FDEP, SFWMD, and UF associated with land acquisition programs including Florida Forever, Save Our Rivers, lee County 2020, Southwest Florida Regional Wildlife Habitat Plan, and Closing the Gaps in Florida's Wildlife Habitat Conservation System.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Jim Beever, FWC, beever@fwc.state.fl.us

Criterion Name: COMPREHENSIVE L AND USE PLAN & Z ONING COMPLIANCE	SSC -2.3.1
Level:	**2 - General Screening Criteria**
Category:	**Regulatory or Legal Factors**

Description:
Identify and consider impacts on the future use of the site resulting from the existing land use and other applicable designation(s) in the local government Comprehensive Land Use Plan (CLUP) and Zoning Code that govern the use of this site and adjacent lands.

Storage Rationale:	Restoration Rationale:
Positive (+1): No changes or special approvals under the existing CLUP & Z oning designation for the site are required to implement the proposed project. **Neutral (0):** The proposed use is compatible with the current CLUP for the site, but requires a special approval under the CLUP process or a zoning change in order to be implemented. These approvals can likely be obtained within the next 6 months due to the timing of the local government's next open application filing period for CLUP approvals. **Negative (-1):** The proposed use requires a change in the current CLUP designation for the site and corresponding zoning changes to implement the proposed project and/or it will likely take at least a year to process the request due to the timing of the local government's next open application filing period for CLUP changes.	**Positive (+1):** No changes or special approvals under the existing CLUP & Z oning designation for the site are required to implement the proposed project. **Neutral (0):** The proposed use is compatible with the current CLUP for the site, but requires a special approval under the CLUP process or a zoning change in order to be implemented. These approvals can likely be obtained within the next 6 months due to the timing of the local government's next open application filing period for CLUP approvals. **Negative (-1):** The proposed use requires a change in the current CLUP designation for the site and corresponding zoning changes to implement the proposed project and/or it will likely take at least a year to process the request due to the timing of the local government's next open application filing period for CLUP changes.

Methodology:
Identify: (1) the applicable local government CLUP and Zoning Code designations which apply to the proposed site; (2) the applicable CLUP and Zoning designations and special overlays or approvals required that apply to the proposed site; (3) whether or not a CLUP amendment or special approval or zoning classification change by the local government is required to implement the project; (4) if a CLUP amendment or special approval or zoning change is required, the ability to prepare and file that request in a timely manner with in the designated application filing periods.

Comments:
If the proposed use would require an amendment to the applicable CLUP or Zoning District in order for the site to be used, this could significantly impact the timetable for and cost of implementing the proposed project due to the amount of time that it typically takes to process a CLUP amendment and/or Zoning classification time. Local governments only allow amendments to their CLUP to be filed during a designated annual or bi-annual filing period, unless they are filed in conjunction with a Development of Regional Impact (DRI) application. It is unlikely that this project would qualify as a DRI. It usually takes several months to a year to process a CLUP amendment. Zoning change requests can typically be filed on a monthly basis, but can still take several months to process depending on the complexity of the proposed project and the issues involved.

There may some situations where: (1) a proposed use, such a reservoir, may be incompatible with an existing CLUP or zoning classification or overlay provision, such as preservation, without modifying the existing CLUP or zoning code designation or overlay; or (2) a proposed use may be allowed within an existing CLUP or Zoning Code designation, but only by special approval and subject to additional special conditions.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Susan Coughanour, SFWMD, scoughanour@sfwmd.gov

Site Screening Criteria: Pending Rule/ Regulatory Compliance	SSC –2.3.2
Level:	**2 - General Evaluation Criteria**
Category:	**Regulatory or Legal Factors**

Description:

Identify and consider the extent to which the proposed use of the site may be affected by: (1) rules that have recently been adopted but whose implementation is officially scheduled for a specific future date; and/or (2) proposed and/or on-going rule making activities. These rule making activities may be undertaken by local governments, regional agencies (water management district/regional planning council/ other), state agencies, federal agencies, and/or Indian tribes.

Storage and Restoration Rationale:

Positive (+1): No recently adopted rules and/or pending rule-making activities that could affect how the site could be used for the proposed project.

Neutral (0): Recently adopted rules and/or on-going rule making activities will have minimal impacts on how the site will be used for the proposed project since: (1) the content of the rule changes is such that it is not expected to significantly impact the project design; (2) the effective date of the adopted/proposed rules is far enough in the future that permits for the proposed project can likely be obtained prior to the rule changes going into effect.

Negative (-1): Recently adopted and/or proposed rule making activities address content areas likely to substantially affect the use of the site for the proposed project, particularly in terms of project design. Proposed rules and/or rule making activities are currently embroiled in extended legal proceedings regarding their validity.

Storage and Restoration Methodology:

Identify all recently adopted rules and/or pending rule making activities by the applicable local, regional, state, and/or federal agencies and/or Indian Tribes that could affect how the site is used for the proposed project;

Review the content of the recently adopted/pending rules to identify potential impacts on project design and/or location;

Review adopted/proposed implementation dates for potential impacts on permit application process and project timetables.

Comments:

Depending on the extent to which proposed, on-going and/or recently adopted rules/rule changes affect a project design, they could have a corresponding impact on the construction timetable and implementation date for the proposed project. When new rules or rule changes are proposed or adopted, they typically specify a future effective date. They also specify whether the new rules are applicable to new applications only and/or to applications that have not yet been found to be complete by the reviewing agency by a specific implementation date. The content of the rule changes could also affect the proposed project design. Consequently, depending on the status of any permit applications already under review or being prepared, the implementation date of the new rules/rule changes, and/or the cout ent of the proposed/adopted rules, the project design, as well as the construction timetable, could be impacted.

Compliance with permit conditions is presumed to be addressed under the Permitting Criteria.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Susan Coughanour, SFWMD, scoughanour@sfwmd.gov

Criterion Name: MITIGATION / CONS ERVATION E ASEMENT / DEED RESTRICTIONS	SSC –2.3.3
Level:	**2 - General Screening Criteria**
Category:	**Regulatory or Legal Factors**

Description:

Identify and co nsider impacts o n t he fu ture u se of th e site resu lting from ex isting mitigation areas, co nservation easements, deed restrictions, or other legal limitations (by permit condition, land use designation, or other) on the use of the site.

Storage and Restoration Rationale:

Positive (+1): No existing conservation or other types of easements or deed rest rictions on t he property that would limit the proposed use of the property.

Neutral (0): Limitations associated with the existing conservation or other types of easements or deed restrictions on the property can be incorporated into the proj ect design without significantly impacting the ability of the project to meet project goals.

Negative (-1): Limitations associated with the existing conservation or other types of easements or deed restrictions on the property will significantly limit the ability of the site to be used for the proposed project design and/or be time consuming and costly to address.

Storage and Restoration Methodology:

Identify: (1) all existing conservation easements and/or deed restrictions on all or part of the proposed site; (2) any other legally protected (by permit, land use designation, or other method) areas on all or part of the proposed site; (3) all li mitations o n allo wable lan d uses and /or land use practices, water levels, clea ring practices, ope ration a nd maintenance practices, including exotic control, special uses such as hunting/fishing, etc., contained in the easements, deed restrictions, and/or any other legally limiting documents that could impact the project design; (4) the ability to incorporate t he li mitations co ntained i n th e ex isting ease ments, d eed restrictio ns, and/or other l egally li miting documents into the project design.

Comments:

It is assu med th at m itigation land s, and o ften st ormwater m anagement areas, a re typically encum bered by conservation easements and/or some type of deed restrictions. Conservation easements, deed restrictions and/or other types of l egal restrictions on land use m ay limit the use of t he property and/or impact t he design of t he proposed project or facil ity as a result of restrictions on allowable land uses, land practices, water levels, control elevations, etc. Due t o t he nat ure o f m ost mitigation areas, c onservation o r ot her types of ea sements/deed rest rictions will typically limit water levels on that portion of the property covered by the easement/restriction and/or mitigation area and disallow its use as a deep water storage area. Additional design features/costs may also be required to use areas adjacent to conservation easement/mitigation lands for deep water storage purposes. Restoration projects can often be designed consistent with existing mitigation/conservation easements.

It is assu med that impacts to natural wetland functions will be evaluated under separate criteria. The existence of these types of encumbrances on the property will influence property values. This issue will be addressed in the Gross Appraisal.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Susan Coughanour, scoughn@sfwmd.gov, SFWMD

Criterion Name: CONSTRUCTION / O&M ACCESS	SSC –2.4.1
Level:	**2 - General Screening Criteria**
Category:	**Transportation Impacts**
Description: This screening criteria will provide an evaluation of each site for temporary ease of construction and permanent O&M access both to the site as well as existing internal roads and bridges which can be used during construction and/or built upon for future use. In addition, staging areas for construction and O&M would be included in the screening.	
Storage and Restoration Rationale: **Positive (+1)**: If significant access is available. **Neutral (0)**: If existing is not adequate for construction access. **Negative (-1)**: If impediments or costly improvements are required.	
Storage and Restoration Methodology: By utilizing aerial photography and GIS -review existing on-site transportation infrastructure.	
Comments: Ingress & Egress to site (distance to and condition of existing roads & bridges) as well as internal infrastructure will impact the costs of construction as well as minimizing the impacts to surrounding areas during construction of the project hauling routes. Capability of the existing roads and bridges to accommodate construction vehicles, equipment, and large components of the projects i.e. HS25 loading capability for bridges. Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.	
Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com	

Criterion Name: IMPACTS TO EXISTING NAVIGATI ON AND TRANSPORTATION INFRASTRUCTURE	SSC -2.4.2
Level:	**2 - General Screening Criteria**
Category:	**Transportation Impacts**
Description: This screening criterion will provide an evaluation of each site for impacts to existing navigation and transportation facilities that are adjacent to the site and would be impacted by the construction and operation of the project. In addition, use of the existing transportation systems by heavy construction traffic may have impacts or be limited by the size and condition of the system.	
Storage and Restoration Rationale: **Positive (+1)**: If project is compatible. **Neutral (0)**: n/a **Negative (-1)**: If project is not compatible with the existing navigation and transportation systems.	
Storage and Restoration Methodology: Utilize existing maps of navigational and highway transportation systems and GIS information.	
Comments: The navigation and transportation systems adjacent to the site may be impacted by the construction activities and by changes to the existing facilities in order to accommodate the project may impact the costs of construction. Capability of the existing locks, roads and bridges to accommodate construction vehicles, equipment, and large components of the projects i.e. HS25 loading capability for bridges. Suitability for traffic detours if needed, future arterials and road widening. Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.	
Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com	

Criterion Name: PUBLIC LANDS	SSC -2.5.1
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
Public lands include those lands that are owned by the federal, state or local government, including sovereign and submerged lands. Sovereign lands include all lands under bodies of navigable water and tidelands within the territorial limits of the State of Florida. Conservation lands are not included in this description since they are described in SSC 2.2.4. Public lands include those lands that may have been acquired or designated for a variety of public uses, including stormwater mauagement, recreation, public facilities, preservation or other public uses.

Storage Rationale:	Restoration Rationale:
Positive (+ 1): Storage on site is consistent with the existing or intended use of this public site. **Neutral (0)**: Storage on site is not contrary to the existing or intended use of this public site. **Negative (-1)**: Storage on site is not consistent with the existing or intended use of this public site.	**Positive (+1)**: Restoration on site is consistent with the existing or intended use of the public site. Land is adjacent to restoration corridors being identified and utilized in other public projects. **Neutral (0)**: Restoration on site is not contrary to the existing or intended use of this public site. **Negative (-1)**: Restoration on site is not consistent with the existing or intended use of this public site.
Storage Methodology: Hendry, Lee & Glades County Plat Books; County Comprehensive Plan & Zoning Maps; Save our Rivers Maps; GIS analysis of FLUCFCS LU/LC data	**Restoration Methodology:** Same

Comments:
The ability to use public lands for the proposed project may be impacted by (1) the purpose for which the land was originally acquired, including funding sources; (2) existing and/or planned public uses of the land; and (3) the extent to which waterways, tidelands, and riparian lands are publicly and/or privately owned and/or controlled. Additional approvals and/or permits may be required to use public lands for a purpose that is different than the purpose for which it was originally acquired and/or what is allowed under the funding source used to acquire the property. If applicable to the site selected, sovereign lands will be addressed in the Gross Appraisal Report for the selected plan.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Antonio Ayuso, Corps, and Susan Coughanour, SFWMD, Antonio.D.Ayuso@saj02.usace.army.mil, scoughan@sfwmd.gov,

Criterion Name: STORAGE CAPACITY	**SSC –2.5.10**
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
This screening criterion will provide an evaluation of each site for the volume of storage capacity.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): If site could store greater than 10,000 ac-ft. **Neutral (0)**: If site could store 5,000 to 10,000 ac-ft. **Negative (-1)**: If site could store < 5,000 ac-ft.	**Positive (+1)**: Depths and hydroperiods appropriate for the maintenance of the natural community can be achieved. **Neutral (0)**: Uncertain **Negative (-1)**: Depths and hydroperiods appropriate for the maintenance of the natural community are not likely to be achieved.

Methodology:
Utilize GIS information and NRCS Soil Surveys to determine the best possible site location.

Comments:
Minimizing the number of reservoir locations reduces the design and construction costs as well. Managing land costs – smaller sites with greater depth – lower costs.

CERP assumed a storage depth of 8 feet for planning purposes, however, a storage depth of greater than 8 feet could yield a larger volume per acre ratio.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com

Criterion Name: HYDROLOGIC NETWORK	SSC –2.5.11
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**
Description: This screening criterion will provide an evaluation of each site for ease of water management, arrangement of cells, gravity flow, maintenance of adjacent existing water management systems, and distribution of flows.	
Storage Rationale: **Positive (+ 1)**: Little to no modification to existing hydrologic infrastructure is necessary to convey water to and from the storage feature. **Neutral (0)**: Some modification or addition to existing hydrologic infrastructure. **Negative (-1)**: Major modifications to existing or construction of new hydrologic infrastructure are necessary to convey water to and from the storage feature.	**Restoration Rationale:** **Positive (+ 1)**: Little to no modification to existing hydrologic infrastructure is necessary to convey water to and from the restoration feature. **Neutral (0)**: Some modification or addition to existing hydrologic infrastructnre. **Negative (- 1)**: Major modifications to existing or construction of new hydrologic infrastructure are necessary to convey water to and from the restoration feature.
Methodology: GIS/H&H exercise to determine the hydrologic infrastructure.	
Comments: Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.	
Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com	

Criterion Name:	**GROUNDWATER RECHARGE**	**SSC –2.5.12**
Level:	**2 - General Screening Criteria**	
Category:	**Land Condition**	

Description:

For the purposes of the se screening cr iteria, ground waters are cha racterized and re gulated in accordance with t he definitions and regulations provided in F ederal and St ate law. It is noted that when ground wat er recharge is the likely result of any specific feature, s pecial attention and po tential protective measures may be necessary to protect the quality of those ground waters and/or their uses. Federal and State regulations restrict the permitting/construction of pr ojects th at m ay cau se or co ntribute to th e degradation of groundwater resources and /or adv erse im pacts to existing legal users and sonrces of water. Impoundment of pollutant runoff from surface waters for a reservoir could result in the introduction of these contaminants to surficial aquifers (ground water).

Storage Rationale:

Positive (+ 1): Min imal p otential for grou nd water recharge.
Neutral (0): Mo derate p otential fo r grou nd water recharge.
(0*) Available in formation i s in sufficient to m ake a determination
Negative (-1): Co nsiderable p otential fo r ground water recharge.

Restoration Rationale:

Positive (+ 1): Co nsiderable p otential for g round water recharge.
Neutral (0): Moderate potential for ground water recharge.
(0*) Available in formation is in sufficient to m ake a determination.
Negative (- 1): Min imal p otential fo r ground water recharge.

Methodology:

Based on available soils, geological maps, recharge maps, well field protection maps, and/or other readily available literature, the degree of surface water and ground water interaction/connection at the site will be assessed.

Comments:

Storage Methodology: The objective is to minimize ground water and surface water interactions. The ability to store water in a reservo ir/impoundment is improved if ground water recharge rates at the site ar e minimal. The goal is to hold water in the reservoir/impoundment and minimize uncontrollable outflow.

Restoration Methodology: The objective is to provide for ground water and surface water in teractions. Th e ability recharge ground water near an aquifer recharge area a nd/or a wet land wi th ground water dom inated hydrology i s improved if ground w ater r echarge r ates at the site are c onsiderable. The go al is to in crease groun d water lev els and/or aquifer recharge rates by impounding water on t he site to enhance the quantity of ground water resources. If restoration is desired, special attention should be afforded to the quality water to be impounded.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Shawn Komlos, EPA / komlos.shawn@epamail.epa.gov

Criterion Name: SURFACE WATER	**SSC –2.5.13**
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
Surface waters are classified by public use criteria (Class I is potable, Class II is shellfish harvesting, and Class III is fishable/swimmable). Surface waters in Florida are considered "impaired" or degraded based upon water quality standards associated with these classifications and evaluative procedures established by the State in the "Impaired Waters Rule." Federal and State regulations restrict and in some cases preclude the permitting of projects in surface waters identified as failing to meet public use requirements.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Source water is not impaired or degraded. **Neutral (0):** Available information is insufficient to make a determination **Negative (-1):** Source water is impaired or degraded.	**Positive (+1):** Source water is not impaired or degraded. **Neutral (0):** Available information is insufficient to make a determination **Negative (-1):** Source water is impaired or degraded.

Methodology:
Maps and lists of waters classified as "impaired" or degraded according to the federal 303(d) list, State 305(b) list, or by other federal environmental assessments, i.e., EA, NEPA, and EIS. etc. will be reviewed to determine if the site is likely to receive from or discharge to water bodies with recognized water quality problems.

Comment:
Storage Comment: The objective is to allow for the capture and detention of as much water as is possible, while maximizing flexibility in storage feature operation. If tributaries that contribute water to the site have been identified as having water quality problems (i.e., excessive concentrations and /or loads of pollutants), future options for the correction of such problems may be reduced via the construction of the storage feature. It is recognized that STAs or other treatment may be needed to meet TMDLs once they are established.

Restoration Comment: If tributaries that contribute water to the site have been identified as having water quality problems (i.e., excessive concentrations and/or loads of pollutants), future options for the correction of such problems could be improved and/or expanded via the construction and/or incorporation of water quality treatment/enhancement features. However, for the purposes of restoration of on-site ecological conditions the goal is to import as little polluted water as possible onto the site to be restored.

This screening criterion is looking at on-site conditions and on-site habitat and the impacts that source water quality could have on those. The project should avoid point sources and not impair water bodies.

Author(s): Shawn Komlos, EPA/ komlos.shawn@epamail.epa.gov

Criterion Name: Hydraulic Differential	**SSC -2.5.14**
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
This screening criterion will provide an evaluation of each site for difference between that elevation and the elevation of the water source available for storage.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Less than 10 feet of difference. **Neutral (0)**: 10 to 20 feet of difference. **Negative (-1):** Greater than 20 feet of difference.	Same.

Methodology:
Utilizing existing topographic maps to determine the differential between the known elevations of the source water and the existing site ground elevation.

Comments:
The average elevation of the site and the difference between that elevation and the elevation of the water source available for storage is a factor to consider in selection of a desirable facility, be it reservoir or restoration. The greater the difference between the elevation at a site and the elevation in the C-43 or other identified source water body, the higher the lift required to move the water into storage; and potentially an increase in pumping cost or number of pumping stages. It is desirable to have a low a lift as necessary and sites with low average elevation relative to the reach on the C-43 will be ranked higher.
The proposed ranking scale is presented below, and takes into consideration the elevations of the water pools in the C-43.

Source Elevation in C-43 between S-79 and S-78, approximately 3 feet ngvd
Source Elevation in C-43 between S-78 and S-77, approximately 11 feet ngvd
Source Elevation in other source water bodies will be determined on a CBC basis.

Note
The criteria is not based on the actual average elevation but on a difference, sites in the East or West basin may have same elevation but differ in ranking due to difference in water level in the C-43 in either basin.
Higher cost associated with additional pumping is the primary undesirable factor
Less than 2 feet difference may necessitate pumping for both filling or releasing from project

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Alternative Development Sub Team

Criterion Name: Degree of Topographic Relief	**SSC –2.5.15**
Level: 2 - General Screening Criteria	
Category: **Land Condition**	

Description:
The degree of topographic relief on the site is a measure of elevation gradient across the site. A relatively flat site would have little change in elevation between its highest region and its lowest region. In the converse, a site with high topographic relief would have a large difference between the elevation at the highest region and elevation at the lowest region. We have used region in place of point in this definition to distinguish the effect of a local and isolated through or knoll (or mound) from that of a more widespread and extensive topographic feature.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Minimal differences in relief. Less than 2 feet of difference across the section. **Neutral (0)**: 2 to 6 feet of difference across the section. **Negative (-1):** Greater than 6 feet of difference across the section.	N/A

Methodology:
USGS Digital Elevation Maps

Comments:
Sites with high topographic relief would require significant earthwork and may limit design of a project by requiring sectioning /partitioning of the site where a single unpartitioned project might have been desirable. In the case of a reservoir, additional pumping / infrastructure may be required to move water between partitioned cells. It is desirable to have as low a topographic relief on the site as possible and sites with low topographic relief will be ranked higher.

A section refers to a one-mile area.

Author(s): Akinitunde Owosina, SFWMD, aowosin@sfwmd.gov

Criterion: WATER SUPPLY SEEPAGE ISSUES	SSC –2.5.16
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
This screening criterion will provide an evaluation of each site for effects of seepage on local water supply wells.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Potential for supplying water via seepage losses, criteria value. **Neutral (0)**: n/a. **Negative (- 1)**: In ability to su pply water via seep age losses.	Same
Storage Methodology:	**Restoration Methodology:**
Utilize a stan dard eng ineering ap proach for con trolling seepage, i.e. seep age collection, which would result in a positive 1 rating v ersus seep age cu toff, which would result in a negative1 rating.	

Comments:
Much of the study area (S-77 to S-79) residential water supply is provided by seepage from the agricultural irrigation seepage. This project m ust main tain th at type of su pply o r provide al ternative sources f or h uman con sumption. Ability to get seepage where and when needed, proximity to people and water supply intakes.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Agnes R amsey/Shawn Waldeck, SF WMD aramsey@sfwmd.gov, St anley C onsultants, I nc, waldeckshawn@stanleygroup.com

Criterion:	UNIQUE NATURAL AND MANMADE FEATURES	SSC –2.5.17
Level:	2 - General Screening Criteria	
Category:	Land Condition	

Description:
This criterion captures unique natural and manmade features that are not listed or eligible for listing on the National Register of Historic Places (NRHP). These would include areas of local and regional importance such as cemeteries, monuments, structures, geological features, significant trees, natural springs, etc.

Storage Rationale:	Restoration Rationale:
Positive (+ 1): No involvement, or site results in a positive impact to such features. **Neutral (0)**: Site results in no negative impacts. **Negative (-1)**: Site results in negative impacts to identified features.	Same
Storage Methodology:	**Restoration Methodology:**
Data sources would include Chambers of Commerce, County Historians, colleetive team knowledge, available maps, and/or reports regarding these types of features within the Caloosahatchee River (C-43) Basin.	Same

Comments:
Items included on the NRHP or eligible for listing fall under the Site Screening Criteria 2.2.3 Cultural Resources.

Author(s):
Sandy Scheda, SEA – Consultant, sscheda@scheda.com

Criterion Name: UNDESIR ABLE ADJACENT L AND US E INFLUENCES		**SSC –2.5.18**
Level:	**2 - General Screening Criteria**	
Category:	**Land Condition**	
Description: This screening criterion will provide an evaluation of each site for: landfills, fuel depots (gas stations), incinerators, water/wastewater treatment or supply facilities, mining, industrial/manufacturing facilities, and airports.		
Storage Rationale: **Positive (+1)**: No potential for land, groundwater, or airborne contamination. **Neutral (0)**: **Negative (-1)**: Potential contamination.	**Restoration Rationale:** **Positive (+ 1)**: No potential for land , groundwater, or airborne contamination. **Neutral (0)**: **Negative (-1)**: Potential contamination.	
Storage Methodology: Utilize land use maps and GIS information to determine adjacent land uses and determine potential contamination based on collective team knowledge.	**Restoration Methodology:** Same	
Comments: Not to put the reservoirs in areas that could be potentially contaminated and therefore spread the pollutauts to the estuary. Recognize the sensitivity of exposed water supply. Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.		
Author(s): Alternative Development Sub Team		

Criterion Name: CONFIGURATION COMPLEXITY	SSC –2.5.19
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
This screening criterion will provide an evaluation of each site for the potential design and construction complexity based upon site geometry.

Storage Rationale:	**Restoration Rationale:**
Positive (+ 1): If site consists of regularly shaped geometry, four sides/corners approx. 90 degree inside angles. **Neutral (0)**: If site consists of near regular shape, 5 – 6 corners, no inside corner angles less than 65 degrees. **Negative (-1)**: If site consists of very irregular shape, > 6 corners, inside corner angles of extreme size.	Same
Storage Methodology: Assessing the shape/configuration of each site on a case-by-case basis for overall shape as well as internal configuration utilizing county maps and GIS information.	**Restoration Methodology:**

Comments:
A site's shape will have a great impact upon the cost of design and construction as wells as the utility/functionality of the site.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com

Criterion: SITE SIZE	**SSC –2.5.2**
Level:	**2 - General Screening Criteria**
Category:	**Land Conditions**
Description:	
This screening criterion will provide an evaluation of each site for site size and ability to acquire adjacent sites if the site is less than one section or 640 acres	
Storage Methodology: **Positive (+1)**: If site is greater than 640 acres. **Neutral (0)**: If site is less than 640 acres and adjacent sites may be available for a cumulative total greater than 640 acres. **Negative (- 1)**: If site is less than 640 acres and no adjacent sites are available	**Restoration Methodology:** Not Applicable
Methodology: Utilize existing county plat maps as well as the County Property Appraiser's Offices website to determine site size.	
Comments: Size assumption is that one section/ 640 acres/ one square mile is capable of storing approximately. 5,000 ac-ft at a depth of approximately 8 feet.	
Author(s): Draft Approved by Site Selection Sub-Team 11/21/02	

Criterion Name: TAX BASED IMPACTS	**SSC –2.5.20**
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
Land use of industrial, commercial, residential, agricultural areas provide the tax base necessary for the counties to provide essential services. Conversion from these units will have an impact on the tax base.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Barren, vacant or abandoned lands when have been impacted. **Neutral (0)**: Unimproved or natural areas. **Negative (-1)**: Improved lands.	**Positive (+1)**: Barren, vacant or abandoned lands when have been impacted. **Neutral (0)**: Unimproved or natural areas. **Negative (-1)**: Improved lands.
Storage Methodology: GIS analysis of FLUCFCS LU/LC data	**Restoration Methodology:** Same

Comments:
Economic impacts are addressed under other criteria.
Improved land is defined as existing industrial, residential or commercial land.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Sandy Scheda, SEA – Consultant, sscheda@scheda.com

Criterion Name: SOIL CHEMISTRY SUITABILITY	SSC –2.5.21
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
This screening criterion will provide a potential contaminant evaluation of each site for suitability of in-situ soil conditions for the pre-construction and operation of storage features.

Storage Rationale:	**Restoration Rationale:**
Positive (+ 1): If soils are chemically suitable for construction of a storage feature with nominal likelihood for mitigation (or small degree of mitigation) or cleanup. **Neutral (0)**: Minimal chemical impacts and/or moderate likelihood for mitigation (or moderate degree of mitigation) or cleanup. **Negative (-1)**: Extensive chemical mitigation and/or considerable likelihood for mitigation (or considerable degree of mitigation) or cleanup.	**Positive (+1)**: If soils are suitable for restoration, minimal likelihood for cleanup. **Neutral (0)**: Unknown or moderate likelihood for cleanup. **Negative (-1)**: Considerable likelihood for cleanup.

Methodology:
Utilizing the IFAS/USDA/FDEP/local/or other databases and resources to identify the current and historical land uses for potential contaminant evaluation. Readily ascertainable databases.
This will not necessarily capture historical hazardous waste incidents, which are captured in the site criterion SSG 1.0.4 Known Superfund Sites.

Comments:
The degrees to which on-site soils may be potentially contaminated due to historical land use practices (such as agricultural, industrial, and/or former military) will likely affect project costs associated with on-site soil quality characterization and/or cleanup/remediation.

If contamination is found on a proposed site location, the private landowner must pay for the clean-up/remediation prior to handing it over to the Caloosahatchee River (C-43) Basin Storage Reservoir Project. However, if the land is under public ownership the Project will have to pay for the clean-up/remediation, which could increase the project costs.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com

Criterion Name: CURRENT LAND USE	SSC –2.5.3
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
Land use is categorized into industrial (planned or completed), commercial (planned or completed), residential (planned or completed), agricultural (row-crops, citrus, cane and pasture), unimproved natural areas or recreational areas.

Storage Rationale:	**Restoration Rationale:**
Positive (+ 1): Conversion of site's current land including agricultural crops, vacant residential, commercial or industrial, barren lands, and abandoned mines to storage facility results in a net positive affect. **Neutral (0)**: Conversion of site's land from improved pasture to storage facility results in no negative affects **Negative (-1)**: Conversion of site's land from unimproved natural areas, existing industrial, residential or commercial to storage facility results in net negative affect	**Positive (+ 1)**: Conversion of site's unimproved natural/native use to restored condition results in a net positive affect **Neutral (0)**: Conversion of site's cane, citrus, or seasonal row-crop or vacant residential, commercial or industrial, barren lands, abandoned mines use to restored condition results in no negative affects **Negative (- 1)**: Conversion of urban, industrial, commercial, or residential use to restoration facility results in net negative affect
Storage Methodology: GIS analysis of FLUCFCS LU/LC data	**Restoration Methodology:** Same

Comments:
Economic impacts are addressed under other criteria.

The conversions of certain land use types to storage facilities result in less environmental and social impacts to natural systems and local human populations. Areas that have been previously legally cleared without significant human infrastructure are predisposed for storage uses. The elimination of native habitats for man-made storage facilities can result in significant environmental impacts.

In contrast, restoration of existing degraded natural areas is easier to achieve, with less cost, using current restoration technologies. Areas developed in cane, citrus, seasonal row-crop, vacant lands, and old mines have been and can be restored using current restoration technologies but at a greater cost. Restoring existing urban, industrial, and commercial or residential land to natural conditions has not been demonstrated to be successful and has not been attempted in many cases due to economic and social costs.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Sandy Scheda / SEA – Consultant, sscheda@scheda.com

Criterion Name: NUMBER OF LAND OWNERS	**SSC –2.5.4**
Level: 2	**– General Screening Criteria**
Category:	**Land Condition**

Description:
Identify the number of parcels, including primary residences (permanent, year-round homes) and/or businesses that may need to be acquired in order to assemble a large enough site to implement the proposed project.

Storage and Restoration Rationale:
Positive (+1): Proposed site has only one landowner; strong potential for willing seller; no homeowners, tenants, and/or businesses who will need to be relocated in order to use the property.

Neutral (0): Less than five landowners; little possibility that condemnation will be necessary to acquire the required parcels; less than five homeowners, tenants, and/or businesses who will need to be relocated in order to use the property.

Negative (-1): Many land owners; strong possibility that condemnation will be necessary to acquire at least some of the required parcels; multiple homeowners, tenants, and/or businesses who will need to be relocated in order to use the property.

Storage and Restoration Methodology:
County Tax Assessor's records, including Tract and Property Ownership data.

Comments:
Dealing with conglomerates, corporations, and/or more than one individual landowner for the purchase of their property may add to the complexity and schedule for acquiring the property needed for the proposed project. If the property must be acquired through condemnation, rather than from willing seller(s), and/or there are property owners who are eligible for relocation, this could significantly impact the acquisition schedule and potentially impact the construction start date. This issue will be addressed more thoroughly in the Gross Appraisal for the selected plan. The target is to minimize the total number of primary residences and businesses that may need to be acquired to implement the proposed project.

A willing seller is defined as a landowner who has offered a potential site to the project.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Antonio Ayuso, Corps/Wanda Simpson, Corps/Susan Coughanour, SFWMD/ Antonio.D.Ayuso@saj02.usace.army.mil, wsimpso@sfwmd.gov, scoughan@sfwmd.gov,

Criterion Name: EXISTING LAND COVER	SSC –2.5.5
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
Conversion of land cover types to storage or restoration facilities may result in less environmental impacts to natural systems and listed species.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): Conversion of Site's current land cover to storage facility results in a net positive affect. **Neutral (0)**: Conversion of Site's land cover to storage facility results in no negative affects, or impacts can be mitigated to equal the same result **Negative (-1)**: Conversion of Site's land cover to storage facility results in net negative affect.	Same
Storage Methodology: GIS analysis of FLUCFCS LU/LC, and NWI data	**Restoration Methodology:** Same

Comments:

The conversions of certain land cover types to storage facilities result in less environmental impacts to natural systems and listed species that depend upon these habitats. Some areas that are legally cleared have no negative impacts since the land cover is predisposed for storage uses. The elimination of some land cover types such as invasive exotic vegetation can result in net positive environmental impacts.

In contrast restoration of existing degraded natural areas is easier to achieve, with less cost, using current restoration technologies. Areas developed in cane, citrus, seasonal row-crop, vacant lands, and old mines have been and can be restored using current restoration technologies but at a greater cost. Restoring existing urban, industrial, and commercial or residential land to natural conditions has not been demonstrated to be successful and has not been attempted in many cases due to economic and social costs.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Sandy Scheda / SEA – Consultant. sscheda@scheda.com

Criterion Name: PROXIMITY TO WATER RESOURCES	**SSC –2.5.6**
Level: 2 - General Screening Criteria	
Category: Land Condition	
Description: This screening criterion will provide an evaluation of the site and proximity to the available sources or receiving waters.	
Storage Rationale: **Positive (+1)**: If the project is hydraulically connected to the source or receiving body. **Neutral (0)**: If within 1 mile of source or receiving body based on the size of the overall project. **Negative (-1)**: If project is more than 1 mile from the source or receiving body based on the size of the overall project.	**Restoration Rationale:** Same
Storage Methodology: Utilize Land Use maps and GIS information.	**Restoration Methodology:** Same
Comments: Costs and reductions in losses of discharges based upon greater distances from the source as well as the topography differences in this basin, which would require multiple pump stations. In addition, additional land acquisition would be required for the construction of connections between the source and the project. Higher O&M costs and head losses for greater distance, system response to rain events or droughts. Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.	
Author(s): Agnes Ramsey/Shawn Waldeck, SF WMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com	

Criterion Name:	GEOTECHNICAL SOIL SUITABILITY	SSC –2.5.7
Level:	2 - General Screening Criteria	
Category:	Land Condition	

Description:
This screening criterion will provide a structural evaluation of each site for suitability of in-situ soil conditions for the construction and operation of storage features and suitability of soils for seepage control.

Storage Rationale:	Restoration Rationale:
Positive (+ 1): If soils are structurally suitable for construction of a reservoir with nominal likelihood for structural or seepage mitigation (or small degree of mitigation). **Neutral (0)**: Minimal structural or seepage impacts and/or moderate likelihood for mitigation (or moderate degree of mitigation). **Negative (- 1)**: Extensive structural or seepage mitigation and/or considerable likelihood for mitigation (or considerable degree of mitigation).	**Positive (+1)**: If soils are structurally suitable for restoration and/or groundwater recharge. **Neutral (0)**: Unknown. **Negative (- 1)**: Soils not suitable for restoration and/or groundwater recharge.
Storage Methodology: Utilize USGS and NRCS/USDA Soil Survey Information.	**Restoration Methodology:**

Comments:
Suitability for use in construction – structural fill for levees & roads, STA/wetland species, slope dressing, and seepage containment.

For Storage, minimizing seepage losses will improve the project efficiency. For Restoration, seepage will improve the groundwater table and water quality, potentially improving natural habitat. Seepage control costs will vary per site due to local geology and fill materials. Seepage issues are more inflammatory in urban/suburban areas.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com

Criterion Name: SITE LOCATION IN THE CONTRIBUTING WATERSHED – WATER QUANTITY	SSC –2.5.8
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
The storage screening criterion will provide an evaluation of each site's location within the watershed for the capture of runoff from watershed (S-77 to S-79).
The restoration screening criterion is tailored toward the ability to provide potential passive/natural storage in the upper tributary.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): If site could capture watershed runoff from >/= 75% of watershed area. **Neutral (0)**: If site could capture watershed runoff from 50 to 75% watershed area. **Negative (-1)**: If site captures watershed runoff of < 50% watershed area.	**Positive (+1)**: Upper tributary floodplain. Storage scheme supports natural hydroperiods. **Neutral (0)**: Location between upper tributary and tail water floodplains. **Negative (-1)**: Tail water floodplain.

Methodology:
Utilize the existing Caloosahatchee watershed map, other existing maps and GIS information.

Comments:
A sites ability to capture a significant amount of water would increase the overall project benefit to the estuary by reducing the impacts of runoff and providing the captured flows during dry periods. Amount of capture, % of basin runoff & volume. Dependent upon other sites under consideration.
Lake O releases can be caught anywhere in the Caloosahatchee River (C-43 Canal) and is therefore not location dependent.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Agnes Ramsey/Shawn Waldeck, SFWMD aramsey@sfwmd.gov, Stanley Consultants, Inc, waldeckshawn@stanleygroup.com

Criterion Name: SITE CONTRIBUTION TO LOAD	SSC 2.5.9
Level:	**2 - General Screening Criteria**
Category:	**Land Condition**

Description:
Does the site land use contribute degrading water quality constituents to the watershed, river, and estuary? By placing a storage or restoration feature within the watershed the load from runoff can be reduced in-place, and reduce the capacity / area needed for project features required for storage or water quality treatment needed for the project as a whole by removing a contributing source of load.

Storage Rationale:	**Restoration Rationale:**
Positive (+1): The land use conversion results in long-term load reduction. **Neutral (0)**: No positive or negative effects to long-term load reduction. **Negative (-1)**: Land use conversion could contribute to downstream water quality degradation.	**Positive (+1)**: Land use conversion results in long-term load reduction. **Neutral (0)**: No positive or negative effects to long-term load reduction. **Negative (-1)**: Land use conversion results in on-site loading.
Storage Methodology:	**Restoration Methodology:**
Urban and Agricultural - i.e. crops high contribution to loads in runoff Pasture – Low to Medium loads Natural Areas – Minimally contributes to loads, or does not contribute to loads.	Urban and Agricultural - i.e. crops high contribution to loads in runoff Pasture – Low to Medium loads Natural Areas – Minimally contributes to loads, or does not contribute to loads.

Comments:
Land use is categorized as Urban, Agricultural/Crops, Pasture and Natural. Other categories can be added as needed.

Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.

