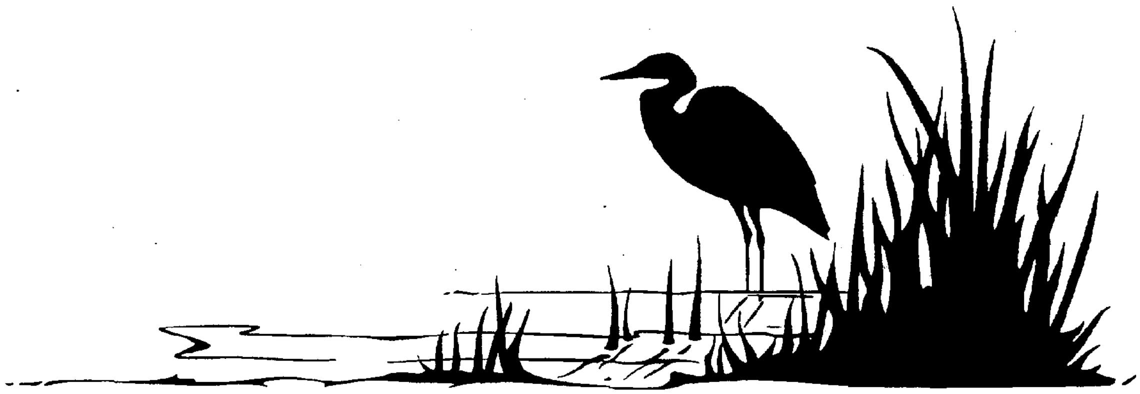
WATERSHED MANAGEMENT PLAN: Rookery Bay National Estuarine Research Reserve and the Ten Thousand Islands Aquatic Preserve



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This report was made possible by a subgrant from the Florida Department of Community Affairs, in cooperation with the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under Cooperative Agreement Award No. NA370Z0427. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its subagencies.

October 1, 1994

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ACKNOWLEDGEMENTS

The following agencies, organizations and consulting firms assisted in the production of this plan. We would like to thank every individual who contributed their time and resources.

Big Cypress Basin Board
Collier County Cooperative Extension Service
Collier County Current Planning Department
Collier County Natural Resources Department
Collier County Office of Capital Projects Management
Collier County Pollution Control Department
Florida Department of Agriculture, Division of Forestry
Florida Department of Agriculture, Division of Plant Industry
Florida Department of Environmental Protection
Florida Department of Health and Rehabilitative Services, Collier County Public Health Unit
Florida Wildlife Federation
South Florida Water Management District
The Conservancy, Inc.
The Marc Group, Environmental Consultants
The Nature Conservancy
United States Army Corps of Engineers
United States Soil Conservation Service
Wilson, Miller, Barton, and Peek, Inc.

EXECUTIVE SUMMARY

The Watershed Management Plan for Rookery Bay National Estuarine Research Reserve (RBNERR) and the Ten Thousand Islands Aquatic Preserve examines land use patterns within the headwaters of these fragile estuarine systems and provides specific recommendations for the restoration and preservation of essential surface water flows. This project was developed by the Florida Department of Environmental Protection at RBNERR, through funding from the Florida Coastal Management Program. The Watershed Plan is intended to be used by management and regulatory agencies, planners and local government as a source of information to support the comprehensive restoration and management of watersheds draining into Rookery Bay and the Ten Thousand Islands.

This Plan includes consideration of future development plans for the freshwater basins which feed into Rookery Bay and the Ten Thousand Islands, as well as how current activities are impacting the system. Planned Unit Developments (PUDs) within the basins have been delineated. Canals, culverts and water control structures which regulate freshwater inflow to the estuaries have been identified. Sources of nonpoint pollution, such as agriculture, nurseries, golf courses, quarries and urban runoff, are addressed. Water quality and quantity data, in the form of conductivity, total suspended solids, nutrients and flow rates, are given for the major canals within the watersheds.

Combined, these impacts and potential impacts on the environmental integrity of the system have been compared with historical flowways delineated within this report. Some flowways have been heavily impacted, while others remain relatively intact. Conservation measures, ranging from fee simple purchase and conservation easements to mitigation and private stewardship, have been considered for restoration and protection of the watershed. Recommendations for restoration activities within the watershed encompass site specific activities (such as additional culverts, road removal and filling of canals), broad projects (such as a regional stormwater management plan for areas of high agricultural activity) and support of on-going projects by other agencies (such as the hydrologic restoration of South Golden Gate Estates by the Water Management District and activities cited within the Fakahatchee Strand State Preserve Management Plan).

This Plan has been reviewed and distributed to Federal, State, Regional and Local government agencies, private environmental organizations and private consulting firms in south Florida. In addition, the information contained within this report has been presented at public hearings and workshops. State and local agencies, as well as private firms, are using this plan as a guideline for restoration activities with the Rookery Bay and Ten Thousand Islands Watershed. This plan has already been utilized to support the State acquisition of environmentally sensitive lands identified within this report. It is hoped that other National Estuarine Research Reserves, National Marine Sanctuaries and Aquatic Preserves will use this Plan as a template for development of similar Watershed Management Plan.

INTRODUCTION

1.1 WATERSHED MANAGEMENT PLAN OBJECTIVE

The Rookery Bay National Estuarine Research Reserve (NERR) Watershed Restoration Plan is a comprehensive examination of the waters entering Rookery Bay NERR and the Cape Romano-Ten Thousand Islands Aquatic Preserve (Figure 1-1). The purpose of the Plan is to examine the relationship between estuarine conditions and watershed alterations and recommend alternative actions with the goal of protecting and restoring estuarine water quality. The primary connection between estuarine water quality and watershed land use is related to the quality and quantity of freshwater input. These waters affect the health and stability of the estuarine systems. Although it will take time to implement any procedures adopted to restore the Watershed, it is important to recognize the need for a comprehensive plan which encompasses the entire watershed, potentially affecting protected estuarine waters.

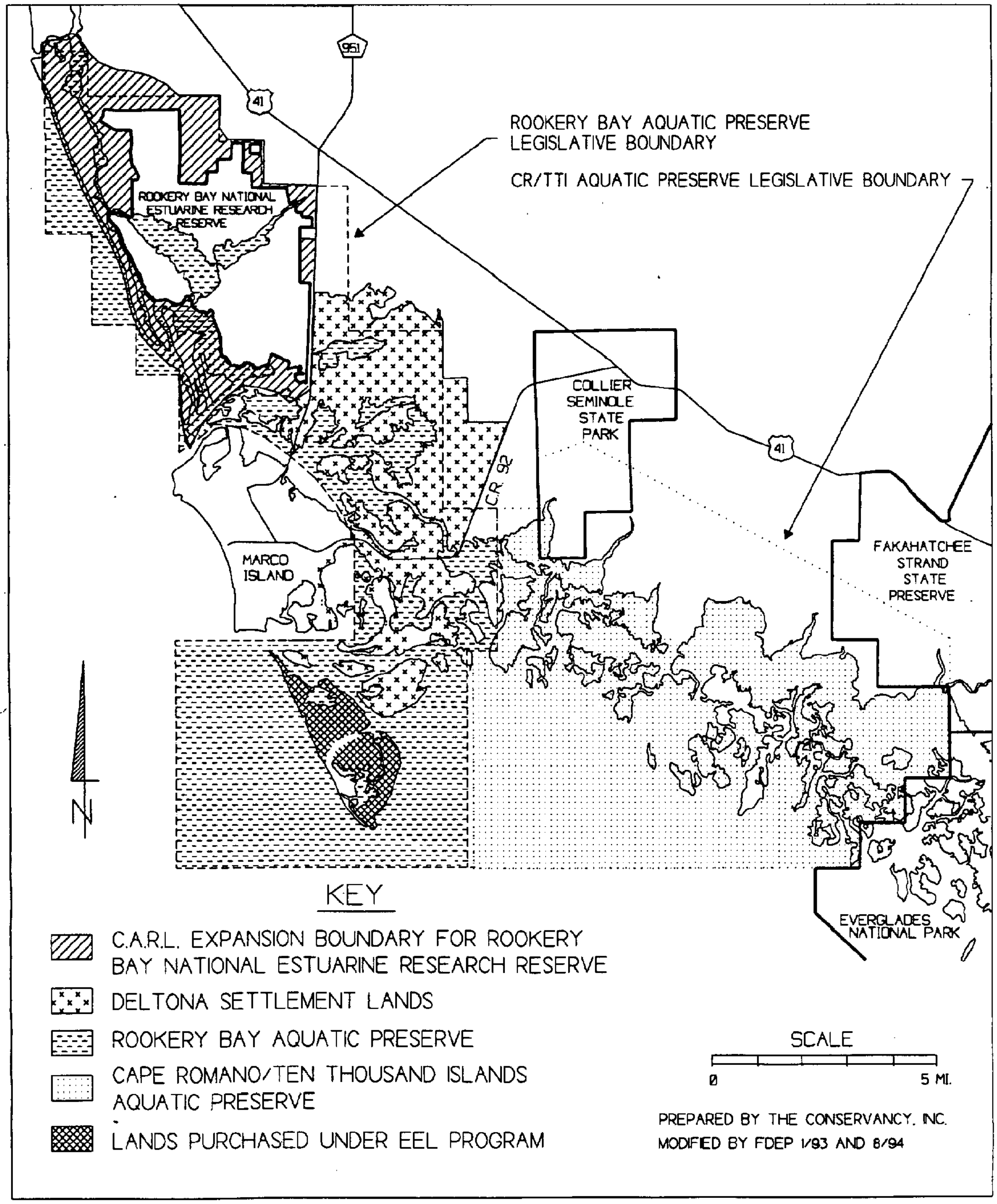
The primary focus of the project is to restore the hydrologic structure, hydrologic function and water quality aspects of the system. This will be accomplished by addressing a number of factors which will contribute to the resultant hydrologic regime: restoration of sheet flow, expanding storage capacity, connecting hydrologic links, incorporating more natural hydropatterns, restoring sheetflow delivery of freshwater to estuaries and bays, restructuring the natural salinity gradient in estuaries and bays and overall restoration of the natural characteristics of the system. The Watershed Restoration Plan indirectly expands the spatial extent of wetlands within Collier County. Large wetlands provide space for numerous animals, including threatened and endangered species, to roam. Wetlands also support a food base for the entire freshwater food web, including top predators such as panthers. The plan increases habitat diversity by restoring historic connections between different communities, reducing impacts caused by exotic species, and reestablishing historic vegetation and communities that have been altered by development. Finally, the Plan improves the water supply and limits saltwater intrusion. If the residence time of the water in the wetlands is longer, more water will percolate into the aquifers recharging water supplies, as well as pushing the salt lens further towards the coast.

1.2 OVERVIEW OF THE CHAPTERS

Each chapter of the report addresses either a specific issue or a specific area within the watershed. The chapters target facts relevant to the topic or region. Chapter 2 looks at water quality within the Watershed. Many groups and organizations (Rookery Bay NERR, Collier County Pollution Control Department, South Florida Water Management District, National Oceanic and Atmospheric Administration and The Conservancy, Inc.) have collected water quality data from within the Watershed. Data on nutrient levels, as well as pesticides and heavy metals, were examined in areas within the Watershed. Point and nonpoint source pollution are discussed, as well as long-term effects of pollution and the potential sources of surface water pollution in southwestern Collier County.

Methods for protecting environmentally sensitive lands are examined in Chapter 3. Ranging from fee simple purchase to voluntary action, each of these options can be used within

FIGURE 1-1. ROOKERY BAY AND TEN THOUSAND ISLANDS AQUATIC PRESERVE BOUNDARIES



the Watershed to aid in restoring historic surface water flow. Positive and negative aspects of each conservation method are discussed, as well as potential funding sources for restoration activities. Funding sources listed may fund the types of projects listed within this report, but actual funding for the projects is dependent upon the proposal submitted and availability of funds.

Historic surface water flowways are addressed in Chapter 4. The flowways were delineated using a number of available surveys, including historic U.S. Soil Conservation Service survey of Collier County soils, historic black & white aerial photographs and U.S. Department of the Interior, National Wetlands Inventory maps. Major uplands were outlined. Wetlands were divided into four flowway categories: cypress slough, cypress-dominant, hydric pine-dominant and prairie. These historic flowways were overlaid on current aerial photographs (REDI maps) of the Watershed to determine changes within the system.

Chapters 5 through 8 examine specific issues in specified areas within the Watershed. Chapter 4 addresses Water Management District 6; Chapter 5, Belle Meade; Chapter 6, South Golden Gate Estates; and Chapter 7, Fakahatchee Strand. The approximate geographic boundaries for each region are given (Figure 1-2), as well as the watershed basins contained within each region (Figure 1-3). Each of these areas have environmentally sensitive lands which need to be protected and managed to return freshwater flow to the estuarine systems. The areas have very different land-use patterns, and therefore, different threats to hydrological regimes. Within each chapter, historic and current surface water flow patterns are delineated and areas of special concern are outlined. Point and nonpoint sources of pollution are discussed. Finally, there are recommendations for hydrologic restoration, including cost of the activities. A number of options have been formulated to address specific concerns within the watershed, ranging from a `no action' approach to fee simple purchase of environmentally sensitive tracts of land. Recommendations are given by combining the options into feasible plans, listing estimates of cost and funding sources for restoration and management practices within the watershed. The cost estimates are just that, only estimates, and actual cost may fluctuate from the values given.

While protecting estuarine water quality, this Restoration Plan looks into the future for water needs, not only for these fragile coastal communities, but also for the future water needs of Collier County. While the implementation of the options contained within the plan may be costly, the long-term benefit to the natural communities and water resources is invaluable.

FIGURE I-2. WATERSHED REGIONS FOR ROOKERY BAY AND THE TEN THOUSAND ISLANDS

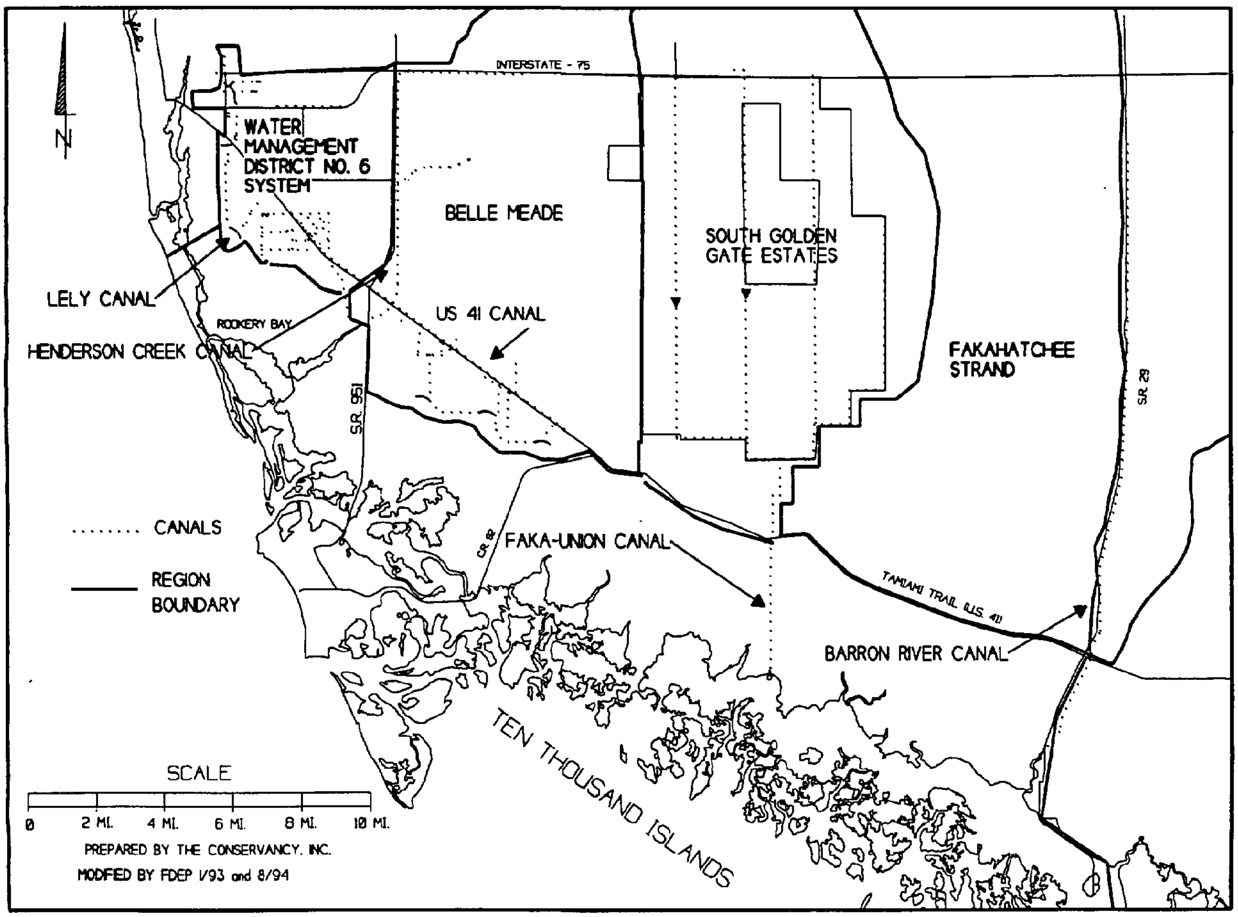
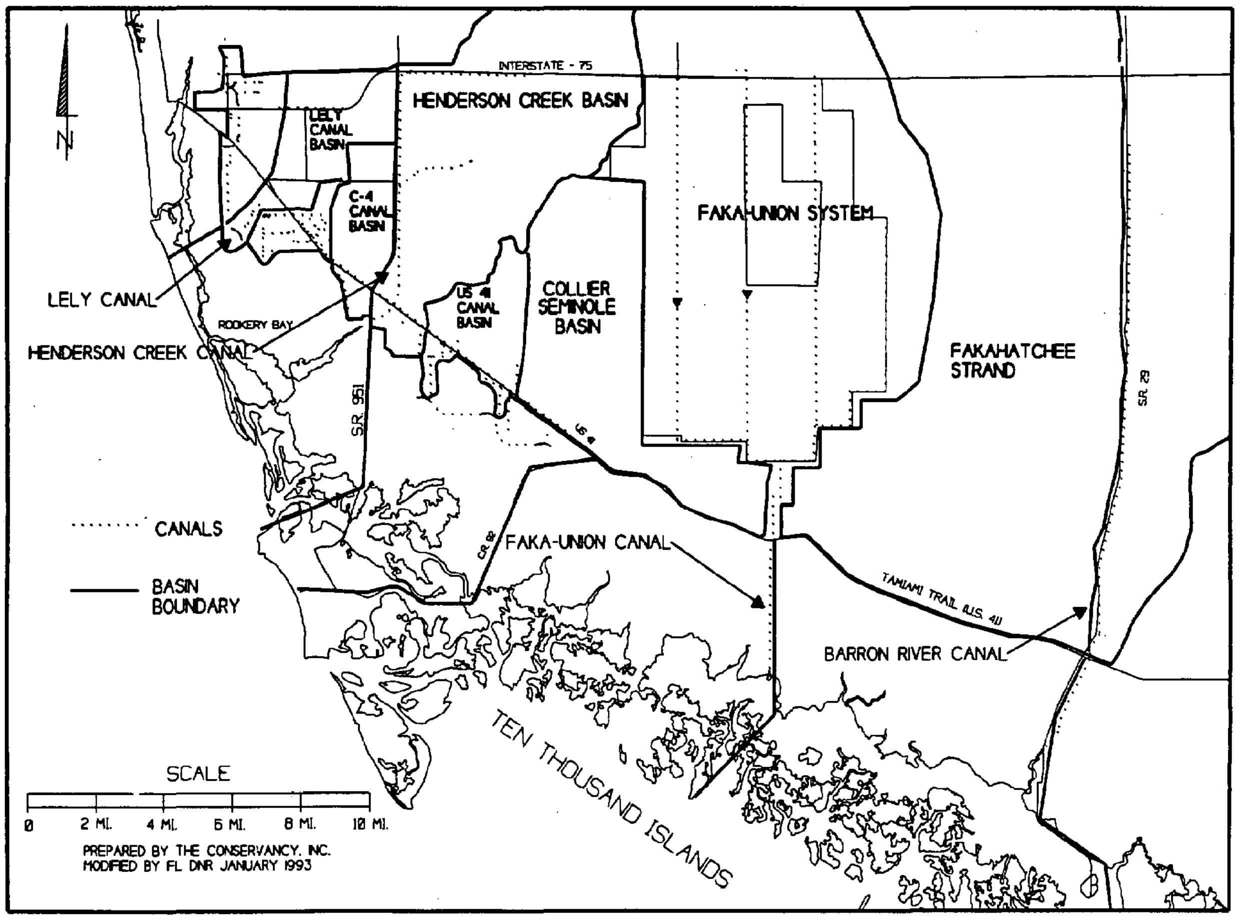


FIGURE I-3. WATERSHED BASINS



1.3 CONTRIBUTORS

Formulation of the Watershed Restoration Plan was possible only with the help of many people. Federal (U.S. Soil Conservation Service, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service), state (Florida Game Freshwater Fish Commission, Division of Forestry, Department of Transportation), regional (South Florida Water Management District) and county (pollution control, natural resources, stormwater management, planning, transportation, development services) officials were consulted while developing this plan. Representatives from environmental groups within Collier County, as well as local developers and consultants were approached for their comments and ideas concerning the hydrologic restoration of this area. These people were not only helpful in determining positive and negative aspects of the Plan, they also submitted their own ideas on bettering the system. *(see Acknowledgements for a list of participants.)* This plan could not have been developed without the help of these individuals.

WATER QUALITY

Collier County, Florida has defined wet and dry seasons, with an average of 50 inches of rain falling annually (Figure 2-1). The wet season generally begins in June and ends in early October. Rain falls intensely over short time periods, creating pulses of freshwater that enter the nearby estuaries through surface water flow.

The construction of canals has changed this surface water hydrology, introducing a greater volume of water over a shorter period of time. Hydrologically, the amount, rate and the timing of freshwater entering the estuarine systems has changed.

Water is an integral component of the Florida lifestyle. Not only is it used for drinking and household purposes, it also plays a major role in drawing tourists to the southwest Florida region. Many people are drawn to the Gulf Coast's beautiful beaches and sparkling shores. Recreational fishing, both saltwater and freshwater, is an important part of the economy of this region. The numerous golf courses are sought out by visitors, especially during the winter or dry season.

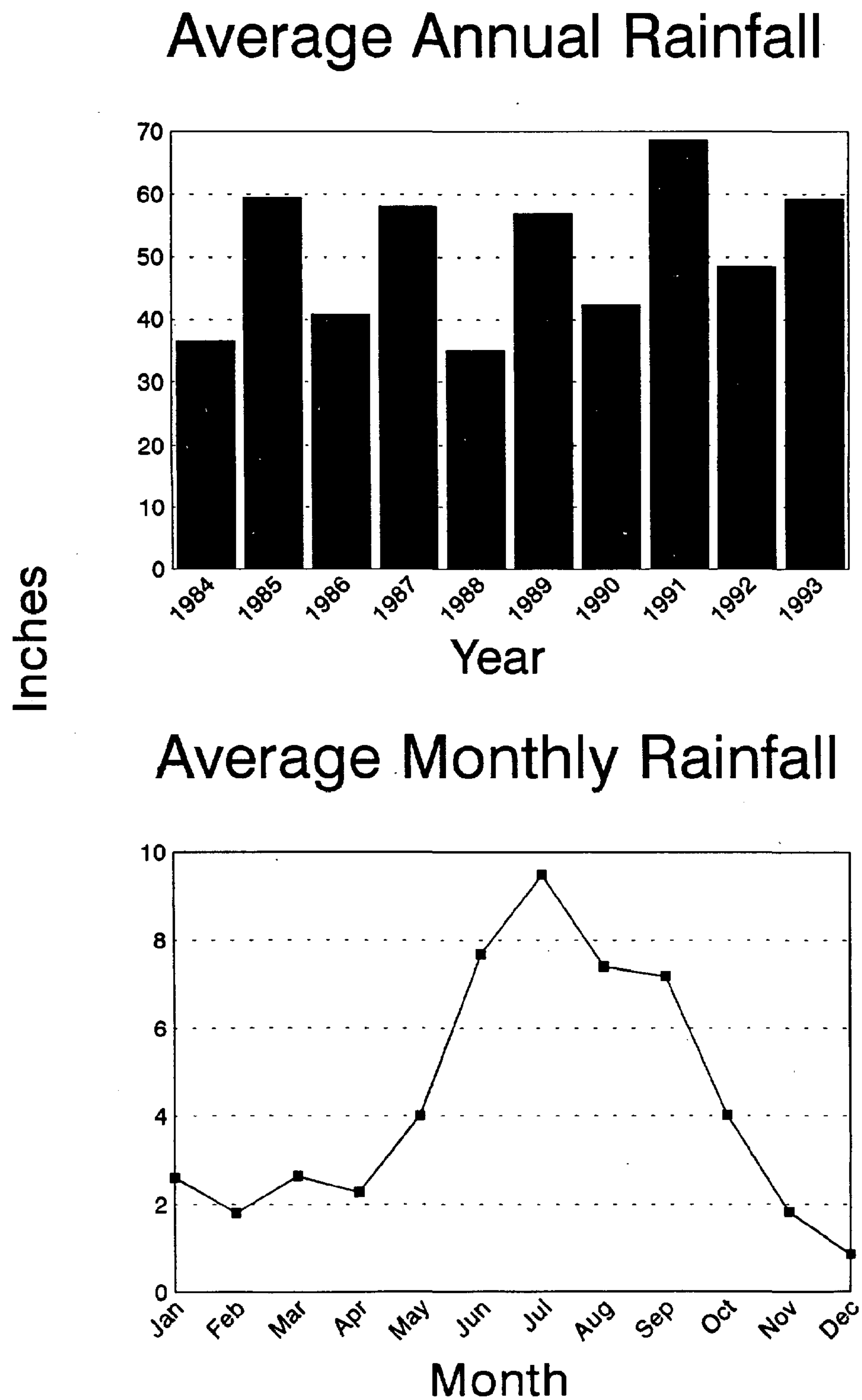
With a community and lifestyle so reliant on water, it would seem that good water quality and an adequate supply would be a top priority item. This is not necessarily the case. Although industry, such as manufacturing, does not threaten the water quality of Collier County, expanding urban lands, numerous golf courses and agriculture can have an impact on water quality.

2.1 REGULATORY AUTHORITY

The Federal Clean Water Act (CWA) is the primary statutory vehicle for achieving goals for water quality. Point source discharges are covered under the National Pollution Discharge Elimination System. Because of the effectiveness of this program, pollution from point sources has decreased dramatically. Section 319 of the 1987 CWA Amendments established an approach that relies on state programs to control NPS pollution. Section 6217 of the 1990 Amendments to the Coastal Zone Management Act requires states to develop NPS pollution control programs for coastal regions. The State of Florida has, since the 1970s, authorized Water Management Districts (WMD) and the Department of Environmental Protection to manage stormwater discharges (Williams 1994). The South Florida Water Management District is authorized to permit the design and construction of surface water management systems within its boundaries under the Florida Administrative Code (F.A.C.) Chapters 40E-40 and 40E-4. Section 17-40.420(1) F.A.C. establishes goals for the State's stormwater management program, including preserving freshwater resources by encouraging stormwater infiltration and reuse. It also attempts to assure that stormwater peak discharge rate, volume and pollutant loading are no greater after than before a site is developed. Section 17-40.420(4) F.A.C. regulates water quality of stormwater discharges. Minimum treatment performance standards require retaining sediment on-site during construction, 80% average annual load reduction for new stormwater discharges to most water bodies, 95% reduction to Outstanding Florida Waters and reduction on a watershed basis of the pollutant loading from older stormwater systems (Williams 1994).

Five classifications of surface waters in Florida have been identified by Florida

Figure 2-1. Collier County Rainfall Data



Department of Environmental Protection, dependent on up to 70 water quality parameters (Chapter 17-302, Florida Administrative Code). Potable waters, Class I, have the most stringent standards, while waters used for navigation, industries and utilities, Class V, have the least stringent standards. Surface freshwaters within the watershed are classified as Class III and are appropriate for recreation, fish and wildlife. Waters within Rookery Bay and the Ten Thousand Islands are designated as Class II, which have higher standards, allowing the taking of shellfish when bacteriologic conditions permit.

2.2 NPS POLLUTION

Point source pollution is discharge of contaminants from an identifiable location such as discharge from a pipe or a culvert, such as from a wastewater treatment plant. Nonpoint source (NPS) pollution is the result of rainwater running over and through a variety of surfaces, removing dissolved substances and particulate material. Some common constituents of NPS pollution are nutrients, pesticides, metals, sediment, oils and greases. NPS pollution contributes over 65% of the total pollution load to inland U.S. surface waters (U.S. EPA 1989). Locally, this number is probably greater. Sources of NPS in Collier County, Florida include urban stormwater, agricultural runoff, construction site runoff and leachate from septic systems, wastewater treatment lagoons and landfills. Studies show that NPS pollution from agricultural lands is of greatest concern (Williams 1994). Because NPS pollution comes from diffuse areas, it is difficult to control if proper management techniques are not utilized on-site or proximate to the site.

2.3 URBAN WATER QUALITY

Urban runoff, including synthetic organic compounds from lawn care products and automobile fluids, heavy metals from phosphate fertilizers and tire wear and sediments, eventually makes its way into natural wetland systems and estuaries along the Gulf of Mexico. These pollutants can have detrimental effects on aquatic communities, causing fish kills in severe cases. Excessive fertilizers entering an aquatic system can result in algal blooms, which deplete dissolved oxygen and destabilize estuarine systems. On-site sewage disposal (septic systems), which discharge into the surrounding soils, can contribute excess nutrients into the surrounding ecosystems. Sewage treatment plant effluent disposal systems are contributors as well (Table 2-1). Eroded sediments from construction activities increase turbidity and can cover bottom plants, thereby, reducing light penetration which is crucial for photosynthesis.

Table 2-1. Permitted Sewage Treatment Plants and Disposal Lagoons Within the Watershed		
Site Name	**Site Location**	**Capacity (gpd)**
Collier-Seminole State Park	Belle Meade (SE)	15,000
Copeland Road Prison	Fakahatchee	10,000
Eagle Creek STP	Belle Meade (SW)	200,000
Kountree Kampinn	Belle Meade (W)	10,000
Lee Cypress Co-Op W. W. Plant	Fakahatchee	20,000
M & E Trailer Park	Belle Meade (SW)	1,500
Naples KOA Kampground	Belle Meade (SW)	15,000
Naples RV Resort	Belle Meade (N)	35,000
Port-Au-Prince	Belle Meade (S)	6,000
Rookery Bay Utilities	Belle Meade (S)	150,000
South County	Water Management District 6	8 MGD*
Southern States	Belle Meade (S)	Lagoons**
Tall Oaks of Naples	Water Management District 6	15,000
Woodlake Condominiums	Belle Meade (S)	40,000

* Disposal by deep percolation ponds or re-use
** Used only as alternative to other disposal methods

Another potential pollutant source is mosquito control spray. Spraying for mosquitos generally occurs from March through November, on an *as needed* basis. In Collier County, the pesticide Baytex is sprayed using an ultra-low volume (ULV) application. The pesticide is distibuted by planes as a mist and is intended as a contact adulticide. The soil half-life of Baytex is approximately 60 hours. The pesticide has the potential to be washed into canals, lakes and estuaries, where it may adversely affect the resident aquatic communities. On-going studies in estuarine waters have found the contaminant to drift from target areas into preserved areas. The extent of impact on freshwater communities has not yet been determined.

Each of these sources of water quality degradation are of concern in this study. Waters entering Rookery Bay and the Ten Thousand Islands systems originate upstream, in areas that are urbanized, have agriculture and have golf courses, as well as areas of undeveloped land.

2.4 GOLF COURSE AFFECTS

Golf course runoff can contain high levels of fertilizers and pesticides which are used to maintain the fairways and greens. Certain fertilizers and pesticides contain heavy metals which leach into aquatic systems. Pesticides are produced to target certain pest species. However, many pesticides also affect non-target species and can have detrimental impacts on those populations. Recently, a number of pesticides have been in the news, implicated in the deaths of fish, birds and mammals. Nemacur, a pesticide used to control nematodes, was linked to at least ten massive fish kills, as well as the deaths of birds and river otters (Associated Press 1994). Diazinon, an insecticide, was implicated in the deaths of more than 700 birds (Edmonson 1987). Daconil, used as a fungicide, caused a severe allergic reaction and eventually the death of a golf player (Edmonson 1987). Both nemacur and daconil are used on golf courses within Collier County. While many golf courses within Collier County continue to use toxic chemicals, some have taken a more environmentally sound stance and are now using biological controls for pest problems.

There are currently about fifteen golf courses within the Rookery Bay-Ten Thousand Islands Watershed. Of these fifteen, only 20% use biological control agents, such as dipel, vector and proax, as a means of controlling pests. All of these courses still use synthetic chemicals as insecticides, fungicides and herbicides to keep the fairways and greens looking their best *(Appendix A)*. Table 2-2 identifies some of the pesticides used by golf courses within the Watershed, their potential effects and the percent of golf courses using each compound.

Table 2-2. Selected Pesticides used within the Watershed and their Percent Usage		
Pesticide	**Effect***	**% Use**
Award	toxic to fish	27%
Daconil	toxic to fish, birds and has been linked with human death - area cannot be grazed	55%
Dursban	toxic to fish, crustaceans and bees - area cannot be grazed	64%
Fusilade	toxic to fish - avoid drift - do not use if rainfall expected within 1 hour	9%
Kelthane	toxic to fish	9%
Kerb	do not use on golf greens - 3-12 month waiting period for crops	27%
MSMA	do not contaminate lakes, streams or ponds - area cannot be grazed	82%
Nemacur	toxic to fish, birds, mammals - under investigation at this time	55%
Oftanol	toxic to fish, moderately toxic to earthworms - area cannot be grazed - absorbed rapidly through skin	9%
Surflan	toxic to fish - do not use on soils more than 5% organic matter - area cannot be grazed - do not use on turf	27%
Turcam	highly toxic to fish	36%

*effects gathered from Associated Press 1994, Edmonson 1987, Thomson 1985, Thomson 1986 and Thomson 1987, based on recommended dilutions.
**Percent use is number of golf courses that use the product divided by total number of courses.

Many of these pesticides, fungicides and herbicides have negative effects on the environment and its inhabitants. Additionally, fertilizers used on these areas can run off and cause eutrophication of aquatic systems by overloading the system with nutrients.

2.5 AGRICULTURAL AFFECTS

Agribusiness operations, including row crops, citrus, nurseries and ranching, can also use large amounts of fertilizers and pesticides. While some of these compounds may degrade over time *in situ*, many are carried by stormwater into drainage ditches, flushed into canals and enter ecosystems downstream. Nutrients and pesticides from agribusiness empty into drainage ditches and canals. These nutrients then feed aquatic exotics, such as *Hydrilla*, and cause algal blooms which degrade aquatic systems downstream by altering light penetration and disrupting normal dissolved oxygen and nutrient cycles. In addition to degradation of the system, removal of aquatic exotics from the clogged canals is costly and time consuming.

2.5.1 Agriculture Pesticide Use

Agriculture also affects the waters entering Rookery Bay and the Ten Thousand Islands. The largest agricultural area within the Watershed lies on the south end of the Belle Meade region. Agricultural chemical use, by type and dosage, is regulated by the Department of Agriculture and is questioned only if there is suspicion of misuse. Agribusinesses have to keep records of the types of chemicals used, concentrations and amounts. However, these records are generally seen only by the Department of Agriculture. Efforts by this office through Florida Department of Agriculture, Department of Environmental Protection and other interests to review the records were unsuccessful.

The following Table lists commonly used pesticides for crops, primarily tomatoes and peppers, grown in the Belle Meade area.