Author(s): Doris Marlin, Corps, Doris.A.Marlin@usace.army.mil

Criterion Name: IDENTIFY ENVIRONMENTAL JUSTICE	SSC – 2.6.1
Level: 2 - General Screening Criteria	
Category: Other Considerations	
Description: This screening criterion will provide an evaluation of each site for negative impacts to low income and minority populations.	
Storage and Restoration Rationale: **Positive (+1)**: If no displacement **Neutral (0)**: If no significant displacement **Negative (-1):** If significant displacement is likely to occur.	
Storage and Restoration Methodology: Utilize census data, collective team knowledge, community-based information, and any additional information sources, such as major employers of low income and minority populations in the region of the proposed site location.	
Comments: The area considered should evaluate those who live, frequent or rely on the resources of the affected area. There may be impacts to those living near the storage site. This is a preliminary evaluation for typical or foreseeable conditions and does not complete the analysis related to any specific selected site. Where subsistence-fishing opportunities are interrupted the impact warrants consideration. Where bank fishing is known to occur the assumption that subsistence-fishing opportunities exist is a reasonable assumption. When the displacement of subsistence-fishing opportunities occurs, the value may be neutral if these can be replaced. Census data is limited to the housing information on-site. Therefore, the census data would indicate where the population resides but would not indicate what activities are present and where they are located, such as subsistence fishing and work on agricultural lands. Census data where housing is displaced may be indicative if tract and site data match. Census data in rural areas is often not indicative, as tracts are large. Jobs will be related to economic activities that employ individuals affected by the site changes. Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation. Further evaluation will be made for construction and O&M access as alternatives are further developed.	
Author(s): Jerry Krenz, SFWMD, jkrenz@sfwmd.gov	

Criterion: RECREATION	**SSC – 2.6.2**
Level: 2 - General Screening Criteria	
Category: Other Considerations	
Description: This screening criterion will provide an evaluation of each site for displacement to public recreation and access.	
Storage and Restoration Rationale: **Positive (+1):** If no displacement or potential enhancement. **Neutral (0):** If no significant displacement. **Negative (-1):** If significant displacement is likely to occur.	
Storage and Restoration Methodology: Utilize land use maps and GIS information. As this is a preliminary evaluation no formal assessment process is expected. Utilize a visual assessment for evidence of boat ramps or other facilities and inquiry of local knowledge from known community leaders or SFWMD service center staff.	
Comments: Recreation includes passive hiking, wildlife viewing and other activities that may not easily be evidenced through this preliminary process. This is preliminary evaluation related to typical or foreseeable conditions and does not complete the analysis related to any specific selected site. Where displacement of activities occurs the value may be neutral if these can be replaced. A positive impact may occur if no passive recreation or access is present but it is likely to be gained. Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation. Further evaluation will be made for construction and O&M access as alternatives are further developed.	
Author(s): Jerry Krenz, SFWMD, jkrenz@sfwmd.gov	

TABLE F-6: SITE SCREENING MATRIX - STORAGE

Caloosahatchee River (C-43) West Basin Storage Reservoir Project - Site Screening Matrix (Storage)

Criteria ID	Gate Criteria GO / NO GO	Potential Sites																														
		P1	A	B	P1+A+B	P2	C Rvr Grv	D Dada	D Peep	D Bron	P2+C	P2+C+D	P2+D	P2E	P3W/4	P3	P3E	P4*	P5	P6**	P7***	P8****	P9*****	P10A	P10B	P10C	P10D	P10E Flirt	P11	P12	P13	P13 South	F Final
SSG 1.0.1	T&E Species/Habitat	Go	Go	Go	Go	No Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	No Go	Go	No Go	No Go	No Go	No Go			N/A	N/A	N/A	N/A	Go	No Go	No Go	Go	Go	Go
SSG 1.0.2	Significant Wetlands	Go	Go	Go	Go	No Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	No Go	No Go			N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go
SSG 1.0.3	Known Significant Cultural Resources	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go			N/A	N/A	N/A	N/A		Go	Go		Go	Go
SSG 1.0.4	Known Superfund Sites	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go			N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go
SSG 1.0.5	Safety Impacts	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go			N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go
SSG 1.0.6	Basin Location	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	No Go	No Go	No Go	No Go	N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go

Criteria ID	Screening Criteria +1 / 0 / -1	Potential Sites																														
		P1	A	B	P1+A+B	P2	C Rvr Grv	D Dada	D Peep	D Bron	P2+C	P2+C+D	P2+D	P2E	P3W/4	P3	P3E	P4*	P5	P6**	P7***	P8****	P9*****	P10A	P10B	P10C	P10D	P10E Flirt	P11	P12	P13	P13 South	F Final
SSC 2.1	**Utility**																															
SSC 2.1.1	Utility Impacts	-1	1	1	0		1	1	1	1	-1	1	1	-1	1		-1							N/A	N/A	N/A	N/A	1			-1	-1	-1
	Sub Total Score =	-1	1	1	0		1	1	1	1	-1	1	1	-1	1		-1	0	0	0	0	0	0	0	0	0	0	1			-1	-1	-1
SSC 2.2	**Use & Density Factors**																															
SSC 2.2.1	Wetland/Habitat	1	1	1	1		1	1	1	1	0	0	0	1	-1		1							N/A	N/A	N/A	N/A	1			1	0	1
SSC 2.2.2	Candidate or Protected Species/Wildlife/Habitat	1	1	1	1		1	1	1	1	0	0	0	0	-1		1							N/A	N/A	N/A	N/A	1			0	0	1
SSC 2.2.3	Cultural Resources	0	1	-1	0	0	-1	1	0	-1	0	0	0	1	1	0	-1							N/A	N/A	N/A	N/A					0	1
SSC 2.2.4	Conservation Lands	1	1	1	1		1	1	1	1	1	1	1	1	0		1	0	0					N/A	N/A	N/A	N/A	1	0		1	1	1
	Sub Total Score =	3	4	2	3		2	4	3	2	1	1	1	3	-1		2	0	0	1	0	0	0	0	0	0	0	3	0	0	2	1	4
SSC 2.3	**Regulatory or Legal Factors**																															
SSC 2.3.1	CLUP Compliance (Comprehensive Plan) includes Zoning	1	1	1	1		1	1	1	1	1	1	1	1	0		0							N/A	N/A	N/A	N/A	1			1	1	1
SSC 2.3.2	Pending Rule/Regulatory Compliance	1	1	1	1		1	1	1	1	1	1	1	1	1		1							N/A	N/A	N/A	N/A	1			1	1	1
SSC 2.3.4	Mitigation/Conservation Easement/Deed Restrictions	1	1	1	1		1	1	1	1	1	1	1	1	0		1							N/A	N/A	N/A	N/A	1			1	1	1

2699

Criteria ID	Screening Criteria +1 / 0 / -1	Potential Sites																																
		P1	A	B	P1+A+B	P2	C Rur Grv	D Dade	D Pomp	D Bron	P2+C	P2+C+D	P2+D	P2E	P1W/4	P3	P3E	P4	P5	P6	P7	P8	P9	P10A	P10B	P10C	P10D	P10E Flat	P11	P12	P13	P13 Swale	P14 F Pool	P14 (P1+A+B+F)
SSC 2.4	**Transportation Impacts**																																	
SSC 2.4.1	Construction/O&M Access	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	N/A	N/A	N/A	N/A	-1	1	1	0	0	1	1
SSC 2.4.2	Impacts to Existing Navigation & Transportation Infrastructure	0	0	0	0	1	0	0	0	0	1	-1	1	-1	1	1	0	1	1	1	1	1	N/A	N/A	N/A	N/A	-1	1	1	0	1	0	0
	Sub-Total Score =	1	0	0	1		1	1	1	1	0	0	0	0	2	2	1	0	1	0	0	0	0	0	0	0	-2	2	2	0	1	1	1
SSC 2.5	**Land Condition**																																	
SSC 2.5.1	Public Lands	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	N/A	N/A	N/A	N/A	0	1	1	1	1	1	1
SSC 2.5.2	Site Size	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1
SSC 2.5.3	Current Land Use	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1
SSC 2.5.4	Number of Land Owners	1	1	1	1	1	1	1	1	1	1	0	1	1	-1	1	1	0	0	0	0	0	N/A	N/A	N/A	N/A	0	1	1	-1	1	1	1
SSC 2.5.5	Existing Land Cover	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1
SSC 2.5.6	Proximity to Water Resources	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1
SSC 2.5.7	Geotechnical Soil Suitability	0	0	0	0	1	-1	0	1	0	-1	-1	-1	-1	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A	-1	0	0	0	0	0	0
SSC 2.5.8	Contributing Watershed - water quantity	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	1	1	1	1	1	N/A	N/A	N/A	N/A	0	0	1	0	0	1	1
SSC 2.5.9	Site Contribution to Load	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	N/A	N/A	N/A	N/A	0	0	0	0	0	1	1
SSC 2.5.10	Storage Capacity	1	0	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1
SSC 2.5.11	Hydrologic Network	0	0	0	0	1	1	1	1	1	1	0	0	1	0	1	0	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	1	1	0	0
SSC 2.5.12	Groundwater Recharge	1	0	0	0	0	0	1	1	1	1	1	1	1	-1	1	1	0	0	0	0	0	N/A	N/A	N/A	N/A	0	1	1	-1	-1	1	1
SSC 2.5.13	Surface Water	0	0	0	0	1	0	0	0	0	-1	-1	-1	-1	1	1	-1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	-1	-1	1	1
SSC 2.5.14	Hydraulic Differential	0	0	0	0	1	1	0	0	0	1	0	0	0	-1	0	1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	0	0	0	0
SSC 2.5.15	Degree of Topographic Relief	0	0	0	0	1	1	0	0	0	1	1	1	1	-1	0	1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	0	0	0	0
SSC 2.5.16	Water Supply Seepage Issues	1	1	1	1	1	-1	0	0	0	-1	-1	-1	-1	1	0	-1	0	0	0	0	0	N/A	N/A	N/A	N/A	0	1	1	1	1	1	1
SSC 2.5.17	Unique/Manmade Facilities	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1
SSC 2.5.18	Proximity to Undesirable Adjacent Land Use	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1
SSC 2.5.19	Configuration Complexity	0	0	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	1	1	0	0
SSC 2.5.20	Tax Based Impacts	-1	-1	-1	-1	1	-1	-1	-1	-1	0	0	0	0	-1	-1	-1	0	0	0	0	0	N/A	N/A	N/A	N/A	1	1	1	-1	-1	-1	-1
SSC 2.5.21	Soil Chemistry Suitability	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	N/A	N/A	N/A	N/A	1	1	1	0	0	0	0
	Sub-Total Score =	12	10	12	12		9	11	10	10	11	8	9	10	2	9	9	15	15	15	15	15	0	0	0	0	13	21	21	7	9	13	13

2700

Criteria ID	Screening Criteria +1 / 0 / -1	Potential Sites																																		
		P1	A	B	P1+A+B	P4	C Rvr Elev	D Drain	D Peep	D Brest	P2+C	P2+C+D	P2+D	P2E	P3W/4	P5	P5E	P6	P6E	P6W	P7	P8	P9	P10A	P10B	P10C	P10D	P10E Hist	P11	P12	P13	P13 South	F Pmt	P14 (P1+A+B+F)
SSC 2.6	**Other Considerations**																																			
SSC 2.6.1	Identify Environmental Justice (OJEEDT)	0	0	0	0	1	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A	1	0	0	0	0	0	0	0	0
SSC 2.6.2	Recreation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A	1	1	1	1	1	1	1	1	1
	Sub Total Score =	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	1	1	1	1	1	1
	Overall Score =	19	19	19	20	13	17	21	19	18	15	14	15	16	5	14	13	13	13	13	13	13	13	0	0	0	0	20	13	13	12	14	21	20		

*** P4 Location Combined with P3W/4**

**** P6 Location Combined with P10C Infrastructure Changes**

***** P7, 8 and 9 Sites Located Outside of the C43 Basin**

These features when combined with Lake Hicpochee constitute sufficient total storage capacity to be considered under the storage criteria

2701

TABLE F-7: SITE SCREENING MATRIX – RESTORATION

Caloosahatchee River (C-43) West Basin Storage Reservoir Project - Site Screening Matrix (Restoration)

Criteria ID	Gate Criteria GO / NO GO	Potential Sites																																				
		P1	A	B	P1+A+B	P2	C Rec Grv	D Dadn	D Pssy	D Bcon	P2+C	P2+C+D	P2+D	P2E	P3W/4	P3	P3E	P4	P5	P4**	P4***	P4****	P4*****	P10A	P10B	P10C	P10D	P10E Flet	P11	P12	P13	P13 South	F Paul	P14 (P1+A+B+F)	P15
SSG 1.0.1	T&E Species/Habitat	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go	Go	Go
SSG 1.0.2	Significant Wetlands	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go	Go	Go
SSG 1.0.3	Known Significant Cultural Resources	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go					N/A	N/A	N/A	N/A		Go	Go		Go	Go	Go	Go
SSG 1.0.4	Known Superfund Sites	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go			Go	Go	N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go	Go	Go
SSG 1.0.5	Safety Impacts	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go			Go	Go	N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go	Go	Go
SSG 1.0.6	Basin Location	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	Go	No Go	No Go	No Go	No Go	N/A	N/A	N/A	N/A	Go	Go	Go	Go	Go	Go	Go	Go

Criteria ID	Screening Criteria +1 / 0 / -1	Potential Sites																																				
		P1	A	B	P1+A+B	P2	C Rec Grv	D Dadn	D Pssy	D Bcon	P2+C	P2+C+D	P2+D	P2E	P3W/4	P3	P3E	P4	P5	P4**	P4***	P4****	P4*****	P10A	P10B	P10C	P10D	P10E Flet	P11	P12	P13	P13 South	F Paul	P14 (P1+A+B+F)	P15
SSC 2.1	**Utility**																																					
SSC 2.1.1	Utility Impacts	-1	1	1	0	1	-1	1	1	1	1	1	1	-1	1	1	-1		1					N/A	N/A	N/A	N/A	N/A	1		-1	-1	-1	-1	1
	Sub Total Score =	-1	1	1	0	1	-1	1	1	1	1	1	1	-1	1	1	-1	0	1	0	0	0	0	0	0	0	0	0	1	0	-1	-1	-1	-1	1
SSC 2.2	**Use & Density Factors**																																					
SSC 2.2.1	Wetland/Habitat	-1	-1	-1	-1	1	-1	-1	-1	-1	1	1	1	-1	0	0	-1		1					N/A	N/A	N/A	N/A	1	0		1	1	-1	-1	1
SSC 2.2.2	Candidate or Protected Species/Wildlife/Habitat	0	0	0	0	1	1	0	0	0	1	1	1	0	0	1	1		1					N/A	N/A	N/A	N/A	0	1		1	1	0	0	0
SSC 2.2.3	Cultural Resources	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					N/A	N/A	N/A	N/A		0			1	1	1	1
SSC 2.2.4	Conservation Lands	0	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0		0					N/A	N/A	N/A	N/A	0	0		0	0	0	0	0
	Sub Total Score =	0	0	0	0	4	2	1	0	0	4	4	4	0	1	2	1		3					0	0	0	0	1	1		2	3	0	0	0
SSC 2.3	**Regulatory or Legal Factors**																																					
SSC 2.3.1	CLLP Compliance (Comprehensive Plan) includes Zoning	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0		0					N/A	N/A	N/A	N/A	1	1		1	1	1	1	0
SSC 2.3.2	Pending Rule/Regulatory Compliance	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					N/A	N/A	N/A	N/A	1	1		1	1	1	1	1
SSC 2.3.4	Mitigation/Conservation Easement/Deed Restrictions	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1		0					N/A	N/A	N/A	N/A	1	1		1	1	1	1	0
	Sub Total Score =	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	2	0	1	0	0	0	0	0	0	0	0	3	3		3	3	3	3	1

2702

Criteria ID	Screening Criteria +1 / 0 / -1	P1	A	B	P1+A+B	P2	C-Kvr Grv	D-Dada	D-Peep	D-Boxo	P2+C	P2+C+D	P2+D	P2E	P3W4	P3	P3E	P4*	P5	P6**	P7**	P8**	P9**	P10A	P10B	P10C	P10D	P10E Fleet	P11	P12	P13	P13 - Scrub	F Paul	P14 (P1+A+B+F)
SSC 2.4	**Transportation Impacts**																																	
SSC 2.4.1	Construction/O&M Access	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1		0					N/A	N/A	N/A	N/A	-1	1		0	0	1	1
SSC 2.4.2	Impacts to Existing Navigation & Transportation Infrastructure	0	0	0	0	-1	0	0	0	0	-1	-1	-1	0	1	1	0		1					N/A	N/A	N/A	N/A	-1	1		0	1	0	0
	Sub-Total Score *	1	0	0	1	-1	1	1	1	1	0	0	0	1	2	2	1		1					0	0	0	0	-2	2		0	1	1	1
SSC 2.5	**Land Condition**																																	
SSC 2.5.1	Public Lands	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1		1					N/A	N/A	N/A	N/A	0	1		1	1	1	1
SSC 2.5.2	Site Size	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0					N/A	N/A	N/A	N/A	0	0		0	0	0	0
SSC 2.5.3	Current Land Use	0	0	0	0	1	0	0	0	0	1	1	1	0	1	0	0		1					N/A	N/A	N/A	N/A	0	1		0	0	0	0
SSC 2.5.4	Number of Land Owners	1	1	1	1	1	1	1	1	1	1	0	1	1	-1	1	1		0					N/A	N/A	N/A	N/A	0	1		-1	1	1	1
SSC 2.5.5	Existing Land Cover	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1		0					N/A	N/A	N/A	N/A	1	-1		0	1	1	1
SSC 2.5.6	Proximity to Water Resources	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1		0					N/A	N/A	N/A	N/A	1	-1		0	1	1	1
SSC 2.5.7	Geotechnical Soil Suitability	-1	-1	-1	-1	1	0	0	0	0	1	1	1	0	0	0	0		0					N/A	N/A	N/A	N/A	1	1		0	0	-1	-1
SSC 2.5.8	Contributing Watershed - water quantity	-1	-1	-1	-1	1	1	1	1	1	1	1	1	1	0	0	1		0					N/A	N/A	N/A	N/A	0	0		-1	1	1	0	-1
SSC 2.5.9	Site Contribution to Load	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1		0					N/A	N/A	N/A	N/A	0	0		0	0	1	1
SSC 2.5.10	Storage Capacity	0	0	0	0	1	1	0	0	0	1	1	1	1	1	0	0		1					N/A	N/A	N/A	N/A	1	1		0	0	0	0
SSC 2.5.11	Hydrologic Network	0	0	0	0	1	1	1	1	1	1	0	0	1	0	1	0		1					N/A	N/A	N/A	N/A	1	-1		1	1	0	0
SSC 2.5.12	Groundwater Recharge	-1	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1		0					N/A	N/A	N/A	N/A	0	-1		1	1	-1	-1
SSC 2.5.13	Surface Water	0	0	0	0	-1	0	0	0	0	-1	-1	-1	0	1	-1	-1		1					N/A	N/A	N/A	N/A	1	-1		-1	-1	1	1
SSC 2.5.14	Hydraulic Differential	0	0	0	0	1	1	0	0	0	1	0	0	0	-1	0	1		1					N/A	N/A	N/A	N/A	1	-1		0	0	0	0
SSC 2.5.15	Degree of Topographic Relief	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0					N/A	N/A	N/A	N/A	0	0		0	0	0	0
SSC 2.5.16	Water Supply Seepage Issues	1	1	1	1	-1	-1	0	0	0	-1	-1	-1	-1	1	0	-1		0					N/A	N/A	N/A	N/A	0	1		1	1	1	1
SSC 2.5.17	Unique/Manmade Facilities	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					N/A	N/A	N/A	N/A	1	1		1	1	1	1
SSC 2.5.18	Proximity to Undesirable Adjacent Land Use	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0		1					N/A	N/A	N/A	N/A	1	1		1	1	1	1
SSC 2.5.19	Configuration Complexity	0	0	1	1	1	1	1	0	1	1	1	1	1	1	0	1		1					N/A	N/A	N/A	N/A	1	1		1	1	0	0
SSC 2.5.20	Tax Based Impacts	-1	-1	-1	-1	1	-1	-1	-1	-1	0	0	0	0	-1	-1	-1		0					N/A	N/A	N/A	N/A	1	-1		-1	-1	-1	-1
SSC 2.5.21	Soil Chemistry Suitability	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0		1					N/A	N/A	N/A	N/A	1	1		0	0	0	0
	Sub-Total Score *	4	5	6	6	12	9	8	7	8	12	9	10	10	5	5	5	0	10	0	0	0	0	0	0	0	0	12	3	3	7	9	6	5

2703

Criteria ID	Screening Criteria +1 / 0 / -1	Potential Sites																																				
		P1	A	B	P1+A+B	P2	C Rsv Grv	D Dada	D Pasp	D Broo	P2+C	P2+C+D	P2+D	P2E	P3W4	P3	P3E	P4*	P5	P6**	P7***	P8***	P9***	P10A	P10B	P10C	P10D	P10E Flirt	P11	P12	P13	P13 South	F Paul	P14 P1+A+B+F)				
SSC 2.6	**Other Considerations**																																					
SSC 2.6.1	Identify Environmental Justice (OJEBECT)	0	0	0	0	1	0	0	0	0	0	0	0	0	-1	0	0		0					N/A	N/A	N/A	N/A	1	1		0	0	0	0				
SSC 2.6.2	Recreation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0		1					N/A	N/A	N/A	N/A	1	1		1	1	1	1				
	Sub Total Score =	1	1	1	1	2	1	1	1	1	1	1	1	1	0	0	0		1					0	0	0	0	2	2		1	1	1	1				
	Overall Score =	8	10	11	11	21	15	15	13	14	21	18	19	14	10	13	8	0	17					0	0	6	0	16	12		12	16	10	9				

* P4 Location Combined with P3W/4

** P6 Location Combined with P10C Infrastructure Changes

*** P7, 8 and 9 Sites Located Outside of the C43 Basin

2704

TABLE F-8: SITING METHODOLOGY SUMMARY

SCORING METHODOLOGY SUMMARY - GENERAL

* This document summarizes methodologies utilized, the site scoring process. Use this document with the scoring notes for storage and restoration

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments
THREATENED AND ENDANGERED SPECIES / HABITAT	GIS layers: T&E species	Endangered and Threatened Species – those animal and plant species defined by federal and/or state regulations to be endangered or threatened.	GO: Not likely to adversely affect threatened or endangered species or their habitat.	GO: Site implements recovery plan goals OR Site (either alone or when combined with other sites) results in the restoration goals being met (as defined in the projects "Goals and Objectives")	Direct impacts – GIS analysis	Direct impacts – GIS analysis	There are several threatened and endangered species found in the Caloosahatchee Basin, including the Florida panther (Felis concolor coryi), wood stork (Mycteria americana), Florida grasshopper sparrow (Ammodramus savannarum floridanus), West Indian manatee (Trichechus manatus), red-cockaded woodpecker (Picoides borealis), Florida scrub-jay (Aphelocoma coerulescens), Everglade snail kite (Rostrhamus sociabilis plumbeus), Audubon's crested caracara (Polyborus plancus audubonii), Bald eagle (Haliaeetus leucocephalus), Okeechobee gourd (Cucurbita okeechobeensis), Beautiful pawpaw (Deeringothamnus pulchellus). In addition, the Everglades snail kite has designated critical habitat.
	Known nesting areas: scrub	Habitat of Endangered and Threatened Species – defined as areas indicated on geographic information system maps of the USFWS and the FWC that contain habitats of endangered and threatened species including the zones established in the Florida Panther protection and Recovery Plan.	NO GO: Likely to adversely affect threatened or endangered species or their habitat	NO GO: Site (either alone or in rational combination with other sites) does not reasonably aid in meeting the project's restoration goals or is contrary to species recovery plan goals.	Secondary impacts – GIS analysis	Secondary impacts – GIS analysis	GIS materials include layers provided by USFWS and FWC associated with South Florida Multi-Species Recovery Plan, Southwest Florida Regional Wildlife Habitat Plan, and Closing the Gaps in Florida's Wildlife Habitat Conservation System.
	Native habitat: from National Wetlands Inventory (NWI) data				Native habitats shall be avoided as well as known nesting areas for these species on sites under consideration for storage.	Reference source material – South Florida Multi-species Recovery Plan, other adopted recovery plans and guidelines. Using a site that has been identified as habitat for threatened and endangered species for	
	T&E Species list for area						
	SW FL Regional Wildlife Habitat Plan						
SSG- SIGNIFICANT 1.02 WETLANDS	National Wetlands Inventory (NWI) data	Wetlands – those areas defined by federal and/or state regulations to be wetlands, in accordance with the regulation-prescribed hydrology, vegetation and soils criteria.	GO: Site results in no to minimal negative wetland impacts to significant wetlands.	GO: Site allows for wetland restoration benefits to target wetland types and an approximation of the original wetland function (either alone or when combined with other sites) results in some of the restoration goals being met (as defined in the project "Goals and Objectives")	Direct impacts – GIS analysis of NWI data	Direct impacts – GIS analysis of NWI data	1. GIS layers include EEA/FWC Wetlands of Significance or Listed Species and the Regionally Significant Wetlands Maps Developed in the Southwest Florida EIS and the LOCWSS (J. Beever 11/8/02). Secondary impacts will be considered in screening criteria.
	Wetland layers	Significant Wetlands – defined as one or a combination of the following:	NO GO: Site results in more than minimal impacts to significant wetlands.	NO GO: Site, alone or in rational combination with other sites, does not reasonably aid in meeting the project's restoration goals.	Direct - within footprint		2. Further detailed screening will occur during Alternatives evaluation.
	Wetlands of Significance list, Species and Regionally Significant Wetlands Maps	Wetlands of regional or state importance as defined by FAC 62-302. Wetlands, which also constitutes headwaters.					

2705

			Storage Rationale	Resources Rationale	Storage Methodology:	Resources Methodology:	
	Information Obtained	Description					Comment:
	Quad sheets for Caloosahatchee Basin	Wetlands, which if affected (positively or negatively), would result in substantial secondary impacts (which may also be positive or negative). Wetlands, which if negatively affected, could not be mitigated.					
	SW Florida EIS						
	NRCS Soil Survey Glades, Hendry, Lee County survey maps						
	GIS layers from SFA/USC						
SSC-1.83	KNOWN SIGNIFICANT CULTURAL RESOURCES	List of Historical Sites	Cultural resources – any prehistoric or historic district, site, building, structure, or object found in,	GO: Site results in no negative impacts to significant resources, or impacts, which can be practicably mitigated.	GO: Site results in no negative impacts to significant resources, or impacts, which can be practicably mitigated.	Utilizing existing and publicly available information.	Some	More detailed analysis will occur in future phases
		List of Cemeteries	or eligible for inclusion in the National Register of Historic Places (NRHP) (as defined by the National Historic Preservation Act of 1966, as amended).	NO GO: Site results in negative impacts to significant resources, which cannot be practicably mitigated.	NO GO: Site results in negative impacts to significant resources, which cannot be practicably mitigated.			Site results in area being rehydrated so its historic aesthetic appearance, OR site results in the preservation of human wooden or other organic artifacts whose condition has been degraded by dehydration.
		Nearby Archeological Sites						
		Existing Publicly available information						
SSC-1.84	KNOWN SUPERFUND SITES	Not Required	This criterion is based on whether or not a site is known as for on the USEPA Superfund hazardous waste sites list.	GO: Site is not listed as a Superfund site.	GO: Site is not listed as a Superfund site.	Compare the list of proposed sites to the list of sites on the Superfund cleanup list. (Note: There are no Superfund listed sites in Glades or Hendry Counties	Compare the list of proposed sites to the list of sites on the Superfund cleanup list. (Note: There are no Superfund listed sites in Glades or Hendry Counties	There are no superfund sites in Glades or Hendry counties.
		Site in Lee County is not in area being studied		NO GO: Site is listed as a Superfund Site.	NO GO: Site is listed as a Superfund Site.			
SSC-1.85	SAFETY IMPACTS	GIS maps	Initial review of the measures that will have to be taken to avoid or prevent the risks to human life, health, and safety by utilizing the site under review	NO GO: The site violates the criteria for dam/levee design currently utilized by the US ACOE standards or higher state standards.	N/A	GIS Assessment that identifies inhabited areas, and general topographic relief, with sites overlaid.	N/A	General JPEG file provided by SWFRPC. Sites identified as having a probability for loss of life enter intensive screening for Mitigation requirements; should such requirements not be able to be met, the site becomes removed from further consideration.
		Census Statistics		GO: The facility at the site can be designed to comply with the criteria for dam/levee design currently utilized by the US ACOE standards or higher state standards.		Distance to habited sites, and topographic assessment, can be evaluated.		Federal law PL 91-646 will be followed in the event of displacement of landowners.

2706

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comment
					Utilizing the design criteria identified above to perform an initial evaluation of suitability.		It is a requirement of CERP to maintain the existing level of flood protection in accordance with WRDA 2000 and applicable State regulations.
							It is recognized that the project will be designed to USACOE standards or higher state standards for public safety or the criteria being specifically adopted for the Comprehensive Everglades Restoration Plan, the more stringent of the criteria. This Gate Criterion relates to the following Screening Criterion: Buffer/Setbacks; and the Land Condition subgroup criteria of Current Land Use, Soils, Topographic Relief, and Configuration Complexity.

27707

	Information Obtained	Description	Storage Rationale	Extraction Rationale	Storage Methodology:	Extraction Methodology:	Comment
SSC- BASIN 1.06 LOCATION		This criterion is based on whether or not a site is known to be in the contributing watershed for the C-43 Basin.	GO : Site is in the C-43 Basin	Same	Compare the location of the proposed sites to the C-43 Basin Map	Same	To be accepted by the PDT
			NO GO : Site is not in the C-43 Basin				
SSC- UTILITY 2.1.3 IMPACTS - 11/15	Utilities maps	Utility Impacts include existing, authorized, and potential utility facilities and/or corridors that are/may be located within, across, and/or adjacent to a proposed project site.	Positive (+2): No existing utility lines, facilities, easements or fee corridors within or immediately adjacent to the proposed project site that would need to be relocated and/or incorporated into the project design.	Same	Use a combination of existing land use information, GIS mapping information, utility information, Sunshine State Utility Locator Service, planning documents, and on-site visits to identify existing, permitted,	Same	Existing or proposed utility lines and/or other utility facilities on and/or adjacent to a proposed project site may impact the design and/or implementation of the proposed project. In some cases, depending on the type of project proposed and the type of existing or proposed lines and/or facilities, it is possible to design the project in such a way that it avoids or minimizes impacts to the existing and/or proposed lines and/or facilities. In other cases, it may not be possible to build the project without relocating and/or modifying the lines and/or facilities. Power needs during construction and/or operation of the proposed project may also be a consideration depending on the location, size and type of proposed project. Depending on the type of line and/or facility,
	*Glades County- this information must be obtained directly from county	Utilities include above ground and underground electric power, telephone, cable, fiber optic cable, water, sewer, and similar lines and related facilities such as substations, switching stations, etc.	Local power distribution lines available to provide power during construction and for operational purposes upon project implementation without major relocation or connection costs. Neutral (0):		and proposed utility lines, facilities, and corridors and specific information about each including the size of the line and/or facility, whether it is a local or regional type line and/or facility, etc.		An additional consideration for utilities that have acquired lands by easement or fee for future lines and/or facilities, but have not yet applied for or received permits for those lines and/or facilities, is the extent to which those lands are part of their overall network for providing service within their service area and how they would impact their ability to meet their service requirements in the future. A related consideration is maintenance of access to these facilities during as well as post construction of the proposed project.
	Existing Land Use Information	Authorized facilities include those that have been permitted, but are not yet constructed and/or operational. Potential facilities/corridors include those for which land has been acquired by easement and/or fee but which have not yet been permitted for a specific use.	Existing utility lines, facilities, easements, etc. can be avoided and/or incorporated into the proposed project design with minimal impacts to the existing utility lines, facilities, easements, etc. and/or the project design or timetable and/or relocated at a minimal cost.Negative (-1): Existing utility lines, facilities, easements, etc.		The number and type (local versus regional service) of existing, permitted, and proposed lines and/or facilities will be evaluated to determine whether a positive, neutral or negative value will be assigned.		
	Utility Plans; Sunshine State Utility Locator Service		cannot be incorporated into the proposed project design and must be relocated at a significant cost in order to locate the project on the proposed site, including project construction and operational needs for power. This value may also be impacted by the number and type of utility lines, facilities, etc. that may need to be relocated.				

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments
KSC- WETLAND 2.2.1 HABITAT	GIS maps		Positive (+1): Potential site use results in no or low level negative wetland impacts, impacts are to lower quality wetland, impacts are mitigatible. Neutral (0): Potential site use results in a low to moderate level of negative wetland), impacts may also be to average quality wetlands, impacts are mitigatable.	Positive (+1): Site contains designated wetland restoration benefits Site potentially may increase the spatial extent of functional wetlands. Neutral (0): Site (either alone or when combined with other sites) results in some of the restoration goals being met (as defined in the projects "Goals and Objectives"). Negative (-1): Site does not reasonably aid in meeting the project's restoration goals.	Direct impacts – GIS analysis Secondary impacts – GIS analysis Uses other appropriate mapping resources such as smaller scale aerials to complete preliminary review of accuracy of GIS database	Same	
	Quad sheets		"Wetlands" means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands are generally classified as hydric or alluvial, and possess characteristics that are associated with reducing soil conditions.	Negative (-1): Potential site use results in high level of negative wetland impacts, impacts may also be to high quality wetland, impacts are difficult to mitigate.	Uses other appropriate mapping resources such as smaller scale aerials to complete preliminary review of accuracy of GIS database		Best professional analysis by team members with ecological expertise that identifies both isolated and interconnected systems that impact the site or are impacted by the site. Adjacent lands that can contribute to the restoration of or preservation of wetlands..
	GIS layers from USFWS, FWC	(Taken from FAC Chapter 62E-4.021, Definitions)	The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions desc These species, due to morphological, physiological, or reproductive adaptation, have the ability to grow, reproduce, or persist in aquatic environments or anaerobic soil conditions.				The screening for this item takes this into further detail than gate criteria.
			Florida wetlands generally include swamps, marshes, hardwoods, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, hydric seepage slopes, tidal marshes, mangrove swamps, and other similar areas. Florida wetlands generally do not include longleaf or slash pine flatwoods, with an understory dominated by saw palmetto, cited above.				

27709

	Information Obtained	Description	Storage Rationale	Restoration Rationale	Storage Methodology	Restoration Methodology	Comment
PROTECTED SPC- SPECIES / 2.2.2 WILDLIFE / HABITAT	GIS maps	Protected Species. These animal and plant species defined by federal and state regulations to be endangered, threatened, or species of special concern.	Positive (+1): Site location results in no adverse impacts to protected species, other wildlife, or their habitats.	Positive (+1): Restoration site implements goals to recover or restore protected species, wildlife, and their habitats	Direct impacts - GIS analysis	Direct impacts - GIS analysis	GIS materials include layers provided by USFWS and FWC associated with South Florida Multi-Species Recovery Plan, Southwest Florida Regional Wildlife Habitat Plan, and Closing the Gaps in Florida's Wildlife Habitat Conservation System
	FWC	Habitats of Protected Species and Wildlife. These areas are defined and maintained in geographic information system by both the USFWS and the FWC. These databases contain habitats of these species.	Neutral (0): Site location results in a slight adverse impact to protected species, other wildlife, or their habitats.	Neutral (0): Restoration site (either alone or when combined with other sites) results in the restoration goals being met.	Secondary impacts - GIS analysis	Secondary impacts - GIS analysis	
	GIS layer from USFWS, FWC		Negative (-1): Site location results in low to high level of adverse impacts to protected species, other wildlife, or their habitats, or site would require a review for potential take.	Negative (-1): Restoration site (either alone or in rational combination with other sites) is contrary to the recovery or restoration of protected species, wildlife or their habitats.		Additional source material - South Florida Multi-species Recovery Plan, other adopted recovery plans and guidelines.	
SSC- CULTURAL 2.2.3 RESOURCES	List of Historical Sites	Cultural resources – any prehistoric or historic district, site, building, structure, or object found in, or eligible for inclusion in the National Register of Historic Places (NRHP) (as defined by the National Historic Preservation Act of 1966 as amended)	Positive (+1): Site consists of less than 10% high probability areas or known cultural resource sites, which can be mitigated.	Positive (+1): Site results in no adverse effect or provides a beneficial effect to eligible historic properties.	Analysis would be conducted using the results of Probability Mapping for belowground resources. Considers location of known above-ground resources	Same	High Probability Areas are areas located by the confluence of creeks and larger bodies of water, and high areas in marshy areas.
	Probability Mapping		Neutral (0): Site consists of 10-20% high probability areas or contains one to three reported cultural resources, which can be mitigated cost-effectively.	Neutral (0): Site results in negative impacts to National Register Listed/Eligible resources, which can be mitigated cost-effectively.			In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, all adverse effects to cultural resources will be avoided or mitigated in consultation with the State Historic Preservation Officer.
			Negative (-1): Site consists of 20% or greater high probability areas or contains more than three reported cultural resources or any cultural resource listed on or determined eligible for the National Register of Historic Places, which cannot be mitigated cost-effectively.	Negative (-1): Site results in negative impacts to National Register Listed/Eligible resources, which cannot be mitigated cost-effectively.			
SSC- CONSERVATIO 2.2.4 N LANDS	GIS layer from USFWS, FWC/FDEP, SFWMD, and UF	Conservation Lands – those lands and waters in conservation and preservation protection defined by federal, state, regional local government or private conservation ownership, including conservation easements.	Positive (+1): Site results in no negative impacts to conservation lands or proposed conservation lands.	Positive (+1): Site implements conservation land or acquisition goals	Direct impacts – GIS analysis	Direct impacts – GIS analysis	There are several conservation lands and on-going conservation lands acquisition projects in the Caloosahatchee Basin, including the Florida panther Ecotone project.
	CARL 1999 layer	Proposed Conservation Lands – those lands and waters in conservation and preservation protection defined by federal, state, regional local government or private conservation ownership, including conservation easements that are on official listing or documents for acquisition in fee or less-than-fee.	Neutral (0): Site results have the potential to secondarily negatively impact the acquisition of proposed conservation lands either by physical or appraisal effects.	Neutral (0): Site (either alone or when combined with other sites) results in some of the restoration goals being met (as defined in the projects "Goals and Objectives")	Secondary impacts – GIS analysis	Secondary impacts – GIS analysis	The screening criteria shall prohibit the selection of sites that will not contribute to the protection of existing conservation lands or interfere with on-going conservation land acquisition in-fee or less-than-fee simple.

2710

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments
	Caloosahatchee Ecoscape		Negative (-1): Site results in negative impacts to existing conservation lands or proposed conservation lands by direct effects or preventing conservation areas or preventing acquisition for conservation purposes.	Negative (-1): Site (either alone or in combination with other Sites) does not reasonably aid in meeting the project's restoration goals or is contrary to conservation goals on existing and proposed	Additional material- official land acquisition proposal lists and documents	Additional material Conservation Lands Management Plans, other adopted restoration plans and guidelines.	GIS materials include layers provided by USFWS, FWC, FDEP, SFWMD, and LN associated with land acquisition programs including Florida Forever, Save Our Rivers, Lee County 2020, Southwest Florida Regional Wildlife Habitat Plan, and Closing the Gaps in Florida's Wildlife Habitat Conservation System.
	Save Our Rivers Map						
	Land Acquisition Programs						
	SW FL Regional Wildlife Habitat Plan						
COMPREHENSIVE 95C- VE LAND USE 2.5.1 PLAN & ZONING COMPLIANCE	Future Land Use - Lee County	Identify and consider impacts on the future use of the site resulting from the existing land use and other applicable designations(s) in the local government Comprehensive Land Use Plan (CLUP) and Zoning Code that govern the use of this site and adjacent lands.	Positive (+2): No changes or special approvals under the existing CLUP & Zoning designation for the site are required to implement the proposed project.	Same	Identify: (1) the applicable local government CLUP and Zoning Code designations which apply to the proposed site; (2) the applicable CLUP and Zoning designations and special overlays or approvals required that apply to the proposed site;		If the proposed use would require an amendment to the applicable CLUP or Zoning District in order for the site to be used, this could significantly impact the timetable for and cost of implementing the proposed project due to the amount of time that it typically takes to process a CLUP amendment and/or Zoning classification time. Local governments only allow amendments to their CLUP to be filed during a designated annual or bi-annual filing period, unless they are filed in conjunction with a Development of Regional Impact (DRI) application. It is unlikely that this project would qualify as a DRI. It usually takes several months to a year to process a CLUP amendment. Zoning change requests can typically
	Comp Plans		Neutral (0): The proposed use is compatible with the current CLUP for the site, but requires a special approval under the CLUP process or a zoning change in order to be implemented. These approvals can likely be obtained within the next 6 months due to the timing of the local government's next open application filing period for CLUP approvals.		(3) whether or not a CLUP amendment or special approval or zoning classification change by the local government is required to implement the project; (4) if a CLUP amendment or special approval or zoning change is required, the ability to prepare and file that request in a timely manner within the designated application filing periods.		There may some situations where: (1) a proposed use, such a reservoir, may be incompatible with an existing CLUP or zoning classification or overlay provision, such as preservation, without modifying the existing CLUP or zoning code designation or overlay; or (2) a proposed use may be allowed within an existing CLUP or Zoning Code designation, but only by special approval and subject to additional special conditions.
	CLUP/Zoning Districts		Negative (-1): The proposed use requires a change in the current CLUP designation for the site and corresponding zoning changes to implement the proposed project and/or it will likely take at least a year to process the request due to the timing of the local government's next open application filing period for CLUP changes.				
	DRI Applicants for area						

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comment
SSC- PENDING RULE 3.3.2 / REGULATORY	List of recently adopted rules/changes affecting project	Identify and consider the extent to which the proposed use of the site may be affected by: (1) rules that have recently been adopted but whose implementation is officially scheduled for a specific future date; and/or (2) proposed and/or on-going rule making activities. These rule making activities may be undertaken by local government, regional agencies (water management district/regional planning council/ other), state agencies, federal agencies, and/or Indian tribes.	Positive (+1): No recently adopted rules and/or pending rule-making activities that could affect how the site could be used for the proposed project. Neutral (0): Recently adopted rules and/or on-going rule making activities will have minimal impacts on how the site will be used for the proposed project since:	Same	(1) Identify all recently adopted rules and/or pending rule making activities by the applicable local, regional, state, and/or federal agencies and/or Indian Tribes that could affect how the site is used for the proposed project;	Same	Depending on the extent to which proposed, on-going and/or recently adopted rules/rule changes affect a project design, they could have a corresponding impact on the construction timetable and implementation dates for the proposed project. When new rules or rule changes are proposed or adopted, they typically specify a future effective date. They also specify whether the new rules are applicable to new applications only and/or to applications that have not yet been found to be complete by the reviewing agency by a specific implementation date. The content of the rule changes could also affect the proposed project design. Consequently, depending on the status of any permit applications already under review or
			(2) the content of the rule changes is such that it is not expected to significantly impact the project design; (2) the effective date of the adopted/proposed rules is far enough in the future that permits for the proposed project can likely be obtained prior to the rule changes going into effect.		(2) Review the content of the recently adopted/pending rules to identify potential impacts on project design and/or location;		
			Negative (-1): Recently adopted and/or proposed rule making activities address content areas likely to substantially affect the use of the site for the proposed project, particularly in terms of project design. Proposed rules and/or rule making activities are currently embroiled in extended legal proceedings regarding their validity.		(3) Review adopted/proposed implementation dates for potential impacts on permit application process and project timetables.		
SSC- MITIGATION / CONSERVATION EASEMENT / DEED RESTRICTIONS 3.3.2	Identify exist conservation easement/deed restrictions	Identify and consider impacts on the future use of the site resulting from existing mitigation areas, conservation easement, deed restrictions, or other legal limitations (by permit condition, land use designation, or other) on the use of the site.	Positive (+1): No existing conservation or other types of easements or deed restrictions on the property that would limit the proposed use of the property.		Identify: (1) all existing conservation easement and/or deed restrictions on all or part of the proposed site; (2) any other legally protected (by permit, land use designation, or other method) areas on all or part of the proposed site; (3) all limitations on allowable land uses and/or land use practices, water levels, clearing practices, operation and maintenance practices, including exotic control,	Same	It is assumed that mitigation lands, and other conservation management areas, are typically encumbered by conservation easement and/or some type of deed restrictions. Conservation easement, deed restrictions and/or other types of legal restrictions on land use may limit the use of the property and/or impact the design of the proposed project or facility as a result of restrictions on allowable land uses, land practices, water levels, control elevations, etc. Due to the nature of most mitigation areas, conservation or other types of easements/deed restrictions will typically limit water levels on that portion of the property covered by the easement/restriction and/or mitigation area and disallow its use as a
	legally protected lands		Neutral (0): Limitations associated with the existing conservation or other types of easements or deed restrictions on the property can be incorporated into the project design without significantly impairing the ability of the project to meet project goals.				It is assumed that impacts to natural wetland functions will be evaluated under separate criteria. The existence of these types of encumbrances on the property will influence property values. This issue will be addressed in the Green Appraisal.

2712

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments
			Negative (-1): Limitations associated with the existing conservation or other types of easements or deed restrictions on the property will significantly limit the ability of the site to be used for the proposed project design and/or be time consuming and costly to address.				
SSC-1.4.1 CONSTRUCTION / O & M ACCESS		This screening criteria will provide an evaluation of each site for temporary area of construction and permanent O&M access both to the site as well as existing internal roads and bridges which can be used during construction and/or built upon for future use. In addition, staging areas for construction and O&M would be included in the screening.	Positive (+1): If significant access is available.		By utilizing aerial photography and GIS - review existing on-site transportation infrastructure.	Same	Ingress & Egress to site (distance to and condition of existing roads & bridges) as well as internal infrastructure will impact the costs of construction as well as minimizing the impacts to surrounding areas during construction of the project hauling routes. Capability of the existing roads and bridges to accommodate construction vehicles, equipment, and large components of the project to H525 loading capability for bridges. Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.
			Neutral (0): If existing is not adequate for construction access.				
			Negative (-1): If impediments or costly improvements are required.				

2713

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comment:
EFFECTS TO EXISTING NAVIGATION AND TRANSPORTATION INFRASTRUCTURE SSC-2.4.2		This screening criterion will provide an evaluation of each site for impacts to existing navigation and transportation facilities, that are adjacent to the site and would be impacted by the construction and operation of the project. In addition, use of the existing transportation systems by heavy construction traffic may have impacts or be limited by the size and condition of the system.	Positive (+2): If project is compatible.		Utilize existing maps of navigational and highway transportation systems and GIS information.	Same	The navigation and transportation systems adjacent to the site may be impacted by the construction activities and by changes to the existing facilities in order to accommodate the project may impact the costs of construction. Capability of the existing locks, roads and bridges to accommodate construction vehicles, equipment and large components of the project; i.e. HS25 loading capability for bridges. Suitability for traffic detours if needed, future acoustic and road widening.
			Neutral (0): n/a				
			Negative (-2): If project is not compatible with the existing navigation and transportation systems.				
SSC-2.5.1 PUBLIC LANDS	GIS analysis	Public lands include those lands that are owned by the federal, state or local government, including sovereign and submerged lands. Sovereign lands include all lands under bodies of navigable water and tidelands within the territorial limits of the State of Florida. Conservation lands are not included in this description since they are described in SSC 2.2.4. Public lands include those lands that may have been acquired or designated for a variety of public uses, including stormwater management, recreation, public facilities, conservation or other	Positive (+2): Storage on site is consistent with the existing or intended use of this public site.	Positive (+1): Restoration on site is consistent with the existing or intended use of this public site. Land is adjacent to restoration corridors being identified and utilized in other public projects.	Hendry, Lee & Glades County Plat Books, Save our Rivers Maps GIS analysis of FLUCFCS LULC data	Same	The ability to use public lands for the proposed project may be impacted by (1) the purpose for which the land was originally acquired, including funding sources;
	Proposed Land Acquisition Plan		Neutral (0): Storage on site is not contrary to the existing or intended use of this public site.	Neutral (0): Restoration on site is not contrary to the existing or intended use of this public site.			(2) existing and/or planned public uses of the lands; and
	Grant Appraisal Report		Negative (-2): Storage on site is not consistent with the existing or intended use of this public site.	Negative (-1): Restoration on site is not consistent with the existing or intended use of this public site.			(3) the extent to which waterways, tidelands, and riparian lands are publicly and/or privately owned and/or controlled.
	Water and Surface Water Permits						Additional approvals and/or permits may be required to use public lands for a purpose that is different than the purpose for which it was originally acquired and/or what is allowed under the funding source used to acquire the property. If applicable to the site selected, sovereign lands will be addressed in the Grant Appraisal Report for the selected plan.
	Permit search						
	Save Our Rivers Map						
	County Plat Books						
SSC-2.5.2 SITE SIZE	Legal Descriptions	This screening criterion will provide an evaluation of each site for parcel size and ability to acquire adjacent parcels if the site is less than one section or 640 acres	Positive (+2): If site is greater than 640 acres.	Not Applicable	Utilize existing county plat maps as well as the Count Property Appraiser's Office website to determine parcel size.		Size assumption is that one section (640 acres) / one square mile is capable of storing approximately 3,000 ac-ft at a depth of approximately 5 feet.
			Neutral (0): If site is less than 640 acres and adjacent parcels may be available for a cumulative total greater than 640 acres.				

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comment:
			Negative (-1): If site is less than 640 acres and no adjacent parcels are available				
SSC- CURRENT 2.5.3 LAND USE	Future Land Use Maps	Land use is categorized into industrial (planned or completed), commercial (planned or completed), residential (planned or completed), agricultural (row-crops, citrus, cane and pasture), unimproved natural areas or recreational areas.	Positive (+1): Conversion of site's current land including agricultural crops, vacant residential, commercial or industrial, barren lands, abandoned mines to storage facility results in a net positive effect.	Positive (+1): Conversion of site's unimproved natural native use to restored condition results in a net positive effect	GIS analysis of FLUCFCS LU/LC data	Same	Ecological impacts are restoration under current criteria. The conversions of certain land use types to storage facilities result in less environmental and social impacts to natural systems and local human populations. Areas that have been previously legally cleared without significant human infrastructure are predisposed for storage uses. The elimination of native habitats for man-made storage facilities can result in significant environmental impacts. In contrast, restoration of existing degraded natural areas is easier to achieve, with less cost,
	Existing Comp Plans		Neutral (0): Conversion of site's land from improved pasture to storage facility results in no negative effects	Neutral (0): Conversion of site's cane, citrus, or seasonal row-crop or vacant residential, commercial or industrial, barren lands, abandoned mines use to restored condition results in no negative effects			
			Negative (-1): Conversion of site's land from unimproved natural areas, existing industrial, residential or commercial to storage facility results in net negative effect	Negative (-1): Conversion of urban, industrial, commercial, or residential use to restoration facility results in net negative effect			
SSC- NUMBER OF 2.5.4 LAND OWNERS	West Coast Land Management Region Map	Identify the number of parcels, including primary residences (permanent, year-round homes) and/or businesses that may need to be acquired in order to assemble a large enough site to implement the proposed project.	Positive (+1): Proposed site has only one landowner; strong potential for willing seller; no homeowners, tenants, and/or businesses who will need to be relocated in order to use the property.		County Tax Assessor's records, including Tract and Property Ownership data.		Dealing with conglomerates, corporations, and/or more than one individual landowner for the purchase of their property may add to the complexity and schedule for acquiring the property needed for the proposed project. If the property must be acquired through condemnation rather than from willing seller(s), and/or there are property owners who are eligible for relocation, this could significantly impact the acquisition schedule and potentially impact the construction start date. This issue will be addressed more thoroughly in the Grant Appraisal for the selected plan. The target is to minimize the total number of primary residences and businesses that may need to be acquired to implement the proposed project.
	County Tax Assessor Information		Neutral (0): Less than five landowners; little possibility that condemnation will be necessary to acquire the required parcels; less than five homeowners, tenants, and/or businesses who will need to be relocated in order to use the property.		5		A willing seller is defined as a landowner who has offered a potential site to the project.
			Negative (-1): Many landowners; strong possibility that condemnation will be necessary to acquire at least some of the required parcels; multiple homeowners, tenants, and/or businesses who will need to be relocated in order to use the property.				

2715

	Information Obtained	Description	Storage Rationale	Restoration Rationale	Storage Methodology	Restoration Methodology	Comment
SSC- EXISTING LS.5 LAND COVER	GIS analysis of FLUCFCS/LULC	Conversion of land cover types to storage or restoration facilities may result in less environmental impacts to natural systems and listed species.	Positive (+1): Conversion of Site's current land cover to storage facility results in a net positive effect.	Same	GIS analysis of FLUCFCS, LULC, and NWI data	Same	The conversions of certain land cover types to storage facilities result in less environmental impacts to natural systems and listed species that depend upon these habitats. Some areas that are legally cleared have no negative impacts since the land cover is predisposed for storage uses. The elimination of some land cover types such as invasive exotic vegetation can result in net positive environmental impacts.
	NWI data		Neutral (0): Conversion of Site's land cover to storage facility results in no negative effects, or impacts can be mitigated to equal the same result				In contrast restoration of existing degraded natural areas is easier to achieve, with less cost, using current restoration technologies. Areas developed in cane, citrus, seasonal row-crop, vacant lands, and old mines have been and can be restored using current restoration technologies but at a greater cost. Restoring existing urban, industrial, and commercial or residential land to natural conditions has not been demonstrated to be successful and has not been attempted in many cases due to economic and social costs.
			Negative (-1): Conversion of Site's land cover to storage facility results in net negative effect.				
SSC- PROXIMITY TO LS.6 WATER RESOURCES	Land Use Maps	This screening criterion will provide an evaluation of the site and proximity to the available sources or receiving waters.	Positive (+1): If the project is hydraulically connected to the source or receiving body.	Same	Utilize Land Use maps and GIS information.	Same	Costs and reductions in losses of discharges based upon greater distances from the source as well as the topography differences in this basin, which would require multiple pump stations. In addition, additional land acquisition would be required for the construction of connection between the source and the project. Higher O&M costs and head losses for greater distance, system response to rain events or droughts.
	GIS		Neutral (0): If within 1 mile of source or receiving body based on the size of the overall project.				
SSC- GEOTECHNICA LS.7 L/SOIL SUITABILITY	Geotechnical Report - Hendry County	This screening criterion will provide a structural evaluation of each site for suitability of in-situ soil conditions for the construction and operation of storage features, and suitability of soils for seepage control.	Positive (+1): If soils are structurally suitable for construction of a reservoir with nominal likelihood for structural or seepage mitigation (or small degree of mitigation).	Positive (+1): If soils are structurally suitable for restoration and/or groundwater recharge.	Utilize USGS and NRCS/USDA Soil Survey Information.		Suitability for use in construction – structural fill for levees & roads, STA/wetland species, slope dressing, and seepage containment.
	USGS quad Sheets		Neutral (0): Minimal structural or seepage impacts and/or moderate likelihood for mitigation (or moderate degree of mitigation).	Neutral (0): Unknown.			For Storage, minimizing seepage losses will improve the project efficiency. For Restoration, seepage will improve the groundwater table and water quality, potentially improving natural habitat. Seepage control costs will vary per site due to local geology and fill materials. Seepage issues are more inflammatory in urban/suburban areas.
			Negative (-1): Extensive structural or seepage mitigation and/or considerable likelihood for mitigation (or considerable degree of mitigation).	Negative (-1): Soils not suitable for restoration and/or groundwater recharge			

2716

			Storage Rationale	Restoration Rationale	Storage Methodology	Restoration Methodology	
	Information Obtained	Description					Comments
SSC-2.5.5 SITE CONTRIBUTION - WATERSHED - WATER QUANTITY	Used infrared map coverage with coverage of project sites provided by Schedo on 01/13/05. Need topo map provided by ACE. Not available at time of this screening.	The storage screening criterion will provide an evaluation of each site's location within the watershed for the capture of runoff from watershed (See 77 on S-79).	Positive (+1): If site could capture watershed runoff from >= 75% of watershed area.	Positive (+1): Upper tributary floodplain. Storage scheme supports natural hydroperiods.	Utilize the existing Caloosahatchee watershed map, other existing maps and GIS information.		A sites ability to capture a significant amount of water would increase the overall project benefit to the estuary by reducing the impacts of runoff and providing the captured flows during dry periods. Amount of capture, % of basin runoff & volume. Dependent upon other sites under consideration.
	Caloosahatchee Watershed Map	The restoration screening criterion is tailored toward the ability to provide potential passive/natural storage in the upper tributary.	Neutral (0): If site could capture watershed runoff from 50 to 75% watershed area.	Neutral (0): Location between upper tributary and tail water floodplains.			Lake O releases can be caught anywhere in the C-43 Canal and is therefore not location dependent.
			Negative (-1): If site captures watershed runoff of < 50% watershed area.	Negative (-1): Tail water floodplain.			Reviewed and accepted by the sub team, pending full PDT concurrence with this recommendation.
SSC-2.5.6 SITE CONTRIBUTION TO LOAD	Pump station data	Does the site land use contribute degrading water quality constituents to the watershed, river, and estuary? By placing a storage or restoration feature within the watershed the land from runoff can be reduced in-place, and reduce the capacity / area needed for project features required for storage or water quality treatment needed for the project as a whole by removing a contributing source of load.	Positive (+1): The land use conversion results in long-term load reduction.	Positive (+1): Land use conversion results in long-term load reduction.	Urban and Agricultural - i.e. crops high contribution to loads in runoff	Urban and Agricultural - i.e. crops high contribution to loads in runoff	Land use is categorized as: Urban, Agricultural/Crops, Pasture and Natural. Other categories can be added as needed.
	Land runoff Data		Neutral (0): No positive or negative effects to long-term load reduction.	Neutral (0): No positive or negative effects to long-term load reduction.	Pasture – Low to Medium loads	Pasture – Low to Medium loads	
			Negative (-1): Land use conversion could contribute to downstream water quality degradation.	Negative (-1): Land use conversion results in on-site loading.	Natural Areas – Minimally contributes to loads, or does not contribute to loads.	Natural Areas – Minimally contributes to loads, or does not contribute to loads.	
SSC-2.5.1 0 STORAGE CAPACITY	GIS analysis	This screening criterion will provide an evaluation of each site for the volume of storage capacity.	Positive (+1): If site could store greater than 10,000 ac-ft.	Positive (+1): Depths and hydroperiods appropriate for the maintenance of the natural community can be achieved.	Utilize GIS information and NRCS Soil Surveys to determine the best possible site location.		Minimizing the number of reservoir locations reduces the design and construction costs as well. Managing land costs – smaller sites with greater depth – lower costs.
	NRCS Soil Surveys		Neutral (0): If site could store 5,000 to 10,000 ac-ft.	Neutral (0): Uncertain.			CERP assumed a storage depth of 8 feet for planning purposes, however, a storage depth of greater than 8 feet could yield a larger volume per acre ratio.
			Negative (-1): If site could store < 5,000 ac-ft.	Negative (-1): Depths and hydroperiods appropriate for the maintenance of the natural community are not likely to be achieved.			

2717

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments:
SSC-1.5.1 HYDROLOGIC NETWORK	Does network map coverage with coverage of project sites provided by Schedule on 02/13/03. H&H modeling not well advanced to determined actual level of pumping required. Determination of level of infrastructure based on how	This screening criterion will provide an evaluation of each site for ease of water management, arrangement of well, gravity flow, maintenance of adjacent existing water management systems, distribution of flow.	Positive (+1): Little to no modification to existing hydrologic infrastructure is necessary to convey water to and from the storage feature.	Positive (+1): Little to no modification to existing hydrologic infrastructure is necessary to convey water to and from the restoration feature.	GIS/H&H exercise to determine the hydrologic infrastructure.		
	GIS layers		Neutral (0): Some modification or addition to existing hydrologic infrastructure.	Neutral (0): Some modification or addition to existing hydrologic infrastructure.			
			Negative (-1): Major modifications to existing or construction of new hydrologic infrastructure are necessary to convey water to and from the storage feature.	Negative (-1): Major modifications to existing or construction of new hydrologic infrastructure are necessary to convey water to and from the restoration feature.			

2718

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comment
WSG-2.5.1 GROUNDWATER RECHARGE	Soils and Geological Maps	For the purposes of these screening criterion, ground waters are characterized and regulated in accordance with the definitions and regulations provided in Federal and State law. It is noted that when ground water recharge is the likely result of any specific feature, special attention and potential protective measures may be necessary to protect the quality of these ground waters and/or their use. Federal and State regulations restrict the permitting/construction of projects that may cause or contribute to the [illegible]	Positive (+1): Minimal potential for ground water recharge.	Positive (+1): Considerable potential for ground water recharge.	Based on available soils, geological maps, recharge maps, well field protection maps, and/or other readily available literature, the degree of surface water and ground water interaction/connection at the site will be	Some	Storage Methodology: The objective is to minimize ground water and surface water interactions. The ability to store water in a reservoir/impoundment is improved if ground water recharge rates at the site are minimal. The goal is to hold water in the reservoir/impoundment and minimize unaccountable outflow.
			Neutral (0): Moderate potential for ground water recharge.	Neutral (0): Moderate potential for ground water recharge.	Based on available soils, geological maps, recharge maps, well field protection maps, and/or other readily available literature, the degree of surface water and ground water interaction/connection at the site will be assessed.		Restoration Methodology: The objective is to provide for ground water and surface water interactions. The ability recharge ground water near an aquifer recharge area and/or a wetland with ground water dominated hydrology is improved if ground water recharge rates at the site are considerable. The goal is to increase ground water levels and/or aquifer recharge rates by impounding water on the site to enhance the quantity of ground water recourses. If restoration is desired, special attention should be afforded to the quality water to be impounded.
			(0*) Available information is insufficient to make a determination	(0*) Available information is insufficient to make a determination.			
			Negative (-1): Considerable potential for ground water recharge.	Negative (-1): Minimal potential for ground water recharge.			
WSC-2.5.3 SURFACE WATER		Surface waters are classified by public use criteria (Class I is potable, Class II is shellfish harvesting, and Class III is fishable/swimmable). Surface waters in Florida are considered "impaired" or degraded based upon water quality standards associated with these classifications and evaluative procedures established by the State in the "Impaired Waters Rule." Federal and State regulations restrict and in some cases preclude the permitting of projects in surface waters identified as failing to meet public use requirements	Positive (+1): Source water is not impaired or degraded. Neutral (0): Available information is insufficient to make a determination Negative (-1): Source water is impaired or degraded.	Positive (+1): Source water is not impaired or degraded. Neutral (0): Available information is insufficient to make a determination Negative (-1): Source water is impaired or degraded.	Maps and lists of waters classified as "impaired" or degraded according to the federal 303(d) list, State 303(b) list, or by other federal environmental assessments, i.e., EA, NEPA, EIS, etc. will be reviewed to determine if the site is likely to receive from or discharge to water bodies with recognized water quality problems.	Some	Storage Comment: The objective is to allow for the capture and detention of as much water as is possible, while maximizing flexibility in storage feature operation. If tributaries that contribute water to the site have been identified as having water quality problem (i.e., excessive concentrations and/or loads of pollutants), future options for the correction of such problems may be reduced via the construction of the storage feature. It is recognized that NPAs or other treatment may be needed to meet TMDLs once they are established.
							Restoration Comment: If tributaries that contribute water to the site have been identified as having water quality problems (i.e., excessive concentrations and/or loads of pollutants), future options for the correction of such problems could be improved and/or expanded via the construction and/or incorporation of water quality treatment/enhancement features. However, for the purposes of restoration of on-site ecological conditions the goal is to import as little polluted water as possible onto the site to be restored.

2719

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comment
							This screening criterion is looking at on-site conditions and on-site habitat and the impacts that source water quality could have on those. The project should avoid point sources and not impair water bodies.
SSC-2.5.1.4	HYDRAULIC DIFFERENTIAL						
	Used coverage of project sites provided by Scheda on 02/13/03. Not available at time of this screening				Utilizing existing topographic maps to determine the differential between the known elevations of the source water and the existing site ground elevation.	Same	The average elevation of the site and the difference between that elevation and the elevation of the water source available for storage is a factor to consider in selection of a desirable facility, be it reservoir or restoration. The greater the difference between the elevation at a site and the elevation in the C-43 or other identified source water body, the higher the lift required to move the water into storage; and potentially an increase in pumping cost or number of pumping stages. It is desirable to have as low a lift as necessary and sites with low average elevation relative to the reach on the C-43 will be ranked higher.
	USGS Topographical maps						The proposed ranking scale is presented below, and takes into consideration the elevations of the water pools in the C-43.
							Source Elevation in C-43 between S-79 and S-78, approximately 5 feet msvd
							Source Elevation in C-43 between S-78 and S-77, approximately 11 feet msvd
							Source Elevation in other source water bodies will be determined on a CBC basis.
							Note
							(1) The criteria is not based on the actual average elevation, but on a difference, sites in the East or West basin may have same elevation but differ in ranking due to difference in water level in the C-43 in either basin.
							(2) Higher cost associated with additional pumping is the primary undesirable factor
							(3) Less than 2 feet difference may necessitate pumping for both filling or releasing from

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments
SWSC-2.5.3.5 DEGREE OF TOPOGRAPHIC RELIEF	USGS Maps	The degree of topographic relief on the site is a measure of elevation gradient across the site. A relatively flat site would have little change in elevation between its highest region and its lowest region. In the converse, a site with high topographic relief would have a large difference between the elevation at the highest region and elevation at the lowest region. We have used region in place of point in this definition to distinguish the effect of a local and isolated through or knoll (or mound) from that of a	Positive (+1): Minimal differences in relief. Less than 2 feet of difference across the section.	N/A	USGS Digital Elevation Maps		Sites with high topographic relief would require significant earthwork and may limit design of a project by requiring sectioning /partitioning of the site where a single unpartitioned project might have been desirable. In the case of a reservoir, additional pumping / infrastructure may be required to move water between partitioned cells. It is desirable to have as low a topographic relief on the site as possible and sites with low topographic relief will be ranked higher.
			Neutral (0): 2 to 6 feet of difference across the section.				A section refers to a one-mile area.
SSC-2.5.1.6 WATER SUPPLY SEEPAGE ISSUES	GIS/ Coverage of the process of developing freshness potential maps and defining areas of potential recharge for C-43 watershed. Freshness potential maps developed for south of C-43 canal as part of SWFS. (Map 22) in GPD/cubic foot. Used infrared map coverage with coverage of project sites provided by Schada on 03/13/03.	This screening criterion will provide an evaluation of each site for effects of seepage on local water supply wells.	Positive (+1): Potential for supplying water via seepage losses, criteria value.	Same	Utilize a standard engineering approach for controlling seepage, i.e. seepage collection, which would result in a positive 1 rating versus seepage cutoff, which would result in a negative1 rating.		Much of the study area (S-77 to S-79) residential water supply is provided by seepage from the agricultural irrigation seepage. This project must maintain that type of supply or provide alternative sources for human consumption. Ability to get seepage where and when needed, proximity to people and water supply intakes.
			Neutral (0): n/a.				
			Negative (-1): Inability to supply water via seepage losses.				
SSC-2.5.1.7 UNIQUE NATURAL AND MANMADE FEATURES		This criterion captures unique natural and manmade features that are not listed or eligible for listing on the National Register of Historic Places (NRHP). These would include areas of local and regional importance such as cemeteries, monuments, structures, geological features, significant trees, natural springs, etc.	Positive (+1): No involvement, or site results in a positive impact to such features.	Same	Data sources would include Chambers of Commerce, County Historians, collective team knowledge, available maps, and/or reports regarding these types of features within the C-43 Basin.	Same	Items included on the NRHP or eligible for listing fall under the Site Screening Criteria 2.2.3 Cultural Resources.
			Neutral (0): Site results in no negative impacts.				
			Negative (-1): Site results in negative impacts to identified features.				

2721

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments
SSC-2.5.4 UNDESIRABLE ADJACENT LAND USE INFLUENCES	GIS	This screening criterion will provide an evaluation of each site for: landfills, fuel depots (gas stations), incinerators, water/wastewater treatment or supply facilities, mining, industrial/manufacturing facilities, and airports.	Positive (+1): No potential for land, groundwater, or airborne contamination.	Positive (+1): No potential for land, groundwater, or airborne contamination.	Utilize land use maps and GIS information to determine adjacent land use and determine potential contamination based on collective team knowledge.	Same	Not to put the reservoir in areas that could be potentially contaminated and therefore spread the pollutants in the estuary. Recognize the sensitivity of exported water supply.
	Land Use maps		Neutral (0):	Neutral (0):			
			Negative (-1): Potential contamination.	Negative (-1): Potential contamination.			
SSC-2.5.5 CONFIGURATION COMPLEXITY	Topographical Maps	This screening criterion will provide an evaluation of each site for the potential design and construction complexity based upon site geometry.	Positive (+1): If site consists of regularly shaped geometry, four sides/corners approx. 90 degree inside angles.		Assessing the shape/configuration of each site on a case-by-case basis for overall shape as well as internal configuration utilizing county maps and GIS information.		A site's shape will have a great impact upon the cost of design and construction as well as the utility/functionality of the site.
			Neutral (0): If site consists of non-regular shape, 5 – 6 corners, no inside corner angles less than 65 degrees.				
			Negative (-1): If site consists of very irregular shape, > 6 corners, inside corner angles of extreme size.				

2722

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comments
SSC-2.5.2 TAX BASED IMPACTS	GIS of FLUCCS/LULC data	Land use of industrial, commercial, residential, agricultural areas provide the tax base necessary for the counties to provide essential services. Conversion from these units will have an impact on the tax base.	Land use of industrial, commercial, residential, agricultural areas provide the tax base necessary for the counties to provide essential services. Conversion from these units will have an impact on the tax base.	Positive (+1): Barren, vacant or abandoned land: when have been impacted.	GIS analysis of FLUCFCS/LULC data	GIS analysis of FLUCFCS/LULC data	Economic impacts are addressed under another criteria.
				Neutral (0): Unimproved or natural areas.			Improved land is defined as existing industrial, residential or commercial land.
SSC-2.5.3.1 SOIL CHEMISTRY SUITABILITY	DEAS/USDA/FDEP local or other database	This screening criterion will provide a potential contaminant evaluation of each site for suitability of in-situ soil conditions for the pre-construction and operation of storage features.	Positive (+1): If soils are chemically suitable for construction of a storage feature with minimal likelihood for mitigation (or small degree of mitigation) or cleanup.	Positive (+1): If soils are suitable for restoration, minimal likelihood for cleanup.	Utilizing the DEAS/USDA/FDEP/local/or other databases and resources to identify the current and historical land uses for potential contaminant evaluation. Readily ascertainable databases.		The degree to which on-site soils may be potentially contaminated due to historical land use practices (such as agricultural, industrial, and/or former military) will likely affect project costs associated with on-site soil quality characteristics and/or cleanup/remediation.
			Neutral (0): Minimal chemical impacts and/or moderate likelihood for mitigation (or moderate degree of mitigation) or cleanup.	Neutral (0): Unknown or moderate likelihood for cleanup.	This will not necessarily capture historical hazardous waste incidents, which are captured in the site criterion SSC 1.3.4 Known Superfund Sites.		If contamination is found on a proposed site location, the private landowner must pay for the clean-up/remediation prior to handing it over to the C-43 Basin Storage Reservoir Project. However, if the land is under public ownership the Project will have to pay for the clean-up/remediation, which could increase the project cost.
			Negative (-1): Extensive chemical mitigation and/or considerable likelihood for mitigation (or considerable degree of mitigation) or cleanup.	Negative (-1): Considerable likelihood for cleanup.			
SSC-2.6.1 IDENTIFY ENVIRONMENTAL JUSTICE	Census data	This screening criterion will provide an evaluation of each site for negative impacts to low income and minority populations.	Positive (+1): If no displacement	Same	Utilize census data, collective team knowledge, community-based information, and any additional information sources, such as major employers of low income and minority populations in the region of the proposed site location.	Same	The area considered should evaluate those who live, frequent or rely on the resources of the affected area. There may be impacts to those living near the storage site.
			Neutral (0): If no significant displacement				This is a preliminary evaluation for typical or foreseeable conditions and does not complete the analysis related to any specific selected site. When subsistence-fishing opportunities are interrupted the impact warrants consideration. Where bank fishing is known to occur the assumption that subsistence-fishing opportunities exist is a reasonable assumption. When the displacement of subsistence-fishing opportunities occurs, the value may be neutral if these can be replaced.

2723

			Storage Rationale	Restoration Rationale	Storage Methodology:	Restoration Methodology:	
	Information Obtained	Description					Comment
			Negative (-1): If significant displacement is likely to occur.				Census data is limited to the housing information on-site. Therefore, the census data would indicate where the population resides but would not indicate what activities are present and where they are located, such as subsistence fishing and work on agricultural lands. Census data where housing is displaced may be indicative if exact and site data match. Census data in rural areas is often not indicative, as tracts are large. Jobs will be related to economic activities that employ individuals affected by the site changes.
							Further evaluation will be made for construction and O&M screen as alternatives are further developed.
3SC-2.6.1 RECREATION	Aerials	This screening criterion will provide an evaluation of each site for displacement to public recreation and access.	Positive (+1): If no displacement or potential enhancement.	Same	As this is a preliminary evaluation no formal assessment process is expected. Utilize a visual assessment for evidence of boat ramps or other facilities and inquiry of local knowledge from known community leaders or SFWMD service center staff.	Same	Recreation includes passive hiking, wildlife viewing and other activities that may not easily be evidenced through this preliminary process.
	List of Parks and Recreation Areas		Neutral (0): If no significant displacement.				This is preliminary evaluation related to typical or foreseeable conditions and does not complete the analysis related to any specific selected site.
			Negative (-1): If significant displacement is likely to occur.				Where displacement of activities occurs the value may be neutral if these can be replaced. A positive impact may occur if no passive recreation or access is present but it is likely to be gained.
							Further evaluation will be made for construction and O&M screen as alternatives are further developed.

2724

APPENDIX G
ECONOMIC AND SOCIAL CONSIDERATIONS

This page intentionally left blank

TABLE OF CONTENTS

G.0 ECONOMIC AND SOCIAL CONSIDERATIONS G-1
G.1.1 Introduction G-1
G.1.2 Purpose of this Investigation G-1
G.1.3 Methodology G-2
G.1.3.1 Without-Plan and With-Plan Conditions G-2
G.1.3.2 Sources and Causes of Economic Effects G-3
G.1.3.3 Methodology for Conducting Economic Analysis G-3
G.1.4 Prior Studies G-6
G.1.5 Organization of Appendix G-6
G.2 POPULATION AND ECONOMY G-6
G.2.1 Overview G-6
G.2.2 Economic and Social Well–Being Problems and Opportunities G-7
G.2.3 Study Area G-8
G.2.4 Existing and Forecasted Land Use G-8
G.2.4.1 Existing Land Use G-8
G.2.4.2 Existing Agricultural Land Use G-10
G.2.4.3 Future Land Use G-11
G.2.5 General G-18
G.2.6 Population G-19
G.2.6.1 Population: Historic Trends and Existing Condition G-19
G.2.6.2 Population: Projections G-20
G.2.7 Econom y G-20
G.2.8 Agriculture Economy G-22
G.3 MUNICIPAL AND INDUSTRIAL WATER DEMAND G-25
G.3.1 Agricultural Water Demands G-31
G.3.1.1 Introduction G-31
G.3.1.2 Land Use G-32
G.3.1.3 MIKESHE Modeling G-32
G.3.2 Future Agricultural Demands G-34
G.3.2.1 Land Use G-34
G.3.2.2 2020 Demands Based on MIKESHE G-34
G.4 FLOOD DAMAGE REDUCTION IMPACTS OF SELECTED ALTERNATIVES G-35
G.5 COMMERCIAL NAVIGATION G-35
G.5.1 Commercial and Recreational Fishing G-36
G.5.1.1 Introduction and Existing Conditions G-36
G.5.2 Expected Conditions G-38
G.5.2.1 Lake Okeechobee Releases to the Caloosahatchee Estuary G-38
G.5.2.2 Management of Lake Okeechobee G-39
G.5.2.3 Effects on Estuarine Ecology G-40
G.5.2.4 Fishing Effects in the Estuaries G-42
G.6 RECREATI ON G-42
G.6.1 Recreation Resources G-44
G.6.1.1 Recreation Demand G-45

G.6.1.2 Regional Recreation Demand G-45
G.6.2 National Recreation Trends G-46
G.6.2.1 National Survey of Recreation and the Environment G-46
G.6.2.2 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation G-49
G.6.2.3 State Recreation Trends G-53
G.6.2.4 State Tourism Trends G-54
G.6.2.5 Potential Changes in Value of Recreation G-54
G.6.3 Recreation Benefits G-54
G.7 COSTS G-57
G.8 COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS G-59
G.8.1 Types of Benefits Analyzed G-60
G.8.2 Habitat Unit Combination Methodology G-62
G.8.3 Average Annual Benefits G-64
G.8.4 Cost Effectiveness Analysis G-65
G.8.4.1 Cost Effectiveness Analysis G-66
G.8.4.2 Increm ental Cost Analysis G-68
G.8.5 Selected Alternative Plan G-69
G.8.6 Next Added Increment Justification G-71
G.8.6.1 Next Added Increment Benefits G-71
G.9 REGIONAL ECONOMIC IMPACTS G-72
G.9.1 Overview G-72
G.9.2 Methodology G-72
G.9.3 IMPLAN Regional Economic Effects Results G-73
G.10 OTHER SOCIAL EFFECTS G-73
G.10.1 Overview G-73
G.10.2 Potential Urban and Community Impacts G-74
G.11 ENVIRONMENTAL JUSTICE G-76
G.12 REFERENCES G-78

LIST OF TABLES

Table G-1 Golf Course Acreage G-10
Table G-2: Total Land and Farm Acreage G-10
Table G-3: Change in land use from 2000-2050 ..... G-18
Table G-4: Population of counties and census tracts G-19
Table G-5: Charlotte, Glades, Hendry and Lee Counties, Population Estimates 2000-2050 (1,000s) G-20
Table G-6: Income and employment for counties G-21
Table G-7: Summary Study Area Agricultural Statistics– G-22
Table G-8: Summary Study Area Agricultural Statistics- G-22
Table G-9: Millage Rate, Assessed Value and Proportion of Agricultural Revenue-by County for 2004* ($1,000) G-23

Table G-10: AGRICULTURE PRODUCTION CROPS: Average Monthly Private Reporting Units, Employment, and Payroll Covered by Unemployment Compensation Law* G-24
Table G-11: AGRICULTURE SUPPORT ACTIVITIES: Average Monthly Private Reporting Units, Employment, and Payroll Covered by Unemployment Compensation Law (NAICS code 115) G-24
Table G-12: Water Use by End-Use Fixture, by Conservation G-27
Table G-13: USGS Estimated Total Water Use, for Selected Counties, 2000 (Excluding Mining and Power Generation) G-28
Table G-14: Caloosahatchee River (C-43) west basin storage reservoir STUDY AREA, M&I CONSERVATION-ADJUSTED G-29
Table G-15: Summary of 1995 Water Use Demand Based on the ISGM for Major Agricultural Land Use Categories. G-34
Table G-16: Summary of 2020 Water Use Demand Based on the MIKESHE for Major Agricultural Land Use Categories. G-35
Table G-17: COMMERCIAL LANDINGS, TRIPS AND VALUE PINE ISLAND SOUND/SAN CARLOS BAY, 1993-1997 ..... G-37
Table G-18: COMMERCIAL LANDINGS CHARLOTTE HARBOR; ESTERO BAY 1997 ..... G-38
Table G-19: COMMERCIAL LANDINGS CHARLOTTE and LEE COUNTIES 2002 ..... G-38
Table G-20: COUNTIES WITHIN SCORP PLANNING REGIONS G-44
Table G-21: DEMAND AND FACILITY NEEDS (1997 and 2010) For SELECTED RECREATION ACTIVITIES SOUTHWEST REGION (SCORP G-46
Table G-22: Participation Rates for Selected Recreational Activities by U.S. Population 16 Years or Older, 1994-1995 ..... G-47
Table G-23: Trends in U.S. Recreation Participation, 1982-1994 ..... G-48
Table G-24: Total U.S. Wildlife Watching Participation, 1996 ..... G-50
Table G-25: U.S. Wildlife Watching Activity, 1996 ..... G-51
Table G-26: U.S. Nonresidential Wildlife Watching by Species, 1996 ..... G-51
Table G-27: Participants in Wildlife-Related Recreation in Florida, 1996 ..... G-52
Table G-28: Florida Wildlife Watching Expenditures, 1996 ..... G-52
Table G-29: Demand for Selected Recreation Activities in Florida User-Occasions (Thousands), 1992 ..... G-53
Table G-30: Participation Rates for Selected Recreational Activities (1985, 1992) G-54
Table G-31: Summary of Recreation Costs and benefits G-56
Table G-32: Sensitivity Analysis Using Multiple Scenarios G-56
Table G-33: Estimated Ned Costs for Alternatives G-58
Table G-34: HSI Scores for alternative conditions G-62
Table G-35: COSTS AND OUTPUTS USED IN COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES G-66
Table G-36: RESULTS OF COST EFFECTIVENESS ANALYSIS: ALL PLANS and COST EFFECTIVE PLANS ARRAYED BY INCREASING OUTPUT FOR EACH OUTPUT CATEGORY G-67

Table G-37: RESULTS OF INCREMENTAL COST ANALYSIS: COST EFFECTIVE and BEST BUY PLANS ARRAYED BY INCREASING OUTPUT G-68
Table G-38: Summary of Alternative Plans G-70
Table G-39: P&G Evaluation Criteria G-70
Table G-40: Summary of Raw hsI Scores G-72
Table G-41: DIRECT, INDIRECT AND INDUCED IMPACTS ON EMPLOYEE COMPENSATION AS A RESULT OF IMPLAN MODEL RUNS (2006 Dollars) G-73
Table G-42: DIRECT, INDIRECT AND INDUCED IMPACTS ON REGIONAL OUTPUT AS A RESULT OF IMPLAN MODEL RUNS (2006 Dollars) ... G-73
Table G-43: DIRECT, INDIRECT AND INDUCED IMPACTS ON EMPLOYMENT AS A RESULT OF IMPLAN MODEL RUNS (2006 Dollars) G-73
Table G-44: 2005 Caloosahatchee River (C-43) West Basin Storage Reservoir Surrounding Counties Socio-Economic Vulnerability Profile G-76

LIST OF FIGURES

Figure G-1: Existing Land Use G-9
Figure G-2: 2050 Land Use G-16
Figure G-3: Difference between 2000 and 2050 land use G-17
Figure G-4: Distribution of Total Conservation-Adjusted M&I Water Use, by County, 2000 and 2050, most-likely Population, scenario G-30
Figure G-5: SWFFS Area, Most-Likely Population Scenario G-30
Figure G-6: M&I Conservation-Adjusted Forecast of Water use by Sector for the Most Likely Scenario G-31
Figure G-7: Caloosahatchee River (C-43) west Basin Storage Reservoir Area of Impact G-63
Figure G-8: Annual Habitat unit Lift G-65
Figure G-9: Caloosahatchee River (C-43) West Basin Storage Reservoir Alternative Plans G-67
Figure G-10: Best Buy Plans G-69

G.0 ECONOMIC AND SOCIAL CONSIDERATIONS

G.1.1 Introduction

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project recommended plan is an important piece of the south Florida ecosystem improvement efforts that together make up the overall Comprehensive Everglades Restoration Plan (CERP). This part of the project report is concerned with the socio-economic issues of plan implementation. The primary effects of the project are the costs of implementation, and the ecosystem restoration and improvement effects. The net national project cost (National Economic Development [NED] cost) represents the largest monetarily expressed impact of plan implementation. Project costs have regional impact dimensions as well, as expenditures on the project can cause changes in local and regional earnings, sales, and employment, due to the ripple effect of project spending throughout the regional economy. The most significant beneficial effect of the project is the ecosystem improvement expected to result from the plan. This major benefit is not expressed in monetary terms, in accordance with policy. A Cost Effectiveness/Incremental Cost Analysis (CE/ICA) is utilized to determine the alternative that provides least unit cost per unit of benefits.