Table 2-3. Common Pesticides Used in the Belle Meade Agricultural Area		
Common Name	**Chemical Name**	**Use/Crop**
Ambush	Permethrin	Insecticide/T, P
Asana	Essenvalerate	Insecticide/T,P
Bravo	Chlorothalonil	Fungicide/T
Cygon	Dimethoate	Insecticide/T,P
Devrinol	Napropamide	Herbicide/T
Dithane	Dithiocarbamate	Fungicide/T
Gramaxone Extra	Bitritylinium	Herbicide/T,P
Lannate	Methomyl	Insecticide/T,P
Manabe	Dithiocarbamate	Fungicide/T,P
Ridomil	Metalaxyl	Fungicide/T,P
Thiodan	Endosulfan	Insecticide/T,P
Treflan	Trifluralin	Herbicide/P
Vydate	Oxamyl	Insecticide/T

* T=tomatoes, P=peppers
*Collier County Cooperative Extension Service, pers. comm. 1994.

The most hazardous of the of inventoried pesticides studied in a 1992 report on agricultural pesticide use in coastal areas was endosulfan. The organochlorine pesticide was responsible for more fish kills in U.S. estuaries between 1980 and 1989 than all currently used pesticides, according to NOAA fish-kill data (Pait et al. 1992). Residues of this chemical have been detected in the sediment in Naples Bay and Vanderbilt Lagoon (CCPCD 1993). This chemical is commonly used to control tomato plant pests. Endosulfan has acute toxicity, high bioconcentration factor and relatively long soil half-life. Another commonly used pesticide is trifluralin. This pesticide readily bioconcentrates and ranks seventh in toxicity of the inventoried pesticides. Permethrin was ranked third hazardous in the 1992 report. Total inventoried pesticide use per year in the Rookery Bay Watershed was less than 100,000 lbs/yr (Pait et al. 1992).

The watershed for Rookery Bay had the highest intensity of hazard normalized application in the nation. The watershed for the South Ten Thousand Islands was ranked sixth. Hazard normalized application is the amount of pesticide that poses the greatest hazard to the estuary divided by the total Watershed area. According to the NOAA report, over 3,500 lbs./sq. mile of inventoried pesticides normalized to hazard are applied each year (Pait et al. 1992).

2.6 WATER QUALITY STUDIES

Many water quality studies have been conducted in the Rookery Bay-Ten Thousand Islands Watershed (Table 2-4). Agencies, such as DEP and SFWMD, Collier County Pollution Control Department, and private organizations, including The Conservancy and various consultants, have analyzed water quality throughout the County. Collier County Pollution Control Department has compiled all water quality data collected within the County into one database for comparison purposes.

Table 2-4. Water Quality Studies Conducted within the Watershed

Study	Dates	Location	Parameter
WQ RBNERR	1986-present	Rookery Bay, Ten Thousand Islands, and vicinity	depth, secchi, temp., pH, D.O.,cond., orp., salinity, TSS, BOD
WQ RBNERR	1987-present	Rookery Bay	PO_4, NH_4, NO_2, NO_3
SFWMD and CCPCD	1979-1991	Canals	Nutrients, metals, and physical properties
The Conservancy WQ	1970-1979	Rookery Bay and Henderson Creek	E. coli, fecal coliform, and bacteria
The Conservancy WQ	1972-1979	Rookery Bay, Henderson Creek, and Stopper Creek	Nutrients, metals, and physical properties
Department of Commerce and NOAA	1989 and 1992	Rookery Bay and the Ten Thousand Islands	selected agricultural pesticides

Unfortunately, most of these studies tested for different parameters and used different methods for determining concentrations. Overall data collection seems to be sporadic, rather than following a well-defined regimen. Long-term, consistent data, with a solid funding source, is needed to show changes within these systems. Upstream/downstream stations with two, preferably three, replicates should be sampled monthly to show seasonal and annual variations in both nutrient and pesticide concentrations in water and sediments.

The major canals in the study area, Lely, Henderson Creek, Faka-Union and Barron

River, have been sampled over a long enough period to adequately compare nutrient concentrations, specifically nitrate/nitrite (NOx) and total phosphate (TPO_4) levels. Sampling stations are shown in Figure 2-2. The Barron River Canal had significantly lower levels of both NOx and TPO_4 than the three other canals (T-test, $P<0.05$). Lely, Henderson Creek and Faka-Union canals did not differ in concentrations of NOx or TPO_4 (T-test, $P<0.05$) (Table 2-5).

Table 2-5. Statistical Differences in Orthophosphate or Nitrate/Nitrite Concentrations in the Major Canals

Canal	Barron River		Faka-Union		Henderson Creek		Henderson Creek East		Lely	
Parameter	OPO_4	NO_x	OPO_4	NO_x	OPO_4	NO_x	OPO_4	NO_x	OPO_4	NO_x
Barron River	X	X	[redacted]	N	[redacted]	N	[redacted]	N	[redacted]	N
Faka-Union	[redacted]	N	X	X	N	N	N	N	N	N
Henderson Creek	[redacted]	N	N	N	X	X	N	N	N	N
Henderson Creek East	[redacted]	N	N	N	N	N	X	X	N	N
Lely	[redacted]	N	N	N	N	N	N	N	X	X

2.7 MITIGATING NPS POLLUTION

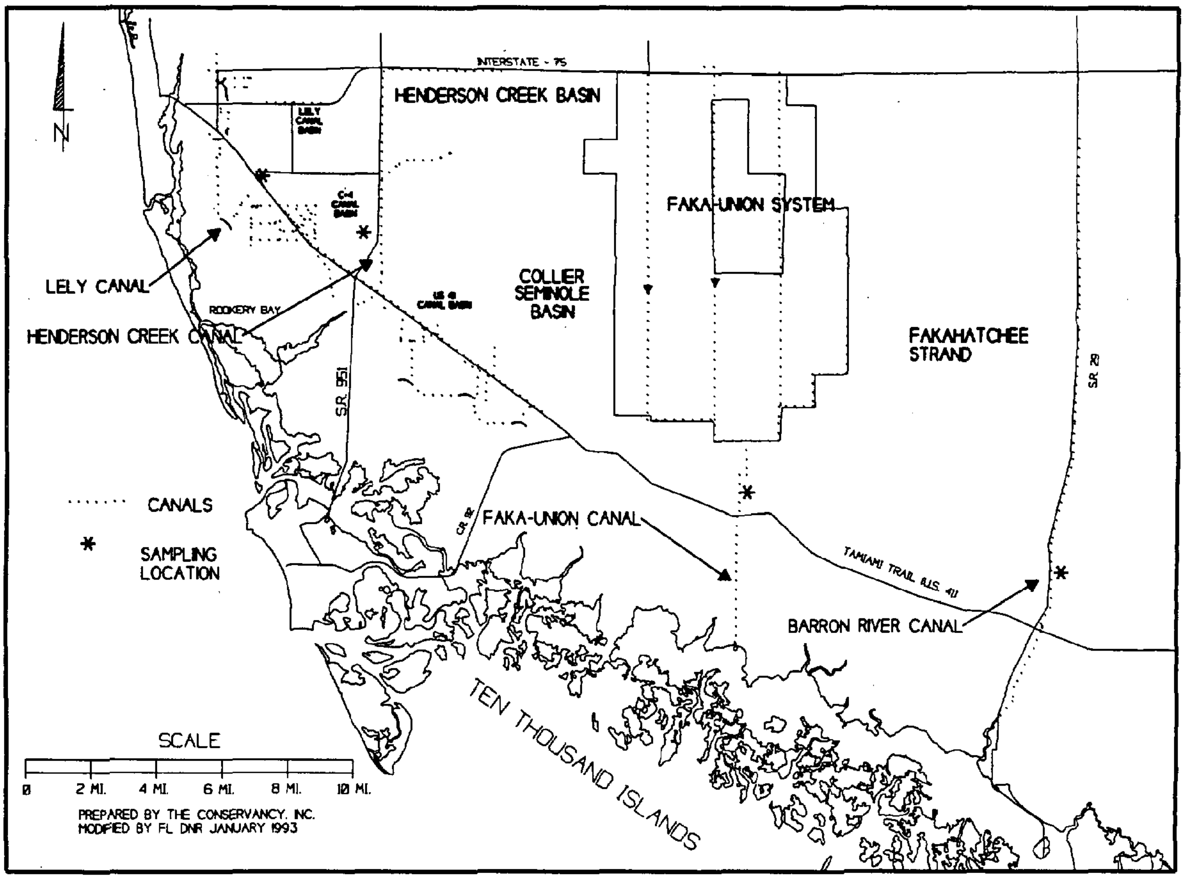
The implementation of stormwater quantity and quality standards is accomplished through the use of Best Management Practices (BMPs). BMPs include infiltration (trenches and retention areas), delayed discharge (permanently wet detention), proper construction and tilling techniques (sediment barriers, screens and terracing), as well as the use of existing and planted vegetated areas.

2.7.1 Wetlands as BMPs

An important natural component of the treatment of NPS discharges are wetlands. The disturbance to wetlands or other historic vegetated communities, the alteration of the permeability of soils, or changes to the topography of the site that often accompanies construction and agricultural activities have severely hindered the ability of the site to adsorb and remove contaminants. The timing, duration and quality of the surface water runoff are adversely affected. By utilizing the ability of wetlands to modify stormwater characteristics in conjunction with constructed BMPs, the downstream affects on water quality from stormwater discharges are lessened.

Water purification functions of wetlands are dependent upon vegetation, water column, substrates and microbial populations (Hammer 1993). Because natural wetlands contain these

FIGURE 2-2. COLLIER COUNTY WATER SAMPLING LOCATIONS



components, while created wetlands require time and capital to attain suitable conditions, preservation and use of natural wetlands should occur as much as possible. However, the use of natural wetlands for the direct treatment of stormwater is limited by the fact that wetlands are considered "waters of the United States" and protected as such under Section 402 of the Clean Water Act. The use of restored or created wetlands as a BMP are not as distinctly regulated (Fields 1993).

On a site-scale basis, this offers many possibilities for the reduction of pollutant loads. The creation of littoral zones or "fringing wetlands" along wet detention areas, as well as in conveyances, such as swales, and other "green" areas, tends to smooth out the pulsing of stormwater discharges. Design of the system should be simple and allow for its functionality to develop over time. Maintenance of the system should be kept to a minimum (Mitsch 1993).

Many older developments adjacent to the Rookery Bay and Ten Thousand Islands systems were not subject to stormwater management rules, and some stormwater management systems do not function adequately. These locations are not easily retrofitted. Capital costs and site limitations may prohibit any alterations to stormwater treatment on-site. Because these discharges are often times connected to water management district or county operated drainage features, off-site management becomes more practical. Much of the existing canal network has limited control structures and allows stormwater discharges at unacceptable rates into sensitive estuarine waters. By redesigning the receiving canal system to include higher stages, overflow to extant wetlands adjacent to the canals will allow for longer detention time for stormwater in canals and wetlands before discharge. This should cause a decrease in nutrient loading. Again, natural wetlands are protected under Federal rule and care should be taken not to expose them to pollutant laden discharges. In addition to more appropriate timing of discharges, ancillary benefits, including increased hydroperiod and enhanced wildlife habitat, will occur.

Outfall locations of existing canals should be redesigned to imitate historic characteristics of surface water flow into tidal areas. The design should include spreading the discharge over a broad area, instead of only the width of the canal. Redesigning the drainage network to more closely imitate natural conditions, while still providing flood protection, should improve water quality entering the estuarine systems.

2.7.2 Management and Storage of Surface Water (MSSW) Permits Issued in Collier County

The table located in *Appendix B* lists the current permits issued for agricultural and residential developments in the study area. Over 23 permits have been issued including 12 for agricultural uses.

CONSERVATION MEASURES FOR ENVIRONMENTALLY SENSITIVE LANDS

There are many ways to ensure that environmentally sensitive lands are managed so that their functions are maintained for the future. The following is a list of measures that have been successfully employed.

3.1 FEE SIMPLE PURCHASE

Direct or outright buying of lands is called *fee simple purchasing*. Many times this method is used by federal, state and local agencies to protect lands that are critical to maintaining the environmental integrity of an area. For example, the South Golden Gate Estates region is being actively acquired by the State of Florida because of the integral part it plays in the hydrology of southwestern Florida. Generally, it is thought to be a good step for the State to purchase lands which have little to no chance for development. These purchased lands are primarily wetland areas, adjacent to other preserved areas or a large area that can be managed as a unit and contribute to the groundwater recharge and surface water flow of an area. Once the land is purchased by the State, it is taken off of the tax rolls; however, existing tax revenues are limited compared to the cost of providing public infrastructure.

3.2 TRANSFER OF DEVELOPMENT RIGHTS

A development right is attached to every parcel of land and is worth the amount that the land would be worth if it was developed. A *transfer or purchase of development rights* involves paying the landowner an amount comparable to the land's developed worth. The land then remains as is, with no threat of development in the future. For example, a private individual owns a 50-acre parcel of wetlands. He uses the land for hunting and camping, with no aspiration to develop it in the future. A developer is constructing a parking lot which will impact 5 acres of wetlands. The developer purchases the development rights from the private individual to compensate for the impacts made during construction of the parking lot. The developer gets his parking lot, the landowner gets a monetary settlement and the wetland is protected in perpetuity from development. Land management, determining who pays for managing the land and who pays for the maintenance, is one problem associated with this method.

3.3 CONSERVATION EASEMENTS

A *conservation easement* is similar to purchase of development rights in that it limits development on property. Conservation easements may be assigned to the plat of the property. Lands adjacent to currently protected lands or connected to sensitive lands may be targeted, with the conservation easement creating a buffer zone between development and sensitive lands. For example, a farmer has a fifty-acre field adjacent to a relatively pristine and protected wetland. To assure that the field will not be converted into residential development in the future, a conservation easement is placed on a portion of the property near the sensitive lands, such that current activities can continue, but development would be restricted. The farmer can continue to farm the fields as long as he pleases and can sell the property to another person to farm; however, the easement is protected in perpetuity from development. Conservation easements have the same management and maintenance problems encountered with transfer of development rights.

3.4 CLUSTER ZONING

Cluster zoning can be used in some cases when property is adjacent to environmentally sensitive lands. If the landowner will not place a conservation easement on his property, he may be able to cluster or group the houses in one area, while protecting the environmentally sensitive lands in another area. For example, a landowner adjacent to Camp Keais Strand wants to build single family houses on his fifty acres of land. Rather than placing one house on each ten-acre plot (the current practice under agricultural zoning designations), the landowner can cluster these five houses on ten or twenty acres set back from the Strand, leaving the environmental buffer in place. One drawback is that human impacts will be concentrated within one localized area. This, however, can also be seen as a positive effect.

3.5 TAX INCENTIVES

Tax incentives for landowners can also be used to limit development on lands. The State or County Government can defer taxes on property if the landowner agrees to certain stipulations, such as limited development and removal of exotic species. Tax breaks given to landowners may fluctuate year to year depending on the economy and enforcement of the stipulations agreed upon may be a problem.

3.6 PRIVATE STEWARDSHIP

Many private citizens are environmentally aware and want to do their part to protect sensitive systems. Unfortunately, there are no *private stewardship* programs set up in Collier County. A private stewardship program would allow landowners to benefit from certain environmentally sound practices on their property. For example, preservation of existing native plant communities and removal of exotic species from the property. This, in conjunction with an education program that teaches environmentally sound practices and the importance of native plants, would be a benefit to Collier County's ecosystems. Voluntary programs are hard to enforce and landowners may decide to participate one year and not the next, making it difficult to keep track of participants.

3.7 MITIGATION AND MITIGATION BANKING

The concept of *mitigation* has been around for a number of years. When impacts to wetlands are compensated for within the particular development project it is termed *on-site mitigation*. For example, a developer wants to build on a site, but he will have impacts on some of the wetlands which are protected by federal and state laws. To offset the impacts to these wetlands, the developer will restore, enhance or create -- mitigate --wetlands elsewhere on-site. The impacted wetlands are given a value, as are the restored, enhanced or created wetlands and the developer works to balance the mitigated value with the impacted value on that particular site.

Off-site mitigation compensates for impacts to wetlands on a development site by purchasing land elsewhere. These lands tend to be within or located adjacent to existing preserve areas. For example, a developer is planning to impact wetlands on a development site. These wetlands are given a value. To compensate for these impacts, the developer purchases lands near Big Cypress National Preserve and deeds them to the federal government. The amount of wetlands purchased for the government balances the impacts made to the development site. This process is termed off-site mitigation.

Mitigation banking is somewhat similar to off-site mitigation in that lands are purchased off-site and used to compensate for on-site development impacts to wetlands. Either an agency or private individual can purchase environmentally sensitive lands for use as a mitigation bank. U.S. Army Corps of Engineers, Florida Department of Environmental Protection or South Florida Water Management District determine if the property is suitable for use as a bank. A bond is placed in a trust to be used for management of the property in perpetuity. Florida Department of Environmental Protection and the South Florida Water Management District assign values or credits to the property. These credits can then be purchased by developers to offset impacts they have on their development sites. Sites can range from pristine areas, which only need to be purchased, to areas which need restoration, enhancement or creation of wetland communities. Each of these ranges is given a separate value or credit for restoration. Table 3-1 shows some of the mitigation ratios recommended for the recently approved Environmental Resource Permit (ERP) permit.

Table 3-1. Proposed Mitigation Ratios for the ERP Program

Method	Target	Ratio*
Preservation	wetlands and surface waters	10:1 - 100:1
Enhancement	wetlands	4:1 - 20:1
Creation and Restoration	mangrove swamps, cypress swamps and hardwood swamps	2:1 - 5:1
	saltwater and freshwater marshes	1.5:1 - 4:1

* ratio = acreage preserved : acreage impacted

For example, a developer impacting 1-acre of wetlands could purchase 10-100 acres of wetlands for preservation, enhance 4-20 acres of wetlands or restore 1.5-5 acres of wetlands, depending on the type of wetlands impacted, restored, enhanced or preserved.

There are five major steps involved with establishing a mitigation bank (Folk, DWP 1994).

- Site Selection and Design
  -locate an ecologically significant site that will positively contribute to the surrounding environment (e.g. endangered species protection, water quality benefits, hydrologic restoration)

- Site Acquisition, Assessment and Survey
  -acquire land within a site, establishing boundaries, identifying historic and present plant and animal components and determine restoration potential
- Planning
  -develop strategies for restoration and long-term management of the site
- Start-Up and Restoration Phase
  -initiate restoration activities, begin site management and develop management plan for long-term conservation of the site
- On-Going Management
  -formulate management plan for the site including plans for acts of nature (hurricanes and droughts), introduction of new species and other unseen challenges

Mitigation banking has great potential in Collier County. State agencies and South Florida Water Management District can target environmentally sensitive areas to be used as banks. Developers and private individuals can purchase the lands and establish the banks. In the end, the developers and consultants get to proceed with their projects, while environmentally sensitive lands are protected in perpetuity.

3.8 POTENTIAL FUNDING SOURCES

3.8.1 Potential funding sources have been identified for the implementation of monitoring, planning/design, purchasing or construction of projects related to the restoration of historic flowways and associated water quality (Table 3-2). Funding is available from Federal, State, and Water Management District sources. Federal grant monies that would be available are used primarily for the restoration of habitat in coastal regions to increase fisheries production. This would include land purchases and construction of stormwater control structures. State funding through the DEP is available for mitigation, restoration of CARL lands, and exotic plant removal. The SFWMD has funding available for Surface Water Improvement and Management (SWIM) water bodies. Currently, Rookery Bay is ranked 19th with slim prospects of seeing funding within the next few years. SWIM funds are used for mitigating pollution effects in degraded water bodies.

Table 3-2. Potential Funding Sources			
Source	**Target**	**Funding Limits**	**Project**
The Florida Communities Trust, Preservation 2000 Program 2740 Centerview Drive Tallahassee, Florida 32399-2100 (904) 922-2207	-lands for acquisition - do not have to be pristine - can have outdoor recreation activities	$1 million +	-land acquisition
Environmental Protection Agency Gulf of Mexico Program Building 1103, Room 202 Stennis Space Center, Minnesota 39529-6000 (601) 688-3726	-habitat degradation - nutrient enrichment - toxics and pesticides - freshwater inflow - living aquatic resources	project dependent, up to $1.2 million/year for all projects	-water quality studies -spreader swales -weirs
National Coastal Wetlands Grant Program U.S. Department of the Interior Fish and Wildlife Service 1875 Century Blvd. Atlanta, Georgia 30345 (404) 679-4159	-acquisition for hydrology, water quality, fish and wildlife - restoration, enhancement or management of coastal wetland ecosystems - need quantifiable results	amount must be matched by State and other agencies for 50% of project cost	-land acquisition -water quality studies -management
South Florida Water Management District SWIM Priority Water Bodies 3301 Gun Club Road P.O. Box 24680 West Palm Beach, Florida 33416-4680 (407) 686-8800	-Rookery Bay is # 19 on the SWIM Priority Water Bodies list	project dependent	-restoration -spreader swales
Florida Department of Environmental Protection Pollution Recovery Trust Fund Fort Myers District Office Fort Myers, Florida (813) 332-6975	-funds from permits for mitigation and enforcement -can be used for exotic removal via mitigation	n/a	-restoration -filling of ditches -removal of roadbeds
South Florida Water Management District Cooperative Funding Program	-will fund a portion of a project (60-80%)	n/a	-culverts -weirs
Coastal America NOAA/NOS (404) 347-1746	-will co-share funding on a 70/30 or 60/40 basis for restoration projects	n/a	-culverts -weirs
CARL Management Funds Florida Department of Environmental Protection Tallahassee, Florida (SC)278-3456	-available to FDEP field site for management, including restoration, of CARL purchased lands -amount based on total acreage	n/a	-Belle Meade restoration projects

Source	Target	Funding Limits	Project
Division of Forestry Fort Myers, Florida	-South Golden Gate Estates CARL lands	n/a	-removal of roadbeds -grading -exotic removal
Big Cypress Basin Naples, Florida	-Belle Meade lands and South Golden Gate Estates	n/a	- culverts -weirs -grading
Department of Community Affairs Coastal Zone Management Program Tallahassee, Florida (SC) 292-5438	-Belle Meade	n/a	-restoration projects

n/a = not available

MEETING COLLIER COUNTY GROWTH MANAGEMENT PLAN AND ROOKERY BAY NERR MANAGEMENT PLAN OBJECTIVES

4.1 COLLIER COUNTY

The Conservation and Coastal Management Element of the Collier County Growth Management Plan contains goals, objectives and policies that plan for the protection, management and appropriate use of its natural resources and protection of its surface waters. This study recommends certain actions that try to meet the various objectives in the Plan. The following is a brief description of some of those objectives:

- **Objective 1.1:** The County will complete the development and implementation of a comprehensive environmental and conservation program that will ensure the natural resources of Collier County are properly protected and managed.

- **Objective 1.3:** The County will delineate, gather data, determine management guidelines and inplement the County Natural Resources Protection Area (NRPA) program. The County shall seek assistance from and support State (e.g. CARL, SOE, etc.) land acquisition programs for County areas qualifying as NRPAs.

- **Objective 2.1**: The county shall prepare Watershed Management Plans for the estuaries.

- **Objective 2.2:** All canals and flowways discharging into estuaries shall meet all applicable Federal, State, or local water quality standards.

- **Objective 2.3:** All estuaries shall meet all applicable Federal, State, and local water quality standards.

- **Objective 6.2:** There shall be no unacceptable net loss of viable, naturally functioning marine and freshwater wetlands.

- **Objective 6.7:** The County will protect, conserve and appropriately use ecological communities shared with or tangential to State lands.

- **Objective 6.8:** The County shall protect natural reservations from the impact of surrounding development.

- **Objective 7.3:** The County shall develop and implement programs for protecting fisheries and other wildlife.

Under the Recreation and Open Space Element, the County has adopted objectives to ensure the establishment of sufficient outdoor recreational areas.

- **Objective 1.1:** The County will establish a comprehensive system of parks.

- **Objective 1.2:** The County shall protect designated open space from incompatible land-uses through land-use regulations.

Additionally, Collier County's Growth Management Plan addressed some goals and objectives specifically catered to South Golden Gate Estates. The County has recognized this region as having special environmental and hydrologic qualities and is supporting the State's land acquisition, as well as the panther recovery efforts, in South Golden Gate Estates through these objectives:

- **Objective 2.1:** The County will immediately implement a system restricting public infrastructure in South Golden Gate Estates.

- **Objective 2.2:** In order to further its goal of protecting this area, the County will coordinate with the State in an effort to assist the State's acquisition of privately owned property within South Golden Gate Estates, such that they recognize existing private property rights.

Collier County Land Development Code, adopted from the Land Use Element, sets standards for construction activities on residential, commercial and industrial projects. Section 3.9.6.6 requires the removal of prohibited exotic vegetation (such as melaleuca, Brazilian pepper, etc.), along with the protection of native vegetation on lands slated for development.

4.2 ROOKERY BAY NERR MANAGEMENT PLAN

Rookery Bay NERR has developed a management plan for the protection and preservation of the natural resources within the boundaries of the Reserve. Included in the plan are a number of objectives that, when implemented, will minimize adverse impacts on the Reserve's resources from changing land uses in the watershed. The following is a brief description of some of the Plan's objectives.

- **Objective 2.1:** Acquire privately owned properties, or secure conservation easements, within the Rookery Bay Acquisition Properties.

- **Objective 2.5:** Support acquisition efforts for the Belle Meade and South Golden Gate Estates areas.

- **Objective 2.6:** Restore sheetflow and freshwater drainage regimes to approximate natural, unaltered conditions.

- **Objective 2.7:** Restore and maintain native plant communities through and maintenance of invasive exotic plants.

- **Objective 2.16:** Develop interlocal agreement with Collier County that allows Reserve staff to have input into watershed management.

HISTORIC WETLAND FLOWWAYS

Historical wetland flowways were identified by combining various vegetation communities with various soil types. The flowways and their boundaries were primarily derived from the 1987 U.S.S.C.S. Soil Survey for Collier County , the 1954 U.S.S.C.S. Soil Survey for Collier County, the 1985 U.S. Department of the Interior, National Wetland Inventory maps, and aerial photographs from 1962 and 1963 of the region, as well as limited groundtruthing. Topographic lines are from the U.S.D.O.I. Geological Survey topographic maps.

These maps should not be interpreted as a description of present day vegetation, nor were they drawn for such purposes. The maps are to be only used as a guide for identification of large-scale, historic and natural flowways for surface water.

5.1 DESCRIPTION OF ABBREVIATIONS USED IN FLOWWAY AND DRAINAGE OVERLAYS

5.1.1 Cypress Strand/Slough (CS): This designation applies to areas vegetated almost entirely by a canopy of mature cypress trees. These areas may also contain a mixed canopy of maple, bay, ash, pond apple, and some pine; however, these plants are located only in isolated pockets and not in a continuous strand. An understory is present consisting of ferns and herbaceous and plants, such as pickerelweed, fire flag, sawgrass, and willow. These plants are able to survive flooded conditions.

Under natural conditions, the water table is within 12 inches of the surface for 3 to 6 months. During extended droughty periods the water table drops to below 40 inches below the land surface. During periods of high rainfall, the land surface may be covered by more than 6 inches of water for a period of up to 30 days and under undrained conditions, up to 200 or more days. The grade adjacent to these areas is greatest of all the other designations but is only at most 2 feet per mile. This creates the slough condition and act as a channel for flow around upland areas or in the southern ends of basins where the sloughs act as freshwater connections to tidal streams.

Individual areas are generally elongated in shape and may be as large as 100 to 3000 acres. Soils in these areas include the Boca, Riviera, Limestone Substratum and Copeland Fine Sand Depressional. Limestone is present from 30 to 54 inches below the land surface.

These areas were extensively logged in the past with most of the large trees removed. The existing canopy is made up of trees ranging from 30 to 80 feet in height and diameters from 3 to 12 inches. The fringe areas are highly susceptible to fire damage (ACOE 1986).

5.1.2 Cypress (CY): This designation applies to areas with at least a 50% canopy of cypress trees but also may contain a high percentage of slash pine. These areas also contains large tracts of "scrub" (also known as "hatrack" or "dwarf") cypress. The understory consists of cabbage palm, wax myrtle, myrsine, and other woody plants and various grasses. Occasional pockets of forested hammocks and cypress domes are located within these areas.

Under natural conditions, the water table is within 12 inches of the surface for extended periods during the wet season. During periods of high rainfall, the land surface may be covered by a shallow slowly moving or ponded water for short durations. These areas differ from the CS designations in that the water table is generally not above the land surface for as long a duration. The slope is generally less than 1 foot per mile.

Individual areas are from 10 to 600 acres or more. Soils in these areas include Pineda and Riviera Fine Sands and in the scrub cypress areas Hallandale and Boca Fine Sands. Limestone bedrock is greater than 54 inches below the land surface in some areas and within 12 of the surface in some of the scrub cypress areas.

These areas have been severely impacted by overdrainage. Fire has extensively reduced the historic coverage of this designation. Pine, which is less stressed by fire and drainage, has "invaded" these areas or, if historically present, has outgrown the cypress, creating a new canopy.

5.1.3 Depressional/Cypress Domes (D): This designation applies to isolated pockets of mixed swamp, cypress, or prairie that hold water for longer periods of time than the surrounding designation. Gator and Chobee soils are located within these areas. They are generally less than 5 acres.

5.1.4 Mixed Swamp (MS): This designation applies to forested areas of bay, cypress, maple, pond apple, pop ash and other trees with no one species dominating the canopy. The hydrology of these areas is similar to that of CS. The areas are often located within the CS designated locations, are smaller than the CS areas, and have more plant diversity. In some locations, plants from this designation have succeeded in areas where cypress have been logged.

5.1.5 Pine Flatwoods (PI): This designation applies to areas with at least a 50% canopy of slash pine but may also contain a high percentage of cypress. An understory of wax myrtle and various grasses is present. This designation differs from CY because of the higher percentage of slash pine and may be less susceptible to flooding. However, during periods of high rainfall, ponded or slowly moving water may cover the land surface. Individual areas may be from 20 to 300 acres or more. Soils in these areas include Pineda and Holopaw Fine Sands, Limestone Substratum.

5.1.6 Prairie (PR): This designation applies to areas with very little canopy present. The predominant plants are scrub cypress, scattered pine, wax myrtle, sawgrass, other grasses and sedges, as well as other wetland plants. These areas are nearly level and act as poorly defined drainageways. The water table is within 12 inches of the land surface for 3 to 6 months and during rainy periods may cover the land surface for extended periods.

Individual areas may be from 20 to 400 acres or more. Soils in these areas include Pennsucco Silt Loam and Ochopee Fine Sandy Loam. In the marl prairies the depth to bedrock is usually within 18 inches of the land surface. Because of shallow bedrock in these areas, a thin soil layer acts as the only substrate for plant growth. When present, this highly organic soil is oxidized when drained or burned.

5.1.7 Tidally Influenced Areas and Mangrove (MN): This designations applies to coastal areas that are low in elevation and, therefore, are influenced by tides. Natural vegetation consists of scattered to dense mangrove, needlerush, saltgrass, and sedges. Scattered pockets of uplands, pine and prairie are located in this designation. Tidally influenced areas were not examined in this study.

Figure 5.1. LEGEND FOR FLOWWAY OVERLAYS

CS	Cypress slough/strand
CY	Canopy >50% cypress
D	Cypress Dome or Depressional Area
MS	Mixed Swamp
PI	Canopy >50% hydric pine
PR	Prairie
MN	Mangrove/Tidally influenced
➜	Direction of flow in significant flowways
→	Direction of flow in broad flowways
➡	Direction of flow in canals and ditches
------	Flowway boundary
□	Box culvert or bridge
○	Circular culvert
11	Elevation
- - -	Elevation Contour

Hatching indicates obstructions to surface flow

KEY FOR HISTORIC FLOWWAYS MAPS

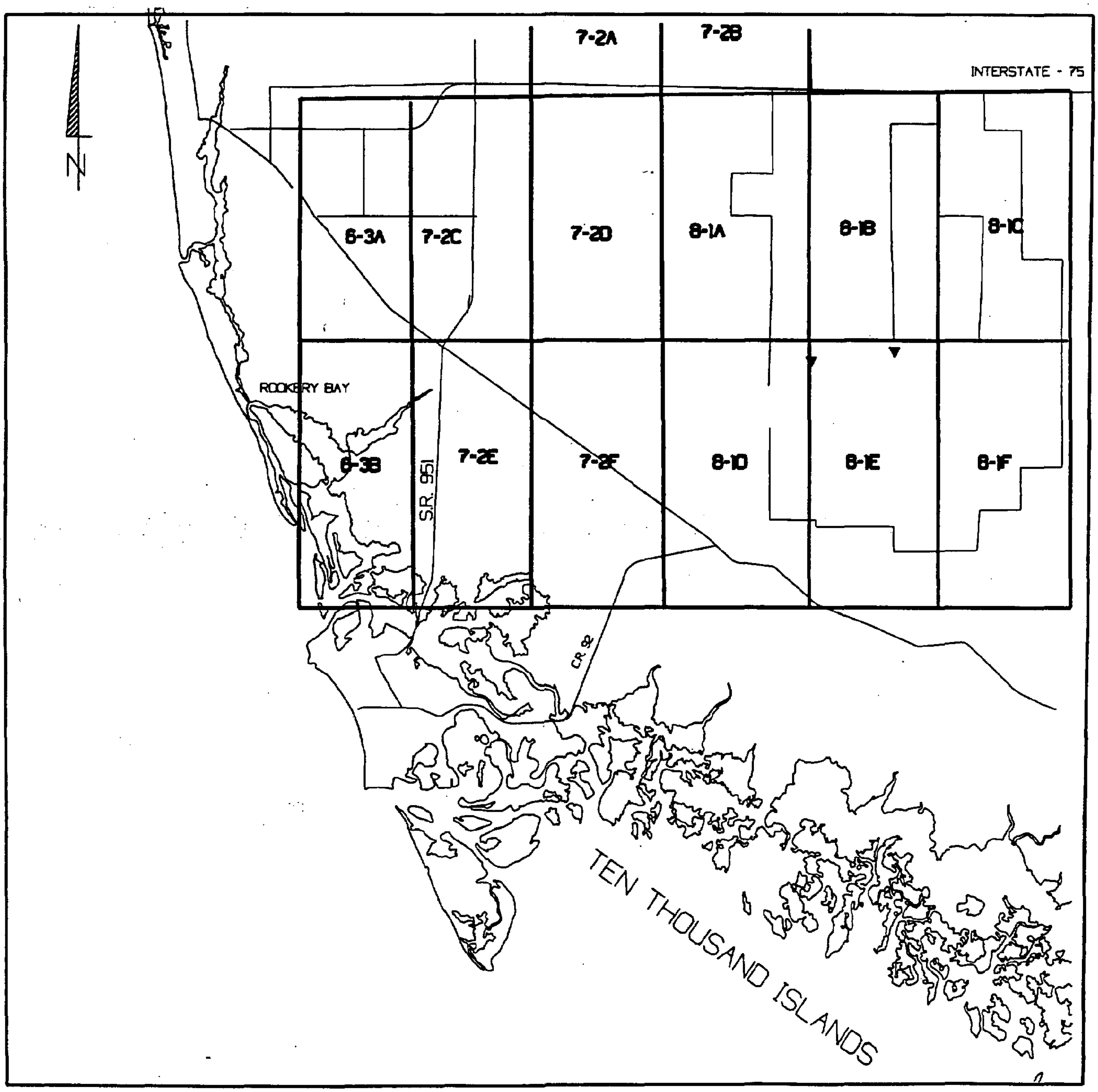


Figure 5.2. LEGEND FOR LAND USE MAPS

ZONING

A	Agricultural
C2, C3, C4	Commercial
E	Estate
IND	Industrial
MH	Mobile Home
PUD	Planned Unit Development
RSF3	Residential, Single Family, 3 units/ac
RV, TTRVC	Recreational Vehicle
CON/ST	Conservation/Special Treatment

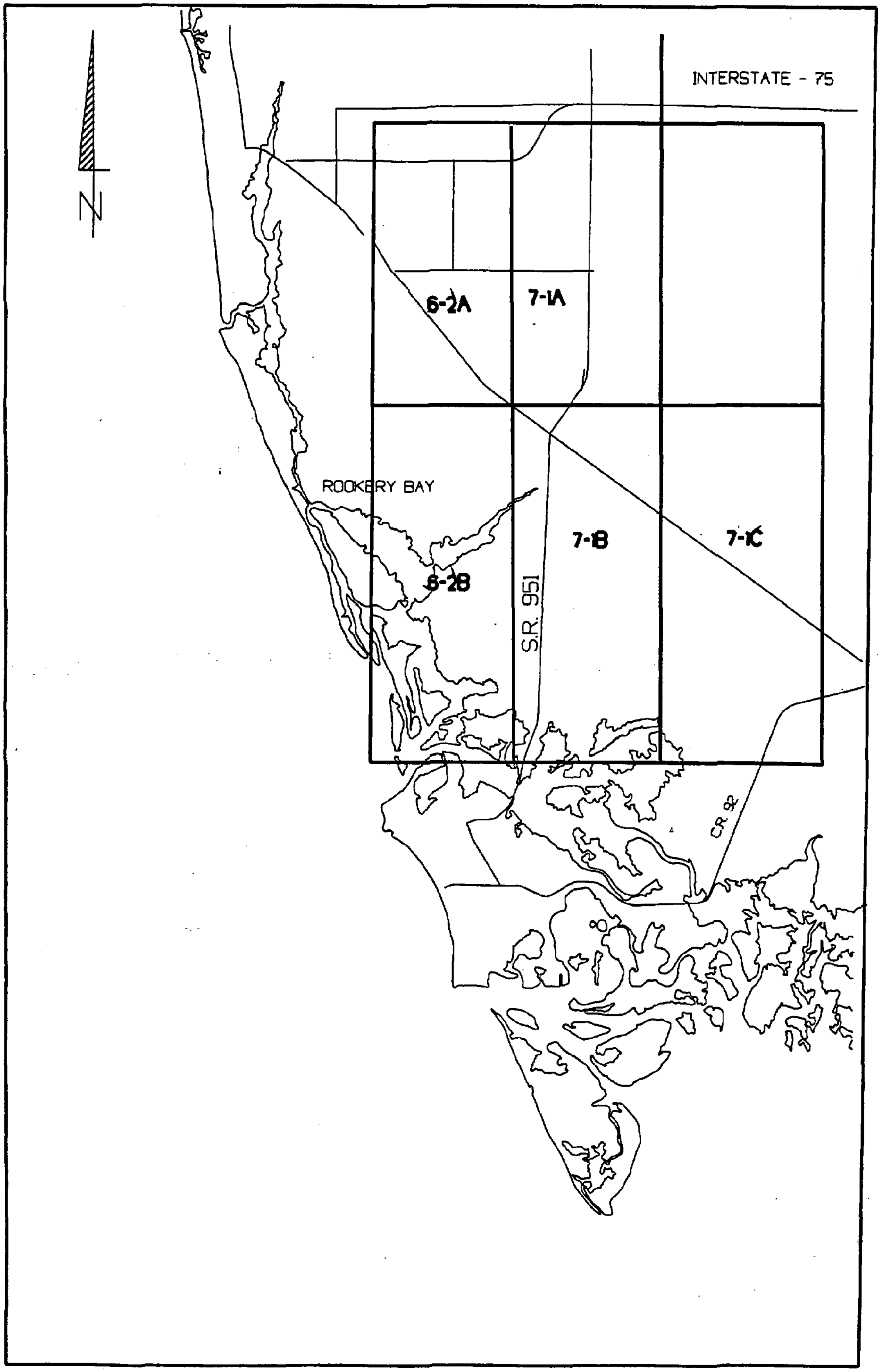
OTHER

AG	Existing Agriculture
GC	Golf Course
NS	Nursery
99	SFWMD MSSW Permit #
➡	Direction of flow from stormwater conveyance systems

SEWAGE TREATMENT

FM	Planned or Existing Sewage Force Main
STP	Sewage Treatment Plant
	Served by Onsite Sewage Disposal Systems
	Served by Central Sewer

KEY FOR LAND USE MAPS



WATER MANAGEMENT DISTRICT 6

Water Management District 6 was established in 1971 to undertake a comprehensive water management study of the district, provide for improved drainage and set development guidelines. The District consists of more than 41,000 acres (Black 1974). For the purposes of this study, the area is bounded by SR 84 to the north, CR 951 to the east, County Barn Road on the west and the Township line between 51S and 52S to the south.

The first major construction in this region occurred at Naples Manor in the 1960s and, subsequently, the Lely development during the early 1970s. As of 1971, approximately 15% of the region was developed (Black 1974). Since that time the region has experienced significant growth. The area, located in the South Naples Planning Community, has had a population increase from 9,805 in 1985 to 15,790 as of 1994 (62%) (Collier County Growth Management 1994). This area is now the most densely developed of all the watersheds that drain into the Rookery Bay-Ten Thousand Island estuarine system. In addition to the regions previous growth, it offers large sections of land that are within the "Urban Residential" and "Urban Coastal Fringe" designations, which will allow intensive urbanization, as seen in Figure 6-1. The current zoning in most of the undeveloped land consists of a mix of agriculture and residential uses, as seen in Figure 6-2.

6.1 VEGETATION

Historically, Water Management District 6 consisted of a mosaic of upland and wetland habitats. Cypress sloughs meandered in a southwesterly direction, merging with freshwater prairies, as well as the brackish mangrove swamps and tidal marshes. Upland areas and hydric pine wetlands are interspersed within the area, with a large amount of coverage by expansive cypress-dominated wetlands. Currently, developments cover much of Water Management District 6 and have severely altered the vegetative composition of the area. Some of the cypress sloughs, such as Rattlesnake Hammock Slough, are still present today. However, these areas are threatened by encroaching development, as well as invasion by exotic species, such as melaleuca and Brazilian pepper. Due to intensive development activities, tables listing acreages of existing vegetation were not compiled.

6.1.1 Habitat Ranking

The Florida Game and Freshwater Fish Commission has ranked habitats for specific species within the area on a scale of 1 to 10, 1 being the lowest value and 10 being the highest value (Cox et al. 1994). Habitat suitable for the endangered Florida panther ranked between 1 and 3, while habitat suitable for the threatened Florida black bear ranked between 1 and 7 (Cox et al. 1994). Strategic habitat areas, or areas identified as important because they provide a base habitat for long-term species persistence, were found within Water Management District 6 for protected fox squirrels (Cox et al. 1994). Additionally, black-whiskered vireos are found in the mangrove areas fringing Water Management District 6 and Florida scrub lizards are present in Rookery Bay National Estuarine Research Reserve to the south of Water Management District 6

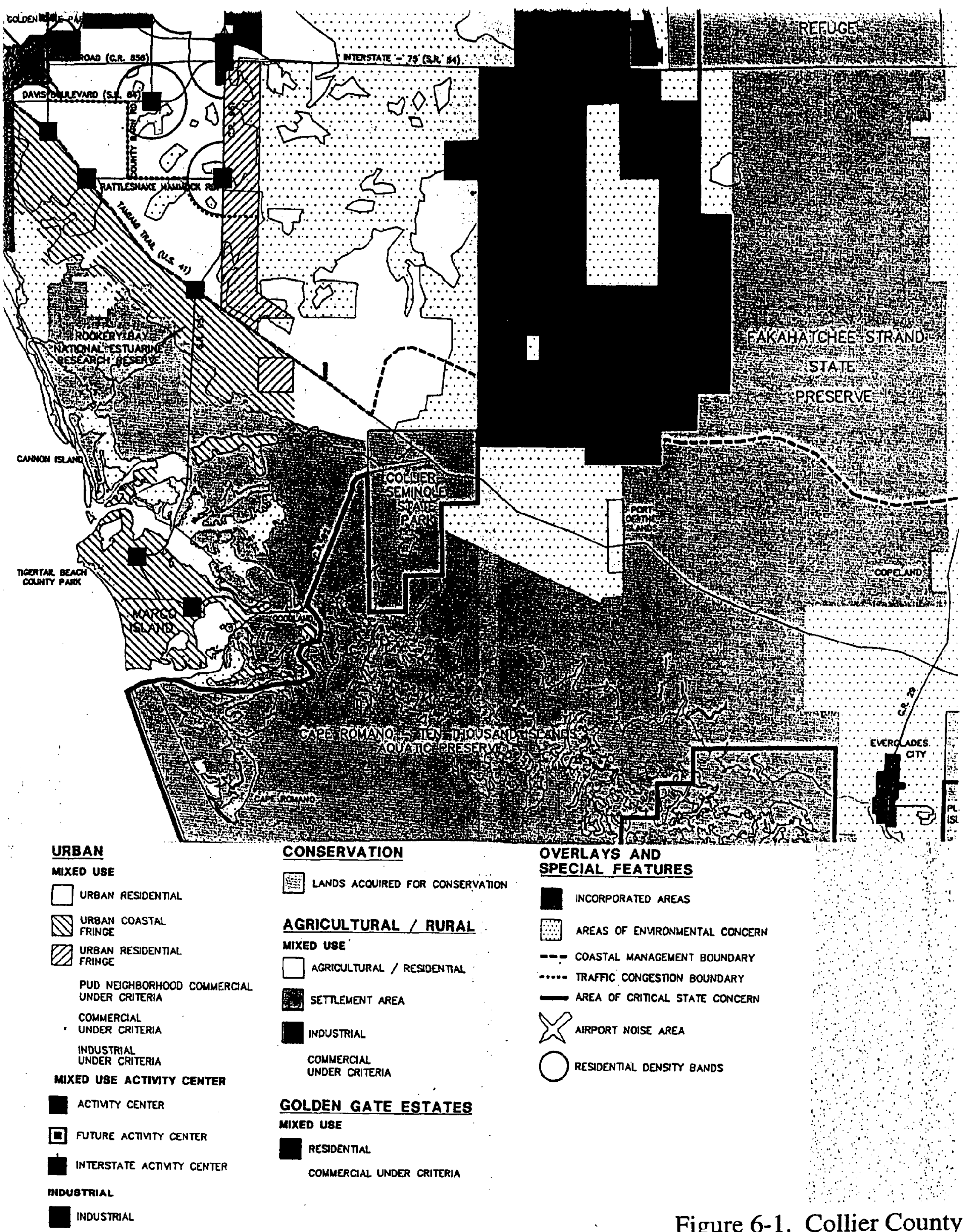


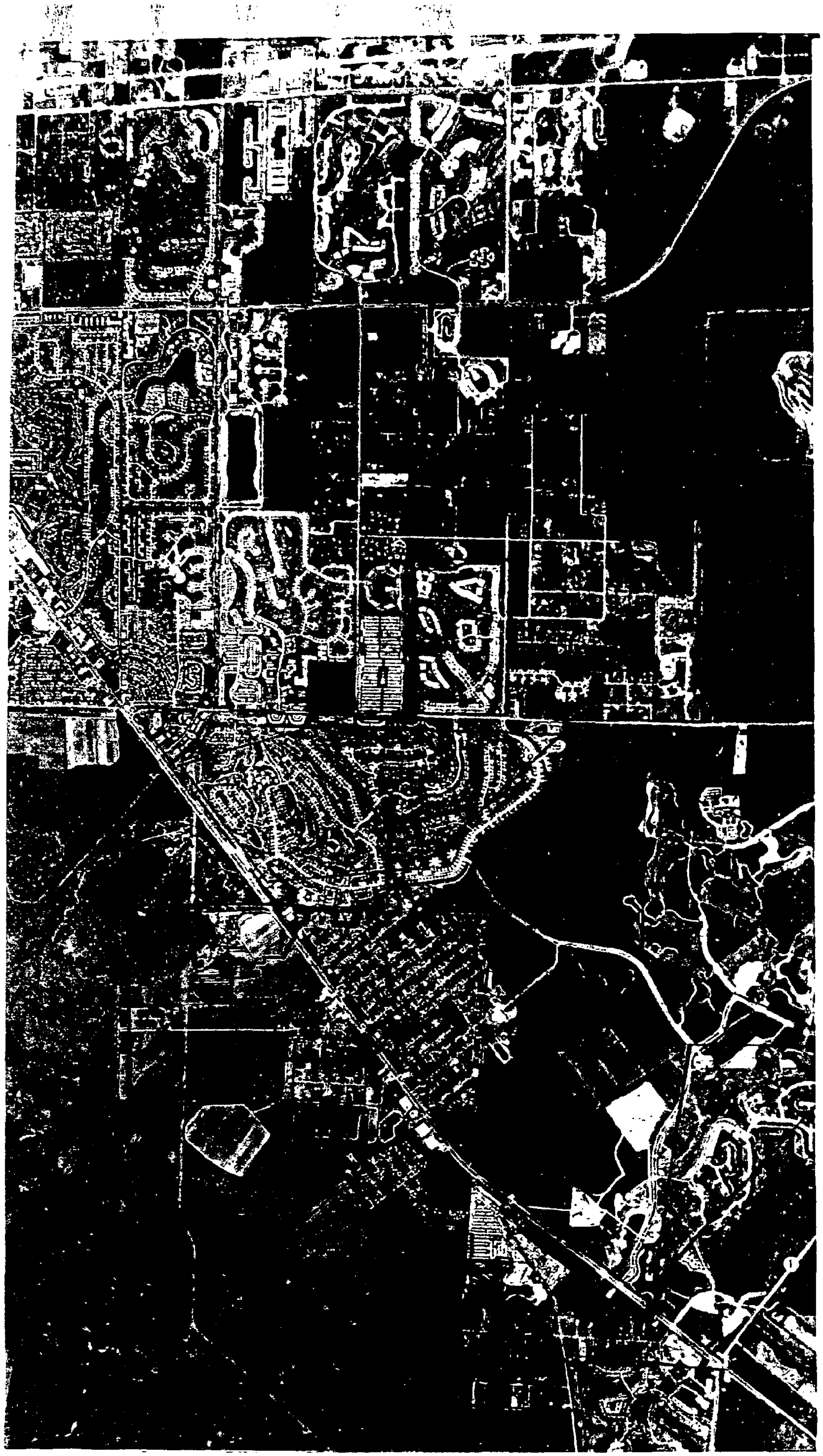
Figure 6-1. Collier County Future Land Use Map

49

TWP 50
RNG 26

LEGEND

JANUARY
1993
PHOTO



TRW·REDI
Property Data

Figure 6-2B

(Cox et al. 1994). An overlay of 120 rare species showed Water Management District 6 as having suitable habitat for 7 to 9 species, a medium ranked designation (Cox et al. 1994).

6.2 HYDROLOGY

6.2.1 Historic: Surface water drainage from the Belle Meade region was directed by small pockets of uplands across the CR 951 line, as seen in Figure 6-3. This water flowed, and still flows, in a southwesterly direction. The water was primarily directed through elongated sloughs toward present day US 41. Outside the sloughs, broad areas of gently sloping, cypress- and hydric pine-dominated terrain acted as flowways to the tidal areas south of US 41. Portions of the sloughs remain intact, including the Rattlesnake Hammock Slough.

6.2.2 Recent: This region contains three primary basins: Lely Canal, Lely Manor, and C4. The topography and soils in the region inhibit rapid removal of surface water. The land is mostly flat with very little slope, going from a high of 11 feet in the north to 1 foot in the south. The soils are mostly fine sands that limit rapid infiltration of rainfall. A series of canals, swales, and ponds act as the main mechanisms of stormwater removal. Individual subdivision surface water management lakes convey much of the runoff to county maintained canals.

Lely Canal Basin drains about 6,300 acres of mostly developed land. Drainage to the canal begins in the subdivisions north of SR 84, during high rainfall, and then south through areas west of County Barn Rd. Additional drainage from the Lely subdivision contributes to the flow. The canal discharges to tidal areas adjacent to Dollar Bay. Flow from the canal is limited by the shallowness of the canal, typically only four feet below land surface (Law 1991). As seen in Figure 6-4, average annual flows since 1983 have not exceeded 100 cfs in Lely Canal and have not fluctuated greatly. Average wet season monthly flows are generally less than 200 cfs.

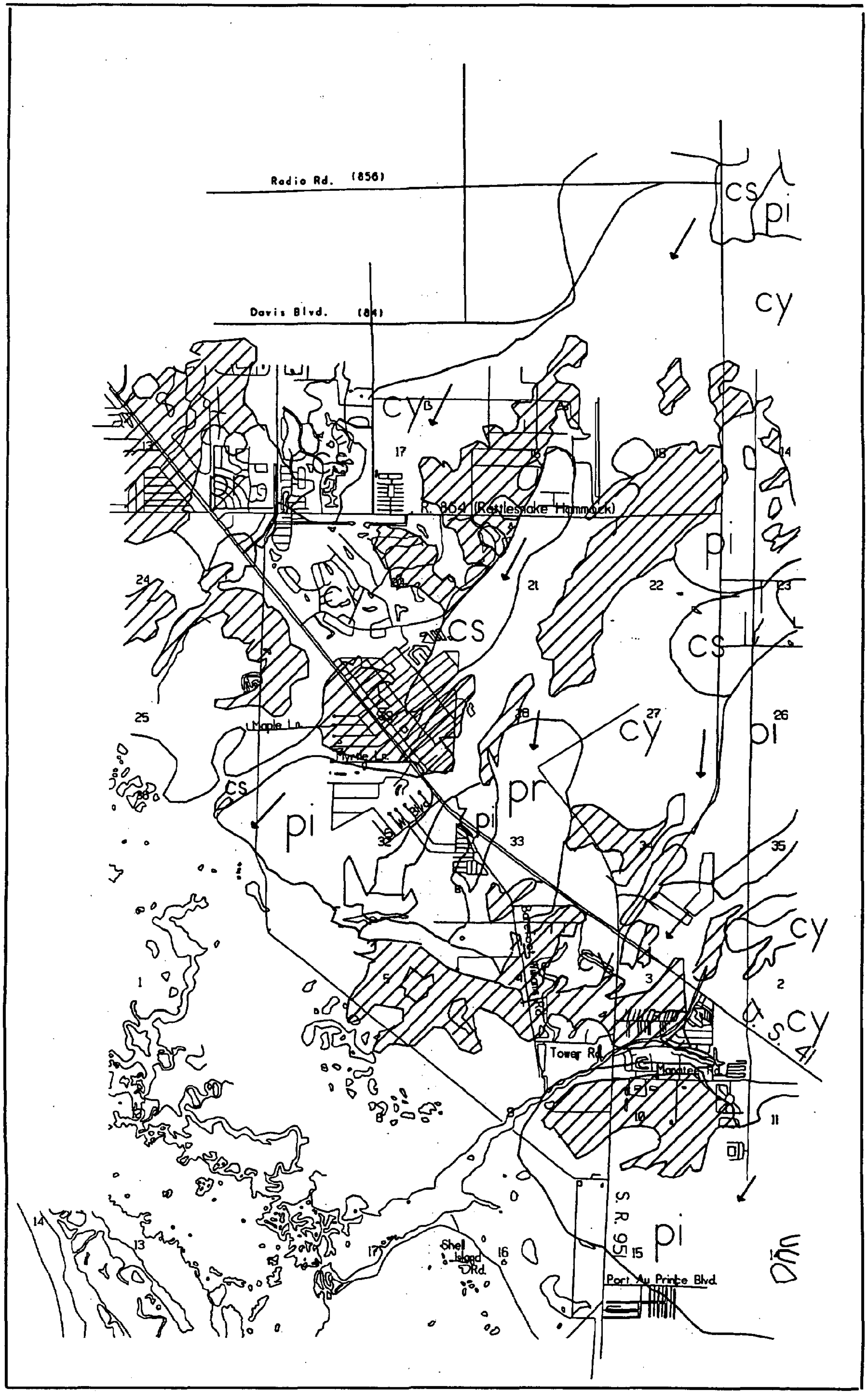
The Lely Manor Canal drains portions of Lely and Naples Manor, as well as the historic slough on the eastern edge of Lely. This canal is of rather limited depth (<6 ft.). It discharges into a freshwater marsh south of US 41 and then by a ditch to a tidal area.

The C4 Basin is located in the Lely Resort area adjacent to CR 951. The drainage network consists mostly of excavated lakes used for stormwater wet detention. Discharge flows under US 41 to the stormwater system at Eagle Creek.

6.3 WATER QUALITY

Results from sampling in Lely Canal from 1979 to 1987 (CCPCD 1993) did not show any significant increase in nitrate and nitrite (NOx), total phosphate or orthophosphate concentrations, as seen in Figure 6-5. From 1988 through 1990 the concentration of these nutrients increased substantially. However, the annual mean concentrations dropped to previously low levels in 1991 (CCPCD 1993). No data is available for recent years. If the proposed expansion of the Lely and Lely Manor Canals proceeds, additional stormwater from golf courses and residential areas could decrease water quality .

FIGURE 6-3. WMD6 HISTORIC FLOWWAYS



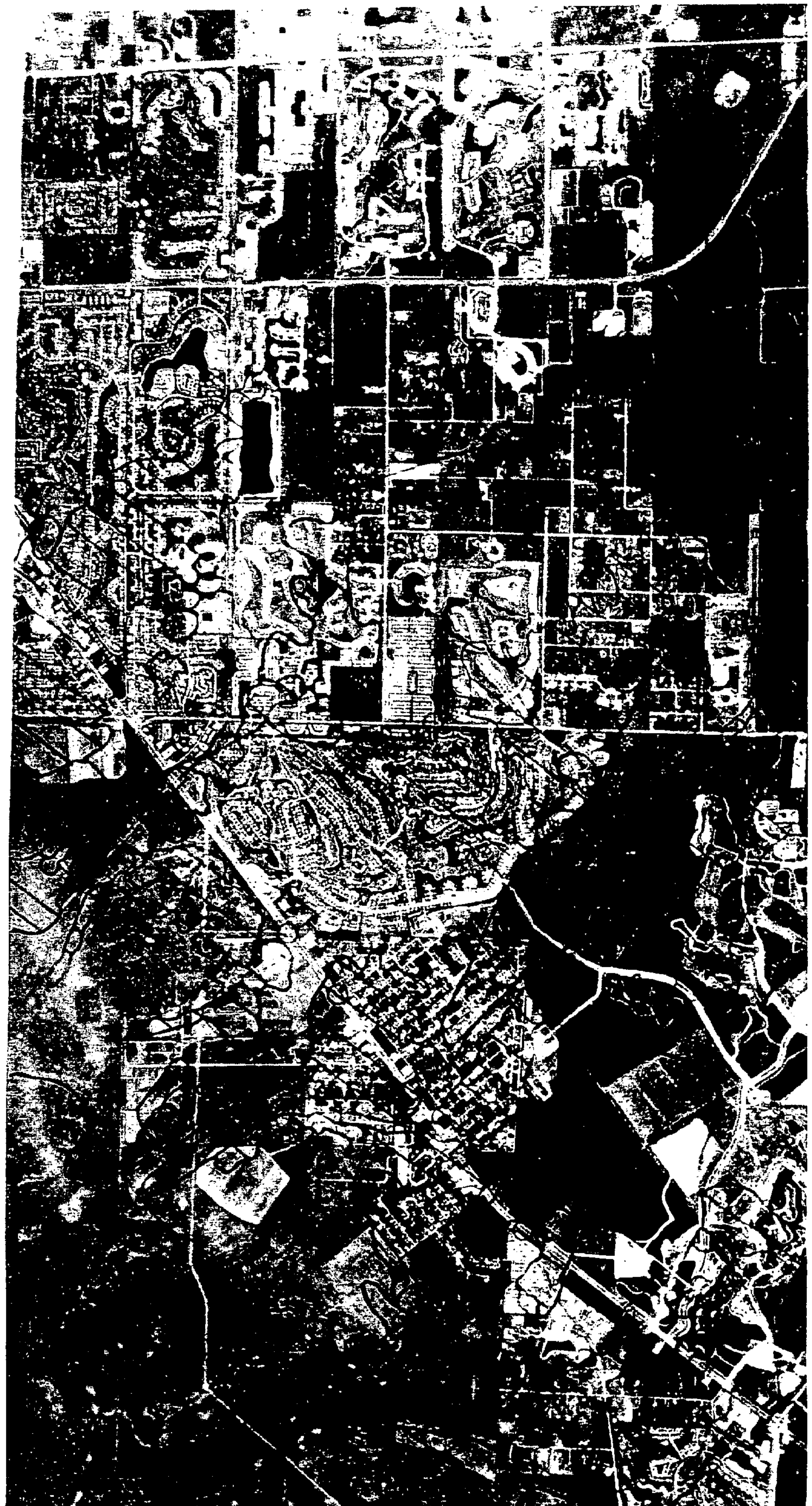


Figure 6-3B

Figure 6-4. Lely Canal Flow Rates

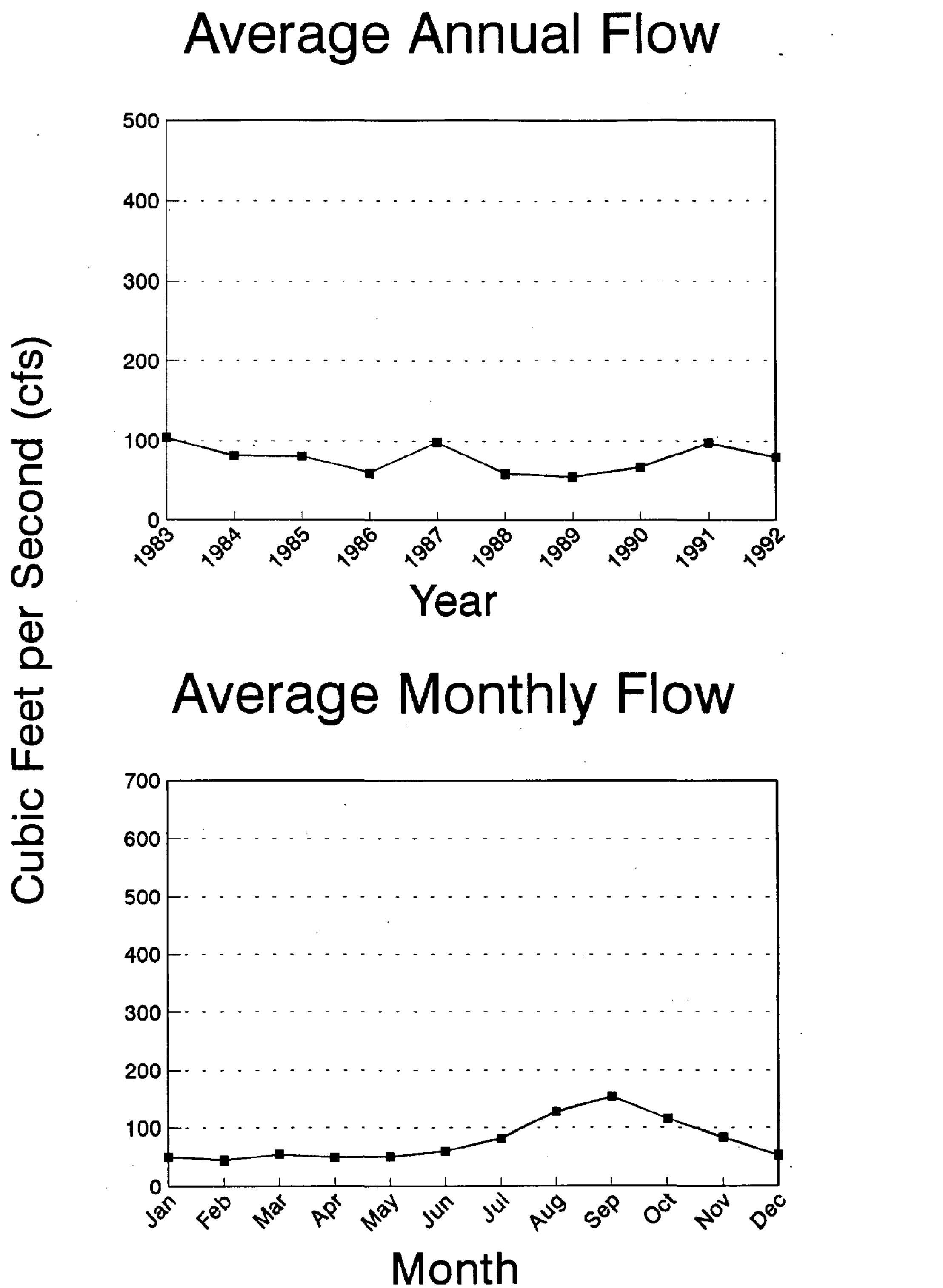
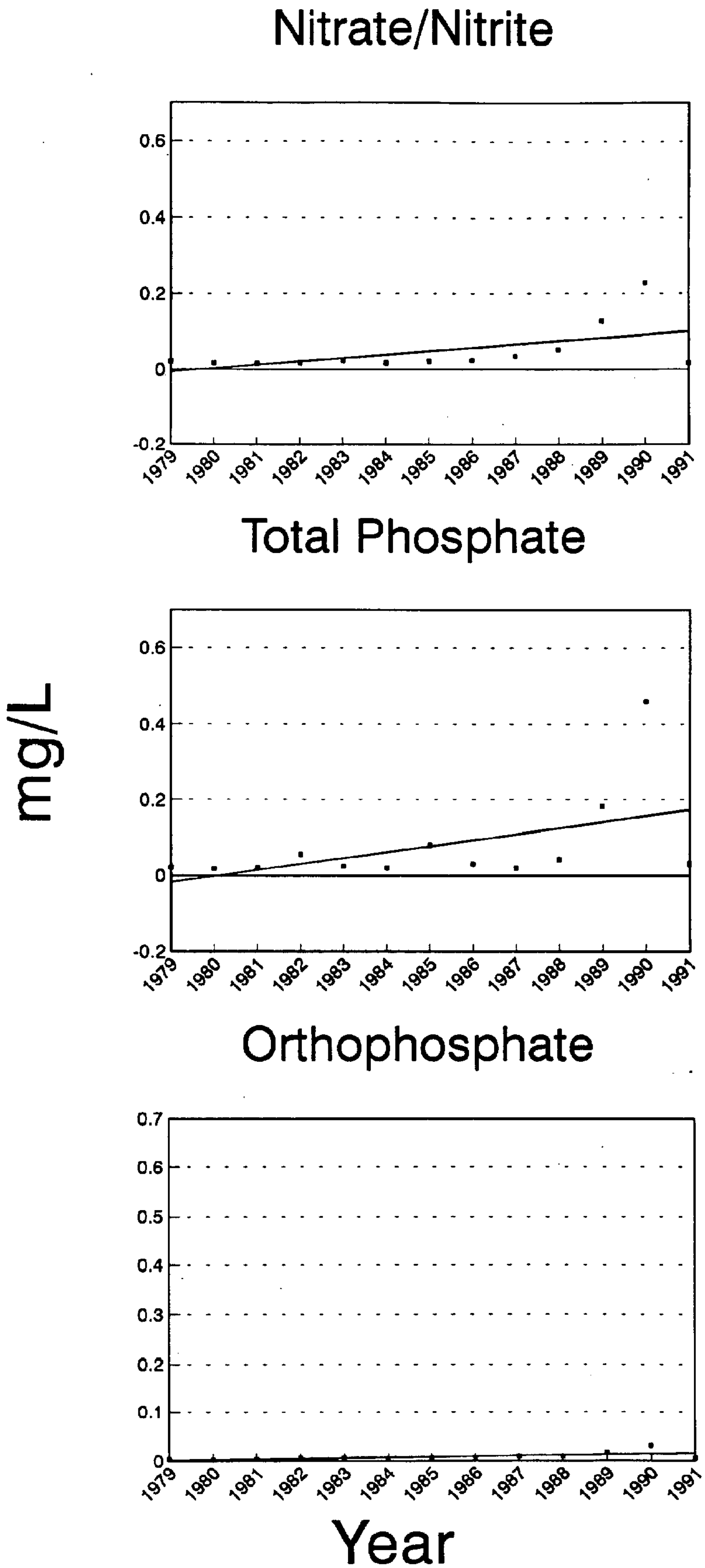


Figure 6-5. Lely Canal



6.4 POINT/NONPOINT SOURCE POLLUTION

Figure 6-2 depicts the potential NPS locations in WMD6.

6.4.1 Agriculture: Agriculture activity has decreased significantly in this region in recent years and, with steady urban growth, will soon not be present.

6.4.2 Golf Courses: Six golf courses have water management discharge points with connections by way of canal to the estuaries. Many of these golf courses continue to use chemicals on their greens and fairways that have the potential to affect aquatic organisms downstream. Fertilizer runoff can play a role in eutrophication, including algal blooms, in the surrounding canals, as well as the estuaries to the south. (See General Water Quality section for additional information.)

6.4.3 Nurseries: This region contains pockets of small (<5 acres) wholesale nurseries and two larger (>5 acres) nurseries. They are located within one mile of Rookery Bay's boundaries.

6.4.4 Residential: This is the most densely populated of the four watershed regions. Run-off from road surfaces, treated lawns and parking lots contribute to the pollutant load from this area. Because most of the residences in this area are served by central sewer, the threat of pollution from septic systems is rather small. Most of the septic systems are located on large lots far from open surface water. Discharge locations for surface water management systems may be seen in Figure 6-2.

6.4.5 Sewage Treatment Plants: The South County Sewage Treatment Plant located at Lely disposes of its effluent by reuse at various golf courses and through percolation ponds during periods of high rainfall and high flow. The only other plant is located at the Tall Oaks subdivision.

6.5 RESTORATION OPTIONS

Since much of this area has been developed or is slated for development, the restoration of flow through historic drainageways is not practical. However, steps may be taken to ensure that the remnant flowways are preserved, enhanced, and utilized.

6.5.1 Hydrologic

- **New construction south of US 41 should restore historic hydrology altered by agricultural and excavation activities.**

  Estimated Cost: dependent upon construction within the area
  Applicable Objectives: RBNERR OBJ 2.5 and 2.6
  CCGMP-Cons. OBJ 2.2, 2.3, 6.2, 6.7 and 7.3

6.5.2 Land Conservation

- **see Figure 6-6 on land conservation recommendations for Water Management District 6.**
  The designation types were determined using the following criteria. A designation of Type I is for sections with a high percentage of wetlands, combined with limited access to infrastructure (transportation, potable water and sanitary facilities). Type II, use of conservation easements, is for sections with a mix of uplands and wetlands, with potential access to infrastructure. Type III, transfer of development rights, is designed for sections of existing intense agricultural activity. Type IV, no action or private stewardship, is for sections that have been impacted by residential or commercial development.

- **Purchase of sensitive wetlands adjacent to Rookery Bay NERR boundaries, south of US 41.**

  Estimated Cost: dependent upon acreage
  Applicable Objectives: RBNERR OBJ 2.1
  CCGMP-Cons. OBJ 6.2 and 6.7
  CCGMP-Rec. OBJ 1.1 and 1.2

6.5.3 Vegetation

- **Preservation of Rattlesnake Hammock Slough.** The slough acts as a natural filtering and conveyance mechanism for stormwater in the central area of this region.