G.1.2 Purpose of this Investigation

This investigation assesses the economic effects of the alternative ecosystem restoration plans formulated in the feasibility phase of the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. The economic evaluation of the alternative restoration plans includes five principal elements:

Socio-economic Profile of the Study Area: This profile includes population and economic forecasts for the region, as well as projections of future water demand.

Anticipated Effects of Alternative Plans on the National Economic Development (NED) Account: Alternative plans could result in positive or negative effects on net national economic efficiency due to project-induced impacts on the following economic activities in south Florida:

- Agricultural water supply
- Municipal and industrial (M&I) water supply
- Flooding potential
- Recreation
- Commercial and recreational fishing

Evaluation of Project Costs: Project costs include all expenditures required to implement the alternative plans. The Federal government and the State of Florida will share these costs. Project costs include those for initial construction; lands; relocations; rights of way; rehabilitation, replacement, and repair; and operations and maintenance (O&M) (including the costs of post-construction monitoring and adaptive management).

Regional Economic Development (RED) Effects: The potential RED effects of the Selected Alternative Plan (SAP) include changes in income, employment, or economic output of the region.

Other Social Effects (OSE): The potential social effects of the SAP include effects on minority, elderly, and disadvantaged groups, population displacement, and effects on community cohesion.

The economic analysis for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project was conducted consistent with Federal statutes and U.S. Army Corps of Engineers (USACE) policy. Procedures for estimating NED and RED effects are specified in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 10 May 1983), Engineering Regulation (ER) 1105-2-100 (22 April 2000), and other USACE guidance.

G.1.3 Methodology

A number of factors were considered prior to developing the methodologies used to evaluate the economic effects of the alternative restoration plans. These factors include: available analytical tools, economic theory, Federal policy, obtainable data, and time and budgetary constraints. These factors are discussed below.

G.1.3.1 Without-Plan and With-Plan Conditions

Proper definition of the without and with-plan conditions are critical to the planning process. The without-plan condition is the most likely condition expected to exist in the future in the absence of a proposed project. The future without plan condition (2050) is the benchmark against which alternative future with-plans are evaluated. National and regional socio-economic parameters considered include income, employment, population, and other aggregate projections such as land use trends, water supply, and water demand. Comparisons of conditions with the implementation of alternative plans to future without-plan conditions were performed to identify the beneficial and adverse effects of the proposed plans. Depending on the alternative and the type of economic impact changes resulting from implementation of a restoration plan, it may be desirable or undesirable when compared to the future without-plan

condition. For example, alternatives that include modifications to the current system to provide additional water storage areas may result in fewer economic losses associated with agricultural (irrigation) water shortages. This would be a desirable ancillary benefit of restoration.

G.1.3.2 Sources and Causes of Economic Effects

The potential economic impacts of the alternative restoration plans are secondary consequences of the environmental improvements and hydrologic changes that are expected to result from the proposed structural and operational modifications to the Caloosahatchee River (C-43) West Basin Storage Reservoir Storage Reservoir project study area. These projected impacts are contingent upon the successful implementation and operation of restoration plans and subsequent outputs and therefore, subject to the uncertainties inherent in those ecosystem restoration activities. Due to the challenges inherent in quantifying National Ecosystem Restoration (NER) benefits, quantifying the resulting NED benefit is also a challenge. Nonetheless, there are methods for evaluating the economic efficiencies of alternative restoration plans.

G.1.3.3 Methodology for Conducting Economic Analysis

Consistent with USACE Guidance, a benefit-cost analysis is not required for NER plans. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective shall be selected. The methodologies used to conduct economic analysis studies for the project were based on a combination of factors, including: economic theory, USACE's ecosystem restoration and economic evaluation policies, and the characteristics of methodologies used by economists to value ecosystem benefits. For this study, the alternative restoration plans were compared using information in monetary and non-monetary units. The economic analysis of Caloosahatchee River (C-43) West Basin Storage Reservoir Storage Reservoir alternative restoration plans include: (1) the NED costs (in monetary terms), (2) the anticipated environmental benefits resulting from restoration measures (in non-monetary terms), (3) the NED benefits and impacts attributable to the following: agricultural water supply, municipal and industrial (M&I) water supply, commercial navigation, recreation, and commercial fishing (in monetary and non-monetary terms) and (4) the positive and adverse regional economic effects (RED) resulting from project implementation.

This section of the report addresses items (1), (3), and (4) above. The economic basis for making policy decisions about whether to invest public funds in ecosystem restoration for this project is comparing monetary costs and non-monetary benefits in order to determine whether the expenditure is justified and

to select the plan which minimizes the cost of obtaining ecosystem benefits. The costs of ecosystem restoration projects include: initial construction costs; major rehabilitation and repair costs; operations and maintenance (O&M) costs; post construction monitoring costs; and adverse NED effects. Typically, these costs can be expressed in monetary (i.e., dollar) terms.

The principal challenge of ecosystem restoration economics is estimating the value of restoration benefits. The primary purpose of each alternative plan is ecosystem restoration. The benefits of ecosystem restoration are usually expressed by ecologists in non-monetary units, such as acres of specific habitat created, indices of biological productivity associated with habitat improvement, or increased abundance and/or diversity of particular species of plants or animals. For decision-making purposes, it would be desirable to express ecosystem restoration benefits in monetary terms, in order to compare them with project costs. Expressing the costs and benefits of alternatives in a common, monetary metric would facilitate selection of the best restoration plan for a given site. However, calculating the monetary value of environmental amenities is both difficult and controversial. Environmental amenities are public goods that are generally not exchanged in the marketplace. For marketable commodities (i.e., items that people buy and sell), the demand and prices paid for these goods can be used as "proxies" for determining their value to consumers. In the absence of data on consumers' expenditures for environmental amenities, resource economists have attempted to develop techniques that can be used to estimate their value using indirect indicators of consumers' "willingness to pay" for ecosystem restoration. For goods and services that are not purchased in the marketplace, non-market valuation approaches must be used to infer their value to the public. There are direct and indirect use values for these goods and services. Use values refer to the value consumers obtain from using a good that is related to an environmental amenity. For example, recreational fishermen obtain direct use value from the freshwater fisheries. The fishermen also obtain indirect use values from the ecosystem, since it provides ecological functions that contribute to the productivity of the fisheries. Use values can be either consumptive or non-consumptive. Consumptive use values refer to the cases for which the good is consumed by the user and is no longer available to others, such as waterfowl hunting. Non-consumptive use values refer to the value obtained by a user in cases for which the good remains to be used by others in the future, such as catch-and-release fishing or bird watching. It is reasonable to expect that the alternative restoration plans will generate additional use values to the public. Non-market activities that would benefit from restoration plans include recreational fishing, subsistence activities, and a variety of eco-tourism related activities (e.g., bird watching, hiking and canoeing).

Non-use values include the values the public obtains from simply knowing that the good or resource is available, even if they have not used it previously.

Individuals may value a good simply from knowing it exists (existence value) or because they may want to have the opportunity to use it at some future time (option value). Again, it is reasonable to expect that the alternative restoration plans will generate additional non-use values to the public. The tremendous interest in and support for ecosystem restoration, not just in south Florida but throughout the country (and the world), is an indication that a broad segment of society values the ecosystem, even though most have never experienced the area first hand.

Theoretically, it should be possible to determine the value of restoring the Caloosahatchee River and Estuary ecosystem by asking people what they would be willing to pay for different levels and types of restoration projects, or by observing what they spend on ancillary costs (e.g., travel, subsistence, equipment) when they engage in these non-market experiences. Economists have developed a variety of techniques to estimate society's willingness to pay for these types of non-marketable environmental amenities. These economic valuation techniques include market-based, surrogate market, and non-market methodologies (see Freeman, 1993). Market-based approaches estimate the value of environmental resources using information generated in the marketplace. These approaches include changes in factors of production, valuation of complimentary goods and services, defensive expenditures, and market valuation of the next best alternative. Surrogate-market techniques estimate value based on preferences revealed in surrogate markets. These techniques include the travel cost method and hedonic valuation. The contingent valuation method (CVM) is the most widely accepted non-market valuation methodology. CVM is perceived as the most effective technique to determine society's willingness to pay for environmental protection and/or restoration and is the only technique able to estimate non-use (i.e., option and existence) values. This method is based on carefully designed surveys that solicit respondent's willingness to pay for a specific environmental resource in a given condition. The survey is intended to reveal both users' and non-users' willingness to pay for the resource.

Unfortunately, these surrogate-market techniques, including CVM, have significant shortcomings that lead to concerns about their reliability and validity. They are especially problematic in cases for which respondents are unfamiliar with the environmental amenity, when the issue is controversial, or where it generates strong reactions, based on ethical, rather than economic motivations. Most importantly for the Caloosahatchee River (C-43) West Basin Storage Reservoir effort, the reliability and validity of these techniques are especially questionable in situations in which the actual changes that would result from the restoration efforts are difficult to precisely describe or visualize. Finally, stated preference methods, such as CVM, can be expensive to implement, especially when multiple alternatives are being evaluated.

As specified in USACE's ecosystem restoration policy (EC 1105-2-210: Ecosystem Restoration in the Civil Works Program), ecosystem restoration projects are not subject to traditional benefit-cost analyses. An ecosystem restoration proposal must still be justified by comparing the monetary costs and non-monetary benefits of restoring degraded ecosystems. USACE ecosystem restoration evaluation procedures focus on the non-monetary benefits of restoration, comparing these benefits to monetary costs using CE/ICA procedures.

G.1.4 Prior Studies

This study relied on the use of prior studies and other secondary information to the extent possible. These studies are contained in the reference list presented at the end of this appendix. The South Florida Water Management District (SFWMD) has previously conducted a wide variety of studies that directly or indirectly support this investigation. Interviews with SFWMD staff and review of SFWMD reports have contributed greatly to this investigation.

G.1.5 Organization of Appendix

The sections that follow evaluate the economic impacts of the alternative restoration plans. Section G.2 develops a socio-economic profile for the region, and Section G.3 contains the water demand forecasts for the region. The following sections develop the basis for critical physical and socio-economic effects of the future conditions, with-plan and without-plan. The costs and the incremental analysis of the alternative plans are presented in Sections G.7 and G.8. The regional economic effects and other social effects (OSE) of the alternative plans are explored in Sections G.9 and G.10 respectively.

G.2 POPULATION AND ECONOMY

G.2.1 Overview

This section of the appendix includes a description of the local economy and demographics of the study area. This descriptive information provides insight into the study area's socio-economic characteristics, and provides part of the basis for different facets of the economic impact evaluation work in the rest of this appendix.

The people who live in the study area, and the economic activity, in which they are engaged, comprise important components of the area's total environment. In addition to the direct use of this data for the water use projections and OSE mentioned above, residents of the study area represent the socio-economic environment for the other impact topics of flooding, water use shortages, fishing, recreation, and navigation.

Any course of action forthcoming from this study will have effects throughout an economic system as well as the natural ecosystem(s), the health and sustenance of which are the impetus for this investigation. The economic system is connected with the natural ecosystem and in general is ultimately dependent upon it for survival. This connection is especially strong in the study area. Adverse changes in the health and condition of the natural system can cause severe negative impacts on the economic system, particularly in the study area for this feasibility study. Conversely, in this study area, beneficial changes to the natural system are expected to have a strong positive effect on the economic system. It is significant, therefore, to describe and understand the general economic and social environment within which such changes could take place. Although the main focus of economic impact evaluation efforts undertaken for this study has been to describe the economic impacts and benefits of alternatives being considered for implementation, describing the broader context for these evaluation efforts is also necessary and important.

G.2.2 Economic and Social Well–Being Problems and Opportunities

As a result of the C&SF project, by providing flood protection and an available supply of drinking water, the population of south Florida has grown from approximately 900,000 as reported in 1950 to a population of over 5.5 million in 1995. By the year 2050, the population of south Florida is projected to grow to 11.6 million. Lee County has one of the fastest growing populations in both south Florida and in the state. The increased growth in population can be attributed to an inflow of retirees and not as a result of high birth rates for this area. The coastal areas in these counties have become highly urbanized. As a result, this urbanization has caused development to move westward into areas that were once agricultural or natural.

The Governor's Commission for a Sustainable South Florida identified agriculture and tourism as "critical industries" for maintaining the economy in the southern part of the state. In Lee and Hendry counties, agriculture is a major industry and citrus production predominates. A rapidly expanding human population demanding more developable lands and advancing agricultural development now threatens the relatively pristine natural areas. The tourism industry is also dependent upon the region's ability to sustain its economy and its quality of life through management of its resources. Agriculture and tourism depend on a system that can provide vital water supply needs and flood protection.

Competition for regional water resources has intensified with the increase in population and agriculture industry growth. This places a strain on existing resources, which will eventually surpass the readily available sources. When the needs of the natural system are then factored in, demands become greater and conflicts among competing water users will become even more severe. While

most people recognize the need for a healthy ecosystem to support the region's economy and jobs, many people are concerned that restoration projects will displace farms and other businesses, limit development, reduce available water supply and reduce job opportunities. By contrast, continued degradation of the south Florida ecosystem will adversely affect the tourism and recreational industry that are important to the regional economy.

G.2.3 Study Area

Located on Florida's lower southwest coast, the Caloosahatchee River region extends approximately 70 miles from Lake Okeechobee to the lower Charlotte Harbor Basin at San Carlos Bay. The Caloosahatchee River Region is the northern portion of the SFWMD's Lower West Coast (LWC) planning area. The Caloosahatchee River region is divided into seven drainage basins according to hydrologic characteristics. These basins are the C-21, East Caloosahatchee and West Caloosahatchee Basin, Orange River, S-236, Telegraph Swamp Basin and the Tidal Caloosahatchee Basin (SFWMD, 1995), (Figure 1-2). These basins include parts of Charlotte, Glades, Hendry, and Lee counties and extend slightly into Collier County. There are three municipalities located within the study area. They are:

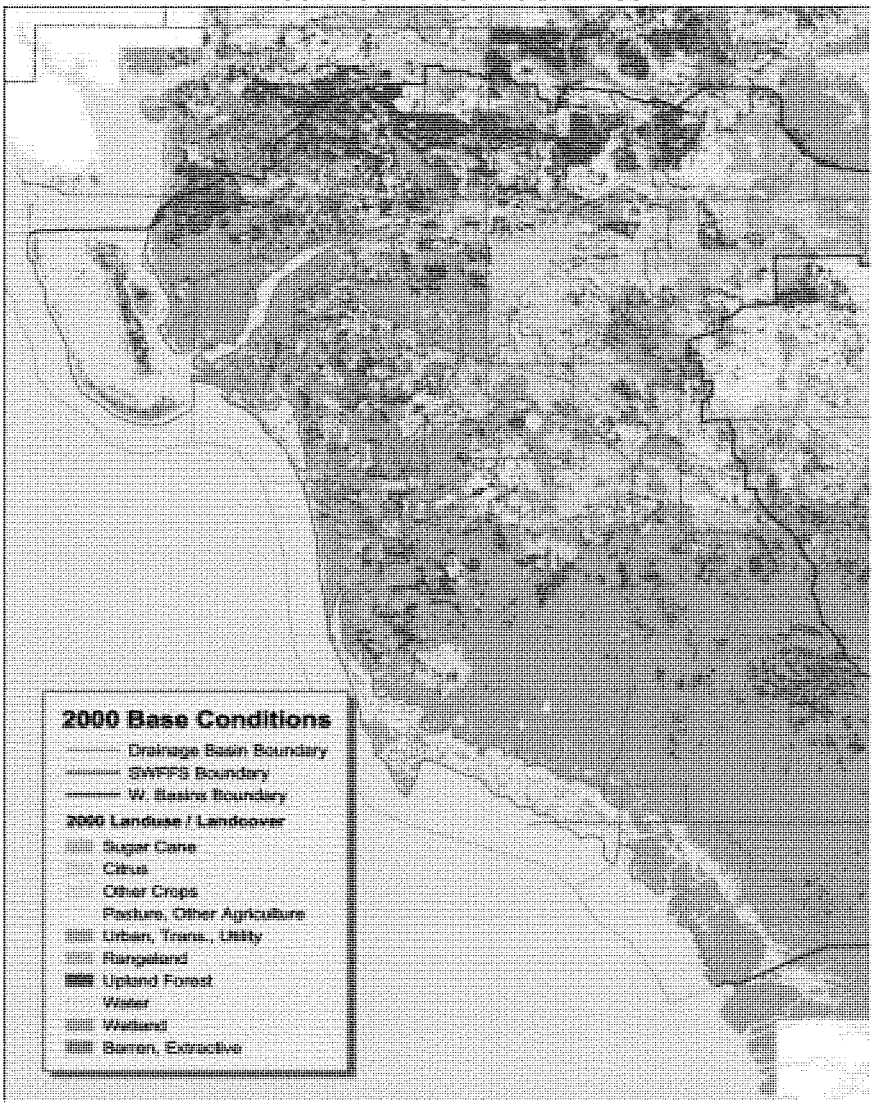
Clewiston
LaBelle
Moore Haven

G.2.4 Existing and Forecasted Land Use

G.2.4.1 Existing Land Use

Figure G-1 depicts the 2000 land use map for the southwest Florida Region. This map was generated for the southwest Florida Feasibility Study and includes the Caloosahatchee River (C-43) West Basin Storage Reservoir Storage Reservoir study area.

FIGURE G-1: EXISTING LAND USE



Much of the land use/cover change occurring in southwest Florida over the past several years can be categorized as either the creation of new developments in previously natural or agricultural areas, or the change in the types of agriculture practiced. Most of the new development appears to be in golf course/residential

areas concentrated near Interstate 75 in Lee County. A majority of these residential areas and small reservoirs were associated with new golf course communities.

Table G-1 presents the number of acres associated with existing golf courses.

TABLE G-1 GOLF COURSE ACREAGE

County	Year	Acreage
Lee	2000	8,962
Hendry	2000	120
Glades	2000	220
Charlotte	2000	460

The agricultural areas are inland from the urban areas and the Gulf Coast. They are being encroached upon by the urban areas and undergoing conversion within agricultural types. Much of Lee County is being converted from cattle farms to citrus, and there is a great deal of conversion year to year between pasture and row crops.

G.2.4.2 Existing Agricultural Land Use

The study area continues to experience growth in irrigated agricultural acreage, especially citrus. The irrigated crops in this region are citrus, sugarcane, vegetables, sod, and greenhouse/nursery. The project footprint is an active citrus grove. Growth in citrus acreage is usually on land that was formerly pastureland. Descriptions of the agricultural acreage in each county are included in ***Table G-2***.

TABLE G-2: TOTAL LAND AND FARM ACREAGE

Item	Florida	Charlotte	Glades	Hendry	Lee
Total Land Acreage	34,513,162	443,907	495,123	737,622	514,323
Farms	44,081	284	231	456	643
Farm Acreage	10,414,877	191,529	379,278	606,839	134,649

Source: USDA, NASS, 2002 Census of Agriculture

The following acreage by specific crop types was obtained from the Lower West Coast Water Supply Plan (LWCWSP) and pertains to acreage in 1995. The study area does not coincide exactly with the LWCWSP study area, but falls within the study area. Citrus is by far the dominant agricultural crop in the LWC study area, and occupies approximately one-half of agricultural acreage in

the region. Between 1968 and 1980 acreage remained at about the same level. From about 1984 until about 1992, acreage grew rapidly, associated with the inter-regional movement of citrus acreage southward from Central Florida following several severe winter freezes in the mid-1980s. Since approximately 1992, citrus growth has slowed in the area. Tropical fruits (primarily avocados and mangos) and nuts are produced only in Lee County. In 1995, there were 1,930 acres of tropical fruits and nuts in Lee County. Vegetable crops grown in the study area include cucumbers, peppers, tomatoes, squash, eggplant, watermelons, Latin vegetables, snap beans, and potatoes. Different types of vegetables are often grown interchangeably, and in 1995 there were 44,231 acres of land used for vegetable production.

Hendry and Glades county areas are the only parts of the study area where sugarcane is produced. As a result of the cultivation practices used for sugarcane, 25 percent of the land used for sugarcane production is fallow in any given year. In 1995, a total of 35,443 acres of sugarcane were produced in the Hendry County area. The seed corn production in southeastern Charlotte County varies from year to year, based primarily on the demand for seed corn, which in turn is dependent on seed corn production in other parts of the country. This variation in production is more a fluctuation than a trend. The estimate for seed corn production is 2,100 acres and 1,000 acres for soybeans. While fluctuations are anticipated, the magnitude of this acreage is typical. Rice in southern Glades County is grown during the summer months in rotation with sugarcane or winter vegetables, and takes place on land that would otherwise be fallow. Rice acreage in southern Glades County was assessed at 200 acres in 1995. In 1995, there were a total of 650 acres of irrigated sod production in the LWC Planning Area. In 1995, there were 6,089 acres of greenhouse/nursery operations in the LWC Planning Area, and this is projected to increase to 10,627 acres by the year 2020.

G.2.4.3 Future Land Use

Future land use projections in the Caloosahatchee Basin were updated as part of the larger regional Southwest Florida Feasibility Study (SWFFS). These regional preliminary draft projections will serve as a starting point for describing the West Basin Storage Reservoir project study area's land use. These projections have been reviewed by agricultural and governmental interests in the study area and will be used as the most likely future scenario. These have been incorporated into all project modeling effort. The draft projections resulting from the SWFFS update apply to 2025 and 2050 conditions. For the Caloosahatchee River (C-43) West Basin Storage Reservoir study area, the 2025 land uses have been extended to reflect expected 2050 conditions. It is not anticipated that the agricultural acreages will increase or decrease substantially

between 2025 and 2050, but the total urban acreages will increase in area and increase in density to account for the increase in population.

G.2.4.3.1 Methodology

In order to support the hydrologic modeling effort, the spatial distribution of land use was estimated for 2025 and 2050 conditions. These estimates are by necessity based on best professional judgment, due to the large uncertainties in predicting trends in population, economics, government policies, and other factors for an area experiencing rapid growth. The assumptions and methodology used to estimate future land uses are described below.

Land Use Data

Land-use patterns have been mapped for all of southern Florida using 1995 aerial photography, according to the Florida Land Use, Cover and Forms Classification System (FLUCCS) adopted by the Florida Department of Transportation. The 1995 database was updated using 2000 aerial photography and other sources to create a 2000-base coverage of land use. This 2000-base land use provides a reference point for a variety of modeling and analyses.

Public and Conservation Lands

A spatial database of public and conservation lands was compiled from a variety of sources. These lands were grouped into three broad categories: lands already acquired as public and/or conservation land, lands formally proposed for acquisition (through such programs as Conservation and Recreation Lands (CARL), Save our Rivers program (SOR), or Florida Forever Board of Trustees land (FFBOT)), or lands informally identified as desirable for acquisition.

Golf Courses

Because of the unique water-use patterns of golf courses in urbanized areas, a database of some 160 golf courses was compiled for southwestern Florida. The golf courses were correlated to existing water-use permits. The best estimate is that the irrigated area of golf courses will grow from 18,500 acres to 28,000 acres by about 2030, with an average of 120 acres per 18-hole course. Using existing patterns of urban development and the locations of water-use permits, both existing and proposed likely locations for about 80 new golf courses were mapped.

County Future Land Plans

The most-recent future-growth plans at the county level were obtained in digital format from Charlotte, Glades, Hendry, Lee, and Collier counties. The planning horizon varies from county to county. Some plans are for 2010, some extend to

2020, and some are simply designated "future." Each county has developed its own classification system for future land use. Because the models require a single, consistent classification, for each county a "crosswalk" table was developed to convert the county-based categories into FLUCCS categories. Meetings were held with county and municipal planners to refine the crosswalk tables and include recent changes to future-growth plans. For residential areas, population densities (in dwelling units per acre) were estimated for 2025 and 2050.

Agriculture

Under previous county land use plans, the accepted estimate for future agriculture was that the Caloosahatchee, S-4, and S-236 basins would have 125,000 acres of sugar cane and 125,000 acres of citrus in 2020. Compared to the 2000-base land use, this represents approximately 25,000 acres of additional sugar cane and 25,000 acres of additional citrus. These numbers were adopted as target values for 2025. In addition, representatives of the agricultural community estimated that 10,000 acres of new vegetable-crop or sod lands would be developed between 2000 and 2025. Likely areas for conversion of pasture/ranges lands to the more intensive agricultural use were identified.

General Rules for Distributing Future Land Use

Using geographic-information-systems (GIS) database structures and software, all of these spatial databases, or layers, were combined for analysis. A few simple rules were developed in order to resolve the combination of layers into a spatial pattern for future land use. The basic rules are:

1) Development is defined as a change of FLUCCS code to a more intensive land use. Examples include conversion of rangeland to citrus or vegetable crops to residential.
2) Some types of land can be developed; some cannot.
3) Lands that can be developed include pasture, rangeland, agriculture, upland forest, mining/gravel operations, open land, transitional land, and barren land.
4) Lands that cannot be developed include wetlands, open water, agricultural water-retention areas, and most existing urban land (including commercial, industrial, institutional, recreational, and utilities).
5) Existing conservation lands cannot be developed. Lands proposed for acquisition are allowed to be developed.
6) Most existing urban use remains constant. Residential areas can develop to higher density.
7) Urban development takes precedence over agriculture, in most cases. Every urban use, with the possible exception of low-density residential (see below), will "trump" agriculture.

Estimation of 2025 and 2050 Land Use

Additional rules were applied in order to differentiate between 2025 and 2050 conditions. For the 2025 estimate, a threshold density was applied for residential lands. If the 2025 density was expected to be two or more dwellings per acre, the land was developed as residential. Otherwise it remained as non-urban. For the 2050 estimate, all lands identified as residential were converted to urban, regardless of density.

It is recognized that these rules are arbitrary and limited by the nature of the source data, and that all estimates of future land use are highly uncertain. It is quite possible that urban growth will exceed these estimates. Because agriculture requires more water than any urban use, however, it is not likely that the future water demands will exceed the demands that are computed from these results. This "conservative" approach to estimating growth helps to ensure that future water demands will not be underestimated.

G.2.4.3.2 Results of Future Scenarios

Land use in the Caloosahatchee Basin is split between agricultural land use, urban/metropolitan land and conservation land. In the eastern portion of the Caloosahatchee Basin, Hendry, Charlotte, and Glades counties have been predominantly agriculture and rural in nature, while in the western portion of the basin, Lee County is more urban and supports industrial and commercial development. The land use, as described by the Southwest Florida Regional Planning Council (SWFRPC), details Hendry County as remaining largely agricultural, with urbanized areas in Clewiston to the east and La Belle to the west, and intermittent preserves and wetlands throughout. Additionally there are two main industrial concerns in Hendry County, one west of Clewiston and one near the Lee County border. Like Hendry County, Glades County remains largely agricultural in 2025, with some urbanized areas (La Belle's northern reaches and Moore Haven on Lake Okeechobee) and preserves and wetlands throughout. Within the study area, Charlotte County will remain vastly agricultural with some preserves and wetlands areas.

The predominant land use in the Caloosahatchee Basin is agricultural, and is expected to remain so in the future. The study area continues to experience growth in irrigated agricultural acreage. The irrigated crops in this region are citrus (the dominant irrigated crop), sugarcane, vegetables, sod, and greenhouse/nursery. Over the past two decades, southwest Florida has had the fastest growing citrus acreage in the state. Growth in citrus acreage is usually on land that was formerly pastureland. Sugarcane closely follows citrus in dominance in terms of crops grown in the Caloosahatchee Basin. It is produced in the Caloosahatchee Basin in close vicinity to Lake Okeechobee (in Hendry and Glades counties). Sugarcane acreage has continued to increase since 1995, and

is expected to continue to increase in the future. Irrigation is typically applied from the surface water sources in the Caloosahatchee Basin and consequently, subsidence is not a significant problem due to the soils being generally sandy, rather than organic.

In terms of urban and industrial development, Lee County is the most populous part of the study area. The Fort Myers /Cape Coral Metropolitan Statistical Area (MSA), unincorporated areas of Lehigh Acres, Buckingham, North Fort Myers, South Fort Myers, and East Fort Myers constitute the bulk of the population in the western portion of the Caloosahatchee Basin (see ***Table G-3*** in Existing Conditions section on population estimates by county). Urban growth in Lee County has the potential to impact the region's environmental and water resources. Drainage of wetlands caused by urban expansion, loss of natural surface water storage areas, and contamination from urban land use is the major water related issues in the urban areas. Growth in this part of the basin generally follows the I-75 corridor, with the greatest portion of the population being located west of the W.P. Franklin Lock and Spillway (S-79). Much of the projected urban growth in this part of the basin is located to the east of I-75 toward the S-79. Much of this development contains a mixture of single family/multifamily dwellings, commercial and industrial facilities, some mining operations and preserves/wetlands. ***Figure G-2*** presents a map of the 2050 future land use conditions in the Caloosahatchee River (C-43) West Basin Storage Reservoir study area. ***Figure G-3*** presents a map showing changes between existing (2000) conditions and future without project conditions. ***Table*** G-3 shows changes to land use for the 2025 and 2050 conditions.

There are a number of areas where urban development, agriculture, and/or proposed conservation areas compete for the same land. While these competing areas are not large compared to the entire area being modeled, they are significant. There were two most likely scenarios that were determined to be applicable to the Caloosahatchee River (C-43) West Basin Storage Reservoir study area. The first of these scenarios corresponds to land use in 2025, the second to land use in 2050. The first scenario has agriculture out-competing or "trumping" new low-density residential urban use, agriculture develops in areas proposed for conservation (not existing conservation lands, however), and marginal urban land has not developed yet. The second scenario, or 2050 conditions, also has agriculture trumping new low-density residential urban, agriculture is allowed to develop in areas proposed for conservation, but marginal urban land has now developed.

From the following table and figures, general characterizations of the study area can be determined which lead to the belief that in the future, urban lands and agriculture will increase in acreage, resulting in a decrease in natural areas. Within the greater Caloosahatchee River (C-43) West Basin Storage Reservoir study area, urban lands are expected to increase from 47,000 acres in 2000 to

114,000 acres in 2025 and 127,000 acres in 2050. Sugar cane is expected to increase to 116,000 acres in 2025 and decline slightly to 113,000 acres in 2050. Acreages for citrus are 118,000 in 2025 and 110,000 in 2050. Vegetable crops and sod production are expected to increase by 10,000 acres by 2025. Given the high probability that urbanization will meet or exceed the counties' current future-growth plans within the next 20 years, it may be difficult for the agricultural community to meet its 2025 goals.

FIGURE G-2: 2050 LAND USE

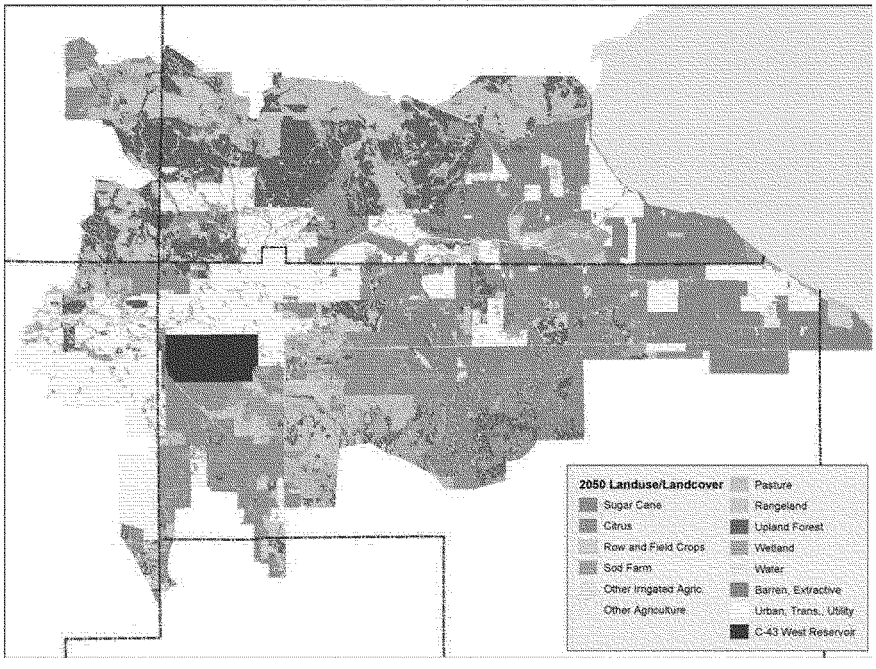


FIGURE G-3: DIFFERENCE BETWEEN 2000 AND 2050 LAND USE

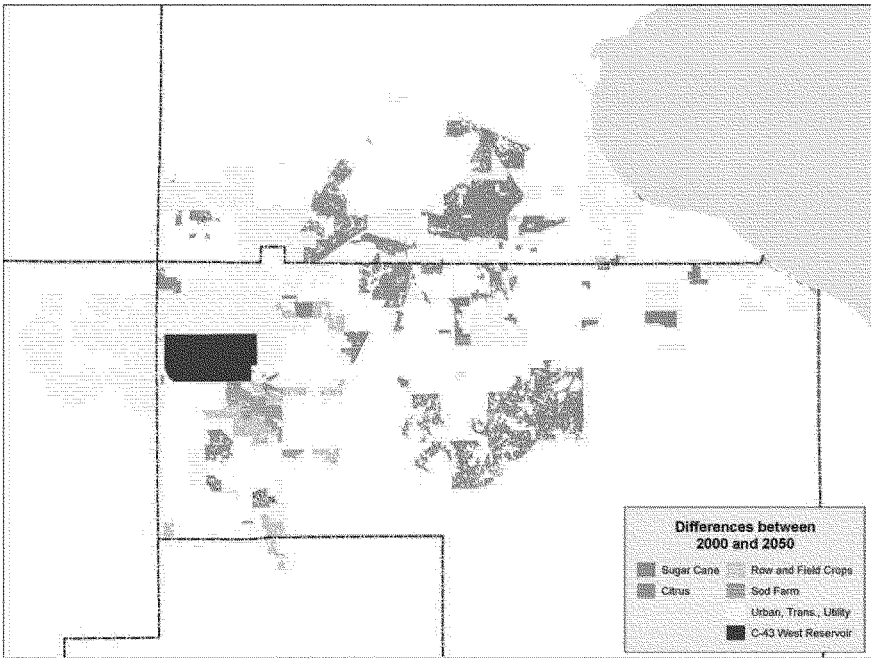


TABLE G-3: CHANGE IN LAND USE FROM 2000-2050

Land Use Category	2000 LAND USE	2025 LAND USE	Change from 2000 to 2025	2050 LAND USE	Change from 2000 to 2050	Change from 2025 to 2050
	(Acres)					
Sugar Cane	101,513	116,105	14,592	112,970	**11,457**	-3,135
Citrus	99,855	118,469	18,614	110,037	**10,182**	-8,432
Row Crops, Field Crops	11,026	17,557	6,531	16,506	**5,480**	-1,051
Improved Pasture	101,170	38,691	-62,479	38,691	**-62,479**	0
Unimproved and Woodland Pasture	28,344	16,493	-11,851	16,493	**-11,851**	0
Other Irrigated Agriculture	508	474	-34	174	**-334**	-300
Sod	482	4,024	3,542	4,008	**3,526**	-16
Other Agriculture	5,220	2,284	-2,936	2,098	**-3,122**	-186
Urban, Trans., Comm., and Util.*	46,800	113,553	66,753	126,671	**79,871**	13,118
Low Density Residential	13,443	54,779	41,335	33,509	20,066	-21,269
Medium Density Residential	4,704	31,633	26,929	61,160	56,456	29,527
High Density Residential	193	1,792	1,599	6,616	6,423	4,824
Range	31,898	20,651	-11,247	20,651	**-11,247**	0
Upland Forest	96,265	76,259	-20,006	76,259	**-20,006**	0
Water	5,447	5,356	-91	5,356	**-91**	0
Wetland	96,056	96,188	132	96,188	**132**	0
Barren, Extractive	6,635	5,115	-1,520	5,115	**-1,520**	0
TOTAL	631,218	631,218	0	631,218	**0**	0

G.2.5 General

Socioeconomic and demographic data for the study area indicate higher than average income when compared to the rest of the state and nation, and much greater economic and population growth than for the rest of the nation. Additional characteristics of the study area include a strong service sector, fishing, tourism, and recreation. Florida's economy is generally characterized by strong wholesale and retail trade, government and service sectors. Florida's warm weather and extensive coastline attract vacationers and other visitors and helps to make the State a significant retirement destination for people from all over the country. Easily developed land, accessible water supply, abundant natural resources, and the aesthetic beauty of the region are the fundamental building blocks of the local economy. Relative to the national economy, the manufacturing sector has played less of a role in Florida, including the study area. However, high technology manufacturing has begun to emerge as a significant sector in the State over the last decade.

G.2.6 Population

G.2.6.1 Population: Historic Trends and Existing Condition

Population for the four counties in the study area (Charlotte, Glades, Lee and Hendry County) increased at a high growth rate during the period from 1990 to 2000. Charlotte increased at 27.6 percent, Lee at 31.6 percent, Glades at 39.3 percent and Hendry at 40.5 percent. The population of Florida and the United States increased 23.5% and 13.1% respectively over the same period.

TABLE G-4: POPULATION OF COUNTIES AND CENSUS TRACTS

		Race							
	Population, 2000	**White**	**%**	**Black**	**%**	**Hispanic**	**%**	**Other**	**%**
Florida	15,982,378	12,466,255	78.0%	2,333,427	14.6%	2,685,040	16.8%	1,182,696	7.4%
Charlotte County	141,627	131,147	92.6%	6,232	4.4%	4,674	3.3%	4,249	3.0%
Census Tract 101	3556	2,916	82.0%	525	14.8%	191	5.4%	115	3.2%
Glades County	10,786	8,305	77.0%	1,133	10.5%	1,629	15.1%	1,348	12.5%
Census Tract 1	2018	1,975	97.9%	2	0.1%	21	1.0%	41	2.0%
Census Tract 2	5669	4,590	81.0%	415	7.3%	1,353	23.9%	664	11.7%
Census Tract 3	2889	1,577	54.6%	697	24.1%	220	7.6%	615	21.3%
Lee County	475,639	417,135	87.7%	31,392	6.6%	45,186	9.5%	27,112	5.7%
Fort Meyers MSA	440888	386,598	87.7%	29,035	6.6%	42,042	9.5%	25,255	5.7%
Hendry County	36,210	23,935	66.1%	5,323	14.7%	14,339	39.6%	7,083	19.6%
Census Tract 1	6567	4,973	75.7%	729	11.1%	2,655	40.4%	41	0.6%
Census Tract 2	7506	3,750	50.0%	2,898	38.6%	2,007	26.7%	664	8.8%
Census Tract 3	6926	4,222	61.0%	132	1.9%	4,256	61.4%	615	8.9%
Census Tract 4	11066	8,503	76.8%	802	7.2%	3,738	33.8%	1,761	15.9%

Hendry County has a large percentage of people that claim Hispanic origin. Of the 36,210 residents in the county during the year 2000, almost 40 percent (14,339 persons) are of Hispanic origin. Glades, Charlotte and Lee counties all have lower proportions of persons of Hispanic origin than does the state.