  Estimated Cost: $0, protection can occur using conservation easements and preserving that area during development
  Applicable Objectives: RBNERR OBJ 2.5
  CCGMP-Cons. OBJ 1.3, 2.1, 6.2 and 6.8
  CCLDC Section 3.9.6.6

6.5.4 Water Quality Assessment

- **Continued long-term water quality monitoring of discharge in Lely Canal.**

  Estimated Cost: $2000/year
  Applicable Objectives: RBNERR OBJ 2.16
  CCGMP OBJ 2.2 and 2.3

- **Comprehensive upstream/downstream water and sediment analysis integrating canal and estuarine analyses in Water Management District 6.**

  Estimated Cost: $50,000/year
  Applicable Objectives: RBNERR OBJ 2.16
  CCGMP OBJ 2.2 and 2.3

Conservation Measures for Water Management District 6	
Type	**Description**
I	Fee simple purchase or use as an off-site mitigation area
II	Use of conservation easements
III	Transfer of development rights
IV	No action recommended or private stewardship

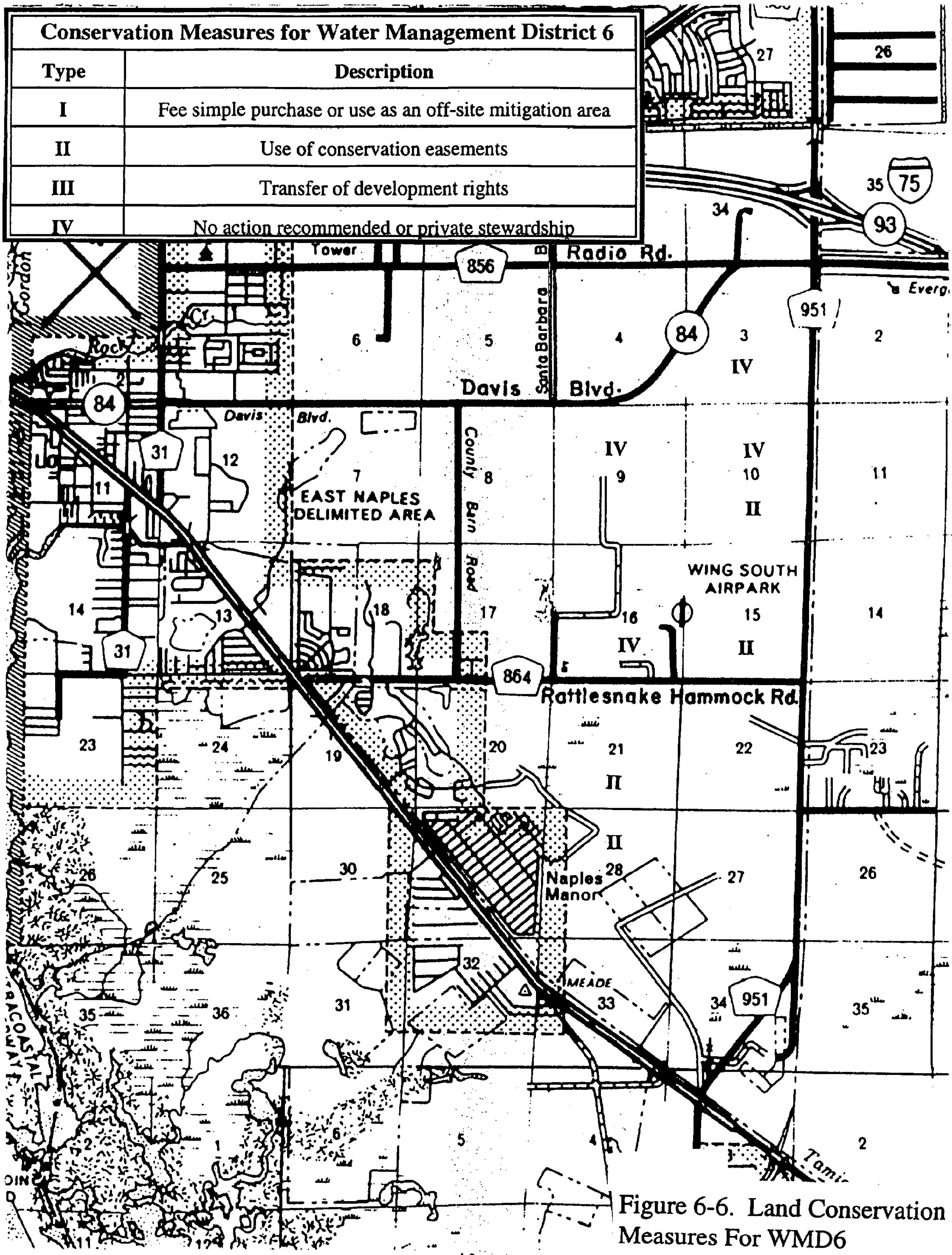


Figure 6-6. Land Conservation Measures For WMD6

BELLE MEADE

The Belle Meade area is defined by the land bounded by the Henderson Creek Basin boundary to the north (a line three miles north of I-75 running east to Everglades Blvd.), CR and SR 951 to the west, the range line between R27E and R28E on the east, and the salinity line about one mile to the south of U.S. 41 on the south.

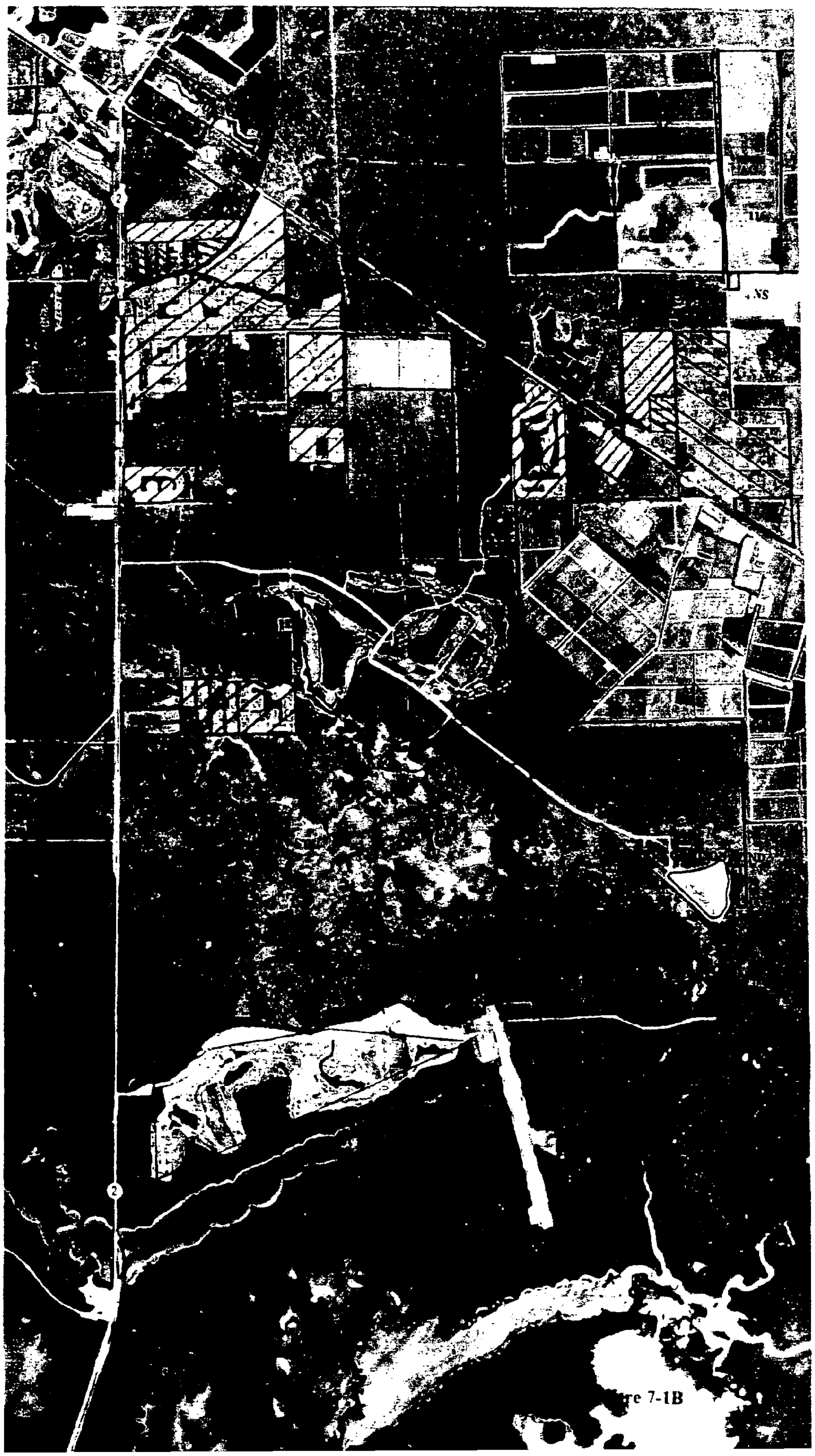
The area is located in the Royal Fakapalm and is part of the south Naples planning community for planning purposes by the Collier County Growth Planning Department. In 1985, the population for the planning unit was 4,675. As of 1994, the population was 5,778 (Collier County Planning Dept. 1994); however, the population figures include areas around Copeland, which in this report fall into the Fakahatchee Strand region. In general, the most densely populated areas are along US 41 and CR/SR 951. A 1982 study by CH2M Hill suggested that at build out the population would reach 151,000, assuming increasing urbanization with average density of 1.5 units/ac and 2.5 persons/unit. Due to zoning and site development constraints, this projection seems unrealistic today even if the area is not restored to its former historic hydrologic condition.

As seen in Figure 7-1, presently much of the remaining developable land in the Belle Meade area is designated as Agriculture (A) zoning. Along US 41, over 400 acres are zoned for Recreational Vehicle and Mobile Home (RV, MH) sites. Along SR 951, since the 1960s when initial construction occurred, about 500 acres of RV and MH have been constructed with an additional 200 acres zoned for future construction.

Approximately 80 acres of land is zoned or built as multi-family along SR 951. In the Deltona Settlement Lands, the Marco Shores Development has the potential to add over 4000 dwelling units. The "Land's End Preserve" development, located within the Henderson Creek watershed, may potentially have 800 dwelling units. Scattered areas of low density housing occurs adjacent to the agricultural areas along US 41. With the present construction of a sewage force main and pump facilities along US 41, many areas presently zoned as "Agriculture" will be made more suitable for more intensive land uses, such as large-scale commercial and residential developments. These areas have been designated as a Mixed Use (residential and agricultural) area on the County's Future Land Use Map.

Much of the area along CR 951 to the eastern edge of Belle Meade is presently zoned Agriculture. With the exception of single family dwelling units along SPR, an RV park proximate to I-75 and developments south of US 41 at CR 951, much of the land is sparsely populated . A few commercial establishments exist in a platted subdivision near I-75 and along CR 951. The County's Comprehensive Plan designates land up to one mile east of CR 951 as Urban Residential Fringe, which will allow intensive development of this region. At the intersection of CR 951 and U.S. 41, an activity center with intense commercial development is planned.


7-1A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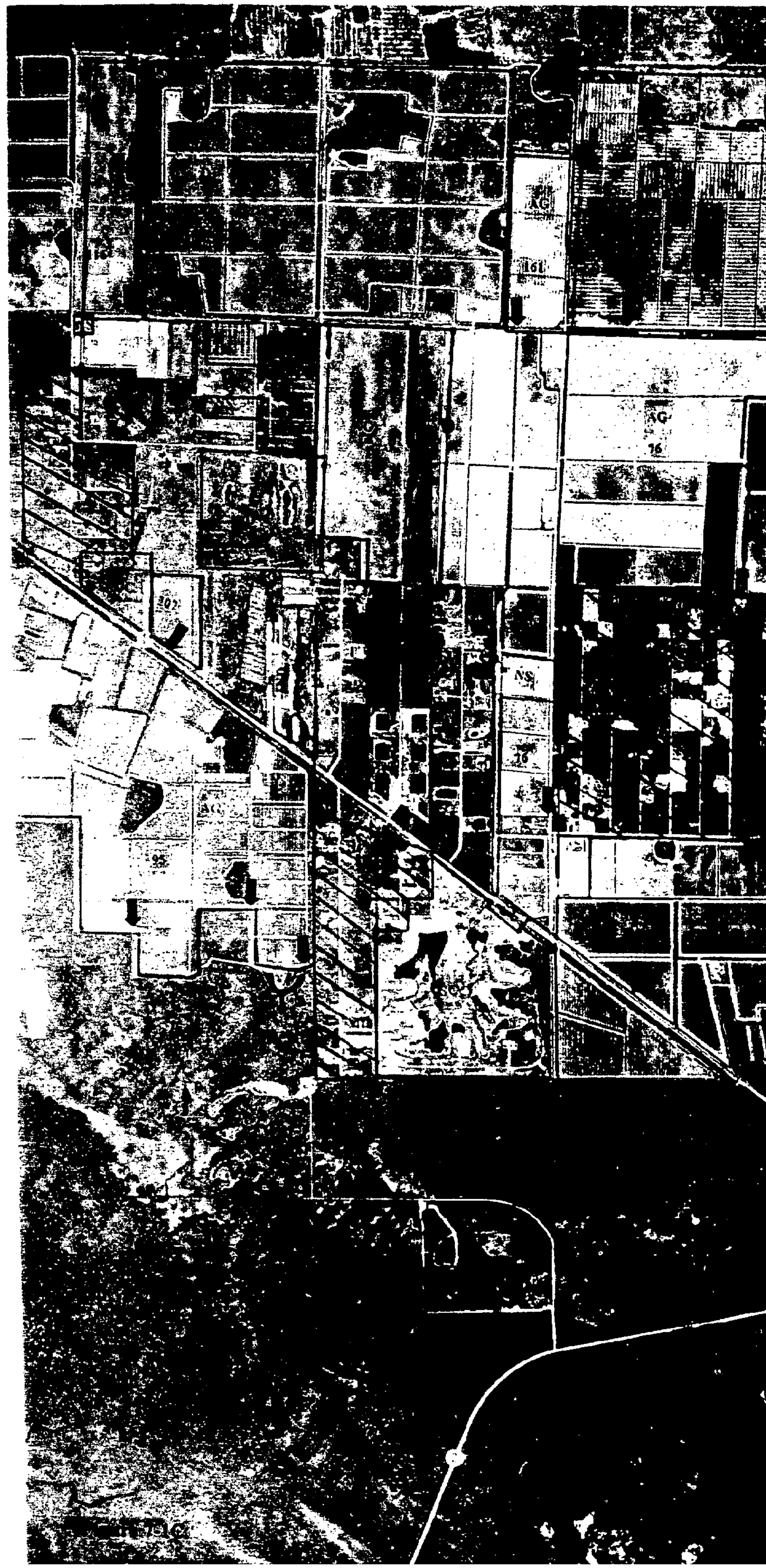
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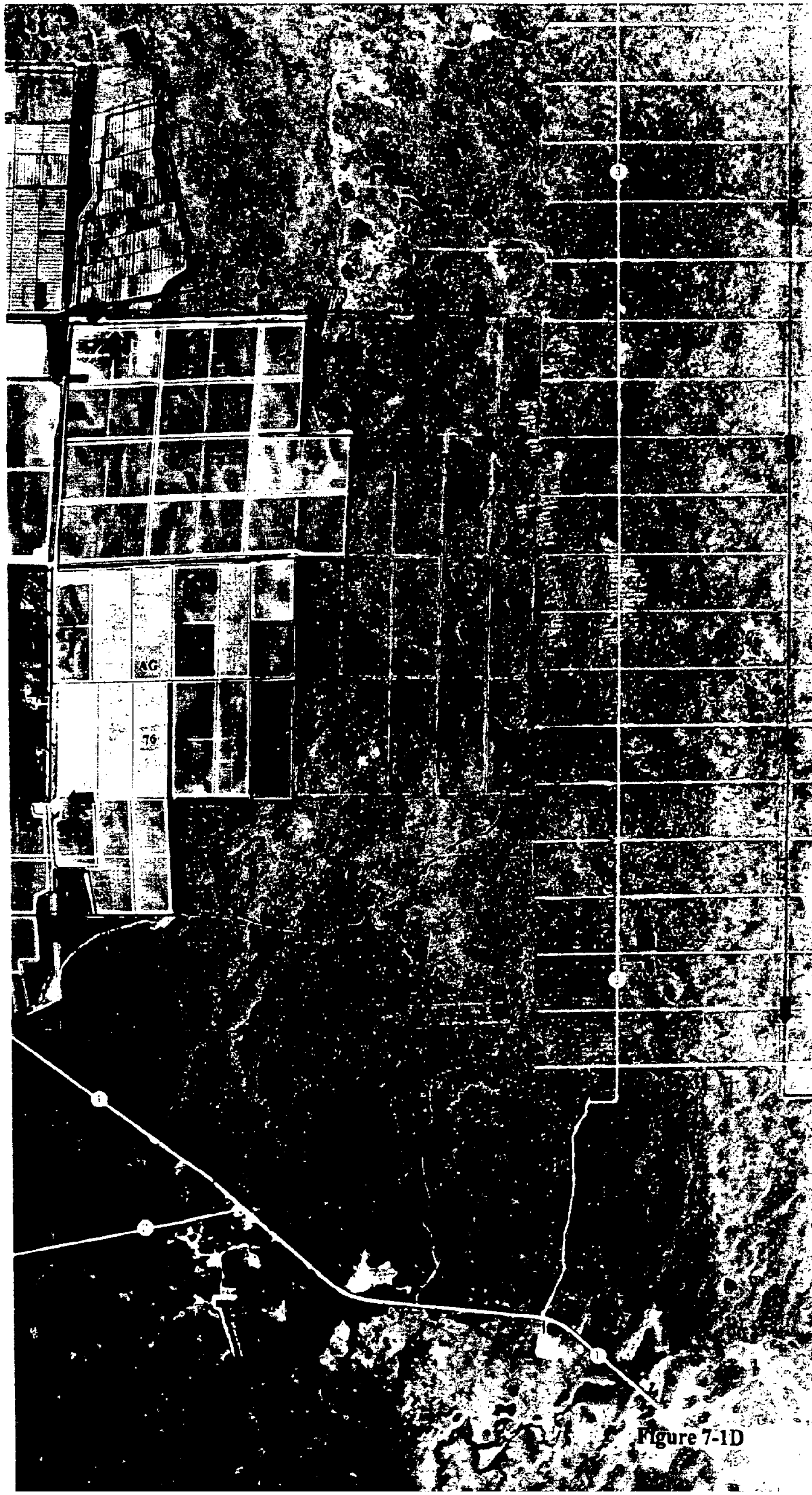


Figure 7-1D

7.1 VEGETATION

Historically, the Belle Meade area was a mosaic of upland and wetland communities. For the most part, this remains true today.

Table 7-1. Vegetative Communities of Belle Meade		
Upland/Wetland Breakdown		
Vegetation	**Acres**	**Percent Cover**
Upland	4,515	16
Wetland	24,310	84
Total	28,825	100

* South Florida Water Management District, Planning Department Staff 1994.
**Total acreage does not include land north of I-75 or the agricultural area on the southern border.

Expansive areas of cypress are intermingled with upland islands and mixed swamp forests. There are some area of hydric pine flatwoods within the boundaries as well.

Table 7-2. Vegetative Communities of Belle Meade		
Wetland Communities		
Vegetation	**Acres**	**Percent Cover**
Prairie/Marsh	690	3
Cypress/Mixed Swamp	17,915	74
Hydric Pine Flatwood	5,705	23
Total	24,310	100

* South Florida Water Management District, Planning Department Staff 1994.
**Total acreage does not include land north of I-75 or the agricultural area on the southern border.

In regions where human actions have impacted the environment, there are areas of exotic infestation, primarily melaleuca. Melaleuca trees along Sabal Palm Road, and in other disturbed areas, serve as a seed source for infesting other areas within the Belle Meade region.

7.1.1 Habitat Ranking

The Florida Game and Freshwater Fish Commission has ranked habitats for specific species within the area on a scale of 1 to 10, 1 being the lowest value and 10 being the highest value (Cox et al. 1994). Habitat suitable for the endangered Florida panther ranked between 3 and 7, while habitat suitable for the threatened Florida black bear ranked between 4 and 9 (Cox et al. 1994). Belle Meade was also identified as an area suitable for the reintroduction of Florida panthers, a rank of 4 to 10 on a scale of 1 to 10 (Cox et al. 1994). Strategic habitat arêas, or areas identified as important because they provide a base habitat for long-term species persistence, were found within the Belle Meade region for the Florida panther, red-cockaded woodpeckers, swallow-tailed kites and fox squirrels (Cox et al. 1994). An overlay of 120 rare species showed the Belle Meade region as having suitable habitat for 7 to 18 species, a high ranked designation (Cox et al. 1994). Additionally, Belle Meade was targeted as a P2000 priority and valuable area for protection (Cox et al. 1994).

7.2 HYDROLOGY

Within this boundary lies the Henderson Creek Basin to the north and west, the U.S. 41 Swale Basins to the east and the Southern Coastal Basin in the south-central areas.

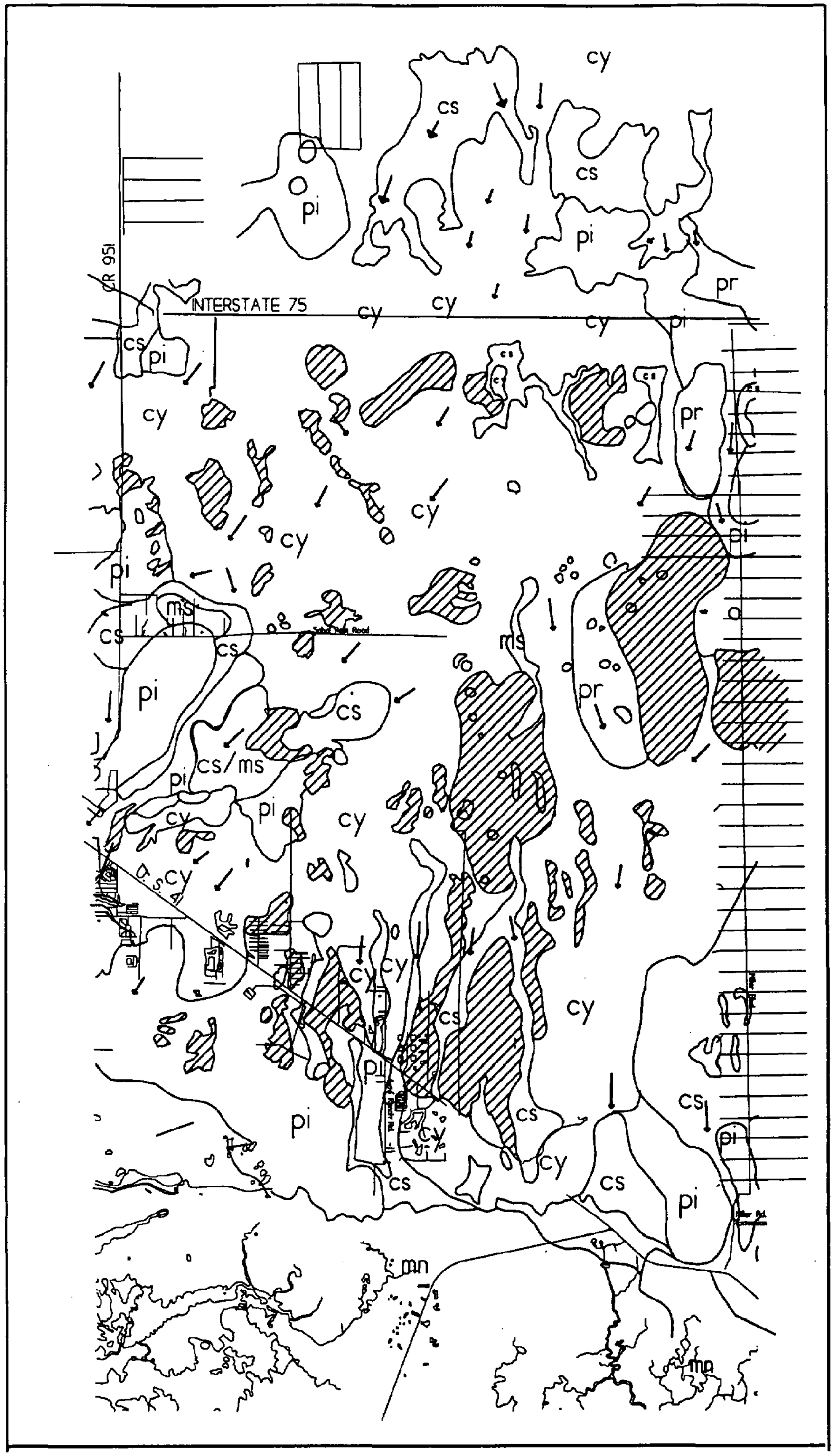
7.2.1. Historic: As seen in Figure 7-2, before the construction of Alligator Alley (SR 84/I-75) surface water runoff to Henderson Creek began in what is the present day edge of the south part of North Golden Gate Estates. Some surface water from upland areas to the north travelled by way of cypress sloughs to the south toward the present day Lely area. Much of the surface water that flowed from north of SR 84, however, flowed to Henderson Creek staying east of the CR 951 line. Surface water from east of CR 951 to about three miles west of Everglades Blvd. flowed to the south in a broad area of gradually sloping terrain dominated by hatrack cypress, cypress and pine. Along present day CR 951, a series of uplands blocked flow to the west in some sections, except where cypress sloughs or mixed swamp forests bisected in a southwesterly direction. South of present day Sabal Palm Road, well-defined drainageways directed the surface water to the headwaters of the historic Henderson Creek.

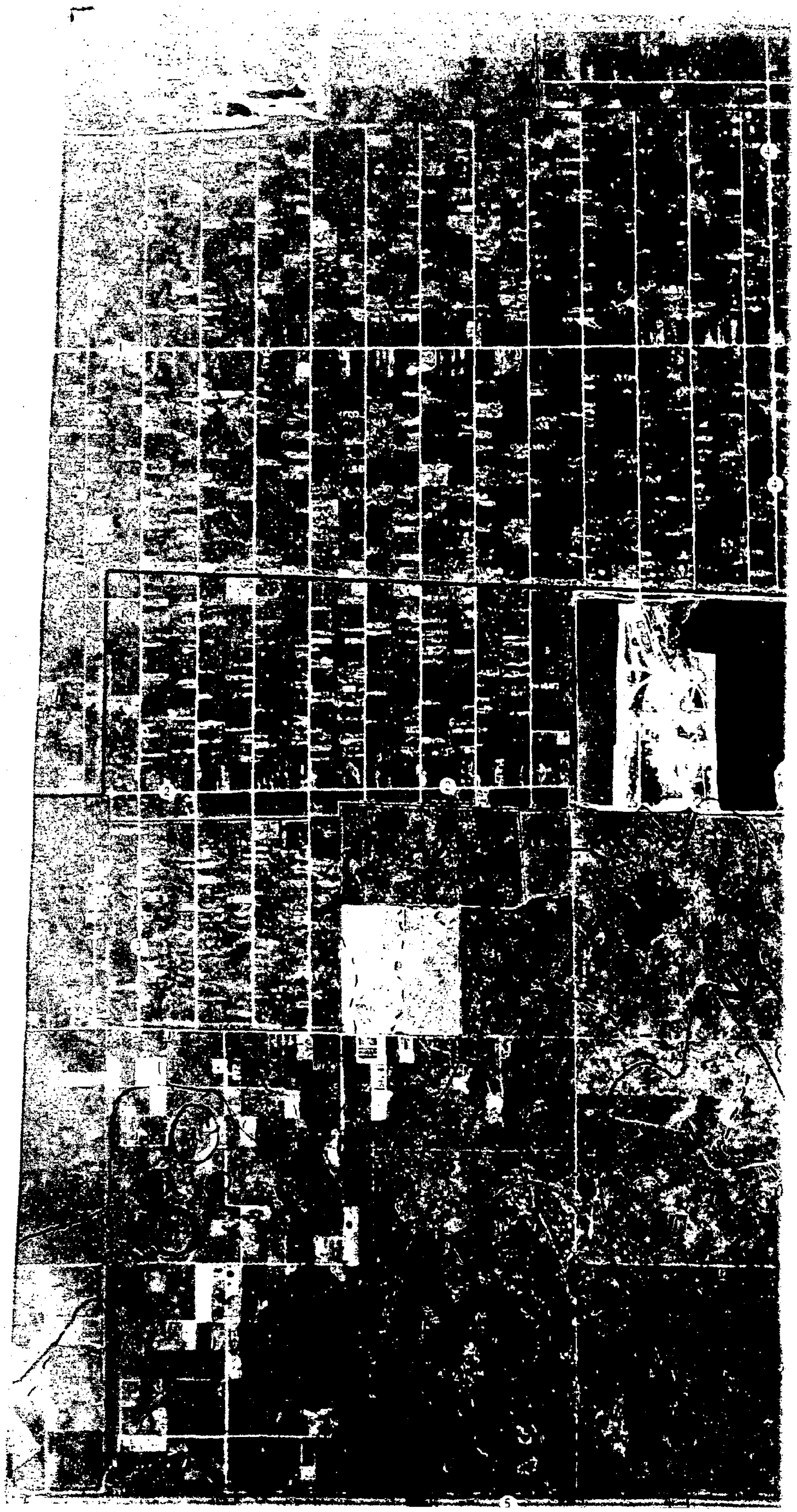
Any surface water not conveyed toward Henderson Creek was directed south in broad flowways to the present day agricultural areas north of U.S. 41 and, subsequently, south to the Ten Thousand Islands. As seen in Figure 7-1, the present day agricultural areas consisted of a mosaic of uplands, prairies and cypress drainageways. Long narrow strands of cypress and hydric pine connected the flow to the tidally influenced areas south of the U.S. 41 line.

7.2.2 Recent: Flow from north of SR 84 was intercepted by the construction of the road and redirected through culverts under the road. There are 9 culvert crossings present under I-75. About 20 miles of canals drain the area, with 2 weirs with gates and 2 weirs with freeboard located within the canal network. The main canals are the Henderson Creek Canal and the US 41 Canal. The Henderson Creek Canal begins on the north edge of I-75 at about 8 miles east of CR 951 and is blocked at two locations during that stretch before it reaches CR 951. The canal ends at Henderson Creek.

From 1915-1928, Tamiami Trail (U.S. 41) was constructed across the southern part of the basin. The road caused the natural sheetflow to be intercepted and redirected under the timber bridges constructed with the road. In the late 1950's, SR/CR 951 was constructed through the

FIGURE 7-2. BELLE MEADE HISTORIC FLOWWAYS





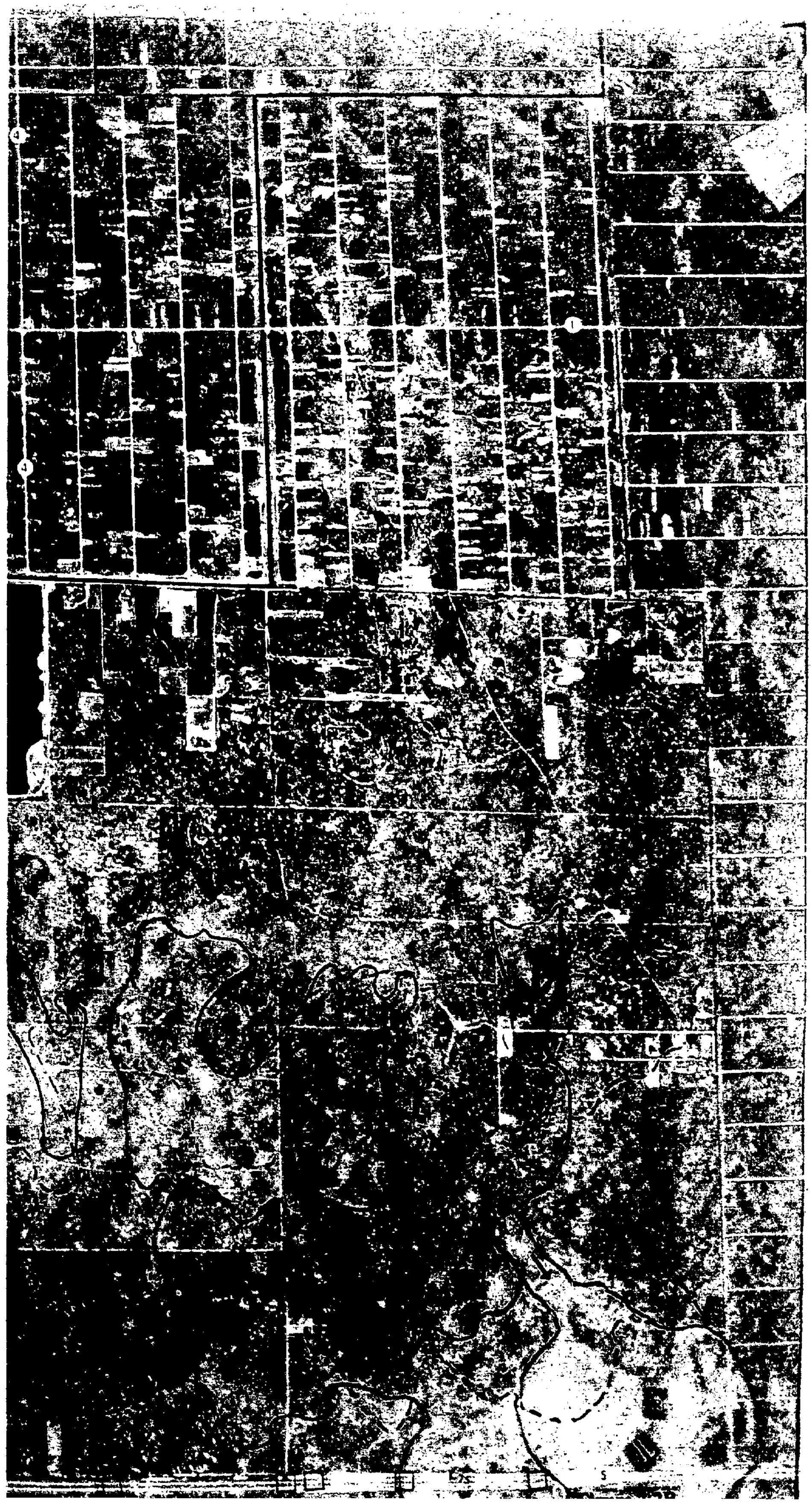



Figure 7-2C

Figure 7-2D

Figure 7-2E

western part of the basin, borrowing fill from the right-of-way. The resulting road and borrow canal, Henderson Creek Canal, intercepted overland flow to the southwest. The canal waters were directed to Henderson Creek. In 1981, Collier County constructed two water control structures in the Henderson Creek Basin (Bruns and Edixon 1982). One is located in Henderson Creek Canal at U.S. 41 and the other is located at the headwaters of the historic Henderson Creek. Both waterways cross U.S. 41 at these locations. Property owners north of the structures complained of increased flooding after their construction. Alteration of the structure, the installation of flashboards, occurred. Henderson Creek empties into Rookery Bay.

Sabal Palm Road, which runs perpendicular to CR 951, was illegally extended beyond its permitted length toward the edge of South Golden Gate Estates in the late 1980s. The fill placed for the roadbed posed a significant threat to the integrity of the wetlands in the area by disrupting sheetflow through the Henderson Creek Basin. The SFWMD Big Cypress Basin Board authorized staff to remove the roadbed with property owners approval and subsequently removed fill. Additional unpermitted filling occurs on occasion in the area of Sabal Palm Road (SFWMD Meeting 1993). In addition, the South Golden Gate Estates canal network has impeded surface water flow into the eastern sections of the Belle Meade area, altering historic drainage patterns (Addison and Lytton 1992).

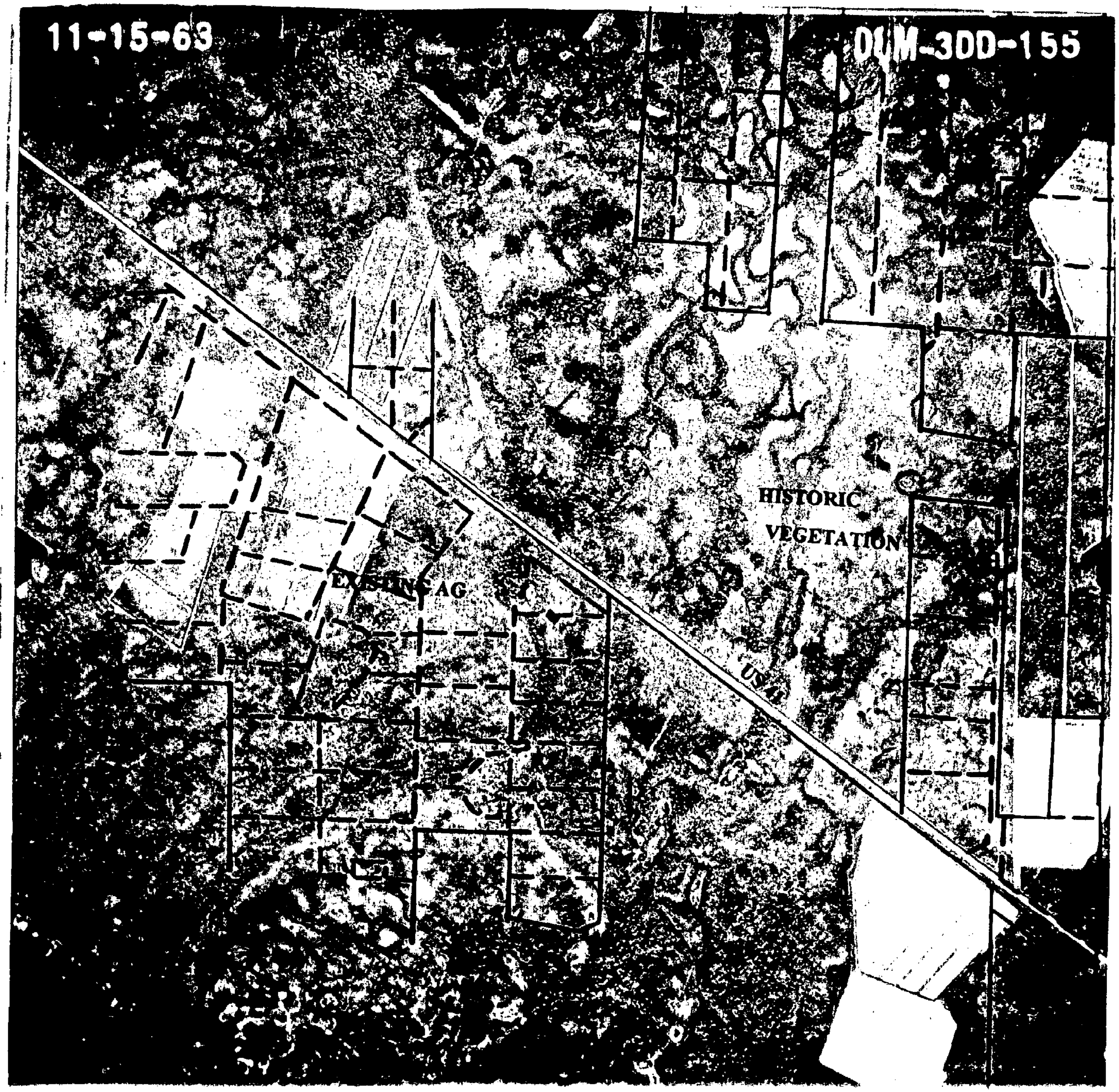
Alterations to the natural vegetative structure of the southern end of the Belle Meade area, primarily due to agricultural development, is seen in Figure 7-3A and Figure 7-3B. Some cypress domes, as well as some slough areas, were retained for on-site stormwater treatment. However, the functioning integrity of the interacting upland/wetland systems has been altered. Drainage ditches for the agriculture fields are delineated in the photographs using dashed lines.

The area in Belle Meade north of US 41 is criss-crossed with over 50 miles of off-road vehicle tracks, as observed from aerial photography. The continual use of the same tracks leads to deep troughs which may significantly alter surface water flow in localized areas.

Henderson Creek Canal begins as the borrow ditch for I-75 one-half mile west of Everglades Blvd. A ditch block was placed in the ditch at the time of the I-75 construction. Culverts under I-75, placed at regular intervals, allow sheetflow to move south of the interstate. Henderson Creek Canal crosses I-75 one mile east of CR 951 and traverses along the interstate before heading south along CR 951 to historic Henderson Creek.

As seen in Figure 7-4, Henderson Creek Canal has an average annual flow of about 100 cfs, with increased flow during the past four years weighting the 12-year average. Average monthly flow during the wet season peaks at 100 cfs. Because of the weir at US 41, water does not flow during the later months in the dry season. This flow represents a significant portion of all surface water and any intercepted groundwater flow from the region. Discharge from the US 41 Canal is not quantified. No data was available from a U.S.G.S. stage in the US 41 Canal, located on the eastern edge of the agriculture area at US 41 and Tomato Rd. The US 41 Canal has a notable discharge at this location.

Along U.S. 41 East about 15 square miles of land has been converted to agricultural use since the 1960s, through a network of swales and ditches maintained by the individual property owners. This drainage network intercepts historic drainageways that directed flow to the south. Remnant patches of cypress domes and sloughs are used as on-site surface water management features. Discharge of surface water from these agricultural areas is to the US 41 Canal. Some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VEGETATION
US 41


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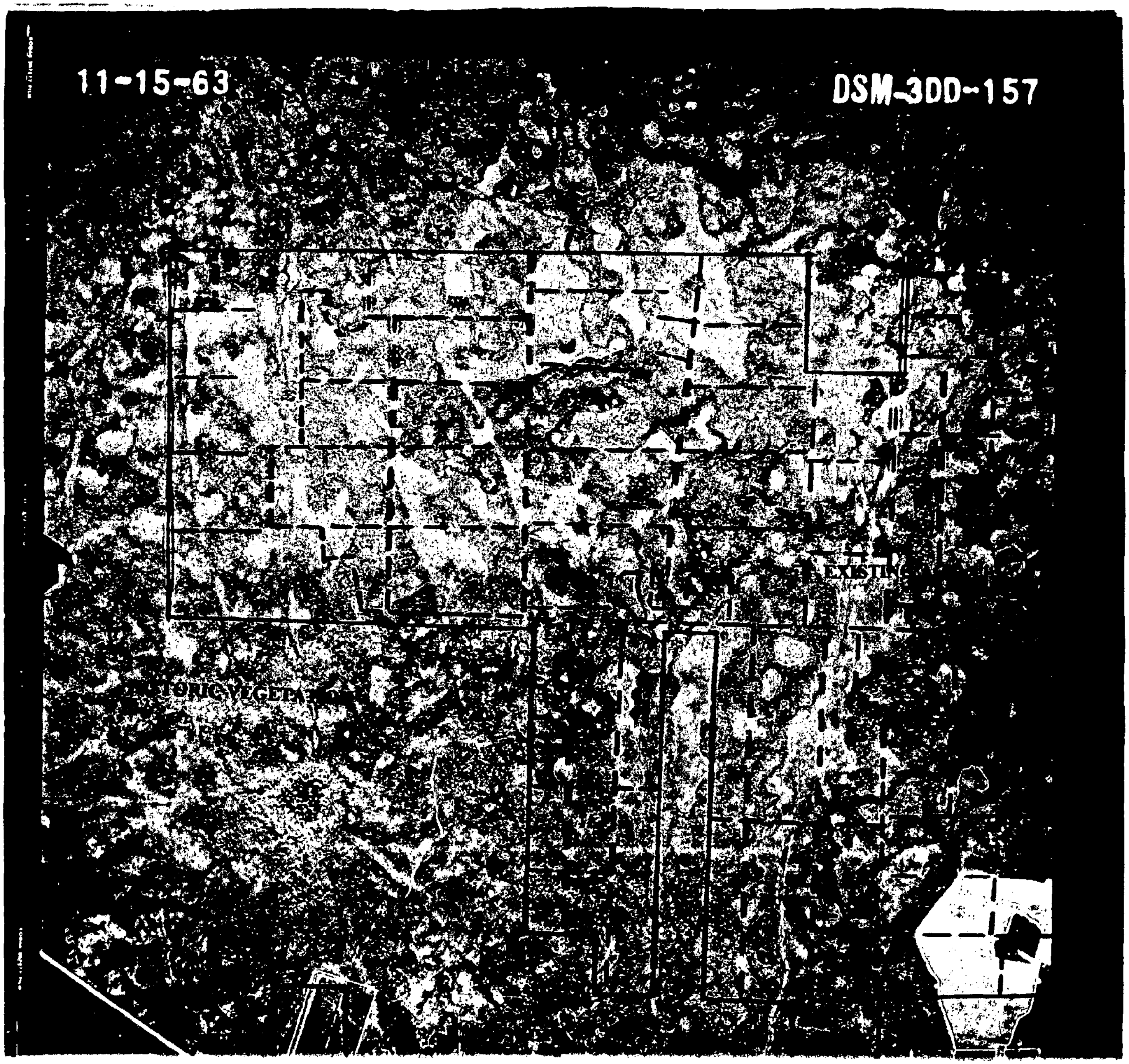
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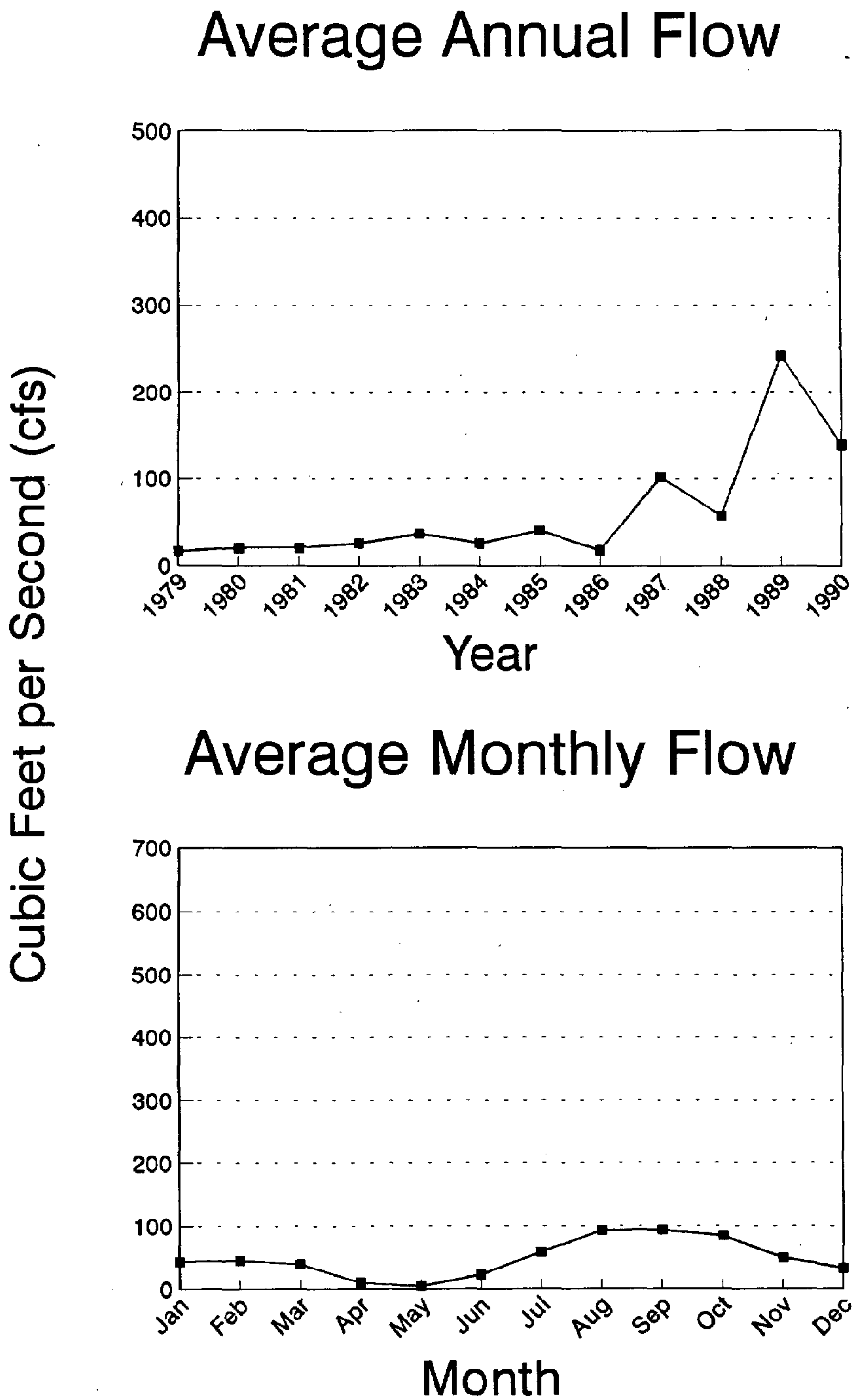
DSM-3DD-157

Figure 7-4. Henderson Creek Canal Flow Rates



of the water drains into the U.S. 41 swale 1 and 2 basin spreader swale located about 1 mile south of US 41. A drainage divide appears to be in the vicinity of Westwinds Mobile Home Park. In addition, some flow from this region is directed under US 41 and through Collier Seminole State Park, and a portion is conveyed west along US 41 and flows into historic Henderson Creek and Henderson Creek Canal. Agriculture south of US 41 discharges directly into tidal water to the south.

A section of smaller tracts of agricultural lands of about 5 acres each are located adjacent and to the west of 6Ls Farm on roads connecting to U.S. 41. These lands are not intensively farmed and are used mostly as homesteads. The area does not have a canal network and relies mostly on roadside swales to drain surface waters to the U.S. 41 canal.

7.3 WATER QUALITY

Water quality in Rookery Bay is directly affected by the quality of water from Henderson Creek, which includes discharges from Henderson Creek Canal, Eagle Creek, and US 41 Canal. Henderson Creek Canal was sampled on a regular basis by the Big Cypress Basin and the County Pollution Control Deparment. As seen in Figure 7-5, no discernible trend in annual nitrate/nitrite (NOx) concentrations could be detected. A slight increase in mean orthophosphate and total phosphate concentrations from 1979 to 1989 was observed. This observed trend was the result of three consecutive years of higher concentrations (1988-90). The mean total phosphate concentrations, however, were less than 0.05 mg/l for that period (CCPCD 1993). The SFWMD has set a target concentration for total phosphates of 0.03 mg/l for the Everglades, a freshwater system (SFWMD 1989). For the years 1989 and 1990, phosphate concentrations were significantly higher, but, in 1991, dropped to levels similar to previous years. The sampling location in Henderson Creek Canal was upstream of the weir at US 41. These years may have been outliers or may have been the result of anthropogenic.

As seen in Figure 7-6, conductivity and total suspended solids in Henderson Creek Canal are inversely related to flow, probably as a result of dilution. Salinity levels in Rookery Bay are affected by the duration and magnitude of freshwater flow from Henderson Creek Canal. Pulses of stormwater during the wet season lower conductivity levels significantly. The amount of suspended solids entering Rookery Bay annually by way of Henderson Creek Canal does not show a clear trend (Figure 7-7). Relatively little construction activity occurred in the Henderson Creek Canal Basin during the time period. This lack of activity may have resulted in lower suspended solids loading.

Figure 7-8 shows the location of sampling stations within Rookery Bay which were analyzed for this study. Results from water quality analyses over a limited time in Henderson Creek (RBNERR 1994) show that there is no statistical difference (95% confidence) in nitrate/nitrite (NO_x), total phosphate (TPO_4) or orthophosphate (OPO_4) concentrations from station to station in the creek headwaters to Rookery Bay, moving downstream. There are no statistical differences in total phosphate concentrations between stations in Rookery Bay. However, between stations 9 and 5 (Table 7-3), there is a difference in nitrate concentrations and a statistical difference in orthophosphate concentrations between stations 10 and 5. As seen in

Figure 7-5. Henderson Creek Canal

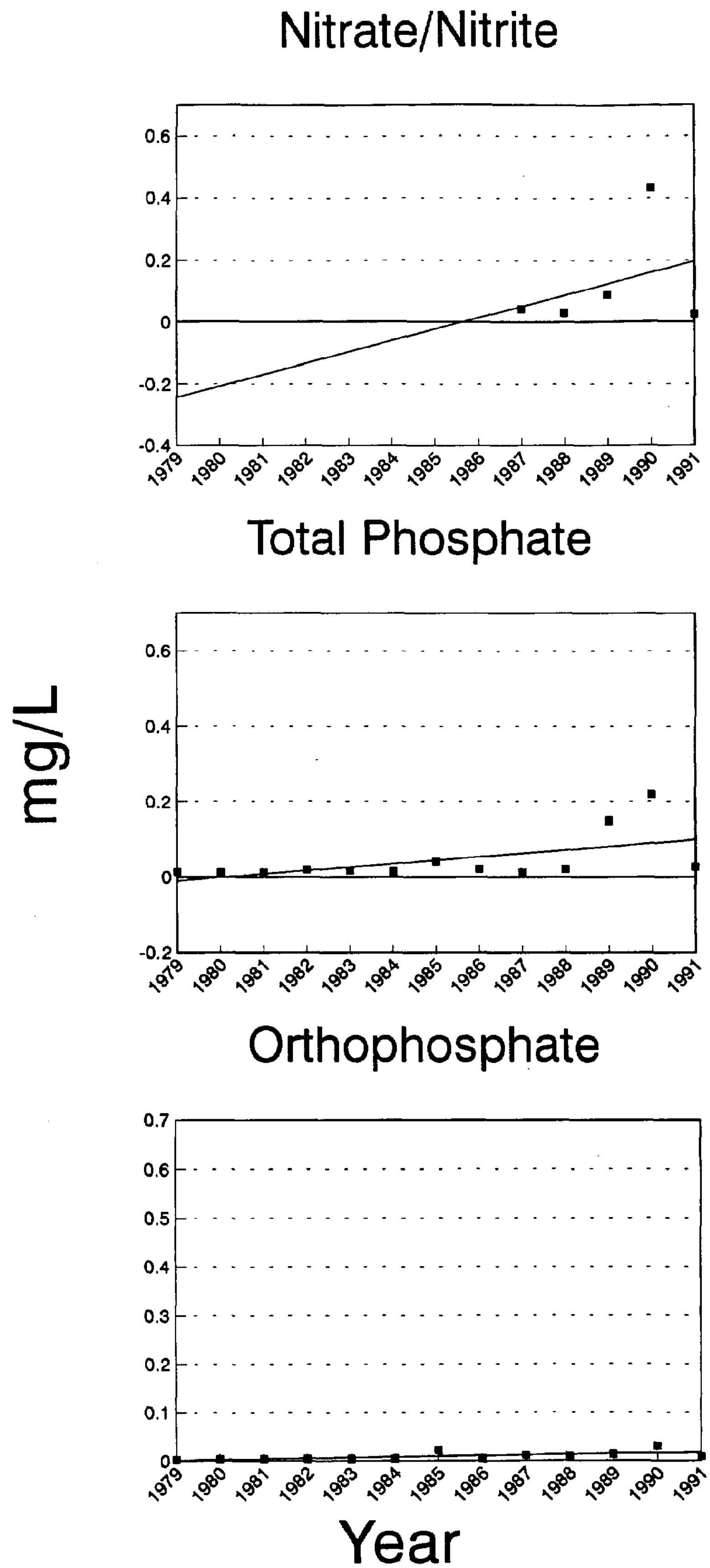
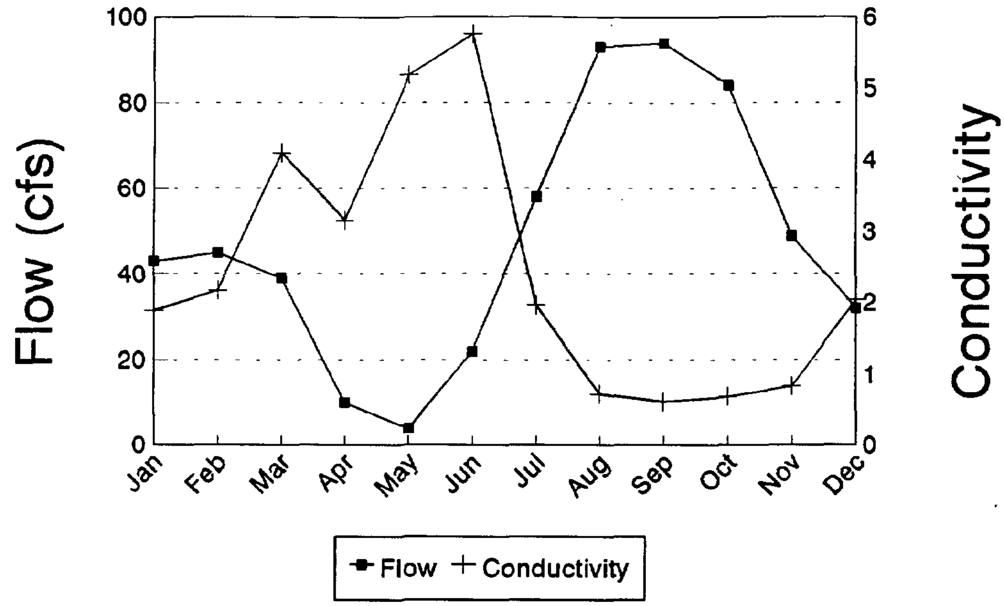
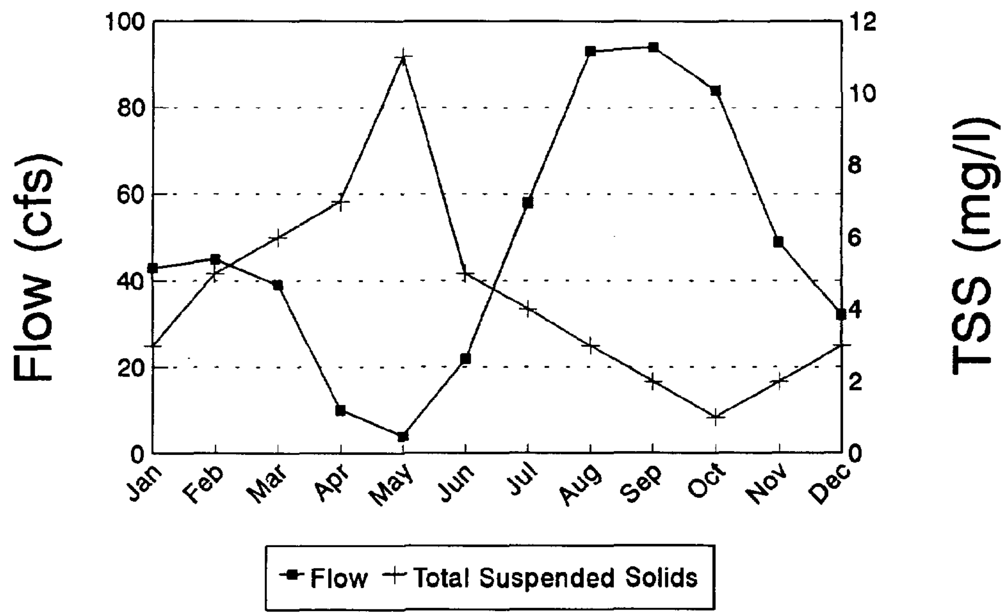


Figure 7-6. Henderson Creek Canal

Average Conductivity and Flow

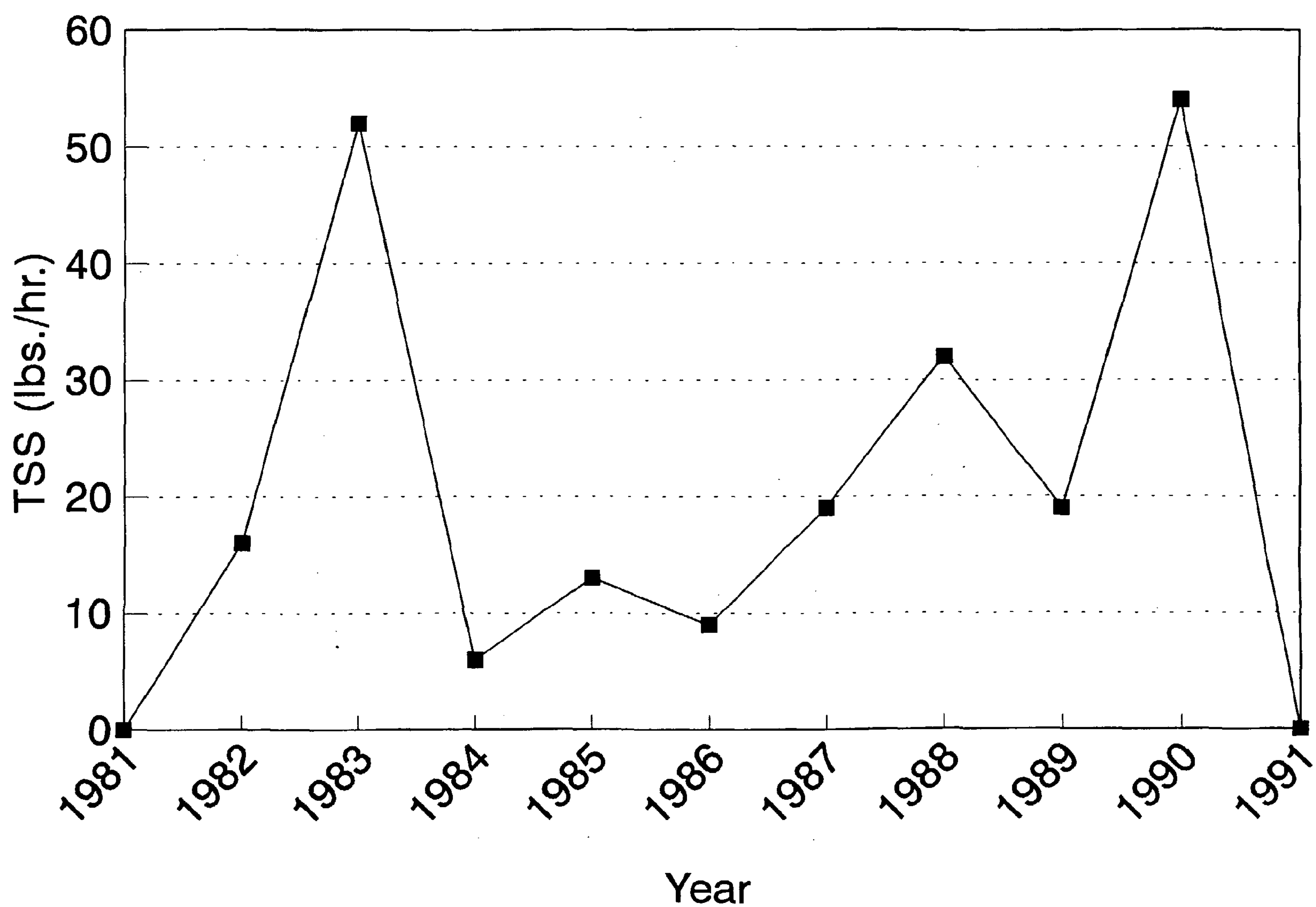


Average Total Suspended Solids and Flow



Month

Figure 7-7. Henderson Creek Canal
Average Sediment Loading Rate



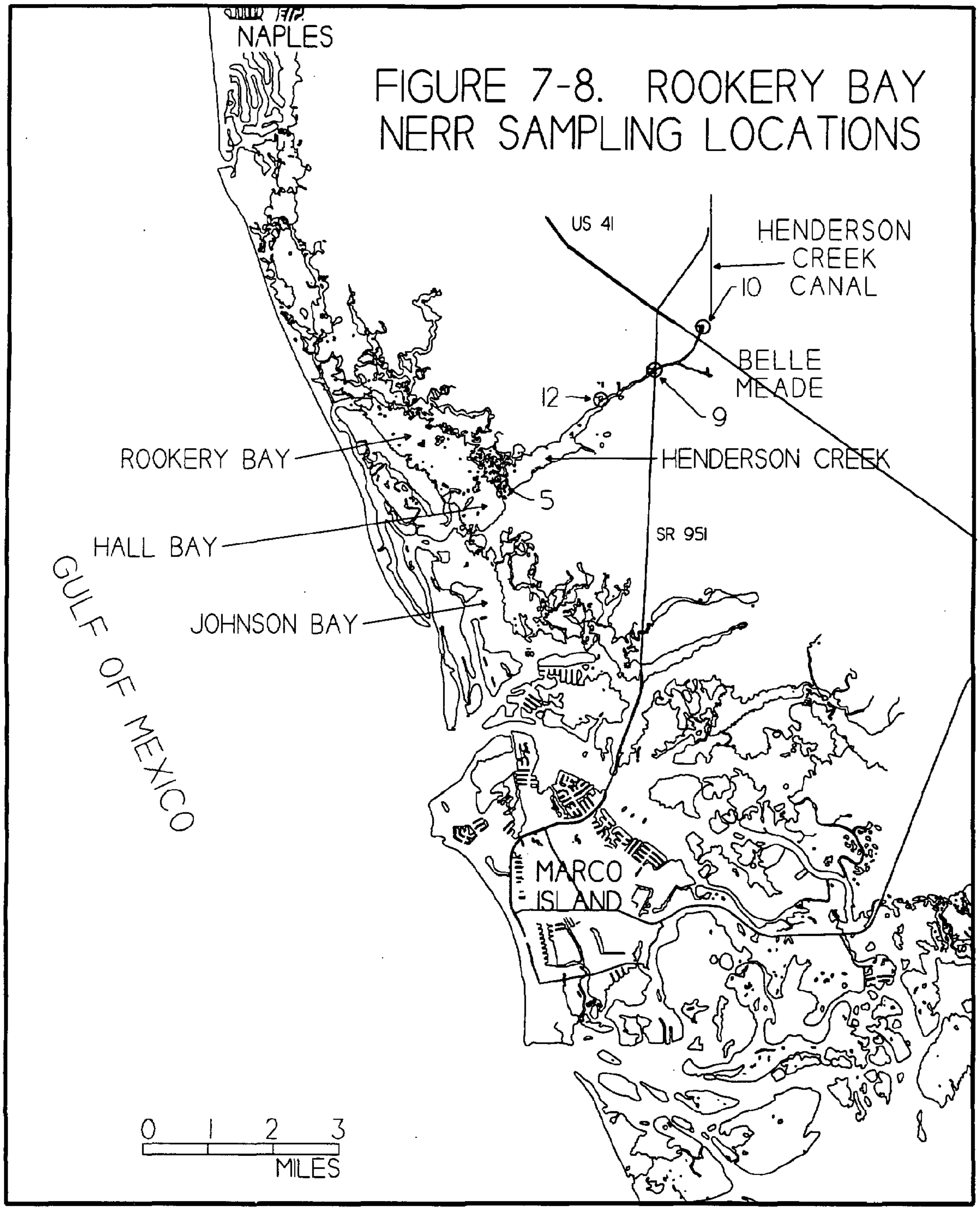


FIGURE 7-8. ROOKERY BAY
NERR SAMPLING LOCATIONS
NAPLES
US 41
HENDERSON
CREEK
CANAL
10
BELLE
MEADE
12
9
ROOKERY BAY
HENDERSON CREEK
5
HALL BAY
SR 951
GULF OF MEXICO
JOHNSON BAY
MARCO
ISLAND
0 1 2 3
MILES

Figure 7-8, station 10 is downstream of the weir on Henderson Creek Canal at US 41, station 9 is located at Henderson Creek at SR 951, station 12 is located farther downstream where a small creek with headwaters near Eagle Creek enters, and station 5 is located in Rookery Bay.

Table 7-3 Statistical Differences in Orthophosphate or Nitrate/Nitrite Concentrations in Henderson Creek

Station	10		9		12		5	
	OPO_4	NO_x	OPO_4	NO_x	OPO_4	NO_x	OPO_4	NO_x
10	X	X	N	N	N	N	Y	N
9	N	N	X	X	N	N	N	Y
12	N	N	N	N	X	X	N	N
5	Y	N	N	Y	N	N	X	X

Sediment sample results indicated silver concentrations in Henderson Creek were above the concentrations at which impacts on biological communities might occur (CCPCD 1993). As well, cadmium concentrations in sediments indicated anthropogenic enrichment (CCPCD 1993).

There are no reports on the quality of water that is being discharged from the agricultural lands into the US 41 Canal. However, aldrin, an organochlorine pesticide, was detected in 1991 in sediment samples taken in Blackwater River, downstream from Collier Seminole Park (CCPCD 1993). Aldrin was used to control a wide spectrum of insects on crops, such as sugarcane, but is no longer produced in the U.S. In addition, evidence of cadmium was noted at this location (CCPCD 1993). A study conducted on the extent of shallow groundwater contamination from pesticides adjacent to agricultural lands in Collier County 1986-1987 did not reveal widespread contamination. The study area, however, was located in the northern part of the county (DER 1990).

7.4 POINT/NONPOINT SOURCE POLLUTION

Within the region there are many potential sources of runoff and drainage that may contain pesticides, herbicides, excessive nutrients and heavy metals. Listed below are possible sources of nonpoint source or point source discharges.

7.4.1 **Agriculture:** The Belle Meade region has some of the most productive agriculture in the nation. During the winter growing season, this area has traditionally supplied the nation with vegetables when most other growing areas have been damaged by freezes. Typically, most of the acreage is dedicated to growing tomatoes, peppers, with some watermelon, cucumber, and cantaloupe. Because the farming methods employed in the area utilize synthetic pesticides, herbicides, fungicides and fertilizers, there exists the possibility that some of these substances travel through the drainage network to the receiving estuarine water bodies. Currently, about 11 permits for the storage and discharge of surface waters have been issued by the South Florida Water Management District for agricultural activities in this area. Generally, most of the fields are not worked during much of the wet season. However, in order to prepare the fields for autumn planting, the fields must be drained. This is likely the most crucial period for the release of pollutants off-site. Additional studies are needed to determine the water quality of farmfield discharge over time.

7.4.2 Excavations: The continued development of lowlands adjacent to Rookery Bay will require the placement of fill to meet minimum flood elevation standards. Because the cost of acquiring fill from off-site locations may prevent affordable construction, on-site excavations are preferred. These excavations may allow the upwelling of saline water into the surficial aquifer. Although the introduction of small amounts of saline water into the estuarine environment does not pose a significant threat, the possibility of discharge of saline waters into freshwater wetlands adjoining the estuaries is of greater concern. The freshwater wetlands could be altered to the point where their ability to filter pollutants is diminished.

7.4.3 Golf Courses: Currently, only four golf courses have been constructed in the region. Stormwater discharges from the Golf Club at Marco into tidal areas by way of a spreader swale. The Eagle Creek golf course discharges to Henderson Creek. Boyne South and Marco Shores discharge to tidal areas south of the courses. These golf courses use fertilizers and pesticides to maintain their fairways and greens. Two of these courses have initiated the use of biological controls to replace some chemicals. Unfortunately, environmentally sound alternatives are not always available. All of the courses use some form of synthetic chemicals to control the pests associated with the turfgrass.

7.4.4 Landfill: The Collier County Solid Waste Department operates a 300-acre sanitary landfill three miles east of CR 951, north of I-75. The facility handles solid waste generated by the City of Naples and most of Collier County. The facility is permitted to discharge stormwater from its 34-acre stormwater retention areas to the Henderson Creek Canal. Leachate from the disposal cells is recovered and treated in an on-site basin. Plans call for pumping the leachate off-site for treatment. A greater threat is posed from the release of leachate from a perforation in a cell liner. The inadvertent release of heavy metals from surface water runoff from the site to Henderson Creek Canal remains a possibility.

7.4.5 Nurseries: There are three major seedling nurseries located in the agriculture areas along US 41. In addition, two retail nurseries located along the banks of Henderson Creek Canal may provide discharges of nutrient and pesticide laden runoff directly into the canal. There is also a nursery located on CR 951, just south of Henderson Creek.

7.4.6 Residential: Negative impacts on the water quality from residential development north of U.S. 41 are minimal because residential development is scattered with low density. South of

U.S. 41, intense development poses the possibility of pollutant loading from lawn and garden chemicals, and road runoff of grease, oils and tire tread wear. Although recent residential developments in the area have been required to meet SFWMD surface water treatment standards, older mobile home parks were not as strictly regulated. Proper control of runoff is limited in these subdivisions. Present-day treatment usually occurs by the use of excavated lakes within the development. Discharge direction and location may be seen in Figure 7-1.

Most of the recreational vehicle and mobile parks in the entire Belle Meade region are served by central sewer, as well as the Eagle Creek development. There are several scattered locations of residences served by on-site sewage disposal (septic) systems: mobile homes in the agricultural areas, along Henderson Creek Dr., Port-Au-Prince Rd., US 41 and Lake Park Blvd.; and residences along Sabal Palm Rd. and scattered throughout the rest of the region. Because of the low density of septic systems in most of the area and because of the lack of reported failures (HRS 1994), the threat of pollution from this source appears to be insignificant. A greater threat of contamination of the waters of Henderson Creek appears to be from the mobile homes clustered along Henderson Creek Dr. and Manatee Rd.; however, most of these residences are served by central sewer. In fact, only about 60 residences along both these roads are served by septic systems: all on the south side of Henderson Creek Dr. The Collier County Public Health Unit has not recorded any appreciable number of violations of illegal discharge from these systems in the past five years (HRS 1994).