Florida's African-American population is 2,333,427, which is 14.6percent of the State's total population. Hendry County has a total African-American population that is slightly higher than that of the state total. There are also three census tracks in the study area that have a higher African-American representation than that of the state.

The Native-American population of the study area represents less than one percent of the aggregate population of the study area.

G.2.6.2 Population: Projections

According to the population projection derived from the Florida Bureau of Economic and Business Resources (BEBR), population in Charlotte County is expected to increase over 83 percent from 2000 to 2050; in Glades County, to increase by 74 percent; Hendry County, to increase by 96 percent; and Lee County, to grow by 97 percent. Florida as a whole is projected to grow 86 percent by 2050. The projected growth of the south Florida Nine-County area is anticipated to be 78 percent over the same 50-year period. These estimated population increases are reflected in future without project condition water demands and land use patterns.

TABLE G-5: CHARLOTTE, GLADES, HENDRY AND LEE COUNTIES, POPULATION ESTIMATES 2000-2050 (1,000S) (BEBR PROJECTIONS, US CENSUS (2000))

Area	2000	2010	2020	2030	2040	2050
Florida	15,982.4	18,866.7	21,792.6	24,528.6	27,118.7	29,714.5
Charlotte County	141.6	169.5	198.9	225.9	242.8	259.8
Glades County	10.6	12.4	14.2	16	17.2	18.4
Hendry County	36.2	44.4	53.3	61.8	66.4	71.1
Lee County	440.9	546.8	653.3	753.9	810.3	866.9

G.2.7 Economy

Generally, a strong wholesale and retail trade, government and service sectors characterize Florida's economy. Florida's warm weather and extensive coastline attracts vacationers and other visitors and helps make the state a significant retirement destination for people all over the country. Agricultural production is also an important sector of the state's economy, and is especially significant to portions of the study area. Compared to the national economy, the manufacturing sector has played less of a role in Florida, but high technology manufacturing has begun to emerge as a significant sector in the State over the last decade.

TABLE G-6: INCOME AND EMPLOYMENT FOR COUNTIES AND CENSUS TRACTS

	Income					Employment	
	Median Household, 1999	Personal Per Capita, 1999	Persons Below Poverty Level	% Below Poverty Level	Average Household Size	In Labor Force (+16 yrs old)	Unemployed
Florida	38,819	21,806	1,997,797	12.5%	2.46	7,407,458	412,411
Charlotte County	36,379	21,557	11,613	8.2%	2.18	52,512	1,822
Census Tract 101	41274	17,560	165	4.6%	2.47	1,176	27
Glades County	38,819	15,338	1,639	15.2%	2.51	3,677	357
Census Tract 1	27604	17,216	374	18.5%	2.47	1,873	29
Census Tract 2	31170	14,597	938	16.5%	2.72	4,268	256
Census Tract 3	34091	15,471	175	6.1%	2.62	2,324	72
Lee County	40,319	24,542	46,137	9.7%	2.31	186,417	7,234
Fort Myers MSA	40139	24,542	42,316	9.6%	2.31	3,120	230
Hendry County	33,592	13,663	8,727	24.1%	3.09	14,579	1,235
Census Tract 1	37210	15,460	1,197	18.2%	2.92	3,120	230
Census Tract 2	31760	13,047	2,034	27.1%	3.15	3,318	420
Census Tract 3	34250	12,315	1,894	27.3%	3.55	3,512	237
Census Tract 4	33022	15,417	2,492	22.5%	2.87	4,425	280

As can be noted in ***Table G-6***, the unemployment rate for Florida is 5.1 percent (2003), which is greater than that of Lee (four percent) and Charlotte (4.4 percent) counties. Hendry and Glades counties had unemployment rates that were much greater than the state total, with Glades' unemployment rate at 8.7 percent and Hendry County's unemployment rate at 11.7 percent.

Personal per capita income in Florida is $21,806 (1999), but is somewhat lower in Charlotte County at $21,557, and substantially lower in Glades County at $15,338 and Hendry at $13,663. Lee County experiences higher per capita income than that of the state average. Every rural census tract associated with the study area has lower than the state average per capita income.

In 1999 it was reported that 12.5 percent of Florida's population lived below the poverty level, while 24.1 percent of Hendry County's and 15.2 percent of Glades County lived below the poverty level. Charlotte County and the census tracts associated with it are both below the state poverty level figures. All census tracts in Hendry County are above the state poverty level.

G.2.8 Agriculture Economy

Agriculture is a significant contributor to the economies of the counties in the study area. Measures of relative significance presented here include: number and average size of farms, number of acres under cultivation, total market value of production, property taxes, and impacts on seasonal employment.

Total production of the four-county study area accounts for more than half a billion dollar total revenue. Of this total amount, Hendry County accounts for more than 60 percent of the total output of the study area, and is the nation's second largest producer of sugarcane, the third largest producer of oranges, and the sixth largest producer of grapefruit.

TABLE G-7: SUMMARY STUDY AREA AGRICULTURAL STATISTICS– BY COUNTY (2002)*

	Number of farms	Average size (acres)	Total acres used for farmland	Market Value of Production
Charlotte	284	674	191,529	$ 42,632,000
Glades	231	1,766	407,950	$ 72,064,000
Hendry	456	1,211	552,352	$ 357,076,000
Lee	643	197	126,484	$ 109,147,000
Total	1,614	792	1,278,315	$ 580,919,000

*NASS, 2002 Census of Agriculture, County Profile

Table G-7, above, presents statistics of county and study area based agricultural activity for 2002. To isolate general trends in agricultural land use so that impacts of the project on agricultural may be represented; statistics for 1997 are presented in ***Table G-8.***

TABLE G-8: SUMMARY STUDY AREA AGRICULTURAL STATISTICS- BY COUNTY (1997)

	Number of farms	Average size (acres)	Total acres used for farmland
Charlotte	287	1,018	292,053
Glades	253	1,499	379,278
Hendry	507	1,197	606,839
Lee	725	186	134,649
Total	1,772	797	1,412,819

In the five years that differentiate ***Table G-7*** and ***Table G-8***, all Charlotte, Hendry and Lee counties in the study area experienced a decrease in the number of farms and the number of acres under cultivation. In Charlotte County the

number of farms declined by one percent. While the number of farms in Charlotte County has not demonstrated a precipitous decline, the number of acres under cultivation decreased by more than thirty percent and the average size of farms also decreased by more than thirty percent. In Lee County the area under cultivation and the number of farms decreased by six percent and 11 percent from 1997 to 2002 while the average farm size increased by six percent for the same period. In Hendry County the area under cultivation and the number of farms decreased by nine and ten percent from 1997 to 2002 while the average farm size increased by one percent for the same period. While Lee County exceeds Hendry County in absolute number of farms, only 16 percent of Lee County farms have sales greater than $50,000 per annum versus 36 percent of Hendry County farms having sales exceeding $50,000. Glades County is the only county in the study area that realized an increase in the number of acres under cultivation. The amount of land in farms increased eight percent with the average size of the farms increasing 18 percent, while the total number of farms decreased by nine percent. Hendry and Glades counties had large increases in the average per farm market value of production, with Hendry increasing 29 percent and Glades increasing 35 percent.

TABLE G-9: MILLAGE RATE, ASSESSED VALUE AND PROPORTION OF AGRICULTURAL REVENUE-BY COUNTY FOR 2004* ($1,000)

	Millage Rate	Agricultural Assessment	Agricultural Revenue	Total Assessment	Total Revenue	Agriculture's Percentage of Total Revenue
Charlotte	15.4667	$99,670	$1,542	$12,296,175	$190,181	0.81%
Glades	24.1233	$143,670	$3,466	$385,736	$9,305	37.25%
Hendry	25.3923	$491,034	$12,468	$1,299,494	$32,997	37.79%
Lee	16.852	$204,340	$3,444	$46,978,992	$791,690	0.43%
Total		$938,714	$20,919	$60,960,397	$1,024,174	1.54%

*State of Florida, Department of Revenue, 2004 Florida Property Valuations and Tax Data

Property taxes on agricultural land add almost $21 million into local reserves. This accounts for approximately one and a half percent of the four county study area. On a per county level, the predominately rural agricultural counties of Glades and Hendry realize about 37 percent of their *ad valorem* taxes coming from agricultural property.

TABLE G-10: AGRICULTURE PRODUCTION CROPS: AVERAGE MONTHLY PRIVATE REPORTING UNITS, EMPLOYMENT, AND PAYROLL COVERED BY UNEMPLOYMENT COMPENSATION LAW*
(NAICS code 111)

	Number of Reporting Units	Number of Employees	Payroll ($1,000)
Charlotte	13	377	$512
Glades	11	110	298
Hendry	39	1,829	$3,513
Lee	37	1,275	$2,637
Total	**100**	**3,591**	**$6,960**

*Florida Statistical Abstract 2004

TABLE G-11: AGRICULTURE SUPPORT ACTIVITIES: AVERAGE MONTHLY PRIVATE REPORTING UNITS, EMPLOYMENT, AND PAYROLL COVERED BY UNEMPLOYMENT COMPENSATION LAW (NAICS CODE 115)

	Number of Reporting Units	Employment	Payroll
Charlotte	5	66	$92
Glades	11	110	298
Hendry	52	2299	$2,814
Lee	N/A	N/A	N/A
Total	**68**	**$2,475**	**$3,204**

*Florida Statistical Abstract 2004

The agricultural industry provides the area with numerous monthly employment positions and income. Activity depicted in ***Table G-10*** is for agricultural production of crops, and ***Table G-11*** is for agricultural support services.

This analysis demonstrates the importance of agriculture to the study area economy. It also suggests some conclusions on the impact a reduction in study area agriculture will have on local government, landowners and workers. The market price of most agricultural commodities demonstrates a highly elastic behavior; the removal or reduction of a single supplier will not affect the market price greatly. As a result the impact of this removal will be highly localized; a reduction in output will result in a primary reduction in seasonal employment and property tax receipts and a smaller secondary reduction in support services employment and revenue.

The unique nature and market recognition of the Florida agriculture industry might mitigate some of the impacts to total revenue and local tax revenue. Given the dominance of agriculture in Glades and Hendry counties, it is anticipated that any impacts resulting in a reduction of agriculture will be more

pronounced in these two counties. It is apparent that agriculture plays a significant role in contributions to tax revenues of the counties located in the study area. Total *ad valorem* property taxes levied on agriculture lands in the Caloosahatchee River (C-43) West Basin Storage Reservoir study area accounts for over $20 million. More significantly, agriculture property taxes may represent over 37 percent of the total revenue of Glades and Hendy counties. Local government fiscal balances of these counties are contingent on the continuation and proliferation of the success of agriculture in these areas.

G.3 MUNICIPAL AND INDUSTRIAL WATER DEMAND

The Comprehensive Review Study for the C&SF project, known as the Restudy, recommended the development of a feasibility study to identify southwest Florida water resource conditions, and to develop potential solutions to any problems that may be identified. This M&I Water Use Forecast is part of the overall SWFFS, but includes Lee County, most of Collier and Henry counties and portions of Charlotte, Glades and Monroe counties, and the Caloosahatchee River Basin which correspond to the Caloosahatchee River (C-43) West Basin Storage Reservoir study area. The water use sectors for which forecasts were developed include public and self-supply domestic (residential), commercial, industrial, government, and unaccounted-for water loss. Water use in agriculture, mining, and power generation were not addressed as part of the M&I forecast. The purpose of the M&I water use forecast was to estimate existing water use and to develop water use projections for the SWFFS area.

An M&I forecast is required as input to modeling that will be the basis for planning and optimally designing the Caloosahatchee River (C-43) West Basin Storage Reservoir project. The planning horizon is the year 2050. Water use estimates from the present to 2050 for natural area environmental purposes, agricultural irrigation purposes, M&I use, and other purposes are needed. The results of the IWR-MAIN effort are a set of projections through the year 2050 for M&I use only.

The M&I water use forecasts were developed using the IWR-MAIN Water Demand Management Suite, a computerized water resource planning tool that allows the development of water use forecasts and the evaluation of water conservation programs. The IWR-MAIN software allows water use forecasts to be developed based on existing water use patterns and existing or forecast socioeconomic parameters and then allows the impact of water conservation measures on those water uses to be evaluated. To maintain consistency with the water use forecasts developed for the Initial CERP Update (ICU), the water use models developed for the western portion of the study area in that analysis will be used in this analysis. In the ICU, residential water use was forecast using a multiplicative forecast model and nonresidential water use was forecast using a constant use rate model.

Golf course irrigation requirements were based on a model developed by the SFWMD and previously used in projecting water use in the LWC WSP. The SFWMD model consisted of using multiple regression analysis to project future golf course acreage, then applying irrigation requirements to those acreages based on the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) model. Golf course acreage was projected for the period of analysis using multiple regression analysis. Multiple regression analysis evaluates the past relationships between a dependent end variable and independent variables. Once this relationship was described through equations, the equations were used to project future golf course acreage, based on projected population. Irrigation requirements from AFSIRS, based on a representative irrigation system/rainfall station/soil type combination for each county, were then applied to the projected golf course acreage to develop projected golf course irrigation requirements. Consistent population projections are critical to the development of M&I water use because they are used to directly project housing and employment counts, the main drivers of the IWR-MAIN water use models. Therefore, considerable time and effort was expended on developing reasonable, acceptable, and defendable projections.

The population projections from 2000 to 2050 were based on population projections produced by the BEBR. BEBR generates low, medium, and high sets of population projections for each county in Florida for 2005 through 2030. The medium population projections are believed by BEBR to most likely provide an accurate forecast of future county populations. The high and low population projections were developed to indicate the uncertainty concerning the medium set of projections, based on past population forecast error.

Three population projection scenarios were developed for this analysis. The BEBR medium projections were the basis for the medium or most-likely scenario for all counties except Collier County, and the BEBR high and low population projections were the basis for the high and low scenarios, respectively. Collier County has formalized an alternative method for projecting population for planning purposes, based on the BEBR high scenario growth rates. Collier County projects the medium population based on the BEBR high growth rate for the first five years (2000-2005). Projections for 2005 to 2030 were based on 95 percent of BEBR high growth rate. In order to develop projections to 2050, the growth rate exhibited in the national population projections from 2030 to 2050 was applied to the projected 2030 BEBR population for each county.

The IWR-MAIN models were calibrated to local water use patterns using the most recent data available (2000), then used to estimate water use for 2000 and project water use, in five-year intervals, to 2050. Four sets of forecasts were developed. Three were based on differing population projection scenarios, and

one was based on one-in-ten year drought conditions. Projection of future water use included the implementation of all reasonable conservation measures.

The use of the calibrated IWR-MAIN forecast models resulted in the development of baseline water use estimates, assuming that future water use patterns will continue into the future. These baseline forecasts are conditional water use forecasts that exclude the potential impacts of existing water conservation programs that may result in a reduction in the average water use per housing unit or employee over time. The SFWMD requires the development of water conservation plans prior to issuing a water use permit. These conservation plans incorporate passive water conservation measures that include an increasing block rate structure, the required use of ultra-low flow water fixtures on new construction or renovation of existing structures, restrictions on lawn watering, requiring rain sensors on automatic sprinkler systems, a leak detection program, and public education concerning water conservation measures. IWR-MAIN was used to forecast water use for each study area assuming that passive water conservation measures would be implemented.

IWR-MAIN employs an end use model to distribute forecast water demand to end-uses (i.e., toilets, showers, washing machines, lawn irrigation) and allows the planner to evaluate the impact of conservation measures on those end uses. The conservation measures incorporated into this analysis can be broadly classified as ultra-low volume plumbing fixture requirement ordinances, irrigation ordinances, and rain sensor switch ordinances. Other requirements such as conservation water rate structure, utility leak detection and repair, and public education programs are addressed in the baseline IWR-MAIN forecast. The water use, by end-use fixture for each conservation level category is presented in ***Table G-12***.

TABLE G-12: WATER USE BY END-USE FIXTURE, BY CONSERVATION LEVEL CATEGORY

End-Use Water Fixture	Unit of Measure	Conservation Level Category		
		Non-Conserving	Conserving	Ultra-Conserving
Toilets	Gallons per flush	5.0	3.5	1.6
Showerheads	Gallons per minute	3.8	3.0	2.5
Faucets	Gallons per minute	3.5	2.5	2.0
Dishwashers	Gallons per load	14.0	9.3	6.0
Clothes washing	Gallons per load	55.0	42.0	24.0
Urinals	Gallons per flush	1.5	1.5	1.0
Lawn irrigation	Percent savings	0.0	10.0	10.0

According the U.S. Geological Survey (USGS) in 2000, estimates of annual water withdraws (***Table G-13***), total public-supply water use for the region is

estimated at 110 million gallons a day (MGD), and from the IWR-MAIN model (***Table G-14***), the total M&I water use is estimated at 177.5 MGD. The addition of 776 MGD of agricultural water use increases total water demand for the region to 951 approximately MGD. Agricultural water use accounts for 81 percent of the total use, and public-supply water use accounts for 12 percent and recreational self-supply accounting for about five percent.

TABLE G-13: USGS ESTIMATED TOTAL WATER USE, FOR SELECTED COUNTIES, 2000 (EXCLUDING MINING AND POWER GENERATION)

	Municipal and Industrial							
		Self-Supply						
County	Public Supply	Domestic	Commercial	Industrial	Recreation	Sub Total	Agriculture	**Grand Total**
Charlotte	14.21	3.55	0.11	0	3.48	21.35	47.19	**68.54**
Glades	0.55	0.61	0.04	0	0.42	1.62	69.02	**70.64**
Hendry	4.72	1.67	0.21	0.51	1.09	8.2	503.91	**512.11**
Lee	52.37	8.86	0.46	0.09	22.66	84.4	60.51	**144.95**
Total	**71.85**	**14.69**	**0.82**	**0.6**	**27.65**	**115.57**	**680.63**	**796.24**

On the county-level, the largest total water user in the study area in 2000 was Hendry County, mainly because of agricultural water use. Hendry County used a total of 512.11 MGD, or 51 percent, of the total regional water use. Of this amount, 503.91 MGD (or 98 percent) was agricultural use and 4.72 MGD was public-supply M&I water use. Collier and Lee counties' public-supply water use were fairly equivalent at about 52 MGD. However, because of high agricultural water use, Collier County had the second highest total water use in the five-county area, at 224.42 MGD, which accounted for over 64 percent of the county's total water use. Lee County's total water use was 144.95 MGD, the third highest in the region. Lee County had the highest self-supply domestic water use in the region at 8.86 MGD. Collier and Lee counties also had high recreational water use, with Lee County having the highest use in the region at 26.17 MGD and Lee County using 22.66 MGD.

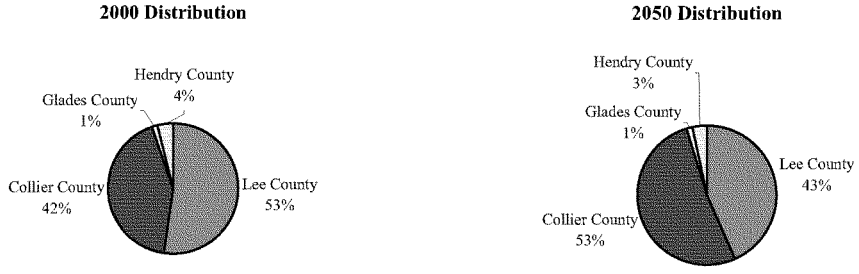
Table G-14 represents the conservation-adjusted, most likely population scenario, water use forecast and the percent of total water use associated with each county or county area in the study area, for 2000, 2025, and 2050. Lee County accounted for 52.2 percent of all M&I water use in the study area in 2000, while Collier County accounted for 42.4 percent. By 2025, Collier County was the largest water user, accounting for 50 percent of all water use in the SWFFS area. By 2050, Collier County is projected to account for 52.2 percent, with Lee County accounting for 43.2 percent of all water use. The percent of total M&I water consumed in Collier County is projected to increase over the period of analysis because of the projected increase in population in Collier County compared to the rest of the study area. Collier County population is

projected to increase by 215 percent from 2000 to 2050, while the population of Lee County is projected to increase by 97 percent over the same time period. The Glades County Area generates the smallest use, at slightly more than one percent of the total regional water use over all time periods. Due to the small population in the Charlotte County portion of the study area, the water use totals for Charlotte County are incorporated into those of Glades County and therefore the USGS 2000 baseline totals do not exactly equal the IWR-MAIN 2000 totals.

TABLE G-14: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR STUDY AREA, M&I CONSERVATION-ADJUSTED WATER USE AND DISTRIBUTION, BY COUNTY AREA MOST-LIKELY POPULATION SCENARIO, 2000, 2025, AND 2050

	2000		2025		2050	
Area	MGD	Percent of Total	MGD	Percent of Total	MGD	Percent of Total
Lee County	92.7	52.2%	129.5	45.2%	148.0	43.2%
Collier County	75.2	42.4%	143.5	50.0%	178.6	52.2%
Glades County Area	2.4	1.4%	4.0	1.4%	4.5	1.3%
Hendry County Area	7.1	4.0%	9.7	3.4%	11.2	3.3%
Total	**177.5**	**100.0%**	**286.6**	**100.0%**	**342.2**	**100.0%**

FIGURE G-4: DISTRIBUTION OF TOTAL CONSERVATION-ADJUSTED M&I WATER USE, BY COUNTY, 2000 AND 2050, MOST-LIKELY POPULATION, SCENARIO



**Charlotte County is included in the Glades County estimate of MGD and Percent of Total

FIGURE G-5: SWFFS AREA, MOST-LIKELY POPULATION SCENARIO TOTAL M&I BASELINE AND CONSERVATION-ADJUSTED WATER USE

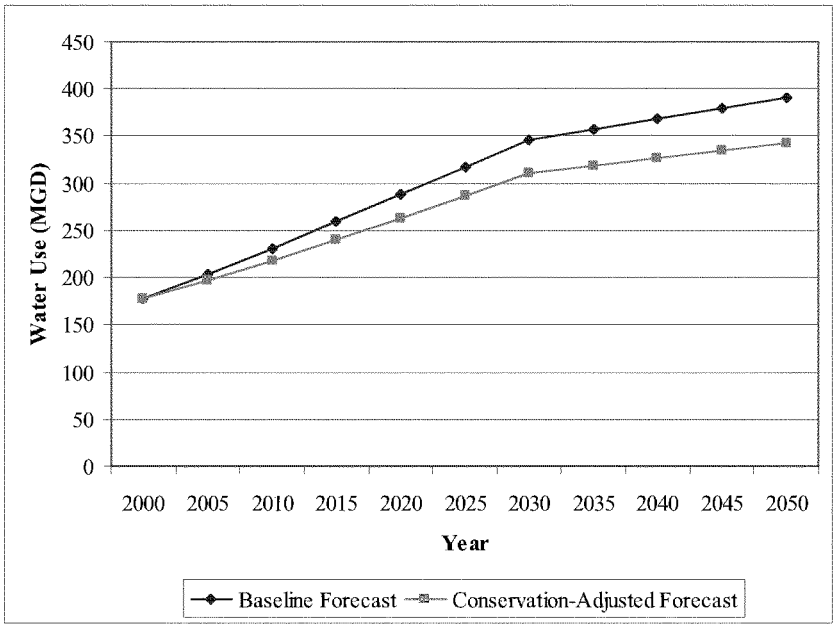
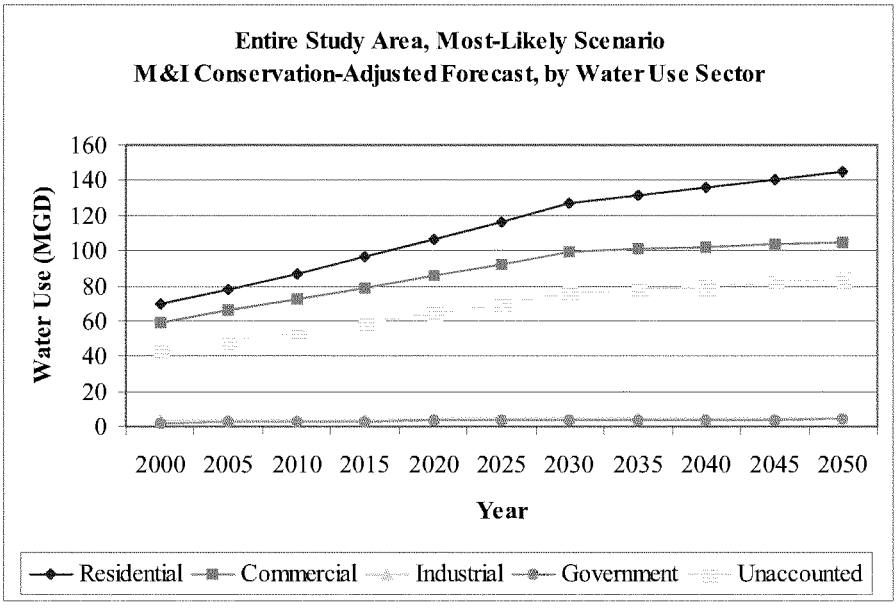


FIGURE G-6: M&I CONSERVATION-ADJUSTED FORECAST OF WATER USE BY SECTOR FOR THE MOST LIKELY SCENARIO



G.3.1 Agricultural Water Demands

G.3.1.1 Introduction

The SFWMD calculated agricultural water demands as part of the Caloosahatchee Water Management Plan (CWMP), in April 2000. These water demand calculations are the most current demands available for the Caloosahatchee River (C-43) West Basin Storage Reservoir study area and are a sufficient base point for demonstrating future demands and trends for the planning horizon.

The following section contains the data collected and presented in the CWMP. The land use information in the following section does not coincide exactly with the acreage counts for sugarcane as presented in the land use section (Section G-2.4), but the general trend in land use changes are similar. The citrus acreage is consistent with what was modeled in the CWMP. The agricultural water demands for sugarcane will be updated to reflect current land use projections, after the land use projections are finalized and adopted. Upon completion of the water demands update, a lower agricultural water demand than was projected

for the CWMP is expected, due to current land use projections showing a smaller increase in agricultural acreage.

G.3.1.2 Land Use

An important factor in accurately estimating agricultural water use is determining the location and acreage of crops. Agricultural water use depends on the crops that are grown in the basin and on how those crops are managed and irrigated. Land use in the CWMP planning area is predominantly agricultural and is expected to remain so in the future. For the CWMP, land use from the 1995 Land Use Coverage was utilized. This 1995 Land Use Coverage has been updated to 2000 since the CWMP was completed, but the projections from 1995 were used in the water demand estimate for the CWMP.

At the time of the CWMP, citrus was the dominant irrigated crop in the basin and occupied more than 91,000 acres, according to the SFWMD's 1995 Land Use Coverage. During the past two decades, southwest Florida has had the fastest growing citrus acreage in the state. This growth is associated with the movement of citrus southward from Central Florida following several severe winter freezes in the early-1980s. Sugarcane, with an estimated 75,000 acres, according to the SFWMD's 1995 Land Use Coverage, closely follows citrus in dominance of land area. Sugarcane is primarily grown in close vicinity to the Everglades Agricultural Area (EAA), in Hendry and Glades counties, where transportation costs to sugar mills can be minimized. Sugarcane acreage has continued to increase since 1995, and is expected to continue in the future. The increase in acres of sugarcane and citrus is not expected to cause expansion of the Lake Okeechobee Service Area (LOSA) but it does assume all development of undeveloped lands in LOSA would rely on Caloosahatchee River (C-43 Canal) waters. The increase in irrigated agriculture stems mainly from a decrease in pasture.

G.3.1.3 MIKESHE Modeling

The Integrated Surface Water/Ground Water Model (ISGM), MIKESHE, includes a module for estimating irrigation requirements based upon land use, soil type, crop type, rainfall and evapotranspiration. It has the capability to utilize a vast amount of raw and processed data to estimate crop needs. These data can be summarized under irrigated crop, irrigated area, and water use.

G.3.1.3.1 Irrigated Crop

The different crop types within the basin that are irrigated are specified within the MIKESHE model. Three major crops are included in the vegetation classification as requiring irrigation. These are sugarcane, citrus, and truck

crops (vegetables). A fourth, improved pasture may or may not be irrigated and is assumed not irrigated in the analyses.

G.3.1.3.2 Irrigated Area

The maximum expanse or extent of irrigated areas needed to be explicitly specified in the MIKESHE model. The MIKESHE model determines what portion of the specified irrigated area requires irrigation at each model time step. The determination is based on soil moisture that is affected by rainfall, soil type, and other factors that are specified in the model. The irrigated areas are specified using 1995 land use maps and the SFWMD water-use permit coverages.. Acreage that is permitted but not cropped is therefore excluded from the analyses.

G.3.1.3.3 Water Use

The actual irrigation practices within the basin vary from farm to farm, at different periods of the year, from crop to crop, and at different stages of crop growth. Irrigation practices by individual users are largely unknown and can not be modeled. In general however, all practices ensure that crop losses through evapotranspiration can be minimized with irrigation. Using this premise, the MIKESHE model computes irrigation demands based on estimates of actual evapotranspiration for each crop and growth stage. The computation of evapotranspiration is based on leaf area index, root depth, soil characteristics of the root zone, and potential evaporation.

The MIKESHE model requires the distribution of irrigation demands not only in space over the basin but in time as well. The result is a process that can be replicated for any time period once the input data such as the crop type, soil type, and land area is known. This was considered desirable for estimating future irrigation requirements within the CWMP planning area. The MIKESHE model was calibrated using ground water levels and river discharges at S-79 and S-78 on the Caloosahatchee River (C-43 Canal). MIKESHE output for inflow and outflow from the basin was used to estimate basin excesses and deficits.

Table G-15 summarizes the water use allocation for major agricultural land use categories for the CWMP area based on the ISGM.

TABLE G-15: SUMMARY OF 1995 WATER USE DEMAND BASED ON THE ISGM FOR MAJOR AGRICULTURAL LAND USE CATEGORIES.

Crop	Water Use (1,000 acre-feet/year)
Citrus	143
Sugarcane	110
Vegetables	36
Total	290

Note: Based on 1995 land use, MIKESHE results indicate an additional 30,000 acre-ft/year of irrigation in addition to citrus, sugarcane and vegetables.

G.3.2 Future Agricultural Demands

G.3.2.1 Land Use

The SWFRPC has estimated that total agricultural acreage will increase between three and seven percent between 1995 and 2020, while citrus acreage will increase between 54 and 81 percent and sugarcane between 62 and 190 percent. The increase in citrus and sugarcane acreage is due in a large part to conversion of existing irrigated acreage that is in other crop types to citrus and sugarcane. Based upon representation from the agricultural industry and CAC discussion and concurrence, a 2020 citrus acreage of 112,500 and sugarcane acreage of 125,000 were modeled. This represented a reduction from the SWFRPC estimate but an increase from the SFWMD *District wide Water Supply Assessment* (DWSA) completed by the SFWMD in July 1998.

A scientific procedure that considered existing land use, ownership, suitability for crop use, and proximity to existing agricultural lands was used to adjust the 1995 land use map to the 2020 land use projections. An explanation summarizing the steps involved in development of the 2020 land use coverage is included in the Land Use section. Based on the 2020 land use map MIKESHE was used to estimate future agricultural demands.

G.3.2.2 2020 Demands Based on MIKESHE

The MIKESHE model developed for the CWMP was used to estimate the future demands by incorporating the 2020 land use information and modifying irrigated areas within the model to match the new land use. The MIKESHE model, unlike the AFSIRS model, was used to simulate demand using an eight-year period (1988-1995). The selected period represents a combination of wet, dry, and average years representative of variations within the Caloosahatchee Basin. The resulting demands for the 2020 Base Case using the MIKESHE methodology therefore represents probable demands based on 2020 land use and hydrologic data corresponding to an eight-year period. The resulting demands

for the entire planning area, including both the LOSA and non-LOSA portions of the basin, were obtained.

Table G-16 summarizes the simulated 2020 irrigation demand for major agricultural land use categories for the CWMP area based on the MIKESHE model.

TABLE G-16: SUMMARY OF 2020 WATER USE DEMAND BASED ON THE MIKESHE FOR MAJOR AGRICULTURAL LAND USE CATEGORIES.

Crop	Water Use (1,000 acre-feet/year)
Citrus	242
Sugarcane	181
Vegetables	27
Total	450

The MIKESHE estimate of demand is 47 percent greater than the AFSIRS estimates of net basin demand. The difference is attributed to the difference in the demand estimated by both methods. While the AFSIRS methodology estimates a net basin demand that adjusts field scale demands by runoff occurring within the same basin, MIKESHE computed irrigation requirement in excess of precipitation. Analyses of output from AFSIRS indicate that field scale demand estimates are between 15 and 70 percent greater than net basin demand estimates for the major crop types within the planning area.

G.4 FLOOD DAMAGE REDUCTION IMPACTS OF SELECTED ALTERNATIVES

A key design criterion and goal throughout the development of the project components has been that flooding of developed areas will remain the same or improved with the plan implemented as compared to without the plan. No flooding of residential or commercial properties will be caused by implementation of the plan. See Appendix A for a detailed analysis of flooding impacts.

G.5 COMMERCIAL NAVIGATION

Navigation will not be negatively impacted by the implementation of the Caloosahatchee River (C-43) West Basin Storage Reservoir project. Existing flows will be maintained in the Caloosahatchee River and the local marinas and boat ramps will not be impacted by lower stages.

G.5.1 Commercial and Recreational Fishing

G.5.1.1 Introduction and Existing Conditions

A profile of commercial and recreational fishing in the Caloosahatchee Estuary can be constructed using field information and data in national and state fishing databases. Much of the available information about commercial and recreational fishing in the estuary is contained in studies and data sets for larger geographic areas.

There is some commercial fishing in the Caloosahatchee Estuary. The Florida Statistical Abstract (FSA) estimates the direct employment in fishing in Lee County. According to the FSA, the fishing industry in Lee County involves an estimated 40 businesses (FSA, 1997), with 180 employees, and an estimated annual payroll of $3.54 million. The use of cast nets in the estuary is reported to be common. In addition, there is reported to be substantial crabbing activity in the estuary. In Lee County, there are 638 saltwater products licenses and 267 permits for blue crab fishing.

The Caloosahatchee Estuary has important ecological connections with offshore commercial fish stocks. As described in Nelson (1992), many commercial finfish and invertebrate species use estuaries for critical stages of their development. ***Table G-17*** presents commercial landings, trips, and value data collected by the Florida Department of Environmental Protection (DEP) for the Pine Island Sound/San Carlos Bay area. As indicated in this table, in 1997 the value of the commercial landings from this area was approximately $1.7 million. The finfish and bait shrimp fisheries account for most of the landings and value. Although the shrimp landings in ***Table G-17*** are small, there is a significant offshore pink shrimp fishery that is based on Sanibel Island. This fishery is reflected in 1997 pink shrimp landings data for Lee County, which totaled 4,033,537 pounds. The Caloosahatchee Estuary and the area affected by freshwater releases from Lake Okeechobee comprise part of the nursery habitat for this fishery. The finfish and bait shrimp poundage, trips, and value data vary widely from year to year. This is due to changes in the fish population dynamics, fishing conditions, and fishing effort.

The data in ***Table G-17*** are complemented by the information in ***Table G-18***. ***Table G-18*** contains 1997 landings data from nearby Charlotte Harbor (to the north) and Estero Bay (to the south). As indicated in ***Table G-18***, the finfish fishery in Charlotte Harbor is substantially larger than that of the Pine Island/San Carlos Bay area. ***Table G-19*** contains 2002 annual landings summary for the coastal counties associated with the study area.

TABLE G-17: COMMERCIAL LANDINGS, TRIPS AND VALUE PINE ISLAND SOUND/SAN CARLOS BAY, 1993-1997

YEAR	CATEGORY	POUNDS	TRIPS	VALUE
1993	Finfish	1,084,476	4,853	$629,297
	Invertebrates	1,484	11	$1,435
	Shrimp	2,017	9	$6,250
	Bait Shrimp	89,165	1,762	$213,630
1994	Finfish	174,582	783	$134,862
	Invertebrates	1,864	13	$1,299
	Shrimp	0	0	$0
	Bait Shrimp	114,982	1,961	$265,397
1995	Finfish	260,175	1,682	$274,862
	Invertebrates	32,583	111	$31,560
	Shrimp	0	0	$0
	Bait Shrimp	118,009	2,105	$369,182
1996	Finfish	479,160	2,745	$492,314
	Invertebrates	410,203	1,391	$219,301
	Shrimp	26,126	7	$3,914
	Bait Shrimp	136,356	2,735	$513,383
1997	Finfish	1,036,342	3,881	$867,150
	Invertebrates	196,409	1,373	$247,464
	Shrimp	215	1	$927
	Bait Shrimp	147,564	2,749	$556,705

Source: Florida DEP, Marine Fisheries Information System, 1997.

TABLE G-18: COMMERCIAL LANDINGS CHARLOTTE HARBOR; ESTERO BAY 1997

AREA	CATEGORY	POUNDS	TRIPS	VALUE
Charlotte Harbor	Finfish	1,787,612	6,103	$1,293,085
	Invertebrates	748,850	4,446	$701,355
	Shrimp	14,609	141	$40,562
	Bait Shrimp	0	0	$0
Estero Bay	Finfish	100,947	428	$70,768
	Invertebrates	2,766	25	$11,236
	Shrimp	0	0	$0
	Bait Shrimp	0	0	$0

TABLE G-19: COMMERCIAL LANDINGS CHARLOTTE AND LEE COUNTIES 2002

AREA	CATEGORY	POUNDS
Charlotte County Total	Finfish	408,400
	Invertebrates	407,151
	Shrimp	18,250
	Bait Shrimp	142
Lee County Total	Finfish	2,056,842
	Invertebrates	888,664
	Shrimp	2,928,307
	Bait Shrimp	82,602

The Caloosahatchee Estuary also supports guided sport fishing and recreational fisheries. Nelson (1992) described the following recreational species as "highly abundant", "abundant", or "common" in the Caloosahatchee Estuary: tarpon, sea catfish, snook, crevalle jack, silver perch, pinfish, spotted seatrout, red drum, black drum, and stripped mullet.

G.5.2 Expected Conditions

G.5.2.1 Lake Okeechobee Releases to the Caloosahatchee Estuary

Stages in Lake Okeechobee are managed to keep lake levels from being too high at the beginning of the wet season (June) to provide flood and hurricane

protection; and to keep levels from dropping during the dry season (November to May) for water supply purposes. Lake Okeechobee has four principal outlets for discharging inflows received from its tributary waterways:

1. evaporation, which in the south Florida climate accounts for 70 percent of the lake's water loss
2. distributary canals that convey water southward to the Lower East Coast and the Everglades
3. Atlantic Ocean via the St. Lucie canal
4. Gulf of Mexico via the Caloosahatchee River

The quantity, quality, and timing of the releases to the Caloosahatchee Estuary are critical determinants of the diversity and productivity of those ecosystems. Management of Lake Okeechobee and the ecological effects on the estuarine ecosystems resulting from the hydrologic changes induced by the alternative restoration plans are described below. The purpose of this discussion is to aid in interpreting the economic consequences of the alternative restoration plans on the Caloosahatchee Estuary.

G.5.2.2 Management of Lake Okeechobee

Water levels in Lake Okeechobee are managed through regulatory (flood control) and non-regulatory releases. Regulatory releases are made according to the regulation schedule established by the USACE in conjunction with the SFWMD to ensure that the integrity of the levee system surrounding the lake is not compromised by high water levels. Non-regulatory releases are made to meet:

1. environmental water supply requirements of the Everglades ecosystem
2. water supply requirements of the Lower East Coast
3. agricultural irrigation water demands in the LOSA
4. environmental needs in the St. Lucie and Caloosahatchee estuaries

Non-regulatory releases from Lake Okeechobee to the two estuaries are made in response to particular circumstances throughout the year. In general, releases are made during low flow periods to provide sufficient freshwater inflows into the estuaries to maintain ecologically desirable salinity levels.