7.4.7 Sewage Treatment Plants: In this region there are ten sewage treatment plants serving over 1800 persons with total average daily flow of over 400,000 gallons per day. The other three regions, Water Management District 6, South Golden Gate Estates and Fakahatchee Strand, contain a total of only four plants. Most of the flow is handled by two systems: Eagle Creek and Rookery Bay Utilities. Eagle Creek provides service only for the Eagle Creek subdivision, while Rookery Bay provides service to over 10 mobile home and recreational vehicle parks. Eagle Creek disposes of its effluent as reuse for golf courses. Rookery Bay Utilities operates polishing ponds south of US 41 adjacent to its plant.

The smaller plants serve only the subdivisions in which they are located. These small plants are not manned. Because sewage treatment plants operate under a combination of physical and bacteriological processes, they are susceptible to perturbation. On occasion some of these plants have not met treatment standards (DEP 1994). These plants dispose of their effluent by way of on-site lagoons. The KOA sewage treatment plant has been reported for discharging treated effluent from a leaking lagoon in the past (CCPCD 1994).

Southern States Utilities, which serves Marco Island, operates a lagoon disposal area adjacent to tidal areas off Marriott Dr. Effluent is disposed of in the lagoon only when their normal means of disposal (deep well injection and re-use) are not available. The utility is required to maintain monitoring wells and provide periodic results to the Department of Environmental Protection (DEP 1994).

Collier County Utilities has existing sewage force mains or planned extensions running the length of CR 951 from SR 84 south to Port-Au-Prince Rd., along all of Rattlesnake Hammock Rd., and along U.S. 41 to about Trinity Pl. All new subdivisions within the County's service area will be required to connect to the County's system when available.

7.5 RESTORATION OPTIONS

7.5.1 Hydrologic: A 1982 study conducted by CH2M Hill recommended the construction of a network of flood control and drainage features for the expected growth in the region. Although implementation of the entire plan would have resulted in the degradation of the quality of the wetlands in this region and may have substantially affected water quality in the Rookery Bay and Ten Thousand Islands, certain features of the design may provide mechanisms for remediation of the inadequacies of the existing drainage mechanisms.

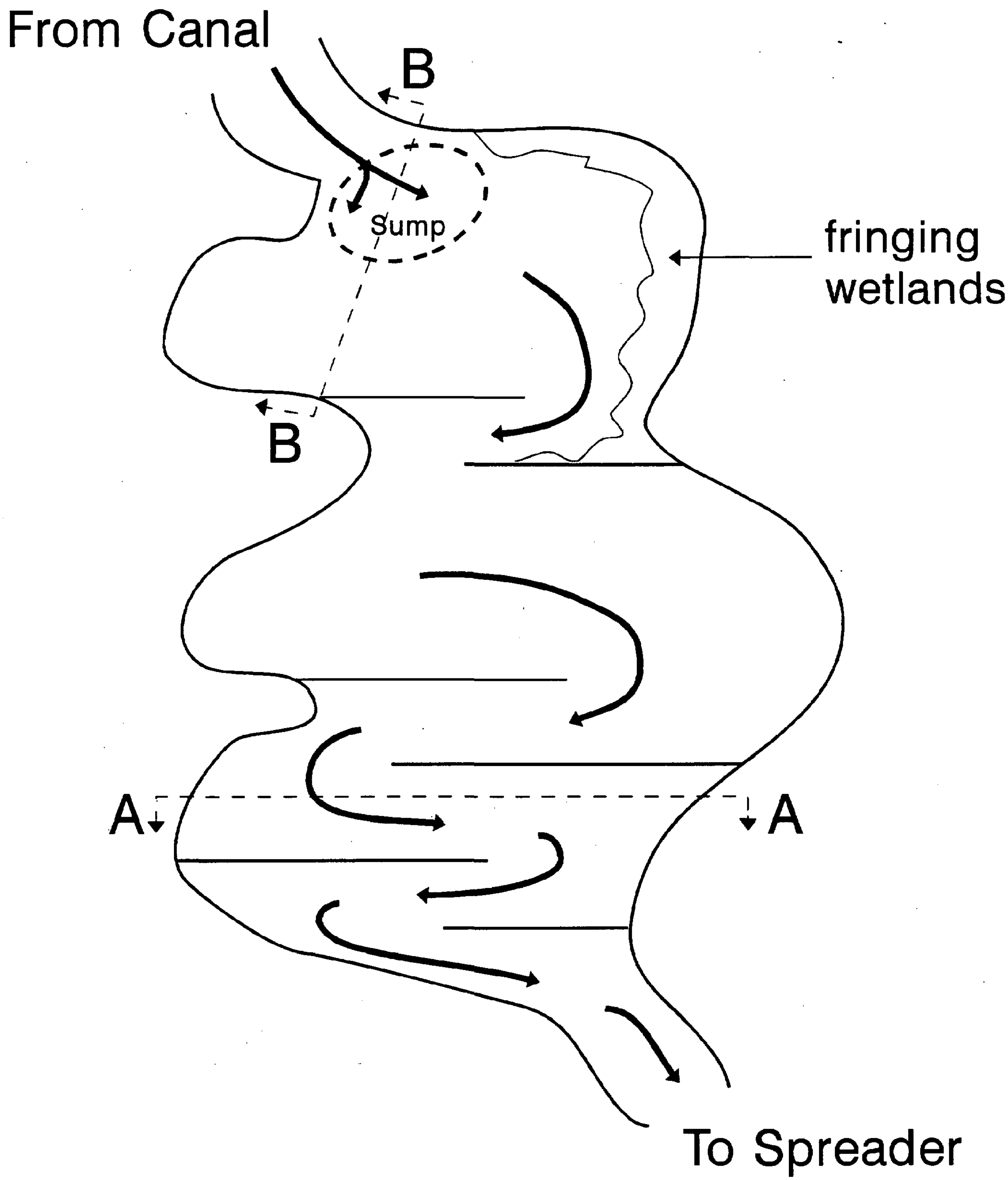
- **The construction of a water control structure about 1-mile north of Sabal Palm Rd. in the Henderson Creek Canal.** The structure should provide additional head that will act to redirect the flow north of this point (historical flow was across CR 951) back to the east. This flow would then travel through flowways to the east and then be conveyed south. The water would be of better quality as it reaches the estuaries and its timing to the estuaries would be improved because of the additional detention time in the freshwater wetlands. The control structure would allow for recharge of the aquifer because of added residence time and allow for some flood protection for the existing residences on Sabal Palm Rd.

  Estimated Cost: $200,000
  Applicable Objectives: RBNERR OBJ 2.5
  CCGMP-Cons. 2.1, 2.2, 2.3 and 6.7

- **The construction of additional culverts under US 41 connected to a spreader swale(s) south of US 41.** The culverts and conveyances should be connected to future developments' surface water management lakes. The surface water should then be discharged to tidal areas. This will deliver the surface water in a more timely manner and allow for better treatment of runoff from the agricultural areas. Current direct discharge from these areas through Henderson Creek to Rookery Bay would be alleviated.

  Flow from the US 41 Canal, which may contain agrochemicals, may be directed away from Henderson Creek by way of a canal-retention lake-spreader system located south of US 41. As seen in Figure 7-9, the lake should be designed to provide maximum residence time by using a meandering shoreline with fringing wetlands. Berms extending from the shoreline into the lake should act to prevent "short-circuiting" of the flow (Figure 7-10). Removal of suspended solids from the incoming water could be accomplished by construction of a "sink" located at the inlet of the lake. Discharge from the lake could be to planned stormwater management locations of future developments to the south (i.e. Marco Shores). The use of a spreader swale system (Figure 7-10) should help to mimic historic discharge patterns in the area. See Figure 7-11 for approximate locations of improvements. The proposed improvements would occur as public works or mitigation activities on publically owned land (for example: Locations A and B in Figure 7-11) or on fallow agricultural land (for example: Location D in Figure 7-11).

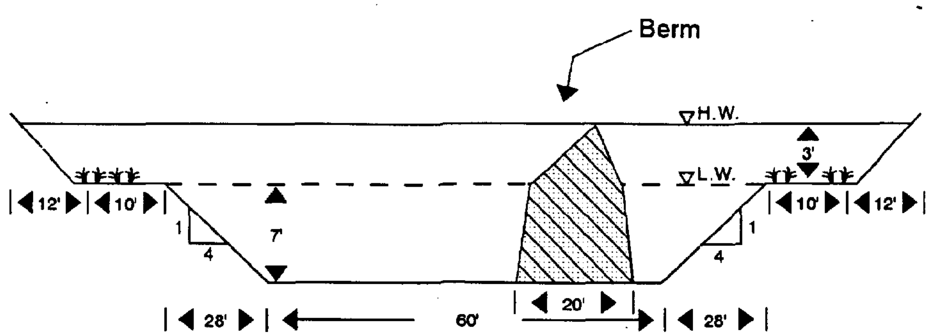
Figure 7-9. Stormwater Management Lake



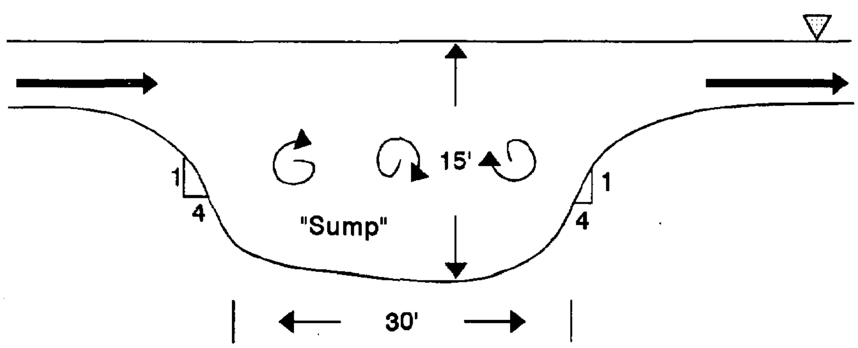
Plan View

Figure 7-10. Cross-sections of Stormwater Management Lake

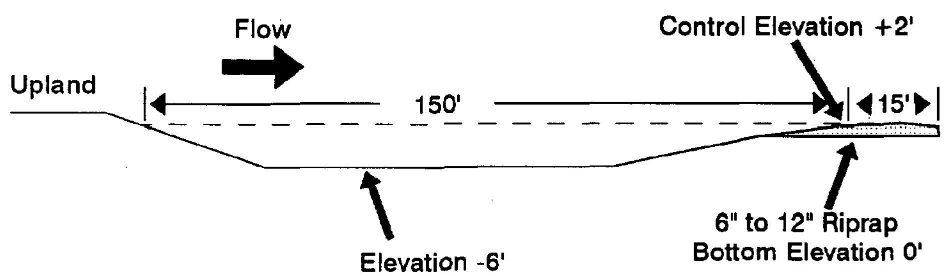
A - A

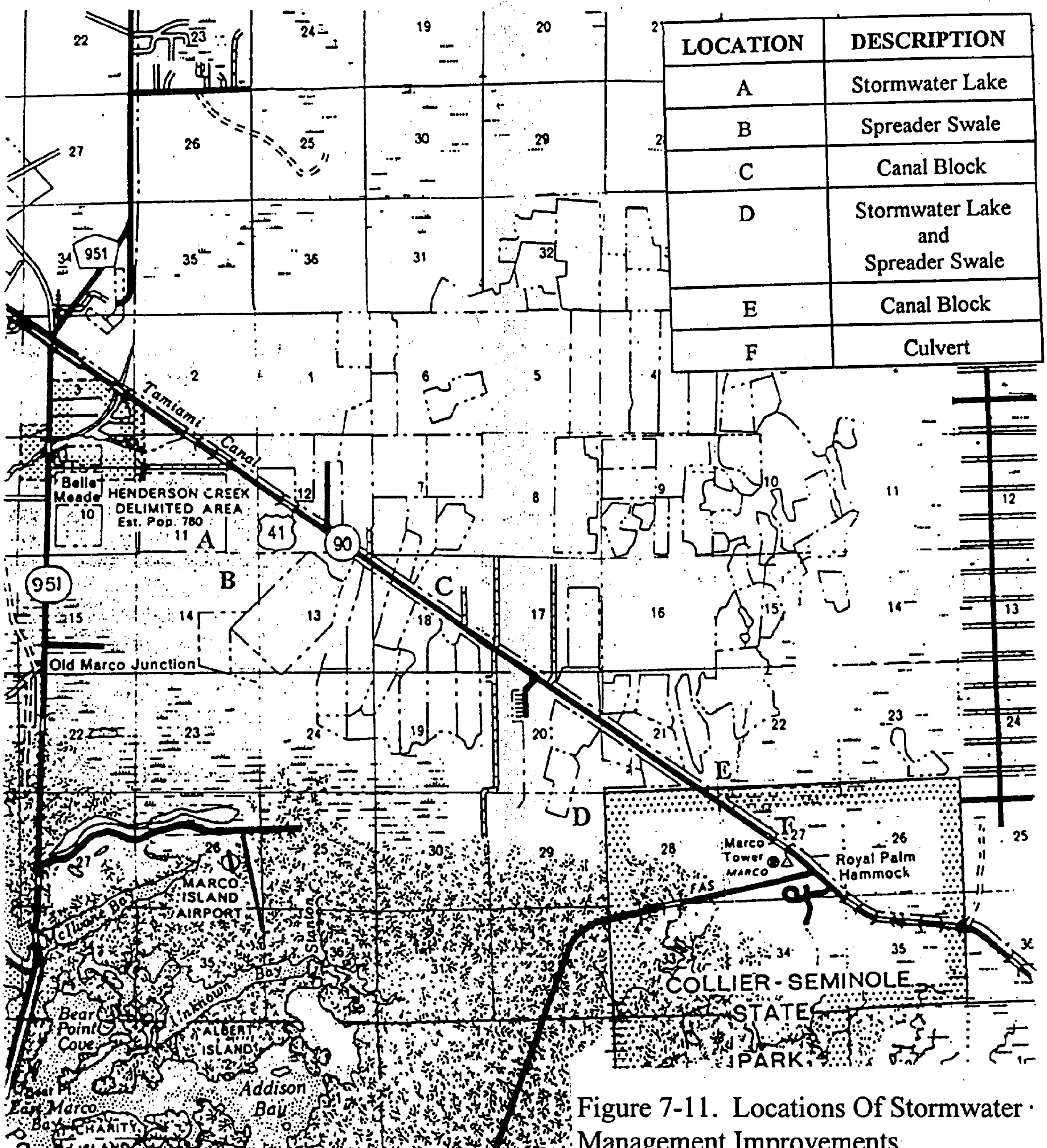


B - B



Typical Spreader





LOCATION	DESCRIPTION
A	Stormwater Lake
B	Spreader Swale
C	Canal Block
D	Stormwater Lake and Spreader Swale
E	Canal Block
F	Culvert

Figure 7-11. Locations Of Stormwater Management Improvements

Estimated Cost: $1-3 million per project depending on scope of work
Applicable Objectives: RBNERR OBJ 2.5 and 2.6
CCGMP-Cons. OBJ 2.1, 2.2, 2.3, 6.7 and 7.3

- **The placement of additional culverts under Sabal Palm Rd. east of the end of the pavement.** Flow is disrupted from its historic course by the road Existing culverts do not provide adequate crossings. This would be an interim step until further restoration activities occur.

  Estimated Cost: $500 per culvert
  Applicable Objectives: RBNERR OBJ 2.5
  CCGMP-Cons. OBJ 2.2 and 6.7

- **Restoration of Duda properties (Sections 11 and 14, Range 27E, Township 51S--southeastern corner of Belle Meade region):** This area was altered by the construction of drainage ditches in a grid pattern. Because a major historic flowway coursed through this area, restoration of the flow patterns will ensure natural timing runoff from storm events into the Collier Seminole State Park.

  Estimated Cost: work to be accomplished by A. Duda and Sons, Inc.
  Applicable Objectives: CCGMP OBJ 2.2 and 2.3
  RBNERR OBJ 2.6, 6.2 and 6.7

- **Development of regional stormwater management plan for the agricultural areas in Belle Meade in the event they are residentially or commercially developed.** This should be a cooperative effort between South Florida Water Management District and Collier County Government to provide for the implementation of elements contain in this report and the development of off-site control of stormwater discharges.

  Estimated Cost: $150,000-200,000
  Applicable Objectives: RBNERR OBJ 2.5 and 2.6
  CCGMP-Cons. OBJ 2.1, 2.2, 2.3 and 6.7

7.5.2 Land Conservation:

- **see Figure 7-12 on land conservation recommendations for Belle Meade.**
  The designation types were determined using the following criteria. A designation of Type I is for sections with a high percentage of wetlands, combined with limited access to infrastructure (transportation, potable water and sanitary facilities). Type II, use of conservation easements, is for sections with a mix of uplands and wetlands, with potential access to infrastructure. Type III, transfer of development rights, is designed for sections of existing intense agricultural activity. Type IV, no action or private stewardship, is for sections that have been impacted by residential or commercial development.

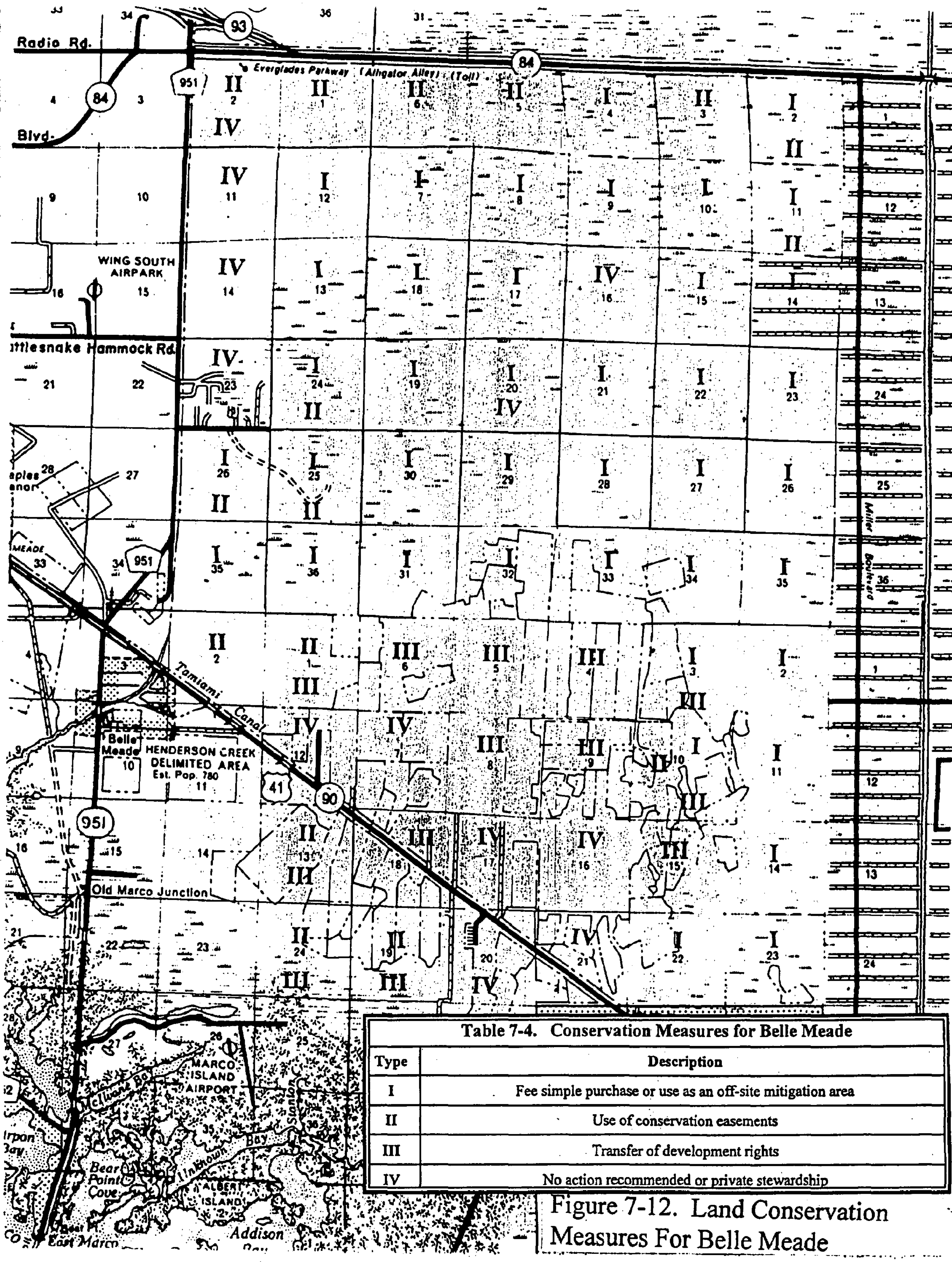


Table 7-4. Conservation Measures for Belle Meade

Type	Description
I	Fee simple purchase or use as an off-site mitigation area
II	Use of conservation easements
III	Transfer of development rights
IV	No action recommended or private stewardship

Figure 7-12. Land Conservation Measures For Belle Meade

- **Purchases:** CARL lands
  Estimated Cost: $60 million
  Applicable Objectives: RBNERR OBJ 2.1 and 2.5
  CCGMP-Cons. OBJ 1.3, 6.2 and 6.8
  CCGMP-Rec. OBJ 1.1 and 1.2

- **Mitigation Banks:**
  Estimated Cost: finances would be paid by organizations establishing bank and dependent upon condition of property
  Applicable Objectives: RBNERR OBJ 2.1 and 2.5
  CCGMP-Cons. OBJ 6.8

- **Section 16 Demonstration Project:** The State of Florida owns a full section (640 acres) of property in Belle Meade, north of Sabal Palm Road (Township 50S, Range 27E, Section 16). The State could proactively use this section to demonstrate land conservation techniques, best management practices (BMPs) and land stewardship for the public. Although the area has not been surveyed in detail for hydrologic obstructions, wildlife or exotic plants, infestation by *Melaleuca quinquenervia* has occurred in surrounding areas. Restoration, involving private landowners and citizens, could serve as a demonstration project of land conservation practices. Annual or semi-annual meetings to encourage public participation could be held with walks and exhibits that show the progress of restoration activities. It is important for the State to act as a leader in promoting BMPs and land stewardship, as well as to have this project available for the public.

  Estimated Cost: $100,000 initially, with remaining cost dependent upon surveys and condition of the land
  Applicable Objectives: RBNERR OBJ 2.5 and 2.7
  CCGMP-Cons. OBJ 6.8

7.5.3 Vegetation: The invasion of exotic plant species, such as melaleuca and Brazilian pepper, poses a great threat to the integrity of the vegetative communities within Belle Meade.

- **Small-scale exotic removal in areas with low infestation can be tackled through a private stewardship and volunteer action program, with landowner approval, coordinated by the State, County or private organizations.**

  Estimated Cost: <$400/acre for low intensity infestation
  Applicable Objectives: RBNERR OBJ 2.7
  CCGMP-Cons. OBJ 1.1
  CCLDC Section 3.9.6.6

- **Mitigation/mitigation banking may prove to be highly beneficial in the removal of monocultures of exotics.**

  Estimated Cost: $3,000-4,000/acre
  Applicable Objectives: RBNERR OBJ 2.7
  CCGMP-Cons. OBJ 1.1
  CCLDC Section 3.9.6.6

7.5.4 Water Quality Assessment:

- **Stormwater discharges from agricultural areas should be monitored.** Sampling of sediments and water from US 41 Canal should be implemented. Flow regimes in the canal should be determined, in conjunction with water quality sampling.

  Estimated Cost: $50,000
  Applicable Objectives: RBNERR OBJ 2.6
  CCGMP-Cons. OBJ 2.2, 2.3 and 7.3

SOUTH GOLDEN GATE ESTATES

The South Golden Gate Estates for this report's purposes shall be described as the area bounded by Interstate-75 to the north, US 41 to the south, the range line between R28E and R29E on the east and the range line between R27E and R28E on the west. The Golden Gate Estates region lies within the Faka-Union Canal Basin. Golden Gate Estates is composed primarily of two political regions: North Golden Gate Estates and South Golden Gate Estates. North Golden Gate Estates, approximately 55,000 acres, is separated from South Golden Gate Estates by I-75. Drainage from a canal network made North Golden Gate Estates suitable for residential development, and the area now houses a large portion of the rural residences. Surface waters from most of North Golden Gate Estates flow through a series of smaller canals, empty into the Golden Gate Main Canal and head to the Gulf of Mexico via the Gordon River. The 55,000-acre South Golden Gate Estates, the area south of I-75, is of great importance to the waters entering the coastal systems bordering the southern side of Collier County. There are a few residences within South Golden Gate Estates. However, during the wet season -- summer -- surface water flows freely over the land and roadways, flooding portions of the area.

In the 1950s, Gulf American Corporation (GAC) purchased the land which now comprises Golden Gate Estates to establish a residential development community. In the 1960s, an extensive gridwork of canals was constructed as the initial step for draining the development area (USACOE 1986). In South Golden Gate Estates alone, there are 50 miles of canals, some up to 200 feet wide, representing 215 acres of waterway and 290 miles of roads with accompanying swales (TCI 1986). Potential landowners were flown over the site during the dry season, shown the layout of the project, then approached for purchasing a site within the project. Many people bought into the GAC project as an investment or home for the future. These landowners did not realize that during the wet season (or summer) their property was covered with flowing water and permits for building would be difficult to obtain. When the flooding problem and hydrologic importance of the area was realized, GAC was sued by the landowners, the company went bankrupt and the State of Florida began to pursue acquisition of the area.

South Golden Gate Estates, because of its hydrologic significance, is being actively acquired through the State of Florida's Conservation and Recreation Lands (CARL) program, as part of the *Save Our Everglades* project.

In 1974, Black, Crow, and Eidsness presented an environmental and engineering evaluation of the canal system. In the report they recommended alternatives to lessen overdrainage and suggested the construction of additional canals. The Golden Gate Study Committee issued a report in 1977 after GAC was subjected to federal court action on their land dealings. The redevelopment of Golden Gate Estates was considered. Clustered housing on suitably developable land was encouraged as well as the restoration of the hydroperiod in South Golden Gate Estates. It was suggested that earthen plugs be installed in the canals in South Golden Gate Estates. In 1977, Stanley W. Hole and Assoc. assessed the effects of restoring water levels in the area. In addition, other engineering studies evaluated the hydraulics of the canal system (USACOE 1986).

The United States Army Corps of Engineers study in 1986 recommended six different alternatives ranging from maintaining the status quo to using the recommended alternative from previous studies to complete restoration of the uninhabited areas. At that time , the Federal government determined that it should not be involved in the implementation of any alternative.

Currently, the South Florida Water Management District is conducting a hydrologic restoration study of South Golden Gate Estates, including hydrologic modeling of various restoration alternatives.

8.1 VEGETATION

Drainage from the extensive canal network has caused changes in the vegetative structure of South Golden Gate Estates. Historically, the area was a cypress and prairie dominated system. Large cypress sloughs graded into prairies, with some mixed swamp islands interspersed within the mosaic. Currently, many of these systems have been altered beyond recognition. Normally, fire occurs in cypress strands about every 20 years (Ewel 1990), while prairies burn every three to five years (Kushlan 1990). Lack of water and a shorter hydroperiod from drainage allowed wildfires to sweep through the area, decimating many of the cypress sloughs. Remnants of these scorched trees can still be seen today. However, due to the drier conditions, cypress did not recolonize the area. Instead, cabbage palm, slash pine and exotics, such as Brazilian pepper, moved into the area, changing the vegetative composition. Many of the prairies are dotted with cabbage palms that moved in after frequent fires had disrupted the system. Currently, wildfires sweep through South Golden Gate each year, continually altering and redefining the vegetative structure.

Historically, slash pines were not a dominant species in South Golden Gate Estates. Presently, however, many of the roads are lined with slash pines, which apparently grew on the spoil banks along the roads and canals. Slash pines are better suited to survive the current fire regime and drier sediment conditions.

Historically, South Golden Gate Estates was fringed on the north boundary by upland pine forests which graded into wetland communities. Wetlands dominated the vegetative communities of South Golden Gate Estates.

Table 8-1. Vegetative Communities of South Golden Gate Estates		
Upland / Wetland Breakdown		
Vegetation	**Acres**	**Percent Cover**
Upland	10,795	20
Wetland	44,002	80
Total	54,797	100

* The Conservancy, Inc. 1986.

Table 8-2. Vegetative Communities of South Golden Gate Estates		
Wetland Communities		
Vegetation	**Acres**	**Percent Cover**
Prairie/Marsh	7,343	17
Cypress/Mixed Swamp	25,919	59
Hydric Pine Flatwood	10,740	24
Total	44,002	100

* The Conservancy, Inc. 1986.

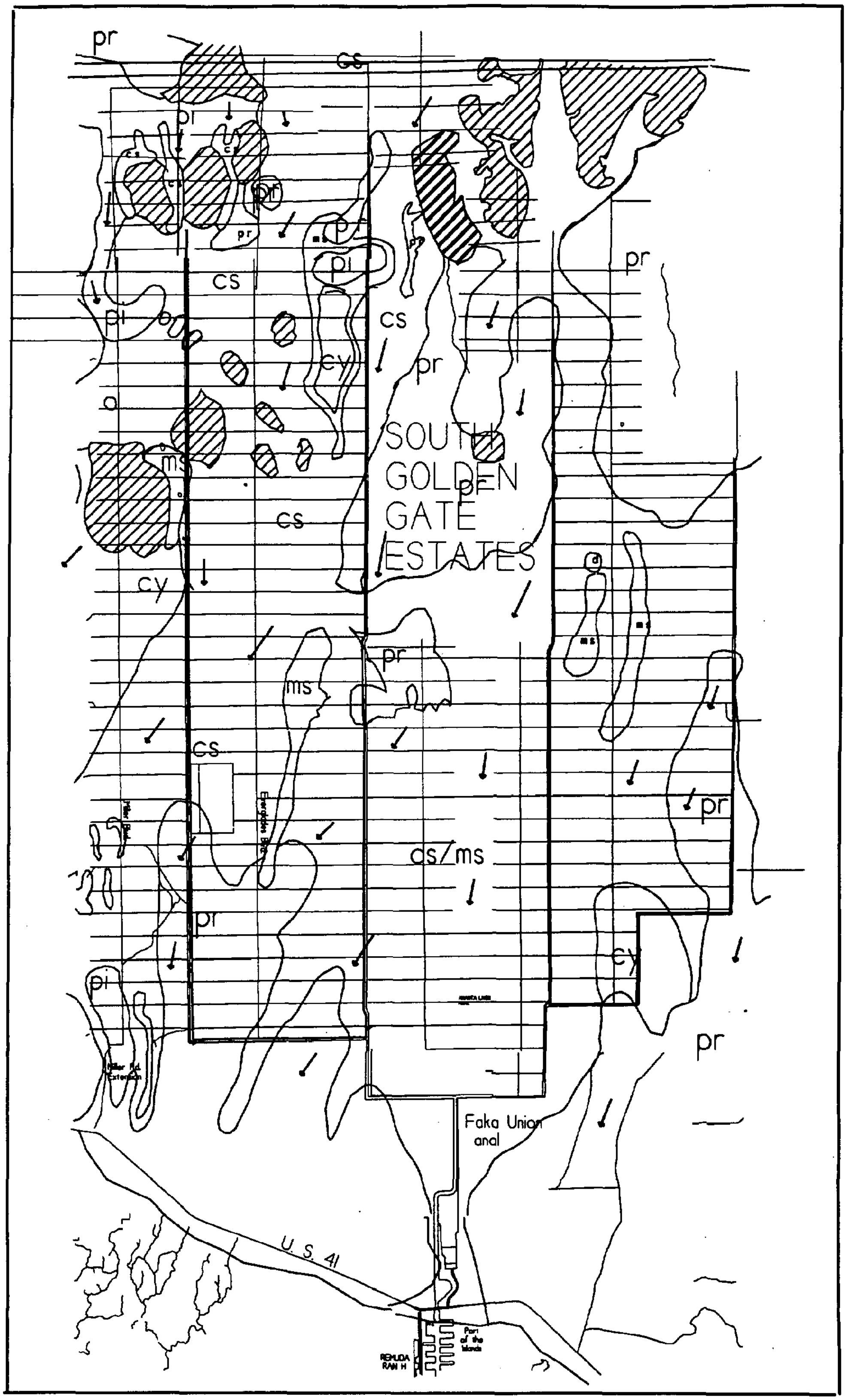
8.1.1 Habitat Ranking

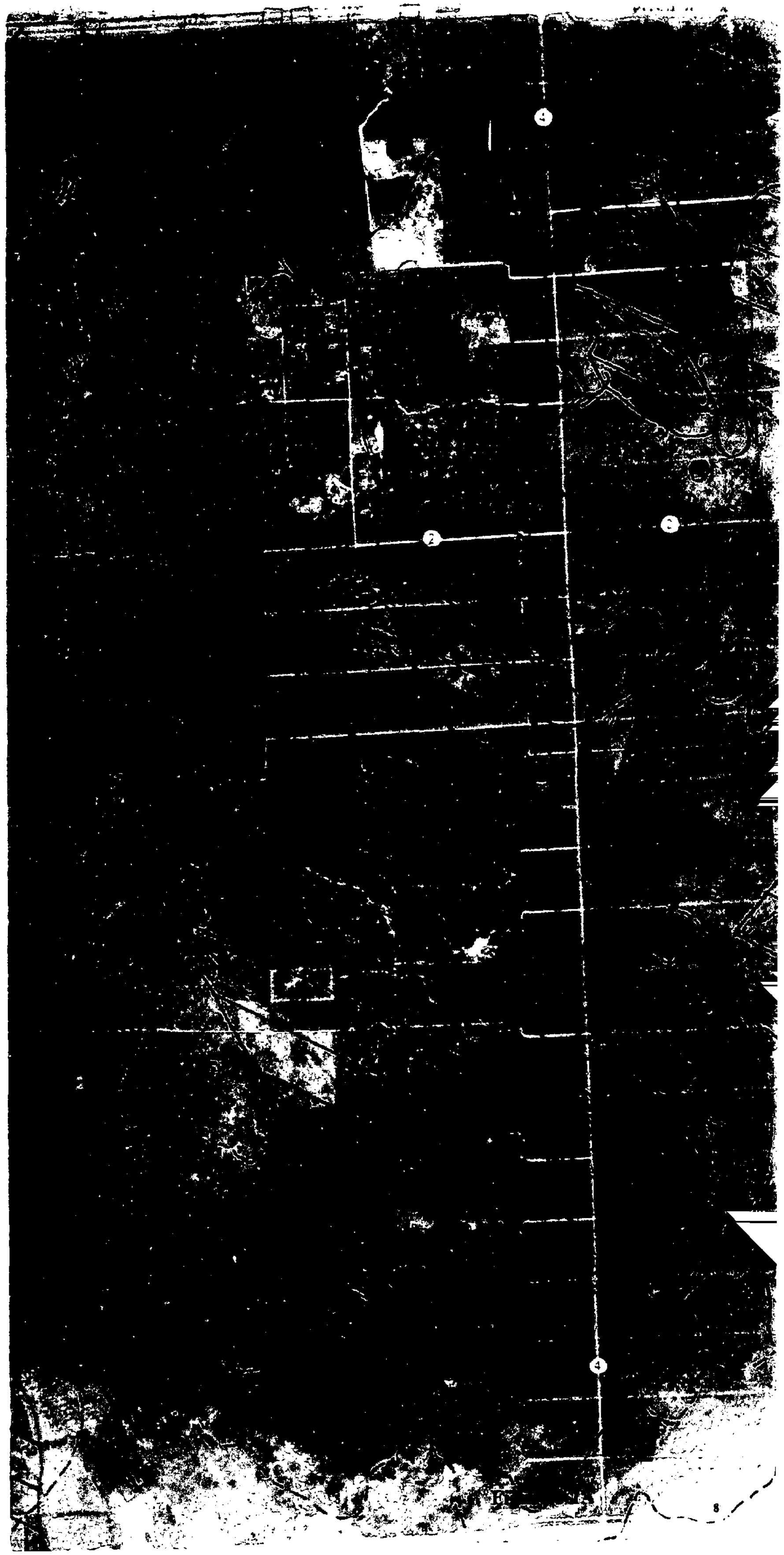
The Florida Game and Freshwater Fish Commission has ranked habitats for specific species within the area on a scale of 1 to 10, 1 being the lowest value and 10 being the highest value (Cox et al. 1994). Habitat suitable for the endangered Florida panther ranked between 3 and 6, while habitat suitable for the threatened Florida black bear ranked 10 (Cox et al. 1994). South Golden Gate Estates was also identified as an area suitable for the reintroduction of Florida panthers, a rank of 4 to 10 on a scale of 1 to 10 (Cox et al. 1994). Strategic habitat areas, or areas identified as important because they provide a base habitat for long-term species persistence, were found within South Golden Gate Estates for the Florida panther, Florida black bear, swallow-tailed kites, short-tailed hawks and fox squirrels (Cox et al. 1994). An overlay of 120 rare species showed South Golden Gate Estates as having suitable habitat for 7 to 18 species, a high ranked designation (Cox et al. 1994). South Golden Gate Estates was recommended as a P2000 priority area for protection (Cox et al. 1994).