As described in Hall (1992), the regulatory releases from Lake Okeechobee are intended to control high lake stages. The releases are controlled by the regulation schedule, which has management zones that specify outlets and release rates according to the time of year and prevailing lake stage. Although the regulatory discharges can have negative effects on the Caloosahatchee Estuary due to excessive freshwater flows into these ecosystems, the releases are necessary during high lake stages to avoid loss of life and property associated with hurricane-generated rainfall and waves.

The current regulation schedule provides for pulse releases to these estuaries during periods of rising lake stage. The pulse releases are designed to avoid the adverse ecological effects of higher releases over more concentrated periods. Pulse releases mimic natural hydrology following rainfall events. The receiving estuaries are able to absorb the pulses without prolonged salinity or ecological effects. While the pulses are effective for moderate regulatory releases, the prospect or occurrence of prolonged high lake stages can necessitate continuous releases from Lake Okeechobee into the estuaries.

The regulatory releases from Lake Okeechobee are directed southward toward the Water Conservation Areas (WCAs) (and the Everglades ecosystem) to the fullest extent possible. When the need for regulatory releases exceeds the receiving capacity of the WCAs, releases are made to the estuary. Maximum non-harmful releases will be made to the Caloosahatchee Estuary when the lake stage is rising.

G.5.2.3 Effects on Estuarine Ecology

The Caloosahatchee Estuary is a highly productive ecosystem that exists at the interface between freshwater and seawater. The Caloosahatchee Estuary is part of the southern portion of Charlotte Harbor, which includes the estuary, San Carlos Bay, Pine Island Sound, and Matlacha Pass. The estuary extends 29 miles from the W.P. Franklin Lock and Dam near Alva to Shell Point at its mouth in San Carlos Bay. San Carlos Bay, which is bounded by Sanibel Island and Pine Island, is located at the confluence of the river, Pine Island Sound, Matlacha Pass, and the Gulf of Mexico. The freshwater released into the estuary is controlled by the Franklin Lock and Dam, which also serve as a barrier to salinity and tidal influences upstream.

The quantity, timing, and quality of freshwater inputs to estuaries are critical determinants of the structure and function of these ecosystems (Bulger et al., 1990). Freshwater flows provide critical functions and materials for estuaries, including:

- nutrients for estuarine biota
- protection from predation by mature life stages that are intolerant of lower salinities or that are unable to find prey in naturally turbid estuarine waters
- a range of salinity conditions for a variety of organisms with different requirements for growth and development
- transportation of many estuarine-dependent larvae

Relative to natural conditions, the releases from Lake Okeechobee and changes in their watersheds have adversely affected the structure and function of these

sensitive ecosystems. In general, the peak flows from Lake Okeechobee to these estuaries are higher than those under natural conditions, and the low flows are lower.

The changes in freshwater inputs to the estuaries have short-term and long-term effects on these ecosystems. The most immediate effect of these changes is the magnification of the natural fluctuations of salinity in these estuaries. Estuarine species evolved under conditions of naturally fluctuating salinity levels, but excessive fluctuations can stress these ecosystems. As described by Bulger et al. (1990), excessive salinity fluctuations can keep estuarine biota in constant flux between organisms that favor higher salinity and those that favor lower salinity. If the fluctuations are extreme, appropriate salinity conditions do not last long enough for organisms to complete their life cycle, and the diversity of organisms is reduced to those few species that can tolerate the dramatic salinity fluctuations. Even moderate releases (such as in Zone B of the regulation schedule) can transform these estuarine systems into freshwater habitats after a few weeks of sustained releases. The estuarine species are displaced or expire during extended periods of low or high salinity. In addition, continuous flow releases tend to create critically low benthic oxygen levels at the transition zone between freshwater and seawater. These ecosystem perturbations affect more than just estuarine species, since estuaries provide important nursery habitat for marine (offshore) finfish and invertebrate species.

In general, when regulatory releases are terminated, the salinity levels in these estuaries return to the normal range, and the ecosystems begin to recover. The estuarine species that were displaced or extirpated return or are replaced. The recovery period is commensurate with the rate and duration of the freshwater inputs to the estuaries. Other longer-term effects of the regulatory releases from Lake Okeechobee on the Caloosahatchee Estuary include sediment and nutrient effects. Both effects are related to the quality of the water releases from Lake Okeechobee, which contain suspended silt, clay, and organic material. Much of the suspended material settles onto the bottom of the Caloosahatchee River during modest, non-regulatory releases. However, during regulatory releases–particularly the high release levels of Zone B and Zone A–this material is re-suspended and carried into the estuaries during the first few days of the release period. Suspended material increases the turbidity of the water in the estuaries and blocks sunlight to seagrass communities in these estuaries. The suspended material smothers some seagrass communities as it settles in the low energy environment of the estuaries. Other seagrass communities are affected by the reduction in sunlight that results from increased turbidity. Nutrient effects result from the nitrates and phosphorus contained in the lake water that are re-suspended by the release flows and stimulate primary production in the estuaries. Releases can imbalance nutrient cycling in these ecosystems, leading

to algae blooms and subsequent declines in dissolved oxygen and further increases in turbidity.

The short- and long-term ecological problems in these estuaries are not entirely attributable to the Lake Okeechobee regulatory water releases, however. These estuaries have perturbations from other sources that contribute to the stresses on these ecosystems. For instance, other estuarine tributaries deposit freshwater, sediments, and nutrients in these ecosystems, including heavy metals that are associated with agricultural pesticide use in the contributing watersheds.

G.5.2.4 Fishing Effects in the Estuaries

The above mentioned ecological effects of the freshwater releases to the estuaries can lead to commercial and recreational fishing impacts. The challenge in estimating the economic effects on commercial and recreational fishing in the Caloosahatchee Estuary is complicated by the need to differentiate between the with- and without-project future conditions. The determination of a dollar value of the loss to commercial and recreation fishing is not feasible due to the inability to quantify the decrease in fish numbers and accurately measure the decrease in fish yields. It is safe to reason that as fish populations decrease due to degraded conditions in the estuary, restrictions will be placed on certain species of fish, the supply of fish will decrease and greater distances will have to be traveled for commercial fishing vessels who in turn will realize smaller catches, all leading to a decrease in economic activity.

G.6 RECREATION

This section examines the potential effects of the SAP on outdoor recreation in the study area. Outdoor recreation in Florida includes many different activities. A common way of differentiating outdoor recreation activities is to classify them based as "user-oriented" or "resource-based" activities. User-oriented activities, such as individual and team sports, are not dependent on any natural resource setting and can be located, space permitting, on any open site. These facilities are provided for the convenience of the user. For example, a basketball court can be added to a playground. Resource-based activities, such as hunting and fishing, depend on the existence and quality of supporting natural or historical resources. The economic value of resource-based recreation is determined by the users' willingness to pay for a recreation occasion. The willingness of current and potential users to pay for resource-based recreation of specific quantity and quality constitutes the demand for that type of recreation. The interaction of demand with the quantity and quality of recreation resources available determines the recreation use or "participation" levels for that resource-based activity. When the quantity or quality of recreation resources is modified by a

project, such as the alternative restoration plans, the change in value of resource-based recreation is based on the difference in the willingness of users to pay under the with- and without-project conditions.

The Caloosahatchee River (C-43) West Basin Storage Reservoir provides a unique and extensive natural resource-based recreational resource. The restoration of the ecosystem could potentially have important impacts on the value of outdoor recreation in the study area. The hydrologic changes associated with the alternative restoration plans have been designed to improve the structure and function of the ecosystems. These improvements can be expected to provide resource-based recreational opportunities compatible with the protection of the natural systems. Many tourists and residents recreate in the natural areas surrounding the study area. If the alternative restoration plans improve the ecology of the study area, the quality of the study area related recreation and/or the number of people who participate in study area related recreation could increase as well. Consequently, the value of outdoor recreation in the study area could also substantially increase.

However, precisely estimating the future value of recreation in the study area is problematic, and anticipating the incremental changes in value associated with restoration is even more challenging. There are four principal uncertainties that challenge forecasting the future quantity and quality of outdoor recreation under with- and without project conditions. Perhaps the most important uncertainty concerns the timing and character of the ecological changes that are expected to result from the alternative restoration plans. At this time, the outcomes of the restoration actions cannot be predicted. Consequently, secondary effects, such as associated changes in recreation patterns and the resulting effect on industries supporting recreation (e.g., marine industry) cannot be accurately quantified.

Another uncertainty regarding the future value of recreation is the marketing of tourism and study area related recreation. If the restored ecosystem is used to market tourism and recreation in the study area, the value of recreation could change dramatically relative to the without-project future conditions.

A third uncertainty is the degree to which recreational facilities and recreational access would be developed as part of a restoration plan. Recreation facilities and access, such as visitor centers, scenic overlooks, nature trails, and roads, can greatly affect participation levels.

Finally, there are a variety of economic factors at the national level that can influence tourist and resident recreation demand. These factors include the health of the national economy, levels of disposable income, and the availability and costs of competing recreation opportunities. As described in the 2000

Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP) (Draft): "The states 1996 tourist population (44.7 million) is expected to increase to 57 million visitors, a 25 percent increase, by 2005. However, Florida tourism and its economic implications are sensitive to national economic and energy policies. The dynamic nature of the industry causes uncertainty in tourism forecasting, making it difficult to accurately project visitation levels for more than one or two years at a time" (Florida DEP, 2000). As evidence of the challenges of tourism and recreation forecasting, the Florida Tourism and Industry Marketing Corporation limits its tourism forecasts to three years, and the most recent SCORP (2000) used a ten-year forecast horizon (to the year 2010).

G.6.1 Recreation Resources

The SCORP is the best source of information on recreation demand and supply at the state and regional scales. It divides the state into 11 planning regions, each with clusters of counties. As indicated in ***Table G-20,*** Region 9 is the planning region that encompasses the study area.

TABLE G-20: COUNTIES WITHIN SCORP PLANNING REGIONS POTENTIALLY AFFECTED BY ALTERNATIVE RESTORATION PLANS

Region	Counties
Region 9	Collier
	Glades
	Hendry
	Lee
	Sarasota
	Charlotte

Source: Florida Department of Environmental Protection, 2000.

The SCORP organizes outdoor recreation in Florida into 47 categories that encompass a variety of recreation activities including team sports (e.g., basketball and baseball), individual sports (e.g., golf and tennis), hunting, fishing, swimming, and boating. ***Table G-21*** presents descriptive information on the recreation facilities in SCORP Region 9 for study area specific recreation categories. These resource-based categories were selected as those that could potentially be affected by the hydrologic changes or ecological changes associated with the alternative restoration plans. This table also includes percentages of the statewide totals for the recreation categories.

G.6.1.1 Recreation Demand

Profiles of existing and future recreation demand in the study area can be developed by drawing on a variety of information at the national, state, regional, and local levels. In general, the variety of recreational interests in the United States appears to be increasing along with recreational participation rates. As future recreation needs and interests develop, it is important to recognize that participation in specific types of recreational activities is often linked to demographic factors such as age and income. For example, participation in activities requiring vigorous exercise is considerably higher for young people than for senior citizens. However, the elderly population has increasing recreation participation because of the growing awareness of the importance of physical fitness. Participation in most activities is low for those with family incomes below $25,000 per year. Interestingly, participation is also low for those with family incomes greater than $100,000 per year. Most outdoor recreational activities appear to be enjoyed largely by the middle class, those with family incomes between $25,000 and $75,000 per year.

G.6.1.2 Regional Recreation Demand

Recreation demands were developed for the SCORP through surveys of residents and tourists. The Division of Recreation and Parks conducts periodic surveys of resident and tourist participation in recreation activities to estimate outdoor recreation in Florida. The recreation participation information was derived from the 2000 surveys conducted by the University of Florida, Department of Recreation, Parks, and Tourism. Participation in outdoor recreation activities is expressed in terms of user-occasions, which occur each time an individual participates in a single outdoor recreation activity. The number of user-occasions was calculated for each planning region as well as the entire state by type of activity. Demand was estimated for 1997, 2000, 2005 and 2010 by applying the per capita participation rates to population projections.

Table G-21 presents 1997 and projected 2010 demands for the selected recreation activities in SCORP Planning Region 9. This table includes user-occasions as well as facility/resource needs. As part of the without-project conditions, all of the regions are expected to have significant increases in demands for the selected recreation activities with a commensurate need to increase development of the regions' recreation resources and facilities.

TABLE G-21: DEMAND AND FACILITY NEEDS (1997 AND 2010) FOR SELECTED RECREATION ACTIVITIES SOUTHWEST REGION (SCORP REGION 9)

Activity	Units	Demand (user-occasions)		Resources / Facility Needs	
		1997	2010	1997	2010
Hunting	Acres	108,131	139,247	0	0
RV / Trailer Camping	Camp Sites	1, 501,713	2,386127	0	0
Tent Camping	Camp Sites	155,069	204,538	0	0
Hiking	Miles	1,299,375	2,011,069	223	517
Freshwater Fishing	Feet	543,125	779,561	0	0
Nature Study	Miles	2,146,713	3,073,615	10.87	56.8
Bicycle Riding	Miles	11,761,917	16,675,164	771.33	1,177.08

Source: Florida Department of Environmental Protection, 2000.

In summation, the Southwest Region (Region 9) ecosystems support a significant amount of outdoor recreation in the LEC of Florida. A significant portion of the expenditures comes from tourists. As can be seen from the table above, the activities that have a lack of supply for recreation purposes are hiking, biking and nature study. These are resources that could potentially be increased through the construction of the Caloosahatchee River (C-43) West Basin Storage Reservoir.

G.6.2 National Recreation Trends

National trends in recreation may help to identify potential or expected changes in the demand for Florida recreation as the result of ecosystem restoration. Two recent national surveys of outdoor recreation have particular relevance for this investigation.

G.6.2.1 National Survey of Recreation and the Environment

The Outdoor Recreation Coalition of America conducted a National Survey of Recreation and the Environment in 1994 and 1995. Approximately 17,000 Americans were interviewed in a random sample telephone survey, providing information regarding their participation in 62 recreational activities organized into 13 broad categories.

Table G-22 presents 1994-1995 participation rates for 26 of the 62 surveyed recreational activities. The activities in this table were selected as those that potentially could be affected by the SAP. Of the selected activities, the three

most popular groups of activities were outdoor viewing, fitness activities, and outdoor social activities that had participation rates of 76.2 percent, 68.3 percent and 67.8 percent, respectively. Walking was identified as the most popular activity with approximately 134 million participating (66.7 percent of the population). Approximately 124 million recreationists (62.1 percent) enjoy visiting a beach or other waterside and gathering outdoors with family. Sightseeing also had a high level of participation (56.6 percent). Other very popular activities include hiking and backpacking, fishing, boating and camping.

The Outdoor Recreation Coalition conducted a similar national survey of recreation and the environment in 1983-1984. (***Table G-23).*** ***Table G-24*** compares the results of the two surveys. The categories are somewhat different due to differences in the surveys.

TABLE G-22: PARTICIPATION RATES FOR SELECTED RECREATIONAL ACTIVITIES BY U.S. POPULATION 16 YEARS OR OLDER, 1994-1995

Recreational Activity	Participants (millions)	Percent of U.S. Population
Fitness	136.9	68.3%
Walking	133.7	66.7%
Viewing / Studying	152.6	76.2%
Nature Centers	93.1	46.5%
Visitor Centers	69.4	34.6%
Bird Watching	54.1	27.0%
Wildlife Viewing	62.6	31.3%
Fish Viewing	27.4	13.7%
Other Wildlife Viewing	27.5	13.7%
Sightseeing	113.4	56.6%
Visiting Beach / Waterside	124.4	62.1%
Water-based Nature Study	55.4	27.7%
Camping	52.8	26.4%
Developed Area	41.5	20.7%
Primitive Area	28	14.0%
Hunting	18.6	9.3%
Big Game	14.2	7.1%
Small Game	13	6.5%
Migratory Bird	4.3	2.1%
Fishing	57.8	28.9%
Freshwater	48.8	24.4%
Saltwater	19	9.5%
Warm water	40.8	20.4%
Anadromous	9.1	4.5%
Catch and release	15.5	7.7%
Boating	58.1	29.0%
Canoeing	14.1	7.0%

Recreational Activity	Participants (millions)	Percent of U.S. Population
Kayaking	2.6	1.3%
Rowing	8.4	4.2%
Outdoor Adventure	73.6	36.7%
Hiking	47.8	23.9%
Off-Road Vehicle Driving	27.9	13.9%
Horseback Riding	14.3	7.1%

Source: Outdoor Recreation Coalition of America, 1997.

TABLE G-23: TRENDS IN U.S. RECREATION PARTICIPATION, 1982-1994

Recreational Activity	1983-1984 (millions)	1994-1995 (millions)	% Change
U.S. POPULATION	234,868 (January '84)	261,575 (January '95)	11.4%
Fitness			
Walking	93.6	133.7	42.8%
Viewing Studying			
Bird watching	21.2	54.1	155.2%
Sightseeing	81.3	113.4	39.5%
Camping (overall)	42.4	52.8	24.5%
Camping, developed	30	41.5	38.3%
Camping, primitive	17.7	28	58.2%
Hunting	21.2	18.6	-12.3%
Fishing	60.1	57.8	-3.8%
Boating	49.5	58.1	17.4%
Swimming			
Pool Swimming	76	88.5	16.4%
River/lake/ocean Swimming	56.5	78.1	38.2%
Outdoor Adventure			
Hiking	24.7	47.8	93.5%
Backpacking	8.8	15.2	72.7%
Off-Road Driving	19.4	27.9	43.8%
Horseback Riding	15.9	14.3	-10.1%

Source: Outdoor Recreation Coalition of America, 1997

Table G-23 contains numbers of participants, not participation rates. As indicated in this table, there has been an increase in the number of participants for almost all activities. The 11.4 percent increase in United States. population during this period explains some of the change in the number of participants. However, some activities are clearly undergoing an increase in participation rates. For example, bird watching has the largest increase (155 percent) in number of participants from 1984 to 1995. Hiking and backpacking also

experienced large increases in participation, 93.5 and 72.7 percent respectively. Walking activity increased 42 percent from 94 million to 134 million participants. Also, since 1984 there has been an increasing interest in specialized outdoor adventure activities such as orienteering, mountain climbing, rock climbing, caving, and special types of wildlife viewing.

In general, the variety of recreational interests in the United States appears to be increasing along with recreational participation rates. As future recreation needs and interests develop, it is important to recognize that participation in specific types of recreational activities is often linked to demographic factors such as age and income. For example, participation in activities requiring vigorous exercise is considerably higher for young people than for senior citizens. However, the elderly population has increasing recreation participation because of the growing awareness of the importance of physical fitness. Participation in most activities is low for those with family incomes below $25,000 per year. Interestingly, participation is also low for those with family incomes greater than $100,000 per year. Most outdoor recreational activities appear to be enjoyed largely by the middle class, those with family incomes between $25,000 and $75,000 per year.

G.6.2.2 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation

The U.S. Fish and Wildlife Service conducted the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation in 1996. As part of this survey, 22,578 anglers and hunters and 11,759 wildlife watchers were interviewed. The purpose of the survey was to gather information regarding participation and expenditures for wildlife-related activities, including fishing, hunting, and wildlife watching. National participation and expenditure data for sportsmen and wildlife watchers are presented in ***Table G-24*** . The survey revealed that 77 million Americans aged 16 or older (40 percent of the adult population) enjoyed some form of wildlife-related recreation in 1996 with total expenditures exceeding $101 billion.

Wildlife watching activities primarily included observing, photographing and feeding wildlife for two types of participants: residential and nonresidential. The residential category included those activities that occurred within one mile of the residents' homes, while the nonresidential group included those who took trips or outings for the primary purpose of observing, photographing, or feeding wildlife. Based on the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, in 1996 over 62.9 million people in the United States participated in wildlife watching. This figure is consistent with the 1995 participation of 62.6 million wildlife watchers reported in the National Survey of Recreation and the Environment.

TABLE G-24: TOTAL U.S. WILDLIFE WATCHING PARTICIPATION, 1996

Category	Participants	Expenditures
Residential	60.8 million	
Nonresidential	23.7 million	
Total*	62.9 million	$29 billion

Source: U.S. Fish and Wildlife Service, 1996.

The sum of residential and nonresidential subcategories does not equal the total due to an overlap in participation. ***Table G-25*** presents residential and nonresidential participation in various wildlife-watching activities. Among all wildlife-watching participants, 97 percent (60.8 million) watched wildlife within one mile of their home (residential). The most popular residential activities included feeding and observing wildlife, 54.1 and 44.1 million participants, respectively. Approximately 23.7 million people (38 percent of all wildlife-watchers) spent 314 million days in 1996 taking trips for the primary purpose of enjoying wildlife. Of all nonresidential wildlife watchers, 68 percent participated only within their home state, 13 percent traveled only to other states and 19 percent took wildlife watching trips in both their state of residence as well as in other states. Survey results indicated that wildlife-watching trips were evenly distributed among male and female participants. The types of sites visited by nonresidential wildlife watchers included woodlands (77 percent), lakes or streamside (69 percent), open field (63 percent), brush covered (59 percent), wetland marsh or swamp (44 percent), manmade area (39 percent) and oceanside (27 percent). Of the 23.7 million nonresidential participants, 22.9 million enjoyed observing wildlife. Observing birds and land mammals was favored by 75 percent of wildlife observers.

TABLE G-25: U.S. WILDLIFE WATCHING ACTIVITY, 1996

Category	Participants (millions)	Average Days / Year (millions)	Average Days / Participant
Total Wildlife Watching*	62.9 (100%)		
Residential*	60.8 (97% of total)		
Observed Wildlife	44.1		
Photographed Wildlife	16.0		
Fed Wildlife	54.1		
Maintained Plantings/Natural Areas	13.4		
Visited Public Areas	11.0		
Nonresidential*	23.7 (38% of total)	314	13.2
Observed Wildlife	22.9	279	12.2
Photographed Wildlife	12.0	79	6.6
Fed Wildlife	10.0	90	9.0

Source: U.S. Fish and Wildlife Service, 1996.

Table G-26 presents a profile of wildlife observed by nonresidential participants by type. Waterfowl and songbirds were among the most popular species watched.

TABLE G-26: U.S. NONRESIDENTIAL WILDLIFE WATCHING BY SPECIES, 1996

Category	Participants (millions)	% of Total
Nonresidential	23.7	
Birds	17.7	75%
Waterfowl	14.3	
Songbirds	12.9	
Birds of Prey	10.6	
Other Shorebirds	9.5	
Other Birds	6.5	
Land Mammals	17.7	75%
Fish	8.4	35%
Marine Mammals	3.5	15%
Other	11.5	49%

Source: U.S. Fish and Wildlife Service, 1996.

The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation also contains state-level information on recreation participation and expenditures. In 1996, approximately 3,642,000 of Florida's 11,239,000

residents (32 percent) participated in wildlife-related recreation with the following distribution: 2,840,000 wildlife watching (25 percent of the state population) and 1,988,000 hunting/fishing (18 percent of the state's population). According to the survey, 79 percent of the time spent wildlife watching by Florida residents is spent within the State of Florida.

As indicated in ***Table G-27***, there were an estimated 1,846,000 participants in wildlife-watching activities in Florida in 1996. Approximately 1,050,000 (57 percent) of these participants were Florida residents and the remainder (796,000 or 43 percent) was from outside the state. Together, the in-state and out-of-state participants spent a total of 14,658,000 days watching wildlife in Florida.

TABLE G-27: PARTICIPANTS IN WILDLIFE-RELATED RECREATION IN FLORIDA, 1996

Participant	Residents	% of Total	Non-residents	% of Total	Total
Anglers	1,878,000	(66%)	986,000	(34%)	2,864,000
Hunters	170,000	(92%)	14,000	(8%)	184,000
Wildlife Watchers	1,050,000	(57%)	796,000	(43%)	1,846,000

Source: U.S. Fish and Wildlife Service, 1996.

Table G-28 presents estimated expenditures associated with wildlife watching in Florida during 1996. As indicated in this table, in-state and out-of-state participants spent over $1.6 billion in 1996 on wildlife watching. This includes trip-related expenditures and equipment expenditures. Wildlife watching equipment includes binoculars, film, bird food, and special clothing. Auxiliary equipment expenditures accounted for items such as tents and backpacking equipment. Other expenditures include magazines and books, membership dues and contributions, land leasing and ownership, and plantings.

TABLE G-28: FLORIDA WILDLIFE WATCHING EXPENDITURES, 1996

Expenditure Category	Total Expenditures (millions)	% of Total
TOTAL EXPENDITURES	$ 1,677.2	100%
Trip-Related Expenditures	$ 754.7	45%
Food and Lodging	$ 439.7	26%
Transportation	$ 189.4	11%
Other Trip Costs	$ 125.6	7%
Total Equipment Expenditures	$ 767.6	46%
Wildlife-Watching Equipment	$ 286.9	17%
Auxiliary Equipment	$ 65.4	4%
Other Expenditures	$ 154.8	9%

Source: U.S. Fish and Wildlife Service, 1996.

G.6.2.3 State Recreation Trends

The Florida SCORP supplements the results of the two national recreation surveys described above with estimates of current and future recreation demand at the state and regional scales. Recreation demands were developed for the SCORP through surveys of residents and tourists. The Division of Recreation and Parks conducts periodic surveys of resident and tourist participation in recreation activities to estimate outdoor recreation in Florida. The Division of Recreation and Parks did not have funds to conduct a new participation survey for the latest SCORP so the recreation participation information was derived from the 1992-1993 surveys conducted by the University of Florida, Department of Recreation, Parks, and Tourism. Participation in outdoor recreation activities is expressed in terms of user-occasions, which occur each time an individual participates in a single outdoor recreation activity. The number of user-occasions was calculated for each planning region as well as the entire state by type of activity. Demand was estimated for 1997, 2000, 2005 and 2010 by applying the per capita participation rates to population projections.

Table G-29 presents 1992 statewide resident and tourist demand in Florida for selected outdoor recreation activities. The activities were chosen based on their potential for being affected by the alternative restoration plans. As indicated in this table, over 45 million residents and tourists participated in these activities in 1992. Hiking, recreational vehicle (RV) camping, and nature study were popular with residents and tourists. With the exception of RV camping, participation by residents outnumbered tourist participation.

TABLE G-29: DEMAND FOR SELECTED RECREATION ACTIVITIES IN FLORIDA USER-OCCASIONS (THOUSANDS), 1992

Activity	Resident	Tourist	Resident & Tourist	% of Total
Hunting	1,656	34	1,690	4%
RV Camping	2,992	5,659	8,651	19%
Tent Camping	1,260	825	2,086	5%
Hiking	5,220	3,668	8,887	20%
Horseback Riding	3,155	491	3,647	8%
Nature Study	4,645	2,215	6,859	15%
Canoeing	846	555	1,401	3%
Total	27,235	18,271	45,506	100%

Source: Florida Department of Environmental Protection, 1994.

Table G-30 presents participation rates for the same set of recreation activities during 1985 and 1992. In general, residents have higher participation rates than tourists, and participation rates for both groups have declined from 1985 to 1992.

TABLE G-30: PARTICIPATION RATES FOR SELECTED RECREATIONAL ACTIVITIES (1985, 1992)

	% of Residents Participating		% of Tourists Participating	
Activity	1985	1992	1985	1992
Hunting	11%	2%	0%	0%
RV/Trailer Camping	8%	3%	4%	5%
Tent Camping	10%	3%	1%	1%
Hiking	10%	6%	3%	3%
Horseback Riding	8%	3%	0%	0%
Nature Study	17%	5%	4%	3%
Canoeing	10%	3%	1%	1%

Source: Florida Department of Environmental Protection, 1994.

G.6.2.4 State Tourism Trends

As described in the SCORP, 49 million domestic and international visitors to Florida per year comprise a significant portion of the overall demand for outdoor recreation resources in Florida. Their participation in resource-based recreation and their relatively high incomes (compared to resident recreationists) make tourists a significant component of project-related recreation in the study area. The Comprehensive Review Study detailed the importance of tourism on the recreation in Florida.

G.6.2.5 Potential Changes in Value of Recreation

The Caloosahatchee River (C-43) West Basin Storage Reservoir can support a significant amount of outdoor recreation in the Florida LEC, with a significant portion of expenditures coming from tourists. Based on the recent adverse effects related to environmental damage of the ecosystem, it may be concluded that improving the environmental quality of the Caloosahatchee River and Estuary ecosystem will substantially support and sustain local recreation-based businesses. Given the potential levels of expenditures and consumer surplus in the future, a small percentage increase in the quantity or quality of project-related recreation could represent an increase in recreation value.

There are potential recreation resources that will be associated directly with the construction of the impoundment. The uses presently considered compatible with resource protection and passive recreation include: freshwater fishing, horseback riding, hiking, off-road bicycling, wildlife viewing and nature study.

G.6.3 Recreation Benefits

The recreation appendix (Appendix H) for the Caloosahatchee River (C-43) West Basin Storage Reservoir project contains a description of the conceptual plan

that is being proposed for recreation purposes. Recreation features are being planned in the Caloosahatchee River (C-43) West Basin Storage Reservoir project as an incidental project benefit. These recreation benefits will not be used in the justification of the recommended plan. Order of magnitude costs have been included as provided by the SFWMD cost estimators and gleaned from other approved reports after updating. Costs have been updated by using the USACE, Jacksonville District, Broward County Water Preserve Areas recreation MCACES costs. SFWMD will be O&M the Caloosahatchee River (C-43) West Basin Storage Reservoir project recreational features. Adjustments may be made to the dollars spent depending on project design. As shown in Appendix H, Recreation, the costs for proposed recreation features would be $2,519,000. An additional ten percent for PED, and an additional eight percent for construction supervision and administration bring the estimated total costs for recreation to $2,972,000.

The NED benefit evaluation procedures contained in ER 1105-2-100 (22 Apr 00), Appendix E, Section VII, include three methods of evaluating the beneficial and adverse NED effects of project recreation: travel cost method (TCM), CVM, and unit day value (UDV) method.

The UDV method was selected for estimating recreation benefits associated with the creation of the Caloosahatchee River (C-43) West Basin Storage Reservoir. The UDV approach in recreation benefit analysis consists of two parts: determining value per visit and estimating visitation. Application of the selected value to estimate annual use over the project life, in the context of the with and without-project framework of analysis, provides the estimate of recreation benefits.

The without project condition in this analysis has no recreation value since the Caloosahatchee River (C-43) West Basin Storage Reservoir would not exist and the land would not be open to the public. It is presumed that the impoundment must be open to the public in order to realize the recreation benefits being claimed. The with-project condition will be the expected value of the recreational activity based on the UDV method.

Economic justification is determined by examining the benefit to cost ratio and net benefits of the proposed recreation sites. The economic justification of the proposed recreation sites can be examined by comparing the equivalent average annual costs with the estimate of the equivalent average annual benefits that would be realized over the period of analysis. These average annual recreation benefits and costs are summarized in

ER 1105-2-100 (The Planning Guidance Notebook) provides economic evaluation procedures to be used in all Federal water resources planning studies. The

guidelines specified in the ER 1105-2-100 dated 22 April 2000 were observed in preparing this cost analysis. The (FY) 2007 federally mandated project evaluation interest rate of 4.875 percent, an economic period of analysis of 40 years and FY 2007 prices were used to evaluate the economic feasibility of the project recreation sites.

The value of a day of general recreation was computed at $6.79. The number of visits per year was estimated at 52,925. Average annual benefits were estimated at $359,000. Average annual cost was estimated at $199,000. A summary of the economic feasibility is shown in ***Table G-31***.

TABLE G-31: SUMMARY OF RECREATION COSTS AND BENEFITS

Recreation Construction Costs	**$2,519,000**
PED & S/A (18%)	$453,000
Total Recreation Construction	**$2,972,000**
Construction Duration	12 months
Interest During Construction Costs	$72,000
Total Recreation Investment	**$3,044,000**
Period of Analysis	40 years
Annualized Cost	$174,000
OMRR&R	$25,000
Total Annual Costs	**$199,000**
Annual Benefits	
User Day Value	$6.79
Daily Use	145
Annual Use	52,925
Average Annual Benefit	**$359,000**

A sensitivity analysis was done to further reinforce expected benefits and provide additional justification for proposed recreation features (***Table G-32***). Minimum and SCORP expected benefits have been provided for comparison with the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir recreation benefits. This economic analysis suggests there would be ample benefits to conservatively justify the proposed recreation facility construction for the Caloosahatchee River (C-43) West Basin Storage Reservoir project.

TABLE G-32: SENSITIVITY ANALYSIS USING MULTIPLE SCENARIOS

Scenario	Annual Users	Daily Users	Annual Benefit
Most Likely	52,925	145	$160,000.00
Worst Case	32,850	90	$24,000.00
SCORP Guidelines	464,280	1,272	$2,953,000.00

A benefit to cost ratio of 1.8 to 1 and net annual benefits equaling $160,000 were calculated based on the conceptual plan.

G.7 COSTS

Data for initial construction/implementation, land acquisition, monitoring, and periodically recurring costs for operation, maintenance, repair, replacement, and rehabilitation (O&MRR&R), have been developed through engineering design and cost estimation, and real estate appraisal efforts. Details of that data development are explained and discussed elsewhere in this report. The main issues requiring economic evaluation attention include equivalent time basis calculations, price levels, and timing of project spending.

For purposes of this report and analysis, NED costs (as defined by Federal and USACE policy), are expressed in October 2006 price levels, and are based on costs estimated to be incurred over a 40 year period of analysis. Costs of a plan represent the value of goods and services required to implement and operate and maintain the selected alternative plan.

The following table displays the costs associated with the alternatives. The costs presented in ***Table G-33*** are preliminary rough order of magnitude (ROM) estimates and include total initial costs of construction features, recreation features, real estate, Interest During Construction (IDC), and total average annual costs for each alternative. These costs were used to formulate and evaluate plans to identify the SAP. The costs for the SAP were further refined based on additional engineering and environmental evaluations, as noted in the main report and can be found in the MCACES cost estimates The O&M cost is an annual estimate for fully implemented components.

TABLE G-33: ESTIMATED NED COSTS FOR ALTERNATIVES

	Alt 2	Alt 3B	Alt 3C	Alt 4
Cost Component				
Construction	$285,800,000	$316,900,000	$368,000,000	$464,300,000
S/A	$18,400,000	$20,400,000	$23,700,000	$29,800,000
PED	$23,000,000	$25,500,000	$29,600,000	$37,300,000
Lands	$80,507,000	$80,507,000	$80,507,000	$80,507,000
Initial Cost	**$407,707,000**	**$443,307,000**	**$501,807,000**	**$611,907,000**
Interest During Construction				
Construction	$26,600,000	$29,500,000	$34,000,000	$43,000,000
Lands	$13,500,000	$13,500,000	$13,000,000	$13,000,000
Total IDC	**$40,100,000**	**$43,000,000**	**$47,000,000**	**$56,000,000**
Total Project Investment	**$447,807,000**	**$486,307,000**	**$548,807,000**	**$667,907,000**
Average Annual Cost				
Interest & Amortization	**$25,700,000**	**$27,900,000**	**$31,400,000**	**$38,300,000**
Operation & Maintenance	$3,265,000	$3,358,000	$5,267,000	$5,556,000
Total Average Annual Cost	**$28,965,000**	**$31,258,000**	**$36,667,000**	**$43,856,000**

* Recreation costs are not included in the NED costs for alternatives
* The costs in this table are preliminary costs and are not exactly equivalent to the costs used in the main report which are detailed costs.

The timing of a plan's costs is important. Construction and other initial implementation for component costs cannot simply be added to periodically recurring costs for project operation, maintenance, and monitoring. Also, construction costs incurred in a given year of the project can not simply be added to construction costs incurred in other years if meaningful and direct comparisons of the costs of the different components are to be made. A common practice of equating sums of money across time with their equivalent at an earlier single point in time is the process known as discounting. Through this mathematical process, which involves the use of an interest rate (or discount rate) officially prescribed by Federal policy for use in water resource planning analysis (4.875 percent per year at the time of analysis), the cost time stream for the alternative plans were mathematically translated into a equivalent time basis value.

There is some admitted uncertainty as to how the plan, if approved and adopted, would be implemented. It is recognized that the plan would likely be implemented over a considerable period of time, little by little. For purposes of this evaluation, construction costs are assumed to be incurred on an equal monthly basis during the implementation of the alternative plan as defined.

ER 1105-2-100 requires that IDC be computed which represents the opportunity cost of capital incurred during the construction period. Interest was computed

for construction and PED costs from the middle of the month in which the expenditures were incurred until the first of the month following the estimated construction completion date. Interest during construction was computed for both real estate and construction costs. Interest during construction was computed for the total real estate cost starting from the month prior to construction commencing.

The cost of a project is the investment incurred up to the beginning of the period of analysis. The investment cost at that time is the sum of construction and other initial cost such as real estate and PED cost plus interest during construction. ***Table G-33*** summarizes the total investment cost and total annual equivalent costs of each alternative plan.

G.8 COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

Plan formulation and evaluation actions for this project focused on management measures and plans developed in prior Everglades ecosystem restoration studies. All of the prior studies with similar planning objectives (to restore fish and wildlife habitat functions in the remaining estuaries and rivers) concluded that additional storage to supplement the regional water management system was needed at the Caloosahatchee River (C-43) West Basin Storage Reservoir location, and an aboveground impoundment was the most cost-effective management measure for creating additional storage.

The initial and final arrays of alternative plans for this project consisted of aboveground impoundments (a single management measure) of varying storage volumes and pump sizes. All other management measures were screened from further consideration as a result of prior studies. Since all of the plans in the final array of alternative plans consisted of the same cost effective management measure, an incremental cost analysis (ICA) was performed to determine the incremental costs of the benefits produced by the remaining four structural plans. ICA of the system-wide effects of the final array of plans was performed using IWR Plan software for the eight remaining alternative plans.

Cost effectiveness analysis begins with a comparison of the costs and outputs of alternative plans to identify the least cost plan for every level of output considered. Alternative plans are compared to identify those that would produce greater levels of output at the same cost, or at a lesser cost, as other alternative plans. Alternative plans identified through this comparison are the cost effective alternative plans. Next, through ICA, the cost effective alternative plans are compared to successively identify the alternative plans with the least additional cost per additional output that is, the "Best Buy" alternative plans that produce the "biggest bang for the buck." Cost effective plans are compared by examining the additional (incremental) costs for the additional (incremental) amounts of

output produced by successively larger cost effective plans. The plans with the lowest incremental costs per unit of output for successively larger levels of output are the best buy plans. The results of these calculations and comparisons of costs and outputs between alternative plans provide a basis for addressing the decision question "Is it worth it?" i.e., are the additional outputs worth the costs incurred to achieve them?

This analysis is based on and follows guidance from the USACE Institute for Water Resources publication, Evaluation of Environmental Investment Procedures Manual, Interim: Cost Effectiveness and Incremental Analyses, May 1995, IWR Report #95-R-1. Costs are based initially on a ROM and include PED and construction costs, Interest During Construction, as well as O&M costs after construction. The most feasible cost effective plans reflect estimates based on ROM quantities

G.8.1 Types of Benefits Analyzed

In practice, USACE ecosystem restoration studies typically measure the ecosystem benefits of alternative plans in terms of physical dimensions (number of acres of wetlands, for example), or population counts (number of wading birds, for example), or various habitat-based scores ("habitat units" based on the U.S. Fish & Wildlife Service's *Habitat Evaluation Procedures*, or "HEP", for example). The evaluation consisted of many performance measures to ascertain how well each of the alternative plans performed on various criteria indicative of ecosystem restoration, and habitat units (HU) were derived from these performance measures and selected by the project delivery team (PDT) as the metric that best integrated information regarding the quality and quantity of improved hydrologic and ecologic function within the study area.

The purpose of the habitat suitability model for the Caloosahatchee River (C-43) West Basin Storage Reservoir project is to portray species response to changes in environmental variables resulting from restoration activities spatially and temporally to facilitate policy decisions. The intent of the habitat suitability model is not to simulate the life-cycles of the species. Rather, it is to estimate the number of HUs to serve as a relative basis for comparing management alternatives.

Habitat Suitability Indices (HSI) models were developed with each stressor variable portrayed spatially and temporally across the study area at scales appropriate to the organism or community being portrayed. The HSI models have been incorporated into a GSI to portray responses spatially and temporally to facilitate policy decisions. That is, the model describes a response surface of habitat suitability values that vary spatially according to stressor levels

throughout the estuary and temporally according to temporal patterns in stressor variables.

Species selected for modeling (focal species) are ecologically, recreationally or economically important and have a well established linkage to stressors of management interest. They may also make good focal species because they engage the public in caring about the outcome of restoration projects. The HSI models were developed by choosing specific life stages of particular species with the most limited, restricted, or tightest range of suitable conditions, to capture the highest sensitivities of the organisms to the environmental changes associated with the planned restoration activities.

The project team originally decided to use seven species–eastern oysters, blue crabs, *Vallisneria,* seagrass (*Halodule and Thalassia)*, spotted seatrout, decapod larvae, and zooplankton. Once all models were run on all alternatives, the team decided to narrow the full analysis to three species–oysters, *Vallisneria* and seagrass.

The following sub-sections describe the annualized ecological benefits for the five attributes studied (three single species/habitats, extreme events, and Restoration Coordination and Verification [RECOVER] Performance Measure). Ecological benefit index scores were then multiplied by the acreage of the affected area to obtain HUs. A detailed description of the HSI model for each species, as well as the method for calculation of HUs is contained in the environmental appendix of the final PIR.

Three of the chosen benefit streams are indicators of the health of certain habitats within the estuary. Although these are single species, they represent habitat for hundreds of individual species which live, feed and breed in these areas. Therefore, although the habitat suitability scores were multiplied by the modeled area to estimate total ecological benefits, the ecological benefits are actually applicable to a much larger area because other species also directly and indirectly benefit from the habitat improvement.

Two of our benefit streams are indicators of whole estuary health. The Extreme Events benefit stream is an average of two habitats and reflects how these habitats react to extreme events. Although only two habitats were considered, the team felt it was appropriate to apply this to the full estuarine acreage, as this is perhaps the best indicator of how the entire estuary would react to differing alternatives during extreme events. NE-03 RECOVER PM based on a flow created to maximize whole estuary ecological health.

Table G-34 includes a list of the raw HSI scores for each of the alternatives and the existing and future without project condition. The details behind the calculations can be seen in the environmental appendix.

TABLE G-34: HSI SCORES FOR ALTERNATIVE CONDITIONS

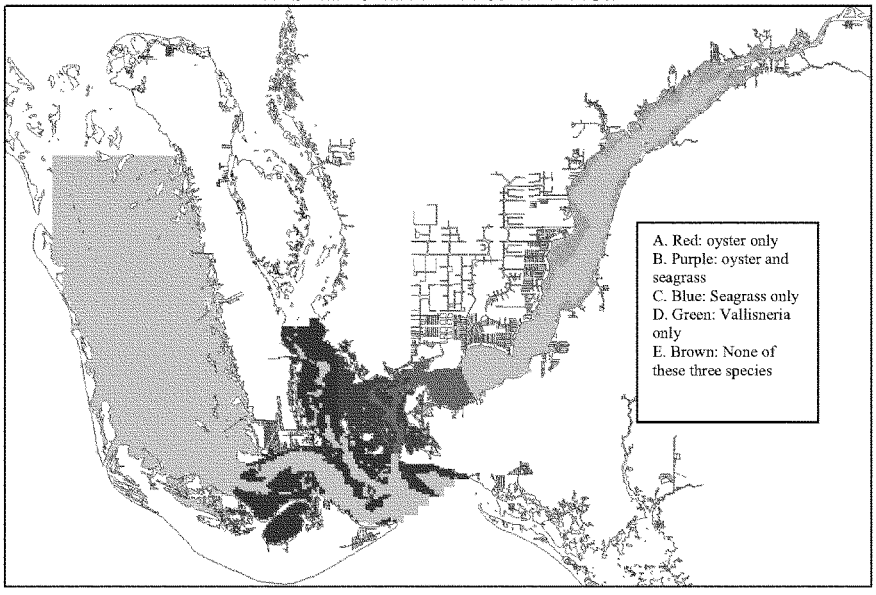
Indicator	2000	2050	ALT2	ALT3B	ALT3C	ALT4
Vallisneria	0.16	0.20	0.31	0.33	0.35	0.35
Seagrass	0.51	0.54	0.59	0.59	0.59	0.59
Oysters	0.48	0.52	0.60	0.60	0.61	0.61
Extreme Events	0.28	0.30	0.42	0.43	0.45	0.45
EST05	0.38	0.43	0.64	0.70	0.80	0.79

G.8.2 Habitat Unit Combination Methodology

Sometimes it is difficult to summarize the results of CE/ICA when the analyses are performed separately on HUs for distinct species or communities. This phenomenon often occurs simply because different management measures or alternative plans "do" different things, provide different types of output, and provide benefits to different biological communities. Therefore, the CE/ICA was performed on the combined HUs for all the performance indicators.

Once the HSI scores were calculated, the five streams of AAHUs were then converted into one project AAHU number. This was done with the Habitat Unit Combination Methodology (HUCM) (***Figure G-7***).

FIGURE G-7: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR AREA OF IMPACT



The basis of the HUCM is that the total HSI values in any one area are summed and then divided by the total number of HSI scores for that area to find an average HSI for the area. Then that score is multiplied by the number of acres for that area. There are two HSI scores which are calculated for the entire area of benefit (extreme event and EST05). Therefore, all areas have at least those two scores in addition to any species specific HSI values. So, for example, if one area has oysters as the only species specific HSI calculated, the HUCM would add the oyster HSI plus the extreme event and EST05 HSI, then divide by three. That value would then be multiplied by the number of acres for the area. Once there is a value for each area, those values are added together to get the total HUs for the project.

Based on ***Figure G-7*** above, the equation for HUCM for the Caloosahatchee River (C-43) West Basin Storage Reservoir is as follows:

Total Project Habitat Units = ((V + EE +ES)/3) x 4,130) + ((O +EE + ES)/3 x 2,392) + ((S + EE + ES)/3 x 9,041) + ((S + O + EE + ES)/4 x 3,506) + ((EE +ES)/2 x 51,910)
Where:
V = Vallisneria HSI
EE = Extreme Event HSI

ES = EST05 HSI
O = Oyster HSI
S = Seagrass HSI

G.8.3 Average Annual Benefits

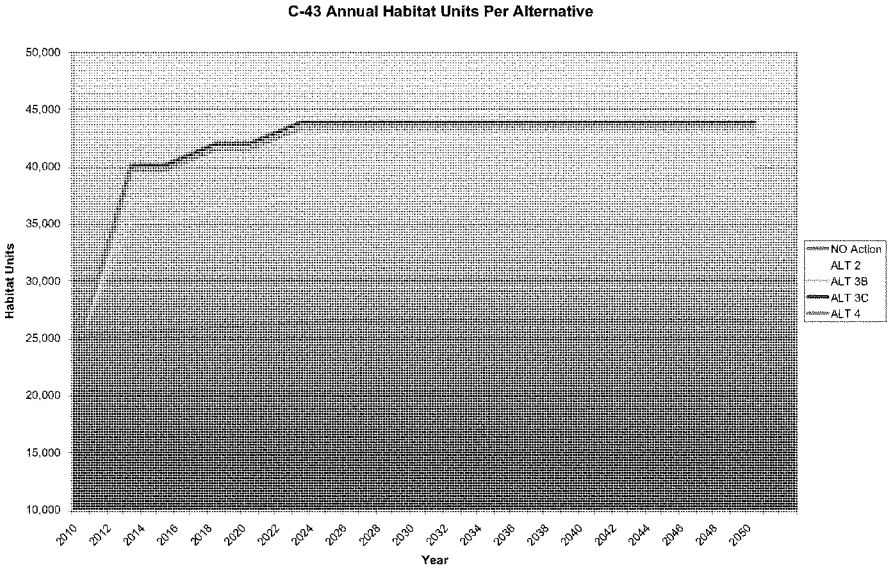
CE/ICA requires a comparison of average annual costs and average annual benefits. In an ecosystem restoration project, the analysis compares the alternative plans' average annual costs against the appropriate average annual HU estimates. The average annual outputs were calculated as the difference between with- and without-plan conditions over the period of analysis (through year 2050). Costs used for CE/ICA are displayed in ***Table G-35***. Note that the output values shown reflect the differences between without project and with project on an average annual basis (i.e., ecological "lift" provided by each of the alternatives).

Figure G-8: A graphically represents the average annual benefits for the combined HUs. There is a plot of the future without condition HUs, and a plot of the future with project HUs. The period of analysis for benefit annualization that was utilized is 40 years. The base year, or the first year benefits begin to accrue, is in 2010. The alternatives that took longer to have benefits begin accruing had costs annualized over 39 years and the 2010 present worth of the annualization calculated. In order to account for the discrepancy in annual benefit period of analysis, the benefits were annualized over 40 years (which is consistent with the cost annualization); with a year of zero lift being included in the average. Any year on this chart can be picked to represent the HUs created in any particular period. The average annual HU lift is calculated as subtracting the future without project HUs from the future with project HUs for each year and averaging over the life of the project, which in this case is 40 years.

The analysis of ecological response times for large, diverse ecosystems is extremely difficult to calculate. For example, when analyzing an estuarine system, certain attributes will have to be examined when predicting the response to changes in salinity. Oysters will generally provide responses within a year of salinity change towards normal conditions. Seagrasses will also normally respond fairly quickly, but these responses are difficult to measure since there will be relocation of certain populations in response to specific currents and salinity concentrations. Small invertebrate and fish species should also respond fairly quickly; however, large vertebrate species of fish will take longer to increase as they take longer to mature and reach reproductive ages. As such, the team took a linear approach to predict ecological response time, and the consensus was 80 percent of the benefits would be realized three years from start of construction, 90 percent within five years after that, 100 percent of the

lift would be realized within ten years of construction. The future without condition would experience a gradual improvement for 15 years at which point the ecosystem would stabilize.

FIGURE G-8: ANNUAL HABITAT UNIT LIFT



G.8.4 Cost Effectiveness Analysis

The results will be demonstrated in the various following charts and graphs. In summary, CE/ICA was performed using a combination of the following five metrics to represent various ecosystem outputs of the project alternatives:

- Vallisneria
- Oyster
- Seagrass
- EST05
- Extreme Event

CE/ICAs were conducted for each of the project alternative plans. The analyses compared the alternative plans' average annual costs against the appropriate average annual HU estimates. The average annual outputs were calculated as the difference between with- and without-plan conditions over the period of analysis (through year 2050). A summary of the average annual lift calculations

and average annual costs used in the CE/ICA analysis are provided in ***Table G-36***.

The total cost of CERP is not included in this CE/ICA. The cost of the balance of the CERP features, those not included in the project alternatives, is the same for all the alternatives. As such, including it in this analysis does not bring any additional insight or differentiation between alternatives. For this analysis, the difference between the alternatives can be shown through a display of the outputs and costs of each alternative without the cost of the other CERP features.

All of the environmental outputs were calculated on an average annual basis to account for the fact that several years may be required for full attainment of the functional capacities to be realized. This was performed for the expected future with and without project HUs, which were used to calculate the average annual benefits for each ecosystem output.

TABLE G-35: COSTS AND OUTPUTS USED IN COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES
(VALUES FOR ALTERNATIVES ARE DIFFERENCES BETWEEN WITHOUT PLAN AND WITH PLAN ON AN AVERAGE ANNUAL BASIS)

	Alternative 2	Alternative 3B	Alternative 3C	Alternative 4
Annual Cost	**$28,965,000**	**$31,258,000**	**$36,667,000**	**$43,856,000**
Average Annual Habitat Units	**10,628**	**12,809**	**16,397**	**15,907**

Note: Values assume system benefits (ecosystem outputs that would accrue to the West Basin Storage Reservoir study area if rest of CERP is constructed).

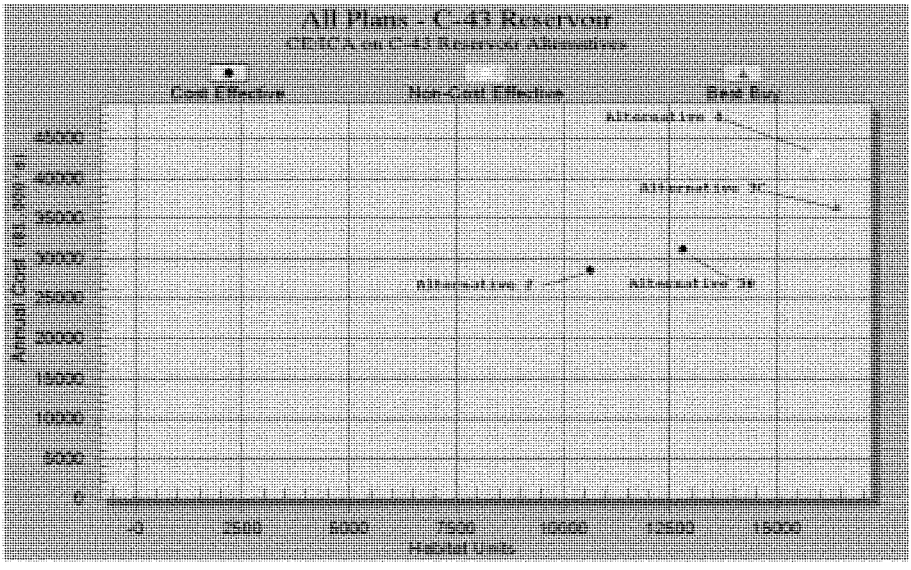
G.8.4.1 Cost Effectiveness Analysis

Table G-36 and ***Figure G-9*** show that Alternatives 2, 3B and 3C are all cost effective alternatives. Alternative 3C provides the greatest habitat lift of all the alternatives, and this alternative also has the lowest average annual cost per unit of output.

TABLE G-36: RESULTS OF COST EFFECTIVENESS ANALYSIS: ALL PLANS AND COST EFFECTIVE PLANS ARRAYED BY INCREASING OUTPUT FOR EACH OUTPUT CATEGORY

	Average Annual Cost ($1,000)	Output (Annual Lift)	Average Annual Cost Per Output	Cost Effective?
Plans	**Freshwater Wetland Habitat Units (HU)**			
Without Plan	$0	0	N/A	
Alternative 2	$28,965	10,628	$2,725	YES
Alternative 3B	$31,258	12,809	$2,440	YES
Alternative 4	$43,856	15,907	$2,757	NO
Alternative 3C	$36,667	16,397	$2,236	YES

FIGURE G-9: CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR ALTERNATIVE PLANS



G.8.4.2 Incremental Cost Analysis

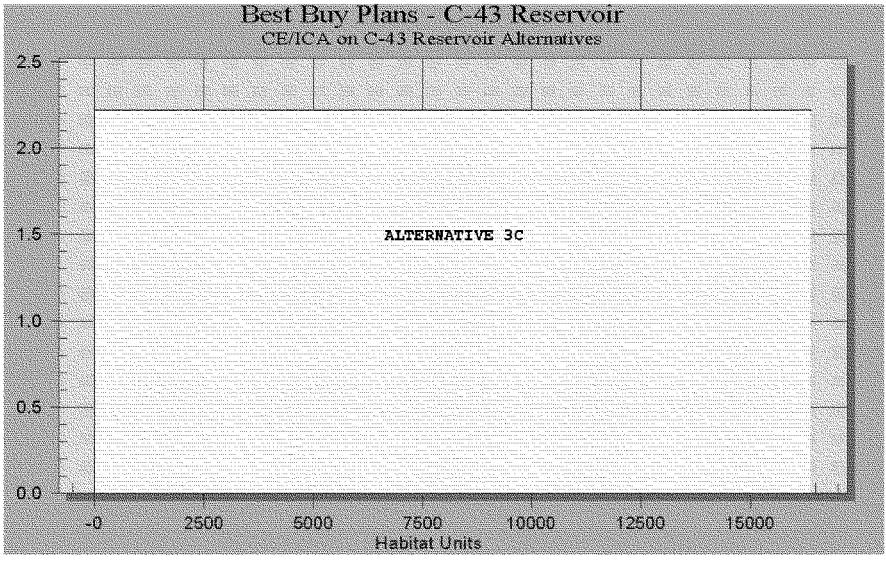
Table G-37 and ***Figure G-10*** present the results of ICA for the alternative plans for respective ecological zones. Typically, the cost effective plans are arrayed by increasing output to clearly show changes in cost (i.e., increments of cost) and changes in output (i.e., increments of output) of each cost effective alternative plan compared to the without plan condition. The plan with the lowest incremental costs per unit of output of all plans is the first best buy plan. After the first best buy plan is identified, all larger cost effective plans are compared to the first best buy plan in terms of increases in (increments of) cost and increases in (increments of) output. The alternative plan with the lowest incremental cost per unit of output (for all cost effective plans larger than the first best buy plan) is the second best buy plan.

These tables and figures show that there is only one best buy plan for the Caloosahatchee River (C-43) West Basin Storage Reservoir project. Alternative 3C provides the greatest HU lift while having the lowest cost per unit of output and is the NER plan which is the plan that reasonably maximizes ecosystem benefits when compared to costs.

TABLE G-37: RESULTS OF INCREMENTAL COST ANALYSIS: COST EFFECTIVE AND BEST BUY PLANS ARRAYED BY INCREASING OUTPUT

	Average Annual Cost ($1000)	Output	Average Cost Per Output ($1,000)	Incremental Average Annual Cost ($1,000)	Incremental Output	Incremental Cost Per Output	Best Buy?
(Habitat Units)							
Without Plan	$0	0	N/A	N/A	N/A	N/A	
Alternative 3C	$36,667	16,397	$2,236	$36,667	16,397	$2,236	Best Buy

FIGURE G-10: BEST BUY PLANS



G.8.5 Selected Alternative Plan

The P&G states: "the alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment (NED Plan is to be selected paragraph 1.10.2)." There is no similar rule for plan selection where outputs are not measured in dollars, as in the case of ecosystem restoration analyses. While the CE/ICA does not provide a discrete decision rule for plan selection, it does provide the types of information to support an informed decision regarding ecosystem restoration. Information about the acceptability, completeness, efficiency and effectiveness can also providing valuable support in making an informed decision in answering the question: "Is it worth it?"

TABLE G-38: SUMMARY OF ALTERNATIVE PLANS

Alternative 2	Alternative 3B	Alternative 3C	Alternative 4
Cost Effective	**Cost Effective**	**Cost Effective and Best Buy**	**Not Cost Effective**

The final array of alternatives was evaluated using the Planning P&G evaluation criteria. These are:

- Acceptability,
- Completeness,
- Efficiency, and
- Effectiveness.

Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies.

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.

Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment.

Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.

In ***Table G-39*** each plan, except the No Action Alternative, was rated on a scale of 0 to 2 on the ability of each plan to meet the specified criteria (0 = does not meet; 1 = partially meets; 2 = fully meets).

TABLE G-39: P&G EVALUATION CRITERIA

	2	3B	3C	4A
Acceptability	1	2	1	1
Completeness	1	1	1	1
Efficiency	1	1	2	0
Effectiveness	1	2	2	1

Alternative 3B is the only alternative that fully meets the P&G evaluation criteria and has therefore been identified as the SAP. The No Action Alternative does not meet any of the P&G criteria.

G.8.6 Next Added Increment Justification

Section 385.26 of the CERP Programmatic Regulations requires that the selected plan be "justified on a next-added increment (NAI) basis." The regulations further require a series of programmatic guidance memoranda be developed, including guidance for performing plan formulation and evaluation process and NAI justification. Initial drafts of the six programmatic guidance memoranda were completed and made available for public and agency review and comment on 26 April 2005.

G.8.6.1 Next Added Increment Benefits

The evaluation of the NAI formulation was completed using the Habitat Unit Combination Methodology (HUCM) approach on the five performance measures for the SAP (Alternative 3B). The NAI was performed by calculating the total NER benefits attributable to the Caloosahatchee River (C-43) West Basin Storage Reservoir Project resulting from the incremental implementation of the project. The NAI analysis demonstrates that the SAP without any other CERP project would produce 15,308 total HUs.

It was determined through this analyses that there are benefits associated with the NAI analyses that was completed for the Caloosahatchee River (C-43) West Basin Storage Reservoir Project. Overall, the project design is consistent with attaining project goals and objectives. Operational flexibility will lead to increased benefits by further minimizing potential high flows to the estuary as well as by minimizing discharges (and associated sediment loads).

In comparing the NAI benefits with the system-wide analysis it can be noted that there is a perception of more benefits realized in the NAI analysis. There were approximately 12,800 average annual HUs calculated for the system-wide analysis compared to the 15,300 average annual HUs in the NAI analysis. In reality the NAI and system-wide HSI scores are relatively close. ***Table G-40*** presents a summary of the raw HSI scores for both the NAI and system-wide calculations.

TABLE G-40: SUMMARY OF RAW HSI SCORES

	SYSTEM WIDE FORMULATION			NAI ANALYSIS		
	2000	2050	ALT 3B	2000	2050	ALT 3B
Vallisneria	0.16	0.20	0.33	0.03	0.08	0.60
Seagrasses	0.51	0.54	0.59	0.49	0.51	0.52
Oysters	0.48	0.52	0.60	0.52	0.52	0.23
Extreme Events	0.28	0.30	0.43	0.22	0.24	0.24
EST05	0.38	0.43	0.70	0.20	0.21	0.71

G.9 REGIONAL ECONOMIC IMPACTS

G.9.1 Overview

This chapter examines the potential effects of the SAP on the RED account. The RED account registers indirect and secondary effects to the region that are expected to result from the direct economic effects of the alternative plans. Direct economic effects represent the impacts of economic stimuli in terms of changes in regional industrial output, earnings, or employment. Indirect economic impacts represent the resultant economic changes in the industries that support and rely upon the industries directly affected by the stimuli. In addition, induced economic impacts are those impacts experienced by all local industries as direct and indirect effects alter household income and ultimately change local household spending patterns.

G.9.2 Methodology

A regional input-output model, *IMPLAN*, was used to estimate the RED effects of the Caloosahatchee River (C-43) West Basin Storage Reservoir SAP. Regional input-output (I-O) analysis provides the classic tool for tracing economic impacts throughout the regional economy. Based on the region's industrial structure, I-O analysis tracks the expected inter-industry flow of goods and services. For the RED analysis, the regional economy was defined as encompassing four southwest Florida counties (Glades, Lee, Hendry and Charlotte) using *IMPLAN*. Using county-level economic data, which was procured from the software vendor, the model was used to estimate the economic effects of the SAP on wages, employment, and industrial output. Specifically, *IMPLAN* was employed in a four-part methodology to: (1) describe the study area economy, (2) create economic scenarios, (3) introduce economic changes, and (4) estimate resulting direct, indirect, and induced economic effects.

The total construction expenditures are listed in ***Table G-33***.

G.9.3 IMPLAN Regional Economic Effects Results

In ***Table G-41***, the direct economic effects and aggregated indirect and induced economic effects are presented for the selected alternative plan. RED effects have only been calculated for construction expenditures and not for changes resulting from impacts to navigation, water usage, flood control or real estate expenditures. Economic impacts to total industry output and employee compensation are expected to persist through each year of construction. Wages include salaries, non-wage compensation, and benefits. Employment is measured as the number of jobs, not necessarily full-time equivalents.

Table G-41 and ***Table G-42*** present the *IMPLAN* output for direct, indirect, and induced impacts of the SAP, and ***Table G-43*** is and provides an indicator of the employment effects of the construction expenditures. These impacts account for less than one percent of total economic activity in each of the different output categories.

TABLE G-41: DIRECT, INDIRECT AND INDUCED IMPACTS ON EMPLOYEE COMPENSATION AS A RESULT OF IMPLAN MODEL RUNS (2006 DOLLARS)

	Direct	Indirect	Induced	Total
Alternative 3B	$30,804,000	$7,764,000	$24,298,000	$62,866,000

TABLE G-42: DIRECT, INDIRECT AND INDUCED IMPACTS ON REGIONAL OUTPUT AS A RESULT OF IMPLAN MODEL RUNS (2006 DOLLARS)

	Direct	Indirect	Induced	Total
Alternative 3B	$183,067,000	$23,225,000	$66,625,000	$272,917,000

TABLE G-43: DIRECT, INDIRECT AND INDUCED IMPACTS ON EMPLOYMENT AS A RESULT OF IMPLAN MODEL RUNS (2006 DOLLARS)

	Direct	Indirect	Induced	Total
Alternative 3B	956	269	786	2,011

G.10 OTHER SOCIAL EFFECTS

G.10.1 Overview

The OSE account considers the effects of alternative plans in areas that are not already contained in the NED and RED accounts. The categories of effects contained within the OSE account include:

- Urban and community impacts;
- Life, health, and safety factors;
- Displacement;

- Long-term productivity; and
- Energy requirements and energy conservation.

The Caloosahatchee River (C-43) West Basin Storage Reservoir Project alternative restoration plan could result in beneficial and adverse OSE within the study area. As is evident throughout this appendix, a variety of positive and adverse NED impacts on water supply, flood damage reduction and recreation are expected to result from the Caloosahatchee River (C-43) West Basin Storage Reservoir construction. Similarly, the alternative restoration plans could have positive or adverse OSE impacts on the study area associated with (1) plan implementation, including land acquisition, project construction, and O&M activities, and (2) operation of the modified C&SF system. As in the case of the NED effects, the OSE account is concerned with the net effects of the alternative plans (i.e., the differences between the with- and without-project future conditions).

Some of the potential OSE impacts would occur primarily at the regional scale, and others would have more localized effects. At both scales, there may be some individuals and communities that are positively affected by project implementation, some that are adversely affected, and many that are not affected at all. Relative to the size of the regional or local economies, the OSE effects may be minimal. However, if these effects occur predominantly within a limited geographic area, or affect a relatively small or vulnerable population, then the impacts can be disproportionately large. Therefore, the purposes of OSE analysis include not only determining the total magnitude of potential impacts, but also identifying the population (and its characteristics) that would be affected by any proposed action.

Some of the categories of effects typically included in the OSE account do not pertain to the alternative restoration plans. For example, the alternative plans are not expected to affect energy use or energy conservation in the study area. As will be noted, other categories of potential OSE impacts have been addressed previously in this appendix.

G.10.2 Potential Urban and Community Impacts

An urban and community impact is the principal category of potential OSE impacts associated with the alternative restoration plans. This category of impacts includes effects on income distribution, employment distribution, population distribution and composition, and quality of community life. Some urban and community impacts have previously been addressed in this appendix. For example, regional income effects and fiscal impacts were discussed in the RED analysis. In addition, the impacts of agricultural water supply and M&I water supply were discussed in detail in earlier sections. The OSE assessment

of urban and community impacts considers both the potential for exposure to the effects of the alternative restoration plans and the degree of vulnerability to potential impacts. Exposure refers to whether an individual or community is subject to the OSE of the alternative plans. Vulnerability refers to the ability of that individual or community to respond or adjust to those effects.

Potential urban and community impacts of the alternative restoration plans could result from: (1) land acquisition and potential relocation of populations for reservoir and other project construction features, (2) reduced agricultural activity associated with taking the reservoir lands out of cultivation, and (3) construction activity associated with plan implementation. In general, construction activity is considered to have positive impacts. At the local scale, construction and O&M activities associated with the alternative restoration plans can have positive effects to local residents and communities by providing jobs, increasing local wages, increasing local sales, increasing tax revenues and generally benefiting the local economy.

There are a variety of social and economic factors that are important determinants of an individual or community's ability to cope with adversity. One of the most important economic factors in the ability of individuals and groups to respond is the number of employment alternatives available locally. The ability to find another job depends on the education and training of the work force as well as the needs of local economic concerns, such as other farms, agricultural-related services, or some other local business. The socio-economic makeup of the community is also an important consideration of the ability of individuals and the community at large to cope with the adverse effects of large-scale agricultural land conversion. Some groups in society are recognized as having less opportunity to respond to adversity. These groups include ethnic and racial minorities, the elderly, and the poor. ***Table G-44*** presents a socio-economic vulnerability profile for the local counties. This profile contains information that indicates the ability of the county population to respond to social and economic adversity. It is important to recognize that the county scale may not accurately reflect the ability of any given community or groups within a community to accommodate potential changes associated with the alternative restoration plans.

Table G-44 contains the racial/ethnic mix of each county in the study area, as well as population over 65 years of age, 2000 unemployment, per capita income, and the expected changes in employment and income.

The surrounding counties have a wide range of ethnic compositions, proportions of elderly population, unemployment rates, and per capita incomes. These socio-economic characteristics suggest that the rural counties of the study area– those that are expected to provide locations for new storage reservoirs– are areas that are least able to accommodate the associated economic and social effects on local

communities. However, in these rural areas the affected populations should be relatively small.

Although the restoration of the estuaries and construction of the reservoir is a unique undertaking, there have been other projects and programs with similar goals and socio-economic contexts. One study conducted by the U.S. Department of the Interior assessed the national and regional economic impacts of not allowing timber harvests in certain old-growth forests in Oregon in order to protect the northern spotted owl. One aspect of this study investigated the re-employment of timber workers who had been displaced by the cessation of local logging activities. Surveys of displaced loggers suggested that they found that 57 percent of displaced workers reported post-displacement wages equal to or above their previous wages. According to the bureau of labor statistics, 92 percent of displaced workers find new jobs within one year, and the remaining eight percent find jobs within two years.

TABLE G-44: 2005 CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR SURROUNDING COUNTIES SOCIO-ECONOMIC VULNERABILITY PROFILE

	Asian	White	Black	American Indian	Hispanic	Population Over 65 (2000)	Unemployment Rate (2000)	2000 Per Capita Income**	Percent of Population Below Poverty Level
Charlotte County	1.1	92.7	5.3	0.2	4.2	33.7	N/A	N/A	9.3
Glades County	0.4	83.6	10.5	4.9	17.6	20.7	5.3	17,434	13.1
Hendry County	0.5	84.2	13.5	1.4	45.8	10.2	7.7	20,093	18.0
Lee County	1.1	90.0	7.5	0.4	14.3	22.7	2.9	33,073	10.2

G.11 ENVIRONMENTAL JUSTICE

EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires the Federal government to achieve environmental justice by identifying and addressing high, adverse and disproportionate effects of its activities on minority and low-income populations. E.O. 12898, Environmental Justice, states that the proposed action would not result in adverse human health or environmental effects. Any impacts of the action would not be disproportionate towards any minority or low-income population. The activity does not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin. The activity would not impact "subsistence consumption of fish and wildlife." It requires the analysis of information such as the race, national origin, and income level for areas expected to be impacted by

environmental actions. It also requires Federal agencies to identify the need to ensure the protection of populations relying on subsistence consumption of fish and wildlife, through analysis of information on such consumption patterns, and the communication of associated risks to the public.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project will provide benefits to quality of life by improving the natural environment. The project features of wetland restoration and improved water discharge are by design in locations remote from urban populations such that negative impacts are eliminated for all communities. The Caloosahatchee River (C-43) West Basin Storage Reservoir is a Congressionally approved project funded with Federal and State dollars to make improvements to hydrology for people and the environment.

In public outreach efforts to date, only one potential environmental justice issue has been identified: the loss of jobs for low income and minority workers as a result of acquiring agricultural land for the construction of the reservoir. The expected loss in employment will occur to seasonal and/or temporary migrant workers, and as can be noted in the future land use section agricultural acreage in the surrounding study area and counties is expected to increase. The Caloosahatchee River (C-43) West Basin Storage Reservoir Project provides an opportunity to somewhat alleviate this potential problem by providing jobs within and during construction of the project, some of which could provide seasonal and temporary employment. In addition, it is anticipated that adjacent lands will continue to support agricultural operations.

The reservoir site is located based upon hydrologic characteristics, land availability and interconnection to existing canals and structures to optimize operations. Furthermore, in the consideration of the project site, urban areas are avoided to eliminate the negative impacts typically associated with site location of large projects. Through "willing seller agreements" a variety of land rights have been or will be acquired that allow the use of land for the resulting improvements to the human quality of life and the intended environmental benefits intended by the impoundment.

These environmental benefits provide quality of life improvements to all people and primarily to people in the communities within the study area. By the nature of design, this operating procedure will maintain if not improve flood damage reduction. This will improve the quality of human life by providing increased wildlife activity; a special bonus for those who appreciate seeing increases in fish and bird populations. This logically translates to the increased benefits in enjoyment, aesthetics, and economics for recreational activities.

G.12 REFERENCES

Bureau of Economic and Business Research, 1997 Florida Statistical Abstract. Tallahassee, Florida. 1997.

Florida Department of Environmental Protection. Outdoor Recreation in Florida, Florida's Statewide Comprehensive Outdoor Recreation Plan.1994.

Florida Department of Environmental Protection. Outdoor Recreation in Florida, Florida's Statewide Comprehensive Outdoor Recreation Plan.2000.

Florida Department of Environmental Protection and the Florida Greenways Coordinating Council, Connecting Florida's Communities with Greenways and Trails, September 1998

Florida Tourism Industry Marketing Corporation. 1996 Florida Visitor Study. Tallahassee. 1997.

Milon, J.W. Thunberg, E. A Regional Analysis of Current and Future Florida Resident Participation in Marine Recreational Fishing. Florida Sea Grant Report #112. University of Florida, Gainesville. 1993.

National Parks and Conservation Association. The Economic Importance of National Parks: Effects of the 1995-1996 Government Shutdowns on Selected Park-Dependent Businesses. 1997.

National Park Service. National Park Service Statistical Abstract. 1995.

Outdoor Recreation Coalition of America. Emerging Markets for Outdoor Recreation in the United States. Results of the National Survey of Recreation and the Environment. 1997.

Planning and Management Consultants, Ltd. (PMCL), IWR-MAIN Water Demand Analysis Software User's Manual and System Description, April 1995.

Recreation Roundtable. Outdoor Recreation in America 1997. Prepared by Roper/Starch. Washington, D.C. 1998.

Snyder, G.H. and Davidson, J.M. "Everglades Agriculture: Past, Present, and Future" in Everglades: The Ecosystem and Its Restoration. S.M. Davis and J.C. Ogden (Eds.). (1994): 85-115.

South Florida Water Management District. Draft Documentation for the South Florida Water Management Model. West Palm Beach. 1997a.

South Florida Water Management District. Twenty-Year Evaluation: Economic Impacts from Implementing the Majory Stoneman Douglas Everglades Restoration Act and United States versus SFWMD Settlement Agreement. Hazen and Sawyer. 1993.

South Florida Water Management District. Water Supply Needs and Sources 1990-2010. July, 1992b.

University of Florida, Bureau of Economic Analysis and Business Research, Florida Population Studies.

University of Florida, Bureau of Economic Analysis and Business Research, The Florida Long-Term Economic Forecasat 1995, Volume 2 – State & Counties.

University of Florida, Bureau of Economic Analysis and Business Research, The Florida Long-Term Economic Forecasat 1997, Volume 2 – State & Counties, September 1997.

U.S. Army Corps of Engineers, Water Resources Support Center, Institute For Water Resources, Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps. IWR Report 94-PS-2, October 1994.

U.S. Army Corps of Engineers, Water Resources Support Center, Institute For Water Resources, Evaluation of Environmental Investments Procedures Manual Interim: Cost Effectiveness and Incremental Cost Analyses. IWR Report #95-R-1, May 1995.

U.S. Army Corps of Engineers, Ecosystem Restoration in the Civil Works Program. (EC 1105-2-210).

U.S. Army Corps of Engineers, Jacksonville District. Central and Southern Florida Reconnaissance Report: Comprehensive Review Study. (Volume I-III). 1994a.

U.S. Army Corps of Engineers, Natural Resources Technical Support Program, Estimating the Local Economic Impacts of Recreation at Corps of Engineers Projects – 1996, September 1998

U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census, Estimates of Housing Units, Households, Households by Age of Householder, and Persons per Household, 1998

U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census, Small Area Income and Poverty Estimates, 1997

U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census, Statistical Abstract of the United States. 1992.

U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, Regional Economic Analysis Division, County Projections to 2040, 1992.

U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, Regional Economic Analysis Division, Regional Multipliers: A user Handbook for the Regional Input-Output Modeling System (RIMS II) , 1992

U.S. Congress, Comprehensive Report on Central and Southern Florida for Flood Control and Other Purposes. House Document No. 643. 6 May 1948.

U.S. Department of Labor. Monthly Unemployment Surveys. Bureau of Labor Statistics. July, 1998.

U.S. Fish and Wildlife Service. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Department of the Interior. 1996.

Van Os, E., Carroll, J.D., and Dunn, J. Creel Census and the Effects of Freshwater, Waddington, D., Boyle, K., and Cooper, J. 1991 Net Economic Value for Bass and Trout Fishing, Deer Hunting, and Wildlife Watching. Report 91-1. U.S. Fish and Wildlife Service.

APPENDIX H
RECREATION

This page intentionally left blank

TABLE OF CONTENTS

H.0 ECONOMIC AND SOCIAL CONSIDERATIONS H-1
H.1 AUTHORIZATION H-1
H.2 INTRODUCTION TO RECREATION FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR H-1
H.2.1 Proposed Recreation Overview H-1
H.2.2 Recreation Facilities Management Overview H-3
H.3 BENEFIT CATEGORIES H-5
H.3.1 Study Area Recreation Background H-5
H.3.2 Project Entrance and Perimeter Canal Area H-7
H.3.3 Levee Crown and Reservoir Impoundment Areas H-8
H.4 RECREATI ON BENEFITS H-9
H.4.1 National Perspective H-9
H.4.2 State of Florida Perspective H-12
H.4.3 Regional Perspective H-13
H.5 ECONOMIC JUSTIFICATION OF RECREATION H-16
H.6 REFERENCES H-22

LIST OF TABLES

Table H-1: Study Area Population Through 2050 (1000's) H-6
Table H-2: Entrance and Perimeter Canal Recreation Features H-8
Table H-3: Levee and reservoir Impoundment Recreation Features H-9
Table H-4: Guidelines for Assigning Points for General recreation H-10
Table H-5: Conversion of Points to Dollar Values H-12
Table H-6: Most Likely Recreation Participation User Day Projection Scenario H-15
Table H-7: Summary of Recreation Costs and benefits H-16
Table H-8: Sensitivity Analysis Using Multiple Scenarios H-17

LIST OF FIGURES

Figure H-1: Conceptual Recreation Plan H-2
Figure H-2: Boat ramp Schematic H-5

This page intentionally left blank

H.0 ECONOMIC AND SOCIAL CONSIDERATIONS

H.1 AUTHORIZATION

The Comprehensive Everglades Restoration Plan (CERP), authorized by the Water Resources Development Act of 2000 (WRDA 2000), will involve modifying the Central and Southern Florida (C&SF) Project, which was constructed with extensive Congressional authorizations from the 1944 Flood Control Act to the WRDA of 1996. The Federal Water Project Recreation Act (Public Letter [P.L]. 89-72) and the WRDA of 1986 (P.L. 99-662) provide additional guidance. Further specific CERP design guidance was signed on 12 May 2000, in the form of the Department of the Army and South Florida Water Management District (SFWMD) Design Agreement for Everglades and South Florida Ecosystem Restoration Project.

Additional authorization and guidance for the proposed ancillary recreation resources development is contained in CECW-AG, 11 June 1998 Memorandum, Policy Guidance Letter No. 59, Recreation Development at Ecosystem Restoration Projects and EP 1165-2-502. Despite austere budgets and policy requirements, recreational developments can and do contribute to community health and well being (CECW, 1998). The recreation resources that are being proposed as part of the CERP Caloosahatchee River (C-43) West Basin Storage Reservoir project will comply with the philosophy and inclusion of the CESAD-PD-J 15 September 2004 Memorandum, are economically justified, and fall within the ten percent rule.