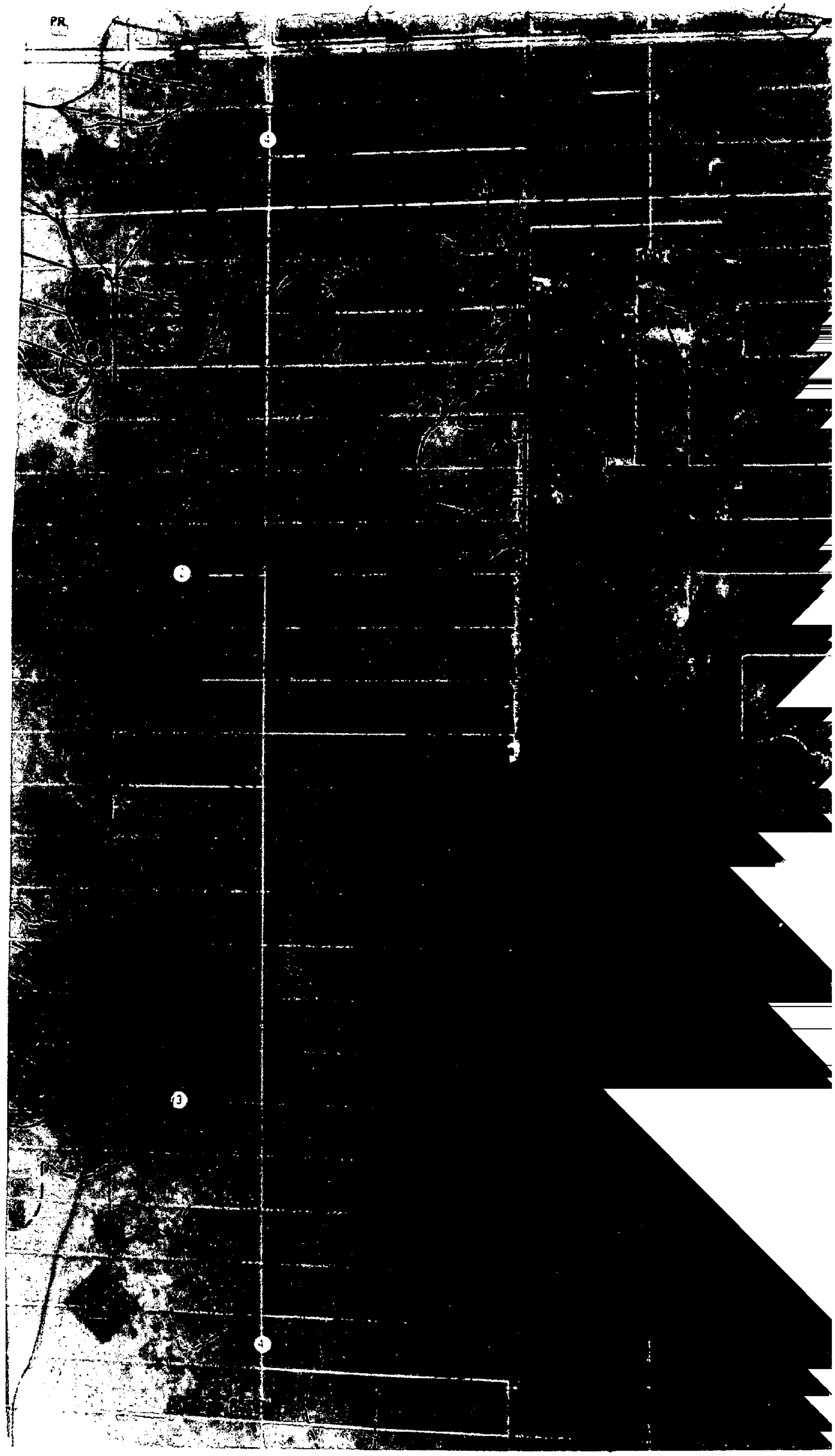
8.2 HYDROLOGY

8.2.1 Historic: Surface water flow into SGGE originated north of present day I-75, as seen in Figure 8-1. Flow around uplands in the northwest corner was directed south around a series of uplands that were aligned north-south. Any flow to the west was hindered by higher terrain running parallel to present day Miller Blvd. Flow in this area was through cypress sloughs and broad areas of cypress. East of that area flow from the north was directed south in cypress sloughs and broad prairies, such as Picayune Strand and Swan Prairie. Along the eastern side of SGGE, adjacent to Fakahatchee Strand, flow was to the south and southwest through mixed swamp and predominantly through historic prairies such as Slate Prairie, Burnt Flat Prairie, and West Prairie. Flow from these prairies extended down to US 41. Large cypress strands covering most of the width of SGGE directed flow, south of present day Stewart Blvd. Fingers of marl prairie extended in a northeast-southwest direction into the southwest corner of SGGE. Flow

FIGURE 8-1. SOUTH GOLDEN GATE ESTATES
HISTORIC FLOWWAYS



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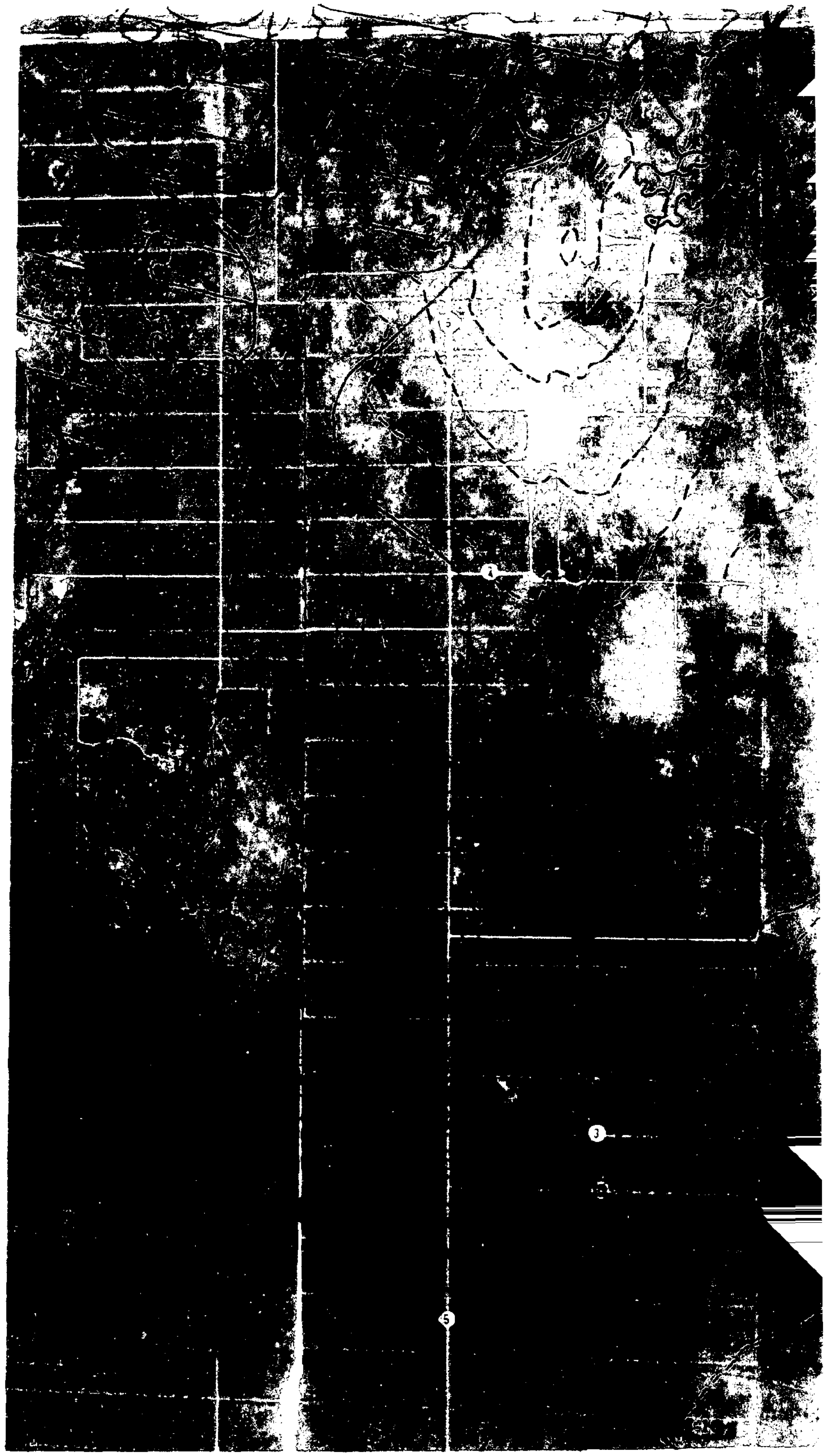
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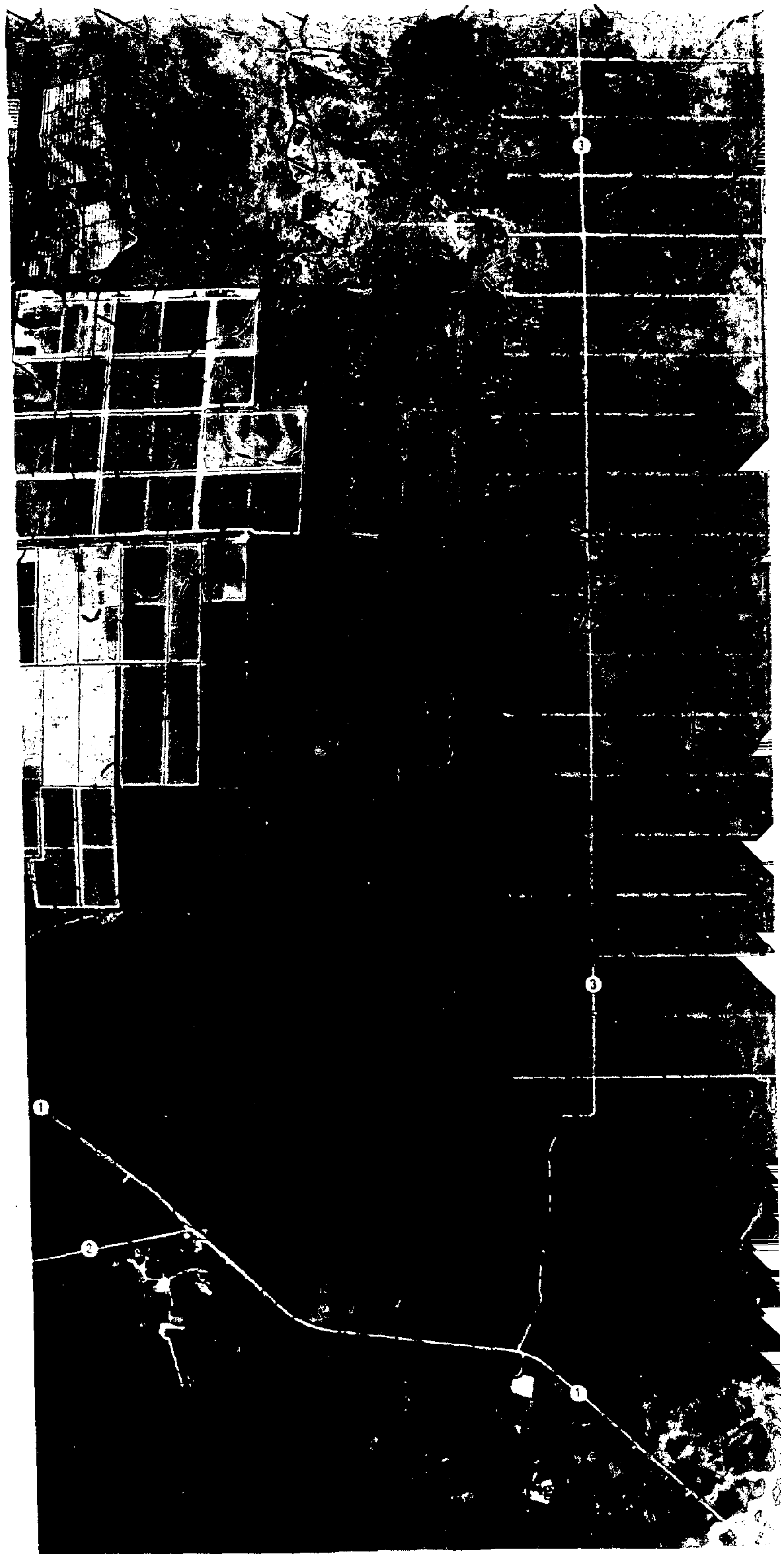

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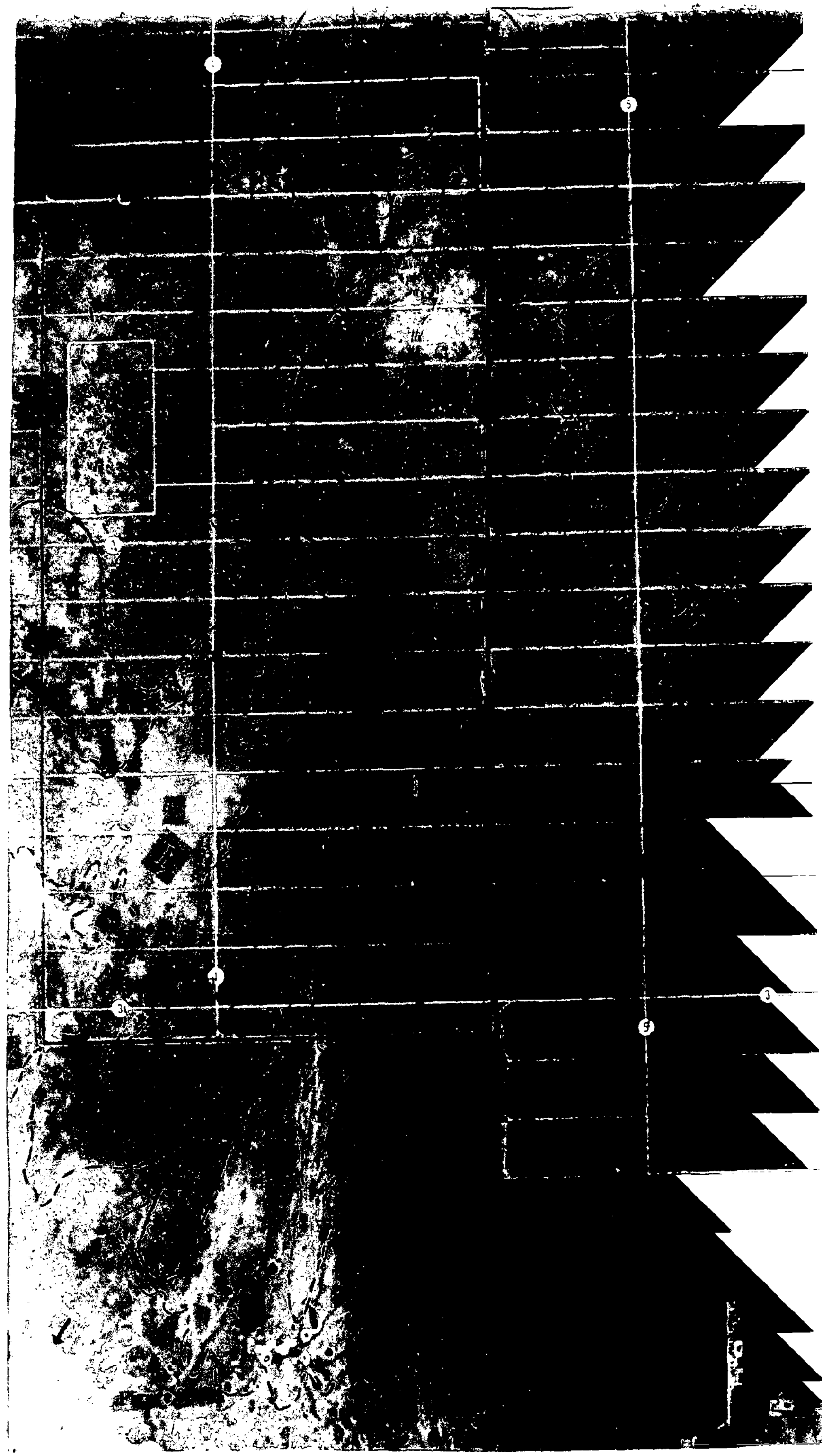

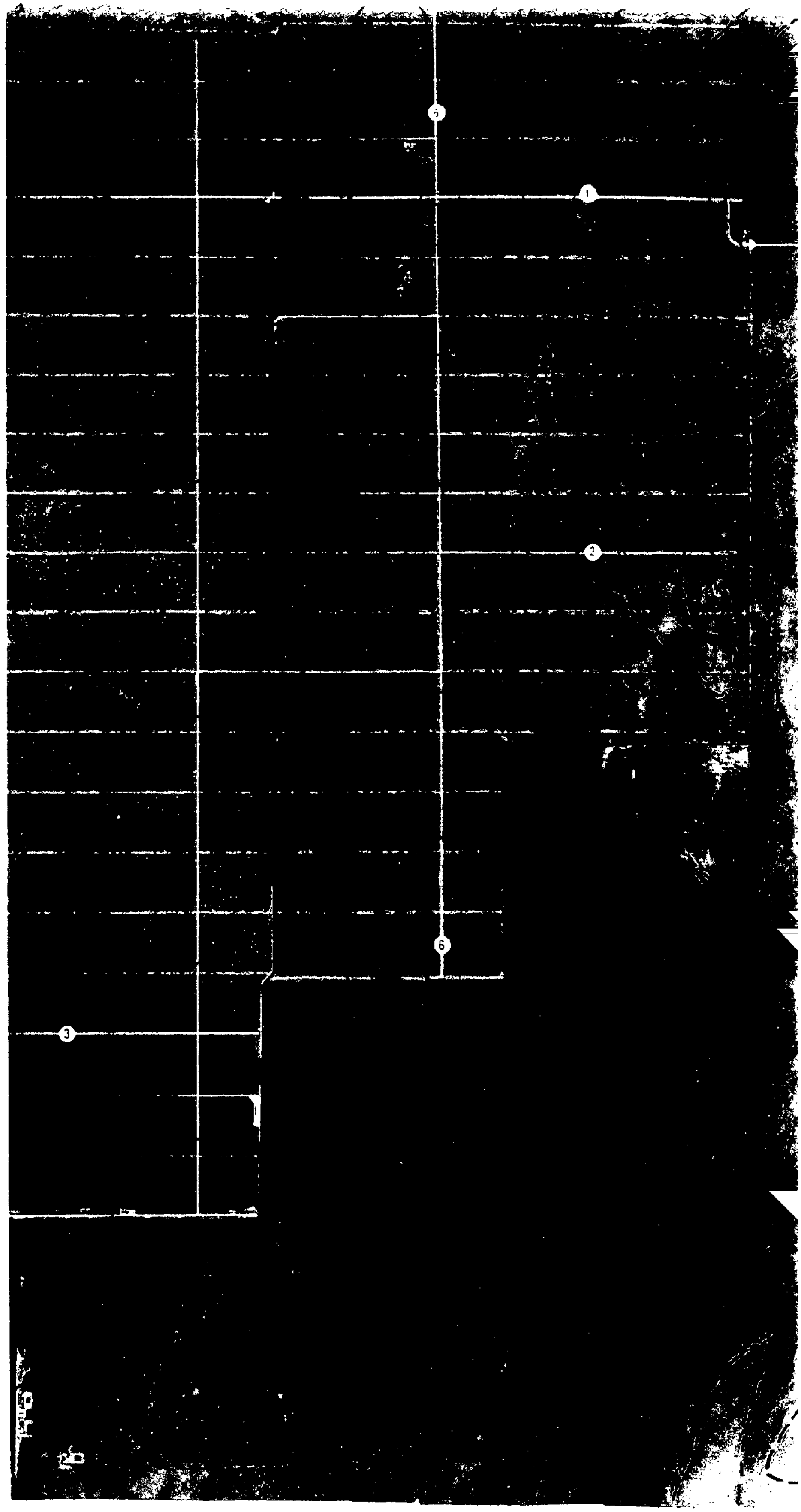
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traveled south through these prairies and sloughs to tidal areas south of US 41.

8.2.2 Recent: Sheetflow, when present, in this region follows historic wetland flowways south, is intercepted by the canal network and finally enters the Ten Thousand Islands coastal ecosystem. Since the construction of the canal network, flooding is limited to areas of lower elevation and for a shorter duration than historically encountered. Approximately 50 miles of canals have drained the area and 290 miles of roads have altered the historical surface water flowways. However, remnants of the original systems are still present and may be able to be restored with the proper plan. The disturbance created by construction of the canals and roads, along with the alteration in hydroperiod, has exacerbated the invasion of exotic species, such as Brazilian pepper and melaleuca.

South Golden Gate Estates is located predominantly in the Faka-Union Canal Basin which drains from the Corkscrew area through eastern North Golden Gate Estates and then through most of South Golden Gate Estates. The canal network combines into the Faka-Union Canal and finally discharges at a point south of the Port-of-the-Islands resort south of U.S. 41 East. The Miller, Faka Union, Merritt, and Prairie canals run the length of South Golden Gate Estates. The Miller Canal, located on the western edge of South Golden Gate Estates drains from north of I-75 to about two miles north of U.S. 41. A weir on the canal with a crest of 6.2 ft NGVD is located one half mile south of I-75. Another weir with adjustable gates is located about 6 miles south. Miller flows into Faka Union at the south edge of South Golden Gate Estates. A weir 1 mile south of I-75 with a crest of 6.2 ft NGVD is located in the Faka Union. Another weir with gates is located 6 miles south. These gates are opened and closed according to storm/rainfall conditions.

The Faka Union Canal drains from Immokalee Rd. south to U.S. 41 and beyond. Merritt Canal, located 2 miles east of Faka Union drains from the historic Lucky Strand near I-75 to the north to a connection with Faka Union 2 miles north of U.S. 41. Merritt has one weir with removable sheet piles located near Stewart Blvd. Prairie Canal drains the historic prairies adjacent to Fakahatchee Strand State Preserve about 2 miles east of Merritt. A weir is located on the canal near the intersection of Jane's Scenic Drive and Stewart Blvd. As seen in Figure 8-2, the Faka Union Canal discharges at an annual average of about 300 cfs, with peak years of over 400 cfs. Flow during the peak of the wet season is over 600 cfs.

8.3 WATER QUALITY

Data collected from 1987-1991 examined water quality in the Faka-Union Canal (CCPCD 1993). Conductivity and flow rate show the predicted inverse relationship (Figure 8-3). Since construction activities ceased in South Golden Gate Estates, the amount of sediment flushing from the canals into the estuaries has decreased (Figure 8-4). Nitrate/nitrite (NOx), total phosphate (TPO_4) and orthophosphate (OPO_4) were examined. However, upstream/downstream comparisons were not possible because of a lack of data at the downstream site. Nitrogen, total phosphate and orthophosphate levels show an increase in concentration from 1979 to 1991 (Figure 8-5), suggesting input to the system. A comprehensive water quality monitoring regime should be implemented to determine the source of inputs to the system, as well as to examine upstream/downstream hydrologic dynamics.

Figure 8-2. Faka-Union Canal Flow Rates

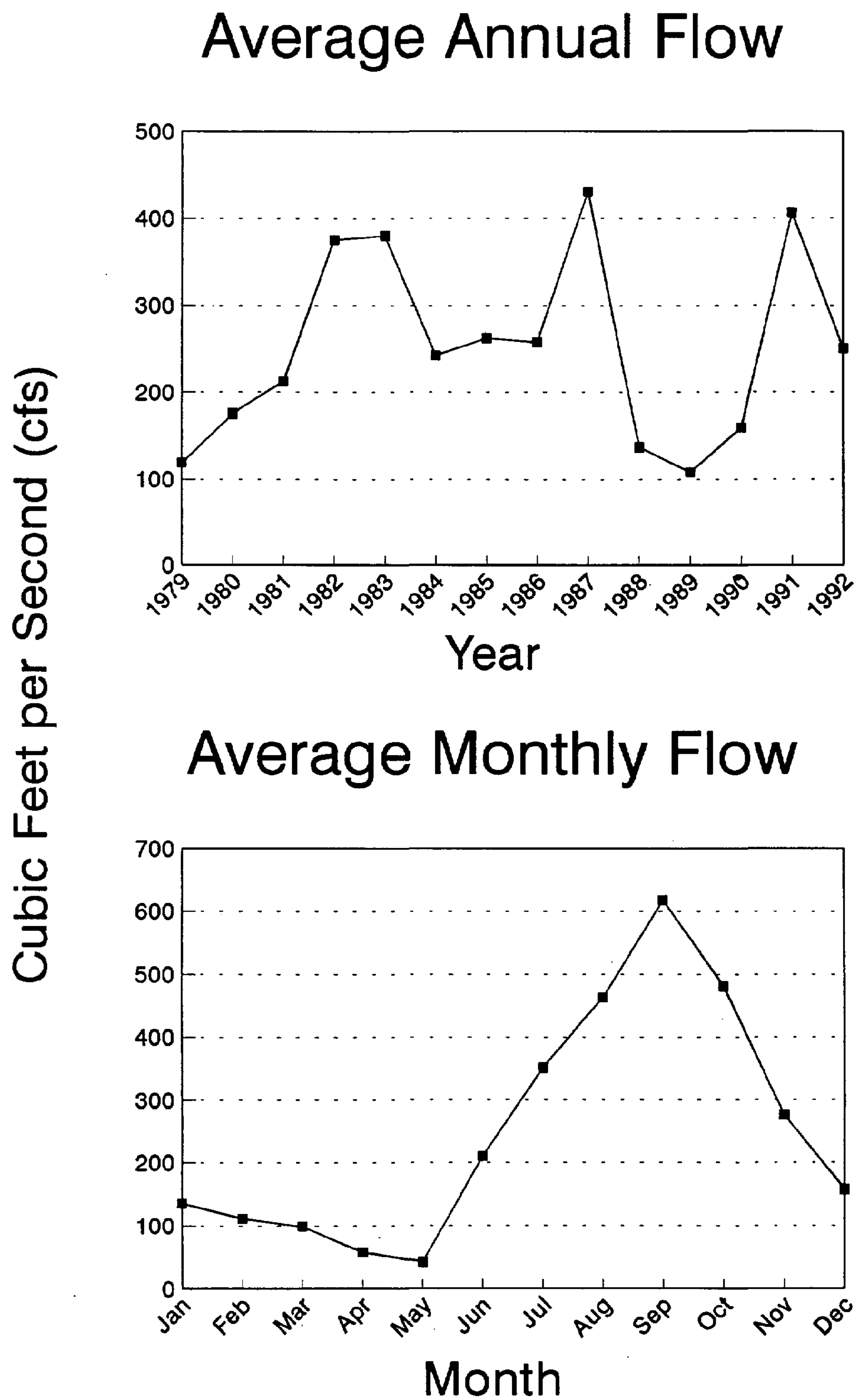
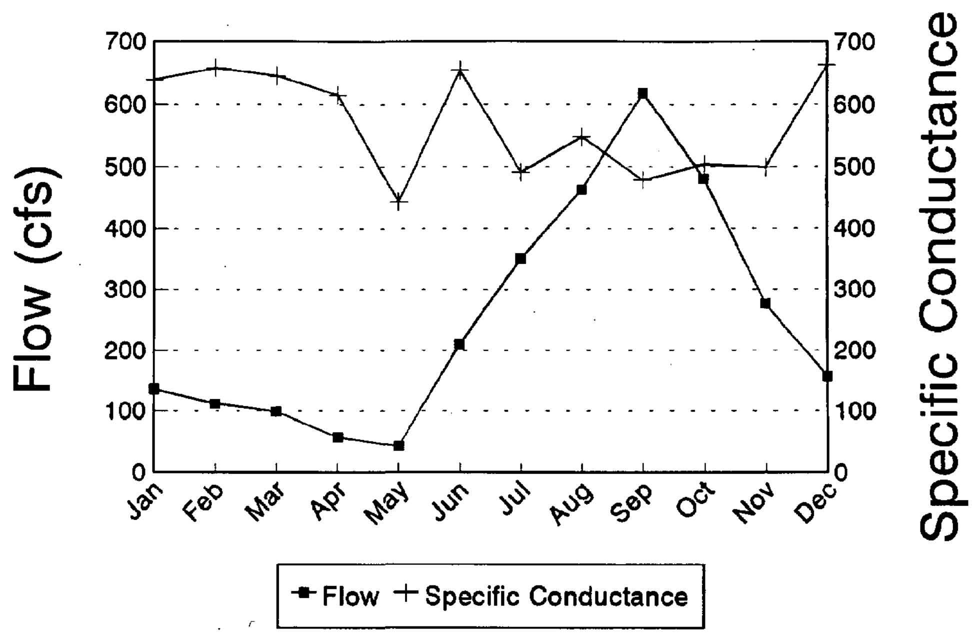
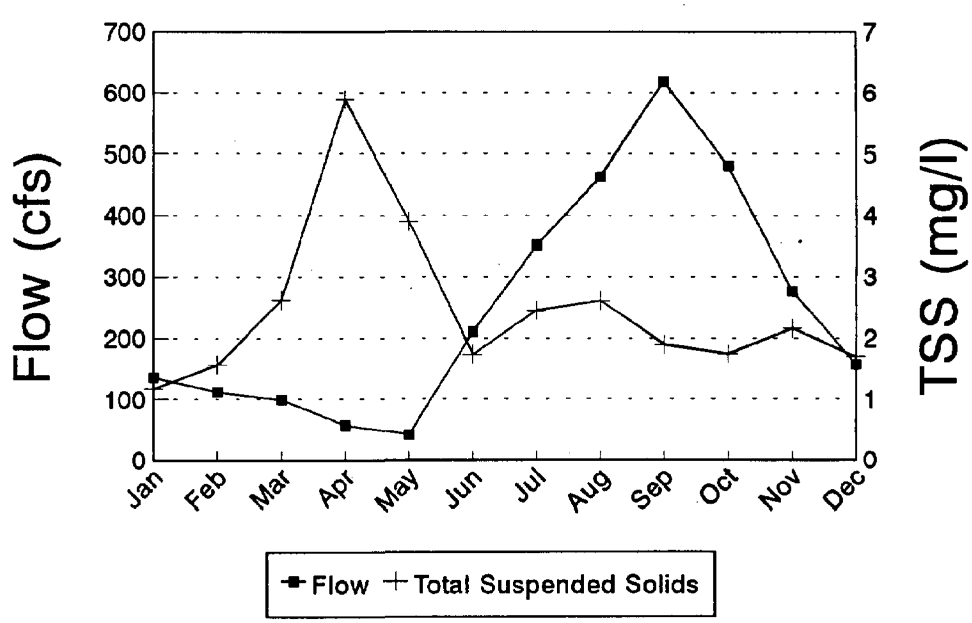


Figure 8-3. Faka-Union Canal

Average Specific Conductance and Flow



Average Suspended Solids



Month

Figure 8-4. Faka-Union Canal
Average Sediment Loading Rate

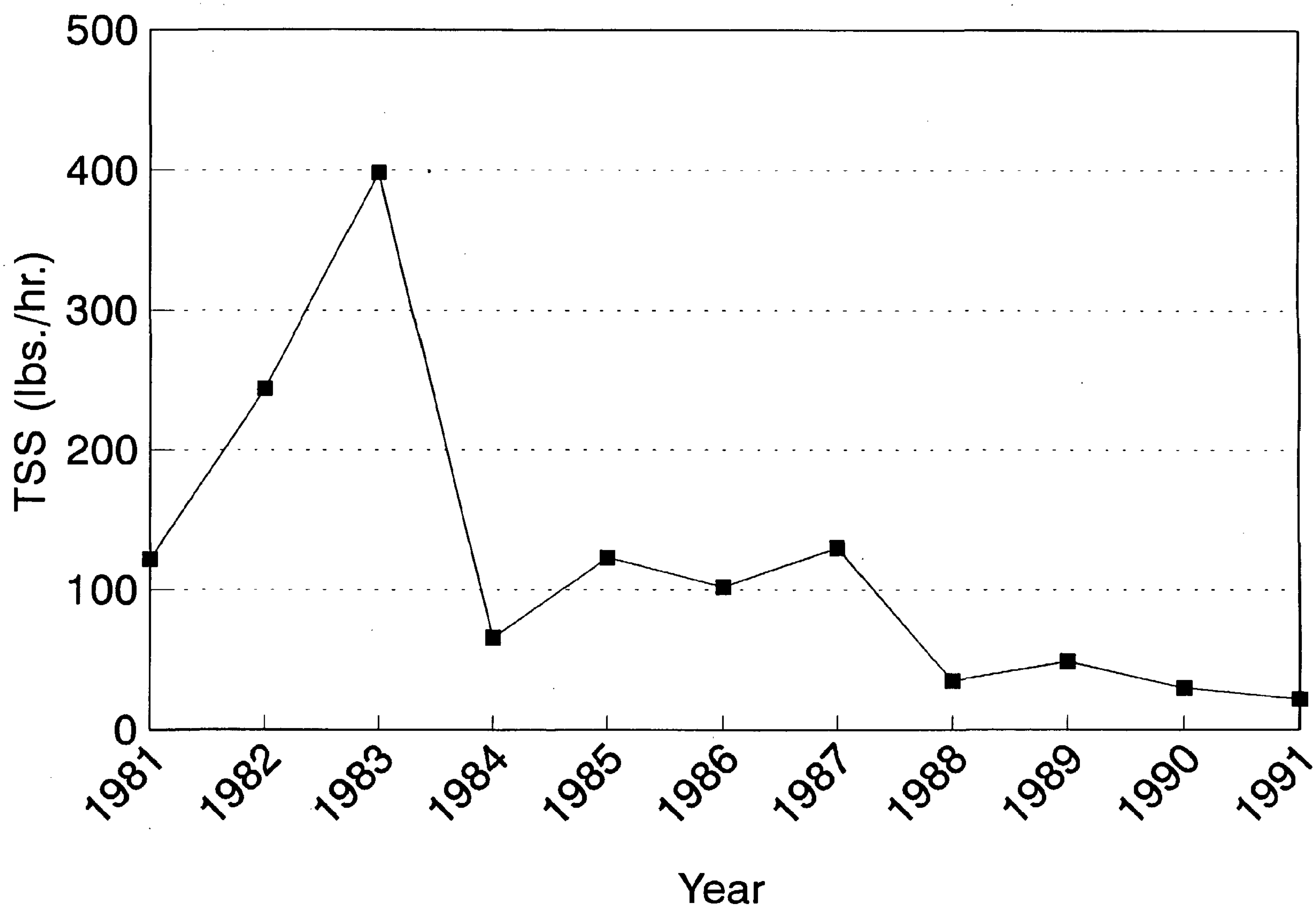
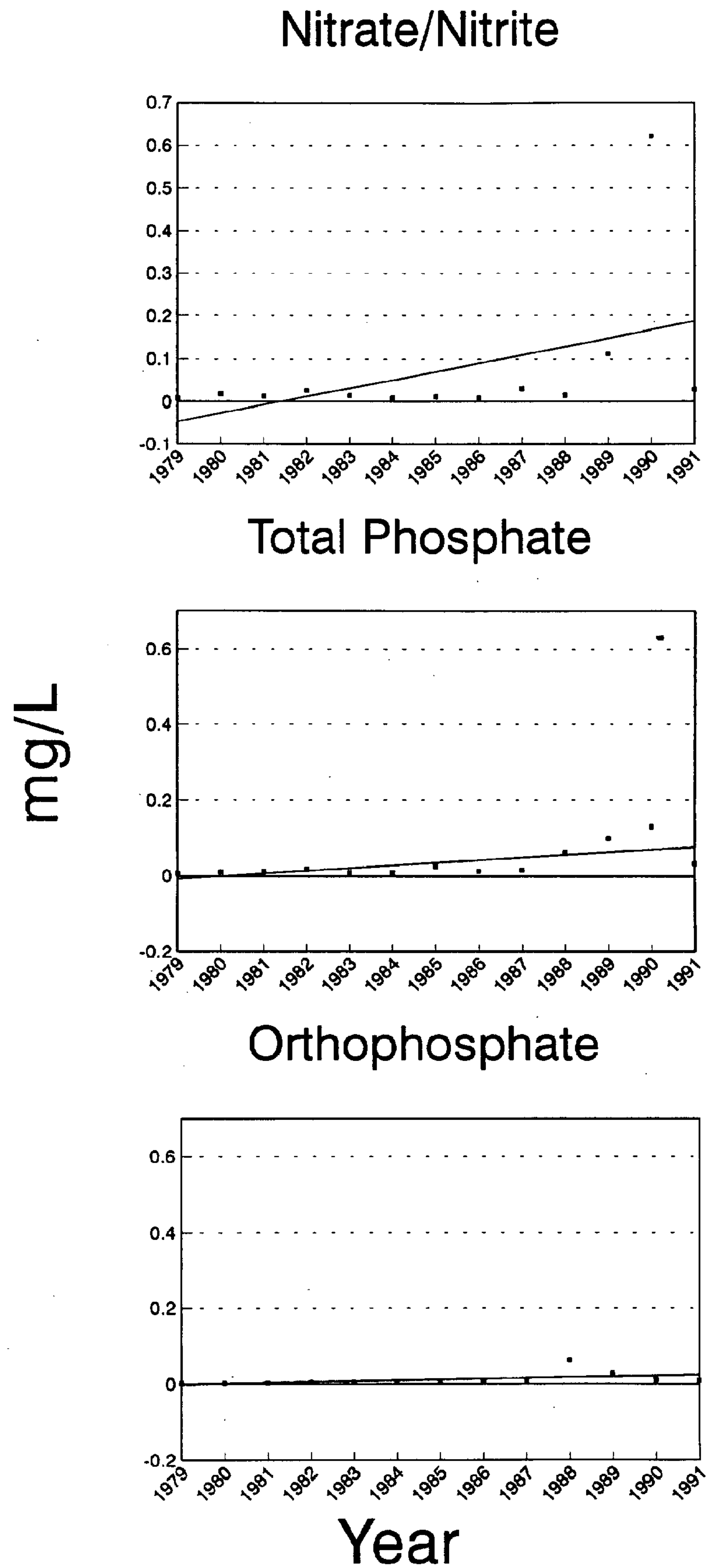


Figure 8-5. Faka-Union Canal



8.4 POINT/NONPOINT SOURCE POLLUTION

Because of limited human activity in this region, pollution in the surface waters is probably minimal. The excessive amount of drainage is the most direct threat to the health of the downstream estuarine waters.