H.2 INTRODUCTION TO RECREATION FOR THE CALOOSAHATCHEE RIVER (C-43) WEST BASIN STORAGE RESERVOIR

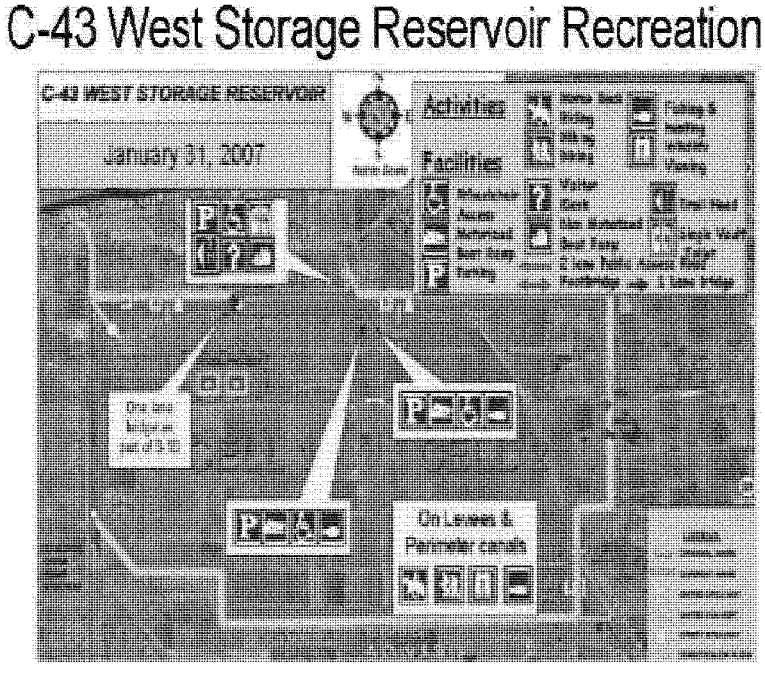
H.2.1 Proposed Recreation Overview

The recreation appendix for the Caloosahatchee River (C-43) West Basin Storage Reservoir project contains a description of the conceptual plan that is being proposed for recreation purposes. The recreation concept map is shown in ***Figure H-1***. Recreation features are being planned in the Caloosahatchee River (C-43) West Basin Storage Reservoir project as an incidental project benefit. These recreation benefits will not be used in the justification of the recommended plan. Order of magnitude costs have been included as provided by the SFWMD cost estimators and gleaned from other approved reports after updating. Costs have been updated using the U.S. Army Corps of Engineers (USACE), Jacksonville District, Broward County water preserve area (WPA) recreation MCACES costs. A determination of recreation facility design standards to meet USACE and local building code requirements is under way. SFWMD will be operating and maintaining the Caloosahatchee River (C-43) West Basin Storage Reservoir project recreational features. Adjustments may be made to the dollars spent depending on project design. The costs for proposed recreation features would be $2,519,000. An additional ten percent for planning, engineering and design (PED), and an

additional eight percent for construction supervision and administration (S/A) bringing the estimated total costs for recreation to $2,972,000.

The Caloosahatchee River (C-43) West Basin Storage Reservoir project will consist of two large reservoir cells that total approximately 170,000 acre-feet of above ground water storage, on approximately 10,500 acres, approximately 10,480 acres of fee land. Perimeter seepage canals will encircle the above ground impoundment areas that are adjacent to each other and share a common levee wall. The scale of the proposed impoundment cells, potential fishing and boating opportunities, could attract users from points across south Florida. Project operations will be undertaken for a couple years to ensure boating access will be safe per water regulation schedules. A tentative boating schedule will be tied to the water schedule. For example, boating will be allowed during the wet season when there is ample water in the reservoir. Boating may not be allowed during the dry season when less water is available. As available adjacent lands become developed, the local draw of visitors to the Caloosahatchee River (C-43) West Basin Storage Reservoir would increase and the impoundment would experience both regional and local visitation. An international draw of visitors may be experienced.

FIGURE H-1: CONCEPTUAL RECREATION PLAN



No additional real estate will be required since all the proposed recreation features will be located on project fee title lands. All features will be compatible with the environmental purposes of the impoundment, and will not detract from the environmental or socioeconomic benefits being generated by the project.

The recreation activities proposed for the Caloosahatchee River (C-43) West Basin Storage Reservoir include: nature study, multi-use trail atop the levee, equestrian use, boat and bank fishing, canoeing/kayaking, motor boating and hunting which will fit with the project purposes as managed by the SFWMD (***Figure H-1***). A major recreation attraction of the Caloosahatchee River (C-43) West Basin Storage Reservoir will be an approximately 12-mile multi-purpose trail loop atop the levee constructed as part of the project. Recreation facilities proposed include: parking and toilet facilities (clivas multrum waterless vault toilets), information kiosk, canoe/kayak launch facility, a shade structure, traffic-control fencing and a pedestrian footbridge bridge over the perimeter canal to provide public access to the reservoir.

Two handicapped accessible, double-lane public boat ramps would be provided; one into each of the two reservoir cells. Vehicle access will be via the single-lane bridge over S-10. The ramps are proposed within the reservoirs on the north levee. A paved two-lane public road will provide vehicular access to a one-lane bridge across the perimeter canal. A two-lane crushed shell road up the levee and to the ramps is proposed. Boat traffic control buoys would keep boaters clear of the reservoir structures. Signage would post warnings. The canoe/kayak launch facility would be on the perimeter canal.

Littoral areas are proposed at the corners of the seepage canal as part of the project and would provide ideal bank fishing locations outside the levee perimeter. The Florida Fish and Wildlife Conservation Commission (FWC) has endorsed the littoral shelf concept for habitat benefit and potential water quality benefits. Shades trees are proposed on the outside area of the north rim canal adjacent to parking areas. Ample public parking will be developed outside of the north levee and perimeter canal in the general area of the construction staging location.

H.2.2 Recreation Facilities Management Overview

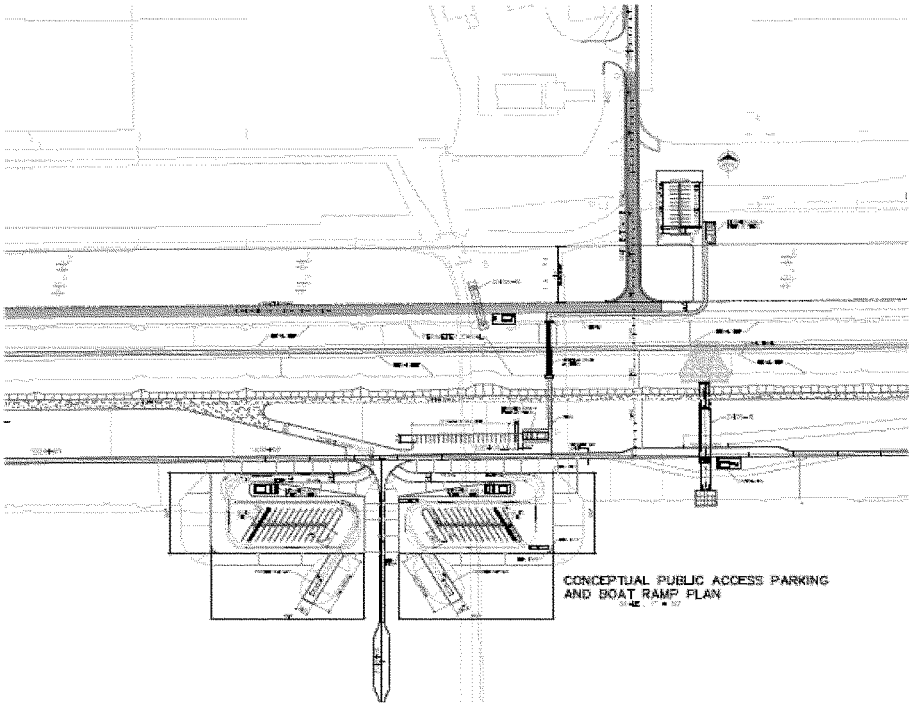
The SFWMD would be responsible for 100 percent of the recreation operations, maintenance, repair, rehabilitation and replacement (OMRR&R) as outlined in Engineering Regulation (ER) 1105-2-100, April 2000, page E-286, the Agreement of May 2000 and the 29 September 2005 OMRR&R USACE Memorandum.

Public access for motorized and non motorized boats is planned for the Caloosahatchee River (C-43) West Basin Storage Reservoir project. A variety of concerns have been expressed regarding the potential of the affect of boating within this and other water resource projects.

The local sponsor, SFWMD, through their rulemaking authority has created rule 40E-7 F.A.C. with enforcement provisions by the FWC officers or other law enforcement officers. This rule has general language applicable to all SFWMD lands and several special provisions for different types of land. Rules allow SFWMD to address hours of public access, the ability to allow or prohibit different activities in different areas or at different times and the overall ability to close public access at any time there are emergencies, pending storms or routine operations and management needs or ongoing protection of the land itself.

The section titled, 40E-7.5384 Special Provisions for Impoundment Areas of the District Open to the Public, has further language that applies to impoundments and boat operation. The rule allows SFWMD to specify boat types, engine types and sizes, operating speeds and areas of operation. Personal watercraft are specifically prohibited while air boats may be allowed where designated. The rules can be adjusted through the posting of signs. This allows SFWMD to adjust rules as necessary to ensure that the projects intended purposes are served, to manage conflicts between users or adjust public use at different water levels, or for other factors. This set of rules allows SFWMD to adjust the boating controls at each impoundment so that the different character of each water body can be enjoyed in a proper manner by the public. The rules are posted on the SFWMD web site through this link
<https://my.sfwmd.gov/pls/portal/docs/PAGE/PG_GRP_SFWMD_LANDRESOURCES/PORTLET_RECREATIONALUSE/TAB1576034/407-E%20RULE%20%20FAC%20%20CHAPTER%2040.PDF>

FIGURE H-2: BOAT RAMP SCHEMATIC



H.3 BENEFIT CATEGORIES

H.3.1 Study Area Recreation Background.

The study area for the recreation benefit analysis for this project includes the counties of Lee, Collier, Hendry, Glades and portions of Charlotte county; approximately the same geographical extent as Region 9 of Statewide Comprehensive Outdoor Recreation Plan (SCORP). The 2000 Florida SCORP identifies the proposed project area as part of Region 9 comprised of Charlotte, Collier, Lee, Sarasota, Glades and Hendry counties. Recreation deficits identified by the SCORP for this region include; bicycle riding, tent camping, hiking, nature study and saltwater beach activities. A statewide need assessment through 2010 identifies these deficits and the unit need for each (miles of trail, camp sites) is provided in SCORP 2000.

Some existing recreational facilities within the Caloosahatchee Basin provide opportunity to hike, boat, fish and camp. Existing recreation facilities near the project site include Ortona Lock Recreation Area, Caloosahatchee Regional Park, and WP Franklin Lock Recreational Area that are used by residents and tourists alike. The Caloosahatchee is used as a boating corridor between the east and west coasts of Florida, boat traffic is moderately heavy with boating and fishing occurring on the river. The banks of the Caloosahatchee are too steep to be useful for bank fishing. Access for boat launch is provided at the three USACE lock structures located along the river. The FWC provides ramps at Wayside Park in Hendry County and at the intersection of State Road (SR) 80 and Highland, east of Ft. Myers, in Lee County. All are well used.

The population growth of south Florida will only add to the calculated existing recreation deficits. ***Table H-1*** shows projected county, State and US population growth per Census 2000.

TABLE H-1: STUDY AREA POPULATION THROUGH 2050 (1000'S)

	2005	2010	2020	2025	2030	2040	2050
Charlotte	159	175	206	221	234	252	270
% Change		1.99%	1.62%	1.44%	1.21%	0.78%	0.71%
Glades	11	12	14	14	15	16	17
% Change		1.62%	1.25%	1.03%	0.98%	0.78%	0.71%
Hendry	39	43	51	55	59	63	68
% Change		2.09%	1.69%	1.48%	1.27%	0.78%	0.71%
Lee	524	593	728	793	852	919	984
% Change		2.63%	2.05%	1.78%	1.50%	0.78%	0.71%
Collier	317	375	490	546	597	644	690
% Change		3.66%	2.68%	2.28%	1.89%	0.78%	0.71%
Florida	17,510	19,252	23,407	25,912	28,686	30,923	33,125
Study Area % of Florida Population	6.00%	6.22%	6.36%	6.29%	6.13%	6.13%	6.13%
United States	295,531	308,936	335,805	349,695	363,584	391,946	419,854
Study Area % of United States Population	0.36%	0.39%	0.44%	0.47%	0.48%	0.48%	0.48%
Florida growth rate		1.99%	2.08%	2.14%	2.14%	0.78%	0.71%
US growth rate		0.91%	0.83%	0.83%	0.79%	0.78%	0.71%

H.3.2 Project Entrance and Perimeter Canal Area

The majority of the project recreation facilities are proposed on the north side of the project perimeter canal, south of SR 80. Public access via the construction access road would be finalized once the construction access route is confirmed. General parking, paved handicapped parking, paved path to an information kiosk and waterless toilet facilities are proposed on the north side of the perimeter canal. A pedestrian bridge across the exterior canal is also proposed. Equestrian use would be staged in this area, allowed on the project lands but not on the levees.

These facilities would be in open view as the project lands are accessed from SR 80 along the construction access route for visual security. The proposed recreation high-use area would utilize the former reservoir project staging area for parking. Once the project staging area is determined the recreation plan will be completed. Shade structures, shade trees, canoe/kayak launching facilities and fencing would also be located along the north side of the perimeter canal. A single-lane operations vehicle bridge is proposed to span the perimeter canal near S-10. The bridge would provide access, for public boating inside the Caloosahatchee River (C-43) West Basin Storage Reservoir, over the perimeter canal to the north levee. The expected boat ramp use falls within USACE road and access guidance in Engineering Manual (EM) 1110-2-400, 1982. The bridge proposal has been coordinated with the Hendry County EMT. No additional recreation costs are proposed for the levee-top trail system. The preliminary cost estimate for the entrance and perimeter canal recreation area is estimated at $504,000 as shown in ***Table H-2***.

TABLE H-2: ENTRANCE AND PERIMETER CANAL RECREATION FEATURES

Features	Quantity	Unit Cost	Total Cost
Shade Trees	200	$250	$50,000
Footbridge	1	$135,000*	$135,000
Shade Shelter 10' x 20'	3	$25,000**	$75,000
Canoe Launch	1	$39,000*	$39,000
Information Kiosk	1	$15,000*	$15,000
Parking Area Handicap Access	15 Spaces	$50,000*	$50,000
Waterless Vault Toile t Facility	2 units	$90,000*	$90,000
Traffic Control Fencing	Lump Sum	$50,000*	$50,000
Entrance and Perimeter Canal Site Total			**$504,000**

*Corps of Engineers, Broward County WPA Nov 06 Provided Costs, ** SFWMD provided costs.

H.3.3 Levee Crown and Reservoir Impoundment Areas

The levee crown and reservoir impoundments will be accessed by the one-lane operation bridge over the perimeter canal near S43-10. A paved two-lane access road would lead to the bridge. A two-lane, crushed shell road would provide access from the bridge over the north levee and into the reservoir impoundment area for the public boat ramp facilities. Paved parking for both boat ramps is proposed. The Caloosahatchee River (C-43) West Basin Storage Reservoir impoundment boat ramp concept would include a handicapped accessible, double-lane boat ramp with parking for each reservoir cell. Boat ramp parking facilities are proposed at the foot of the north levee. If needed, additional parking would be available on the north side of the perimeter canal (see ***Figure H-2***).

A footbridge is proposed to provide pedestrian access across the perimeter canal and up the levee separate from vehicular traffic. Two to five acres of grassed parking for vehicle and trailers is proposed. Pedestrian and bicyclist access to the levee trail would be via the pedestrian bridge and crushed shell road to the north levee crown. Vehicle fencing along the north side of the perimeter canal would keep vehicles out of the canal and off the levee. A vehicle gate would be placed across the paved road

at the base of the levee to secure the area when needed. The preliminary cost estimate for this site is $2,015,000 as shown in ***Table H-3***.

TABLE H-3: LEVEE AND RESERVOIR IMPOUNDMENT RECREATION FEATURES

Feature	Quantity	Unit Cost	Total Cost
Double-lane boat ramp (linear feet)	2	$1,000,000**	$2,000,000
Finger Pier (handicapped accessible)	1	Included in boat ramp	
Vehicle Gate	1	$15,000**	$15,000
Paved road from bridge up levee and down to boat ramp	LF	Included in project costs	$0
Levee and Reservoir Impoundment Site Total			**$2,015,000**

H.4 RECREATION BENEFITS

H.4.1 National Perspective

The national economic development (NED) benefit evaluation procedures contained in ER 1105-2-100 (22 April 2000), Appendix E, Section VII, include three methods of evaluating the beneficial and adverse NED effects of project recreation: travel cost method (TCM), contingent valuation method (CVM), and unit day value (UDV) method.

The UDV method was selected for estimating recreation benefits associated with the creation of the Caloosahatchee River (C-43) West Basin Storage Reservoir. When the UDV method is used for economic evaluations, planners will select a specific value from the range of values provided annually. Application of the selected value to estimate annual use over the project life, in the context of the with- and without-project framework of analysis, provides the estimate of recreation benefits.

The without project condition analysis has no recreation value since without the Caloosahatchee River (C-43) West Basin Storage Reservoir project there would be no public access. The with-project condition will be the expected value of the recreational activity based on the UDV method. ***Table H-4*** illustrates the method of assigning a point rating to a particular general recreation activity. The table also shows the point values assigned based on measurement standards described for the five criteria of activities, facilities, relative scarcity, ease of access, and aesthetic factors.

TABLE H-4: GUIDELINES FOR ASSIGNING POINTS FOR GENERAL RECREATION

Criteria	Judgment factors				
Recreation experience[1] Total Points: 30 Point Value: 14	Two general activities[2] 0-4	Several general activities 5-10	Several general activities: one high quality value activity[3] 11-16	Several general activities; more than one high quality high activity 17-23	Numerous high quality value activities; some general activities 24-30
Availability of opportunity[4] Total Points: 18 Point Value: 6	Several within 1 hr. travel time; a few within 30 min. travel time 0-3	Several within 1 hr. travel time; none within 30 min. travel time 4-6	One or two within 1 hr. travel time; none within 45 min. travel time 7-10	None within 1 hr. travel time 11-14	None within 2 hr. travel time 15-18
Carrying capacity[5] Total Points: 14 Point Value: 8	Minimum facility for development for public health and safety 0-2	Basic facility to conduct activity(ies) 3-5	Adequate facilities to conduct without deterioration of the resource or activity experience 6-8	Optimum facilities to conduct activity at site potential 9-11	Ultimate facilities to achieve intent of selected alternative plan 12-14
Accessibility Total Points: 18 Point Value: 10	Limited access by any means to site or within site 0-3	Fair access, poor quality roads to site; limited access within site 4-6	Fair access, fair road to site; fair access, good roads within site 7-10	Good access, good roads to site; fair access, good roads with in site 11-14	Good access, high standard road to site; good access within site 15-18
Environmental Total Points: 20 Point Value: 8	Low esthetic factors[6] that significantly lower quality[7] 0-2	Average esthetic quality; factors exist that lower quality to minor degree 3-6	Above average esthetic quality; any limiting factors can be reasonably rectified 7-10	High esthetic quality; no factors exist that lower quality 11-15	Outstanding esthetic quality; no factors exist that lower quality 16-20

Point value assignments for ***Table H-4*** above are based on Economic Guidance Memorandum (EGM) 07-03. The Criteria and Judgment Factors for General Recreation were used as the basis of the estimated point values for the proposed recreation area. Judgment factors were reviewed after conducting site visits and coordination with local agencies. The following selection factors were used for the criteria outlined in ***Table H-4***.

- The Caloosahatchee River (C-43) West Basin Storage Reservoir proposed recreation resources would provide an area specific, unique recreation opportunity afforded by the project setting and the project levees. The site offers solitude and panoramic views outside a growing metropolitan region, and would provide specific recreation amenities (as outlined in ***Table H-1***) for expanding regional populations that would increase demands. Levee crown walking, biking and nature study use would also experience the panoramic viewshed. The point value rating is estimated in the middle end of the judgment factor scale because of the general activities that would sustain a regional use in the Hendry County area.
- The availability of opportunity rating is based upon current local recreation facilities near the project area within the proposed recreation resource location. At the high end of the scale are those recreational facilities which are a geographical rarity; these are sites for which there is no close substitute within two hours. For example, two hours of drive time is sufficient for an east west transit across the lower part of Florida. For this study let us assume that two hours is sufficient to travel approximately 80 miles (non-interstate travel). With exception of jogging and walking activity and equestrian trails, alternative facilities exist for all other classifications. Scores for this judgment factor are therefore expected to be mid to low scale. One note; with the exception of equestrian activity the proposed recreation resources will help provide facilities necessary to alleviate both current and projected SCORP Region 9 deficits in those activities.
- The proposed Caloosahatchee River (C-43) West Basin Storage Reservoir, project recreation resources carrying capacity point values are estimated to improve with the recreation component construction. The general recreation values are based on the optimum use of the site potential, without overuse of the proposed recreation resources. Good water resources and access to them for non-boat fishing, multi-use trail and environmental observation comprise a large part of the projected recreation resources use. Peak use is conservatively projected to occur during half of the calendar year.
- The accessibility rating is based upon the availability of local highways, roads and streets in good condition that would provide access to the proposed recreation facilitates. Direct routes from the east on paved roads provide good access.
- The environmental quality rating is based upon the existing aesthetic values of the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir Area recreation resource facilities and the ease of correcting any limiting aesthetic factors. The proposed site would possess panoramic views. The best aesthetics of the proposed project area are views from the Caloosahatchee River (C-43) West Basin Storage Reservoir levees to the west during a sunset.

The value of a day of general recreation at the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir Area Project was determined for each project activity using the guidelines for assigning points for the general recreation in ***Table H-4***. The points were then converted to dollar values using conversion factors included in the EGM 07-03, UDVs for Recreation, 2006, which is based on ER 1105-2-100.

The Outdoor Recreation Coalition of America notes the trend in walking and bird watching has increased 42 percent and 155 percent from the 1984 survey to the 1995 survey. The U.S. Fish and Wildlife Service, National Survey of Fishing, Hunting and Wildlife-Associated Recreation shows a 98 percent and 38 percent increase in residential and non-residential wildlife watching in the State of Florida (Restudy, 1999). Recreation trends show increased usage of existing facilities and a need to develop new facilities. With ensuing development in the project area, and the increase in population projections for the State of Florida, the study team believes there would be ample use of the proposed recreation facilities.

Table H-5 displays the point value conversion to a UDV fiscal year (FY) 2007 dollar amount. The 46 points generated a user day value of $6.79. Estimation of the annual use over the project life is next.

TABLE H-5: CONVERSION OF POINTS TO DOLLAR VALUES

General Recreation Point Values	General Recreation Dollar Values
0	$3.32
10	3.95
20	4.36
30	4.98
40	6.23
50	7.06
60	7.68
70	8.10
80	8.93
90	9.55
100	9.97

H.4.2 State of Florida Perspective

The State of Florida's Department of Environmental Protection, Division of Recreation and Parks (DEP) developed the SCORP for 2000. The SCORP was used to obtain state regional recreation participation rates. The SCORP also provides

recreation user day guidelines for resource based outdoor recreation activities listed in ***Table H-6***. These guidelines are based on maximum carrying capacity levels developed by the DEP. The Caloosahatchee River (C-43) West Basin Storage Reservoir is a geographically large inland body of freshwater in an area of the state where state based recreation resources are mainly environmental/ecological or riverine in nature.

Using the guidelines available from the SCORP, reasonable user rate projections can be determined. Due to the Caloosahatchee River (C-43) West Basin Storage Reservoir rural location and rustic/minimal recreation features planned, it was determined that a conservative usage rate would be used. The projected Caloosahatchee River (C-43) recreation use rates referenced the resource needs and guidelines published by the SCORP, but use rates developed were substantially lower than the SCORP published rates. It is expected that recreation use within the study area would be reduced during reservoir dry periods. The probability that only the two miles on either side of the access points will be used for the multi-use trail and perimeter canal paddle boating was factored into the recreation use scenario.

In many areas, even where water bodies are accessible, they are unusable due to the lack of facilities. As previously noted, the regional level needs assessments in this plan (SCORP) are not capable of identifying local needs. Nonetheless, it is well known that there is a need to fund development of access facilities such as boat ramps, canoe launches, docks, catwalks and piers, as well as support facilities such as bathhouses, restrooms, and parking areas. Federal, state and local governments should work together to fund construction of these facilities in all areas where there is sufficient access to water bodies suitable for recreation. (SCORP, 2000).

H.4.3 Regional Perspective

The current SCORP indicates regional recreation demands not met for the year 2010 for three activities associated with the proposed Caloosahatchee River (C-43) West Basin Storage Reservoir recreation. In the current or existing without project condition miles of hiking, nature trail and biking trail are needed to fill projected regional demand. Analysis of supply and demand within Region 9 indicates that future demand for equestrian trails will overcome supply sometime between 2010 and 2015.

The use guidelines for designated bicycle, hiking and nature study trails were based on carrying capacity guidelines adopted by the SCORP and used by the state park system (see ***Table H-6***). Since SCORP provides no guidelines for boat ramp or bank fishing use, the SFWMD and USACE provided use rates of ten per weekday and 15 per weekend day. The Caloosahatchee River (C-43) West Basin Storage Reservoir consists of approximately 12 miles of trails and canals that are available for use. Only four miles of trails and canals were used to determine daily usage

rates because it is expected that two miles to either side of the access point and parking will be used most often.

A balanced mix of ecosystem compatible recreation use and facilities are proposed for the Caloosahatchee River (C-43) West Basin Storage Reservoir. The proposed recreation would help to fill existing and projected SCORP 2000 recreation deficits for Region 9. Even though SCORP 2000 shows no projected shortage of boat ramps in the region by the year 2010, the Caloosahatchee River (C-43) West Basin Storage Reservoir recreation proposal is planning to provide these public use facilities to accommodate and facilitate use of the site by the boating public.

The Florida Fish and Wildlife Conservation Commission (FWCC) provided the Everglades Restoration Program a letter (23 February 2007–Addendum I) that discusses the need for boat ramps in the south Florida area. The letter also states that the Florida SCORP does not identify boat ramp deficits or future needs in Florida. FWC stated freshwater boat access for fishing is consistently voiced by their stakeholders. The CERP Master Recreation Plan, Public Outreach Summary Report (January 2007) lists boat access needs as the third most heard public comment.

The DEP Office of Park Planning who authors the SCORP has also provided the Everglades Restoration Program a letter that supports the need for south Florida boat ramps (March 1, 2007 letter, Addendum II). FDEP's letter explains why SCORP does not quantify need for some water related activities including boat ramps and directs the team to a quote currently within SCORP on that subject. Further DEP cited Florida legislative documents that also concur that Florida needs boat ramps.

Since 1994, recreational vessel registration in Florida has increased by 36 percent but public boating facilities have not kept pace. In response, the 2005 Florida Legislature enacted and Governor Bush signed HB 955 directing the Florida DEP to evaluate recreational boating access in Florida State Parks. The document, *Recreational Boating Access in Florida State Parks* (Jan 2006) identified boating access needs and summarized potential for providing new and expanded facilities to increase public boating access.

TABLE H-6: MOST LIKELY RECREATION PARTICIPATION USER DAY PROJECTION SCENARIO

Activity	Units Provided	SCORP Maximum Area Requirements	SCORP Turn over Rates	SCORP Capacity Guidelines	SCORP Region 9 Resource Needs (2010)		Caloosahatchee River (C-43) Projected Expected Users
					User Occasions	Units	
Bicycling Jogging Walking	12 miles/ 4 utilized	10-20 users Per Mile	4/day	40-80 users per mile per day	16,675,164	1,177 miles	20 20 20
Equestrian Trails	12 miles/ 4 utilized	2-8 groups/mile-4/ group	3/day	24–96 equestrians/ trail mi/ day	204,592	0 miles	15
Canoeing / kayaking	2 miles of canals and Impoundment	1-2 users per canoe	2/day	1-2 canoes per acre or mile	N/A	N/A	25
Nature Study	12 miles/ 4 utilized	5-20 groups per mile	4/day	40-160 users per mile of trail/day	3,073,615	56.80 miles	20
Bankfishing†	50 mi of canal & reservoir banks	10 Linear Feet/ fisherman	2/day				10/day (wkday/wkend average)
Freshwater Motorboat Access†	2-double-lane paved boat ramp				NA	4	15/day (wkday/wkend average)
General Recreation Total							145 users per day

† = signifies conservative user rates developed between by Corps and SFWMD recreation planning POCs after SCORP review.

H.5 ECONOMIC JUSTIFICATION OF RECREATION

The justification of incurring additional costs for recreation features is derived by utilizing a benefit to cost ratio. The tangible economic justification of the proposed project can be ascertained by comparing the equivalent average annual charges with the estimate of the equivalent average annual benefits, which would be realized over the period of analysis. These average annual recreation benefits and costs are summarized in ***Table H-7***.

ER 1105-2-100 (The Planning Guidance Notebook) provides economic evaluation procedures to be used in all Federal water resources planning studies. The guidelines specified in the ER 1105-2-100 dated 22 April 2000 were observed in preparing this cost analysis. The Federally mandated project evaluation interest rate of 4 7/8 percent, an economic period of analysis of 40 years and current prices were used to evaluate economic feasibility.

TABLE H-7: SUMMARY OF RECREATION COSTS AND BENEFITS

Recreation Construction Costs	**$2,519,000**
PED & S/A (18%)	$453,000
Total Recreation Construction	**$2,972,000**
Construction Duration	12 months
Interest During Construction Costs	$72,000
Total Recreation Investment	**$3,044,000**
Period of Analysis	40 years
Annualized Cost	$174,000
OMRR&R	$25,000
Total Annual Costs	**$199,000**
Annual Benefits	
User Day Value	$6.79
Daily Use	145
Annual Use	52,925
Average Annual Benefit	**$359,000**

The benefit to cost ratio for the proposed recreation features is approximately 1.80, with net annual benefits equaling approximately $160,000.

A sensitivity analysis was done to further reinforce expected benefits and provide additional justification for proposed recreation features (***Table H-8***). Minimum and SCORP expected benefits have been provided for comparison with the proposed Caloosahatchee River (C-43) recreation benefits. This economic analysis suggests there would be ample benefits to conservatively justify the proposed recreation facility construction for the Caloosahatchee River (C-43) West Basin Storage Reservoir project.

TABLE H-8: SENSITIVITY ANALYSIS USING MULTIPLE SCENARIOS

Scenario	Annual Users	Daily Users	Annual Benefit
Most Likely	52,925	145	$160,000.00
Worst Case	32,850	90	$24,000.00
SCORP Guidelines	464,280	1,272	$2,953,000.00

ADDENDUM I–FWC South Florida Boat Ramp Deficit Letter

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

RODNEY BARRETO, Miami
SANDRA T. KAUPE, Palm Beach
H.A. "HERKY" HUFFMAN, Kenansville
DAVID K. MEEHAN, St. Petersburg
KATHY BARCO, Jacksonville
RICHARD A. CORBETT, Tampa
BRIAN S. YABLONSKI, Tallahassee

KENNETH D. HADDAD, Executive Director
VICTOR J. HELLER, Assistant Executive Director

SOUTH REGION, OFFICE OF HABITAT CONSERVATION
CHUCK COLLINS, Regional Director

February 23, 2007

Dennis Duke, Chief of Everglades Restoration
U.S. Army Corps of Engineers
701 San Marco Boulevard
Jacksonville, FL 32207-8175

Dear Mr. Duke:

The purpose of this letter is to convey a regional need for boat ramp access in south Florida. It has come to our attention that Florida's Statewide Comprehensive Outdoor Recreation Plan (SCORP), the primary tool being used to quantify recreational needs for CERP projects, does not quantify the needs for more boat ramps in south Florida. We think that the regional overview generated by SCORP may not address Florida's growing public boat access needs.

There are more than one million registered boats in Florida. Additionally, we average around 400,000 boats from other states that frequently visit Florida. Our waterways increasingly show the strains of congestion as each year brings more residents and visitors to use our water resources. There are approximately 1,300 publicly managed boat ramps in the state, 200 of which are maintained by the Florida Fish and Wildlife Conservation Commission (FWC). South Florida has the fewest number of freshwater boat ramps in the state, but has the majority of the State's population. As south Florida becomes increasingly urban, access to public waters becomes more of an issue.

The need for additional access to freshwaters in south Florida for recreational boating and fishing is an issue that we consistently hear voiced by our stakeholders. We view many of the above ground storage impoundments that are being planned as suitable for boat ramps, to provide access to newly created freshwaters. We currently have staff working alongside the Corps and the South Florida Water Management District on the Master Recreation Plan, as well as other CERP projects.

8535 Northlake Boulevard, West Palm Beach, FL 33412
Visit...MyFWC.com

ADDENDUM I–FWC South Florida Boat Ramp Deficit Letter–Page 2

Dennis Duke
Page Two
February 23, 2007

It is our opinion that there is a need for additional boat ramps in south Florida, that SCORP does not adequately evaluate this need, and that certain CERP/Acelle8 project offer an opportunity to address this need. We look forward to continuing to work on this issue with you. Thank you very much.

Sincerely,



Chuck Collins, Regional Director
South Region
Florida Fish & Wildlife Conservation Commission

cc: Paul Stevenson
Lawrence Gerry
Jerry Krenz
Jon Fury

ADDENDUM II–DEP South Florida Boat Ramp Deficit Letter–Page 1



Florida Department of Environmental Protection

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Charlie Crist
Governor

Jeff Kottkamp
Lt. Governor

Michael W. Sole
Secretary

March 1, 2007

Jerry Krenz, AICP
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

Dear Mr. Krenz:

This letter will follow up on our conversation of last week regarding the need for boat ramps within the CERP project area.

How best to identify needs for outdoor recreation resources and facilities has been a much discussed topic in recreation planning for many years. In Florida, state government's role has been to identify needs that exist at a statewide and broad regional level through a statewide outdoor recreation plan. Since that level of planning is not well suited to assessing needs on a local or site-specified scale, assessments at those levels are most appropriately done by regional, county or municipal agencies.

We recognize that many water-related recreational activities are difficult to quantify, especially in Florida which has a myriad of water features and a wide range of activities that take place in and around them. It is clear to us that Florida needs additional boat ramps and related facilities that are suitable for public outdoor recreation. The following excerpt from the currently approved state outdoor recreation plan reflects this recognition:

> In many areas, even where water bodies are accessible, they are unusable due to the lack of facilities. As previously noted, the regional level assessments in this plan are not capable of identifying local needs. Nonetheless, it is well known that there is a need to fund development of access facilities such as boat ramps, canoe launches, docks, catwalks and piers, as well as support facilities such as bathhouses, restrooms and parking areas. Federal state and local governments should work together to fund construction of these facilities in all areas where there is insufficient access to water bodies suitable for recreation. (Source: *Outdoor Recreation in Florida-2000*, Chapter 6-10.)

ADDENDUM II–DEP South Florida Boat Ramp Deficit Letter–Page 2

Mr. Jerry Krems
Page 2
March 1, 2007

The Florida Legislature has also recognized the state's increasing need for boat ramps and associated facilities. In November 2004, the Senate Committee on Community Affairs released a report entitled Working Waterfronts, which urged the Legislature to expand programs to preserve recreational working waterfronts and expand public access through boat ramps. The report noted that boater registrations in Florida increased by 61 percent between 1987 and 2003, while the number of boat ramps grew by only 14 percent during roughly the same period. Also in 2006, the Department of Environmental Protection, in cooperation with the Florida Fish and Wildlife Conservation Commission, prepared a report on boating access in Florida's state parks. That report, Recreational Boating Access to Florida State Parks, identifies substantial needs for improvements and new facilities in every one of the five state park regions.

We appreciate this opportunity to discuss the need for additional boat ramps in Florida and clarify our role in identifying these needs. I hope this information will be helpful in explaining the need for boat ramp facilities as part of the CERP project. If we can be of any further assistance, please do not hesitate to let me know.

Sincerely,

Albert Gregory, Chief
Office of Park Planning
Division of Recreation and Parks

AG/ agl

cc: Patricia Brown, Planning Consultant, Office of Park Planning

H.6 REFERENCES

Bureau of Economic and Business Research (BEBR), UF, Bureau of Economic and Business Research, Warrington College of Business. *Florida Statistical Abstract 2004* 38 (2004).

Design Agreement Between The Department of the Army and South Florida Water Management District for the Design of Elements of the Comprehensive Plan for the Everglades and South Florida Ecosystem Restoration Project (12 May 2000).

Florida Fish and Wildlife Conservation Commission, "Boating Access to the South Region Counties", http://myfwc.com/boating/access/ramps/so-ramps.html#180> (12 Feb. 2007).

Florida Fish and Wildlife Conservation Commission, Boat Access Need Letter (23 Feb 2007).

Personal Communication: Jerry Krenz, Everglades Recreation Program Manager, South Florida Water Management District, 6 July 2006.

Personal Communication: LuAnn McVicker, PhD, PE, Acceler8 Project Manager, South Florida Water Management District, 22 February 2006.

Personal Communication: Patricia Evans, Planning Consultant, Division of Recreation and Parks, Department of Environmental Protection, 14 February 2007.

Personal Communication: Jon Fury, Florida Fish & Wildlife Conservation Commission, 20 February 2007.

Public Law (PL) 78–534. *Flood Control Act of 1944,* Washington, D.C .

PL 89-72. *The Federal Water Project Recreation Act of 1965,* Washington, D.C.

PL 99-662. *Water Resources Development Act (WRDA) of 1986,* Washington, D.C.

PL 104-303. *Water Resources Development Act of 1996,* Washington, D.C.

PL 106-541. *Water Resources Development Act of 2000,* Washington, D.C .

State of Florida, Department of Environmental Protection, Division of Recreation and Parks, Outdoor Recreation in Florida-2000: Florida's Statewide Comprehensive Outdoor Recreation Plan, Tallahassee, FL (SCORP, 2000).

State of Florida, Department of Environmental Protection, Division of Recreation and Parks, Recreational Boating Access in Florida State Parks, Tallahassee, FL (Jan 2006).

South Florida Water Management District (SFWMD), Public Access Rule 40E-7, Florida Administrative Code, Tallahassee, FL (Feb 2007).

U.S. Army Corps of Engineers (USACE), Economic Guidance Memorandum, 06-03, Unit Day Values for Recreation, Fiscal Year 2006, Washington, D.C. <ftp://ftp-fc.sc.egov.usda.gov/Economics/ recreate/egm_0603.pdf>

U.S. Army Corps of Engineers, Central and Southern Florida Study (Yellow Book, 1999), Jacksonville District, Jacksonville, Florida.

U.S. Army Corps of Engineers, Final Site 1 Impoundment PIR and EA: Recreation Appendix H. Central and Southern Florida Project, CERP, Jacksonville, FL (April 2006).

U.S. Army Corps of Engineers, South Atlantic Division (CESAD-PDD-J). Multi-Purpose Project Memorandum, Atlanta, GA (15 Sep. 2004).

U.S. Army Corps of Engineers, South Atlantic Division (CESAD-PDD-J). OMRR&R Memorandum, Atlanta, GA (29 Sep 2005).

U.S. Army Corps of Engineers, South Atlantic Division (CESAD-PDD-J), Recreation Authority Memorandum, Atlanta, GA (26 Jan 2007).

U.S. Army Corps of Engineers, Civil Works, Water Resources Policies and Authorities (CECW-A), Economic Guidance Memorandum (EGM) 06-03, Unit Day Values for Recreation Fiscal Year 2006, Washington, D.C. (Oct. 2005).

U.S. Army Corps of Engineers, Ecosystem Restoration - Supporting Policy Information Engineer Pamphlet (EP) No. 1165-2-502, Washington, D.C. (Sep. 1999).

U.S. Army Corps of Engineers, Civil Works, Policy Division (CECW-AG), Policy Guidance Letter (PGL) No. 59, Recreation Development at Ecosystem Restoration Projects. Memorandum (June 1998).

U.S. Army Corps of Engineers, Planning Guidance Notebook, ER 1135-2-100 (APR 2000). Washington, D.C.

U.S. Army Corps of Engineers, Design of Recreation Areas and Facilities - Access and Circulation (DEC 1982). Washington, D.C.

USACE/SFWMD, Comprehensive Everglades Restoration Plan, Master Recreation Plan, Public Involvement Summary Report, (Jan 2007).

U.S. Census Bureau. "State and County Quick Facts." 28 June 2006, <http://quickfacts.census.gov/qfd/states/12/12093.html> (2005).

U.S. Department of Commerce, Population Projections Program, Population Division, (NP-D1-A) Projections of the Resident Population by Age, Sex, Race, and Hispanic Origin: 1999 to 2100 28 July 2006, <http://www.census.gov/population/projections/nation/detail/d2041_50.pdf> (13 Jan. 2000).



US Army Corps
of Engineers®

Jacksonville District



South Florida Water
Management District