8.4.1 Agriculture: There are some small scale farming operations in South Golden Gate Estates which may provide some fertilizer and pesticide input. Larger agricultural operations north of I-75 may contribute pollutants to the Faka-Union canal system.

8.4.2 Nurseries: A few nurseries are located within the boundaries of North and South Golden Gate Estates, potentially adding fertilizers and pesticides to the system. Most are small scale facilities.

8.5 RESTORATION OPTIONS

This region, of the three undeveloped regions, is the most severely drained. Because of this condition, the most intensive restoration/remediation efforts will have to be employed in this region.

8.5.1 Hydrologic: The South Florida Water Management District is planning extensive work to restore a semblance of the historic hydrology in this region. At the time of this study, SFWMD has developed three different alternatives for the remediation of past hydrologic alterations in SGGE. The three alternatives developed include 1) installation of spreader swale at Dan House Prairie northeast of Port of the Islands resort, 2) complete removal of roads and canals south of I-75 and 3) partial removal of roads and selected filling of canals. These scenarios will be modeled to evaluate their effectiveness at meeting the desired objectives of the project (Big Cypress Basin 1994).

In the event that the modeling suggests extensive restoration efforts would be most prudent, the following activities should occur:

- **Installation of Spreader Swale and Appurtenances Adjacent to I-75**
  Sheetflow on the northern edge of SGGE should be reestablished by construction of a spreader swale system along the south edge of I-75. This system should be designed in such a manner as to allow for additional water to be spread across the top of Belle Meade when warranted.

  Estimated Cost: >$2 million
  Applicable Objectives: RBNERR OBJ 2.6
  CCGMP-Cons. OBJ 2.2

- **Filling of Canals**
  Faka-Union Canal should be removed as the sole point source discharge of freshwater. A spreader swale should be placed north of US 41 to spread freshwater across the entire

southern boundary as surface flow, which will enter the estuaries through culverts under US 41.

Based on an unpaved, limerock road base thickness above natural grade of 12 inches (including stabilizer), one mile of road will provide 4400 yd^3 of fill. If the canals are blocked completely at intervals of 1300 foot centers (at the end of each road) and filled the width of a road easement, the scraping and complete removal of one road between the canal and a Boulevard (Everglades, DeSoto, etc.) will not provide adequate fill. Using fill from the roads on opposite sides of the canal, however, will provide sufficient amounts for all but the largest cross-sectional areas. Surveying of spoil banks alongside the canals may reveal additional fill suitable for blocking other sections of the canals. *(see Appendix C for fill estimates)*

Estimated Cost: $3,000-20,000/60ft. plug
Applicable Objectives: RBNERR OBJ 2.6
CCGMP-Cons. OBJ 2.2, 6.2, 6.7, 6.8 and 7.3

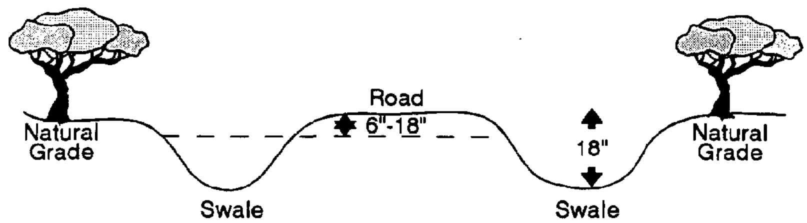
♦ **Removal of Roadbeds**

While some paved and unpaved roadways will be maintained for emergency purposes, removal of as many roadways and their adjacent swales as possible will aid in the hydrologic restoration of the area. The unpaved roads should be scraped down to their original elevation. Some of the fill could be used in the swales, the remaining fill could be pushed directly into the plugged canals or sold , with the proceeds used for the restoration activities. Slash pines growing in spoil piles along the roadside swales could be logged and sold, with the proceeds again funding additional restoration activities. In areas where roadways disrupted a major slough, replanting of native vegetation, including cypress, should be completed to help the system recover some semblance of its former integrity.

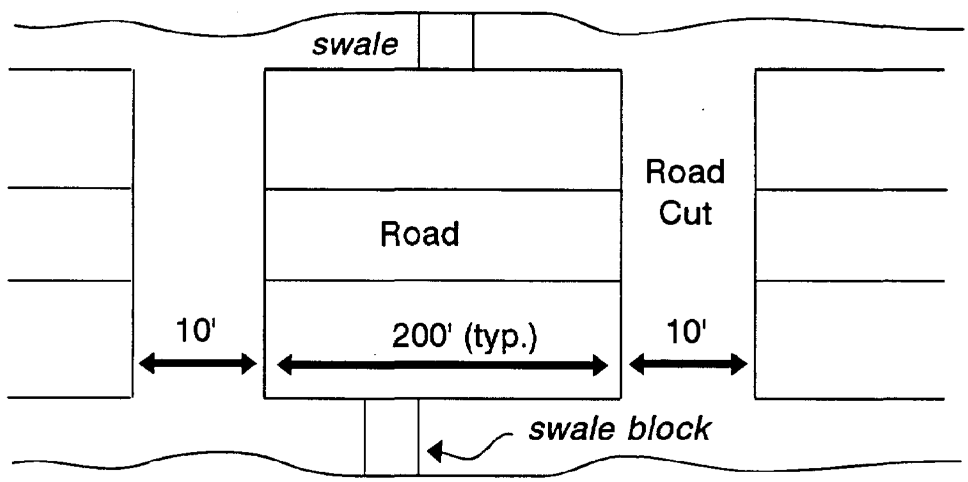
If complete removal of the roadbeds is not economically feasible for all locations, partial removal may be sufficient to remediate past hydrologic alterations. As seen in Figure 8-6, the roads could be cut at approximately 200 foot intervals or as appropriate at slough crossings. The cuts could average 10 feet wide with the removed fill used as plugs in the adjacent roadside swales. Final restoration might include replanting of cypress as mitigation. As seen in Figure 8-7, road removal may be accomplished in a stepwise fashion by removing whole or parts of certain roads based on priority. If a spreader swale system is installed in the northern part of SGGE, roads and canals south of the spreader swale but north of roads that currently flood should be removed first to restore historic water flowways. Roads at the southern end, which now are susceptible to flooding, should be removed as funding permits. On the very northern edge, roads should not be completely removed until they are no longer in use by residents. Culvert placement in these roads should allow proper dispersion of water from the spreader system. A complete topographic survey of road elevations should occur prior to any restoration efforts. Type A removals are classified as priority in order to convey surface water

Figure 8-6. Restoration Options for Roads in South Golden Gate Estates

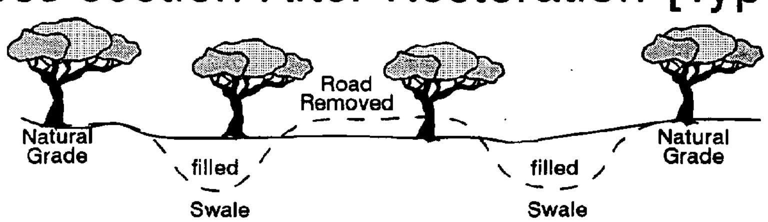
Cross-section Before Restoration



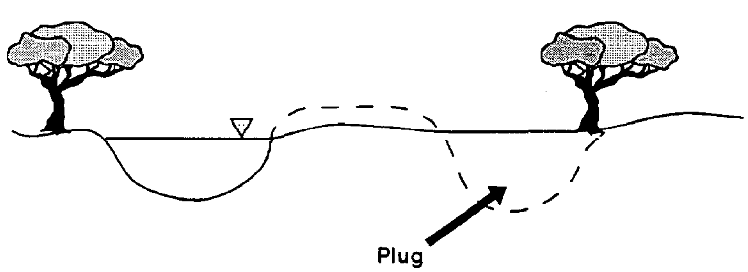
Roadways with Cut-throughs [Type II]

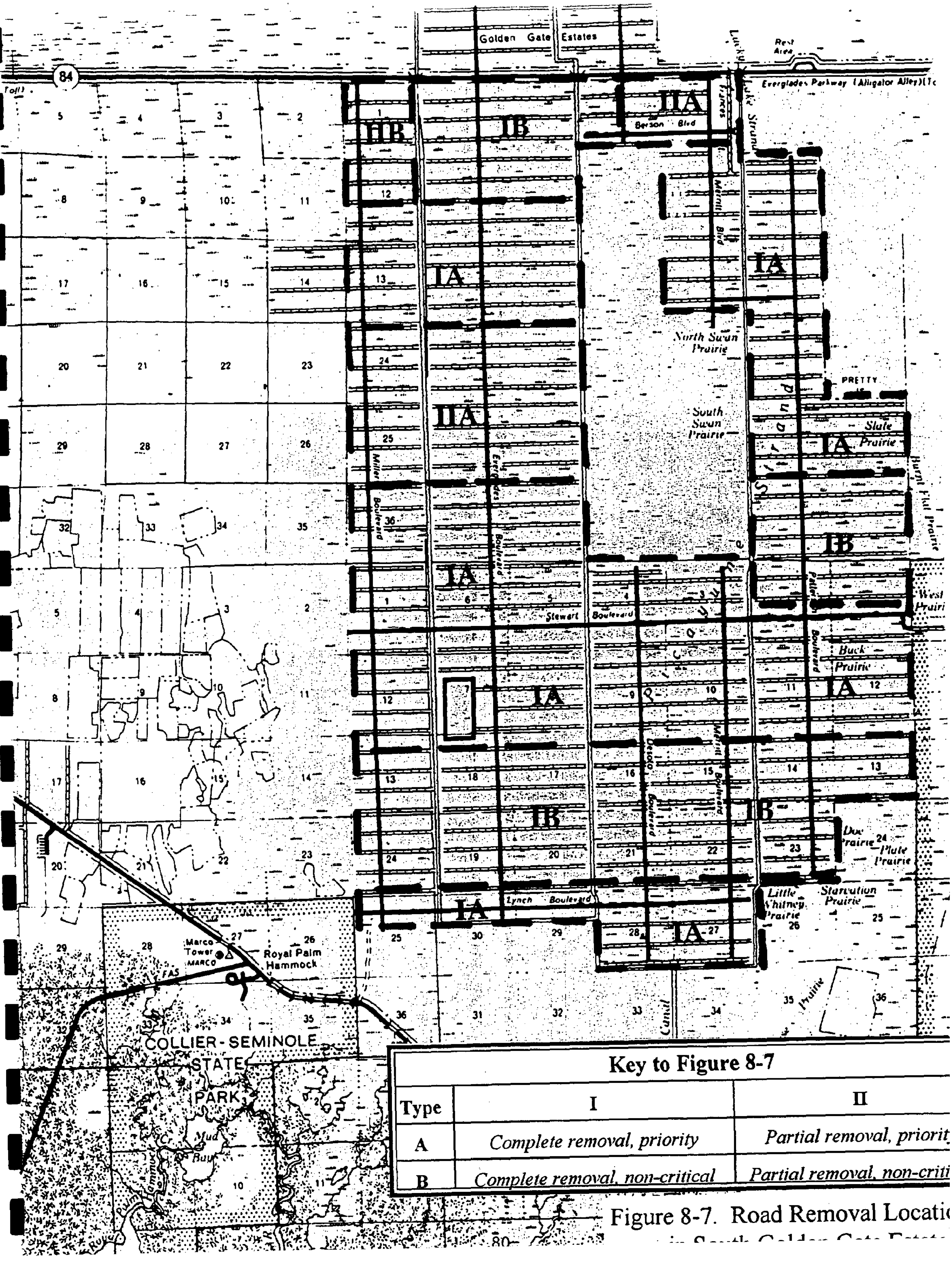


Cross-section After Restoration [Type I]



Profile of Plugged Swale [Type II]





Key to Figure 8-7		
Type	I	II
A	*Complete removal, priority*	*Partial removal, priorit*
B	*Complete removal, non-critical*	*Partial removal, non-criti*

Figure 8-7. Road Removal Locati

through historic wetland sloughs. Currently, the existing road elevations impede historic flow patterns. Type B areas are lower priority since they are used to access residences or are already susceptible to flooding. Type I designations refer to roads that do not cross large upland areas. Type II designated roads cross upland areas.

Estimated Cost: Removal of the fill from the roads will run on the order of $2,000 to $3,000 per mile.
Applicable Objectives: RBNERR OBJ 2.5
CCGMP-Cons. OBJ 2.2 and 6.7

- **The Use of SGGE as a Mitigation Area:** Because of the rapid development of SW Florida, certain wetlands in areas designated for development will be destroyed. The need for parcels of land off-site of the development area that can be hydrologically and vegetatively restored for mitigation creditswill increase. If SFWMD will not be able to efficiently, effectively and in a timely manner be able to complete the remediation work in this area because of fiscal constraints, it is suggested that SGGE be used as a mitigation site. The state should designate either the Division of Forestry or SFWMD or a third party for management of the mitigation.

  Estimated Cost: to be financed by development interests
  Applicable Objectives: RBNERR OBJ 2.6 and 2.7
  CCGMP-Cons. OBJ 2.1, 2.2, 2.3, 6.8 and 7.3

8.5.2 Land Conservation:

The purchase of lands under the CARL program should be intensified. Funding of a staff position to be located in Collier County or greater cooperation with local public and private groups and individuals should occur to expedite the purchases.

Estimated Cost: $25 million (given that approximately 2/3 of the area has been purchased)
Applicable Objectives: RBNERR OBJ 2.5
CCGMP-Cons. OBJ 1.3

8.5.3 Vegetation:

- **Division of Forestry, who will be managing the land, should formulate and implement an Exotic Removal Plan.** Reflooding the system will not halt the invasion and proliferation of Brazilian pepper and Melaleuca. A strict plan of removal is needed to keep these exotics under control.
  Estimated Cost: <$400/acre, low intensity infestation
  $3,000-4,000/acre, high intensity infestation
  Applicable Objectives: RBNERR OBJ 2.7
  CCGMP-Cons. OBJ 6.8
  CCGMP-Rec. OBJ 1.1

8.5.4 Water Quality Assessment:

- **A comprehensive sampling of water and sediment from the canal network for nutrient, metal and pesticide concentrations should occur prior to, throughout and following restoration efforts.**

  Estimated Cost: $50,000
  Applicable Objectives: RBNERR OBJ 2.16
  CCGMP OBJ 2.2, 2.3 and 7.3

FAKAHATCHEE STRAND

The geographic region known as Fakahatchee Strand lies within the Fakahatchee Strand Watershed Basin. The area is bounded by I-75 to the north, US 41 to the south, SR 29 to the east and South Golden Gate Estates to the west. Topographically, the majority of the basin lies between 5 and 15 feet above mean sea level, with the southern boundary sloping down to sea level (DEP 1994). In 1974, under the Environmentally Endangered Lands program, land within the Preserve boundaries began being purchased (DEP 1994). The State Preserve area currently totals 63,203 acres, with an additional 24,000 acres identified for acquisition by the State (DEP 1994).

The small town of Copeland is a cluster of residences situated on the southeastern boundary of the Strand, with a few scattered residences within the Strand proper. Additionally, the Copeland Road Prison, which houses approximately 60 inmates, is located on SR 29 along the eastern boundary of the Strand.

9.1 VEGETATION

Beginning in the 1940s, cypress trees were logged from the Strand for use in shipbuilding, crates and other wood products. Removal of the trees, in conjunction with construction of tramlines, altered the vegetative structure of the Strand. In cypress-dominant areas, removal allowed less dominant species to take their place, e.g. slash pine and mixed swamp species. Tramlines altered surface water hydrology and, in some cases, the hydroperiod in a particular area, initiating subtle changes in the vegetative structure of the Strand, such as an influx of slash pine due to the shortened hydroperiod.

The Preserve is composed almost entirely of wetland communities (DEP 1994). Only a few upland islands, primarily prairie hammocks, are present within the Preserve (DEP 1994).

Table 9-1. Vegetative Communities within Fakahatchee Strand

Upland / Wetland Breakdown		
Vegetation	**Acres**	**Percent Cover**
Upland	139	0.3
Wetland	52,007	99.7
Total	52,146	100

* DEP 1994

The dominant wetland vegetation, cypress and mixed swamps, form sloughs which direct surface water flow south into the estuaries.

Table 9-2. Vegetative Communities within Fakahatchee Strand		
Wetland Communities		
Vegetation	**Acres**	**Percent Cover**
Prairie/Marsh	12,863	25
Cypress/Mixed Swamp	37,597	72
Hydric Pine Flatwood	1,547	3
Total	52,007	100

* DEP 1994

9.2 HYDROLOGY

9.2.1 Historic: Surface water flows to the south seasonally through Fakahatchee Strand. During the wettest months, June through October, water historically moved as sheet flow from Okaloacoochee Slough in the northeast corner of Collier County south across the Preserve at a rate of 0.5 miles per day, and continued south into the adjacent estuaries (DEP 1994).

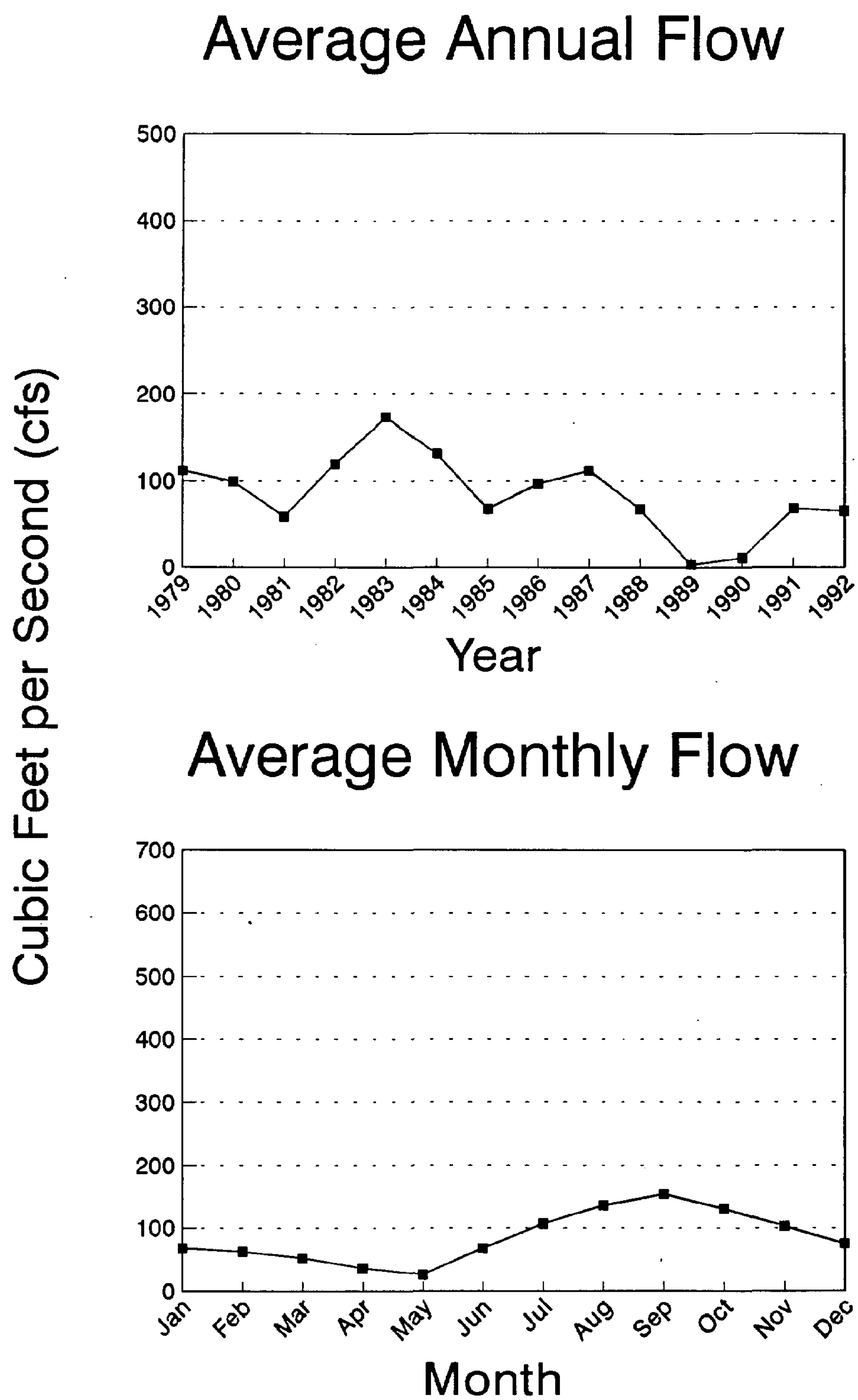
Surface water from the Fakahatchee Strand Basin flows south into the Ten Thousand Islands (DEP 1994). The Ten Thousand Islands, in conjunction with Cape Romano, has been designated as an Aquatic Preserve. The southern boundary of Fakahatchee Strand State Preserve joins the Cape Romano-Ten Thousand Islands Aquatic Preserve, forming a protected linkage between freshwater wetland ecosystems to the north and estuarine wetland ecosystems to the south.

9.2.2 Recent: Tram lines were built in the 1940s and 1950s within Fakahatchee Strand to remove logged cypress trees from the area (DEP 1994). While the tram lines have altered some of the surface water flowways (DEP 1994), it is believed that their impact on the system and its function has been minimal.

Presently, flow originating north of I-75 passes through culverts under the highway, entering the Fakahatchee Strand Basin (DEP 1994). Some of the water from north of I-75 is directed into a borrow canal on the south side of the highway (DEP 1994). The remainder of the water flows south, passing under W.J. Jane's Memorial Scenic Drive and US 41 via culverts, and enters the Ten Thousand Islands estuarine system (DEP 1994). The Golden Gate Canal System to the west causes drainage along the western boundary of the Fakahatchee Basin, indirectly affecting surface water flow (DEP 1994).

Drainage canals along US 41 have reduced freshwater flow from inland areas toward the coast, allowing salt water intrusion in areas south of US 41 and expansion of mangrove forests northward (DEP 1994). The average annual flow for Barron Canal is about 100 cfs, with a seasonal peak flow of approximately 180 cfs (Figure 9-1).

Figure 9-1. Barron River Canal Flow Rates



9.3 WATER QUALITY

Water quality parameters were analyzed from 1979 through 1991 on the Barron River Canal (CCPCD 1993). The Barron Canal exhibited the characteristic inverse relationship between flow rate and specific conductance (Figure 9-2). Nitate/nitrite (NOx), total phosphate (TPO_4) and orthophosphate (OPO_4) were examined for the Barron Canal station. NOx levels showed an overall increase over time, as did total and orthophosphates levels (Figure 9-3). This suggests a gradual influx of nutrients to the system and may be a cause for concern if the trend persists.

Long-term and consistent data for both upriver and downriver stations along the Barron Canal and River are needed to determine the amount of nutrients entering the Ten Thousand Islands estuarine system. Additionally, the source of these nutrients should be determined so that practices can be altered and the system is not overloaded, causing eutrophication.

9.4 POINT/NONPOINT SOURCE POLLUTION

9.4.1 Agriculture: On the north end of the Preserve, fertilizers and pesticides may potentially enter the system from the concentrated agricultural lands on the east side of Camp Keais Strand. Runoff from these fields moves south through the Florida Panther National Wildlife Refuge and under I-75 via culverts.

A recent concern has arisen over the presence of methyl mercury in the tissues of Florida panthers that frequent the Preserve. The most likely sources of methyl mercury include atmospheric emissions from solid waste incinerators, atmospheric emissions from the burning of sugar cane and emission from the oxidation of natural peat soils containing mercury, which can result from draining marshlands for agriculture (DEP 1994). In addition to these sources, certain fertilizers and pesticides used on agricultural fields contain mercury which may become bioavailable within the system. While the source may never be known, the presence of these pollutants within Fakahatchee Preserve is of concern.

9.4.2 Sewage Treatment Plants: There are two wastewater treatment plants within the basin: one at the Copeland Road Prison and one in the town of Copeland, called the Lee Cypress Co-Op Waste Water Treatment Plant. While the prison plant is operating adequately, the Lee Cypress Plant needs repair. If left in its present state, the plant could discharge nutrient laden water, causing eutrophication within a pristine system.

9.4.3 Urban Runoff: Runoff from I-75 may enter the Strand, potentially degrading the system. On the southern end of the Preserve, runoff from US 41 flows under culverts and enters the fragile estuarine communities.

9.5 RESTORATION OPTIONS

The options suggested below, or forms there of, have also been targeted by Fakahatchee State Preserve in their Management Plan.

9.5.1 Hydrologic: Observations on flow dynamics should be implemented to determine if the

Figure 9-2. Barron River Canal

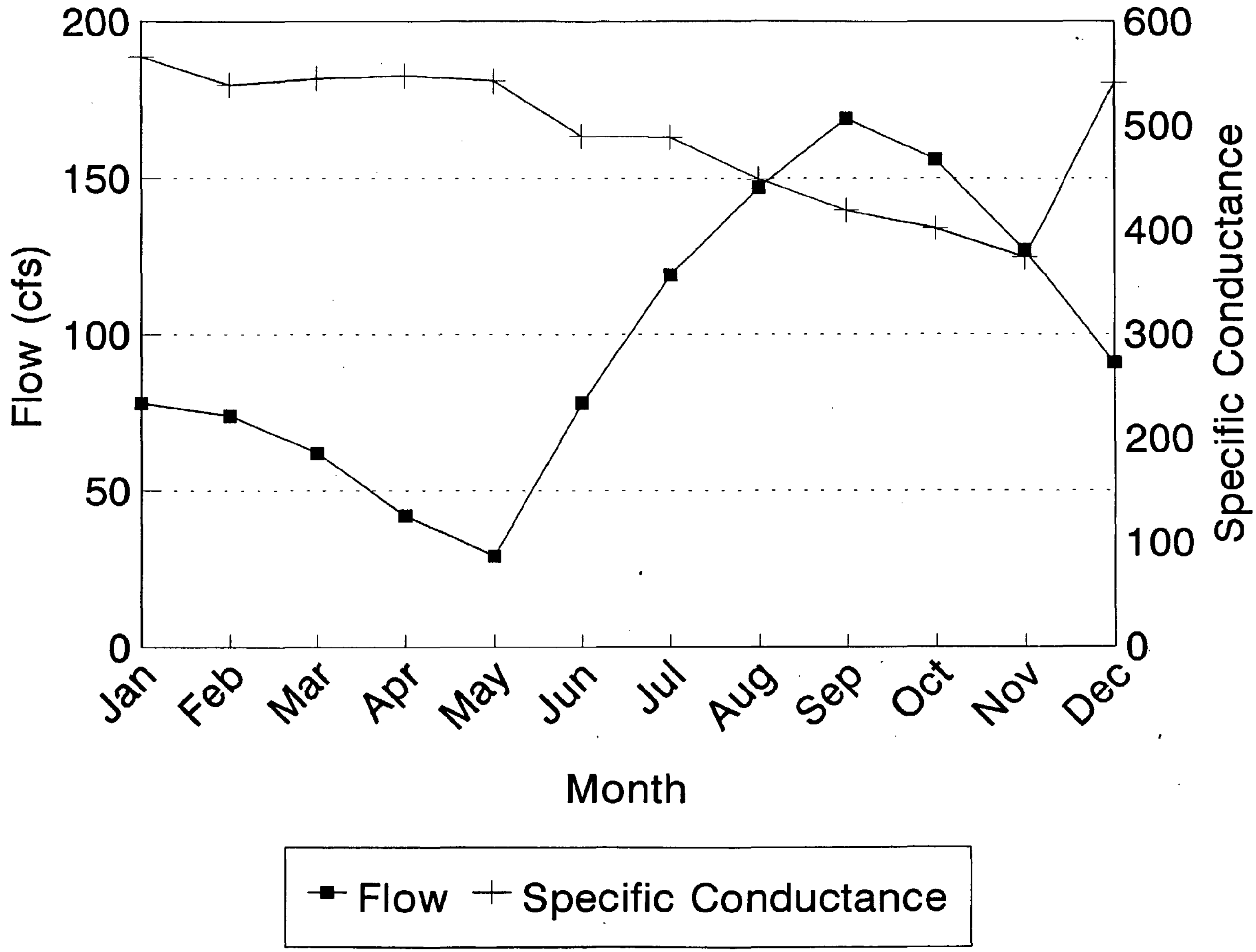
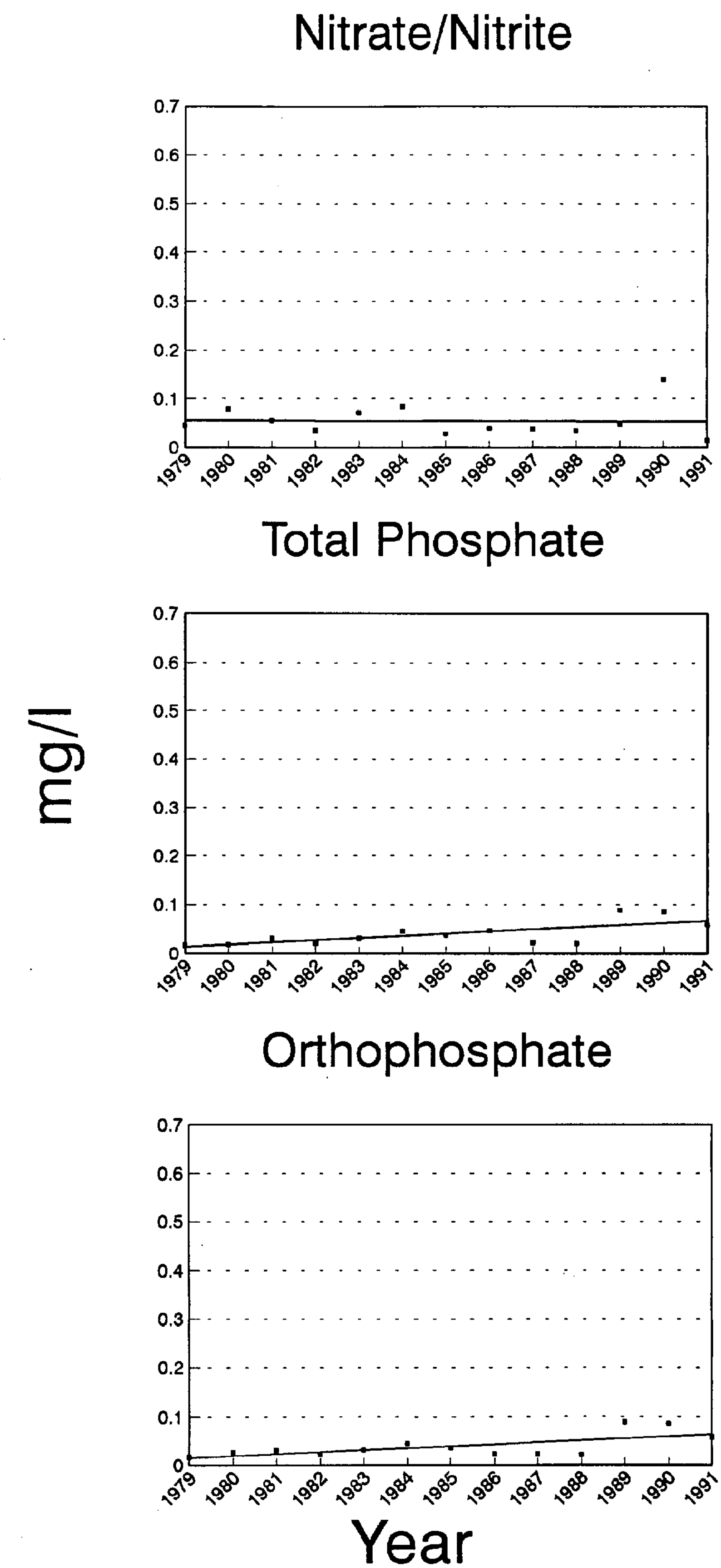


Figure 9-3. Barron River Canal



culverts under SR 29 are sufficient to rehydrate prairies on the east side of Fakahatchee Strand.

Estimated Cost: to be incorporated within normal staff duties at Fakahatchee Strand State Preserve
Applicable Objectives: RBNERR OBJ 2.6
CCGMP-Cons. OBJ 1.1

9.5.2 Land Conservation: Following the State acquisition of lands remaining within Fakahatchee Strand, the region can be managed as a whole, with no remaining outparcels. Management of this land should include a schedule of prescribed burns (DEP 1994).

Estimated Cost: dependent upon number of parcels and condition of land
Applicable Objectives: RBNERR OBJ 2.5
CCGMP-Cons. OBJ 1.3 and 6.8

9.5.3 Vegetation: Many of the wetland communities, which were historically present, remain intact today. Some of the communities have been altered due to invasion of exotic species, such as melaleuca, Brazilian pepper and air potato (DEP 1994), and logging activities. Australian pine and melaleuca are currently under control and will soon be eradicated from the Preserve (DEP 1994). The estimated population of melaleuca within the Preserve was 10,000 trees in 1990 and, due to exotic control practices, was reduced to 2,000 trees in 1992 (DEP 1994).

Additionally, some areas have been developed as roadways and tramlines. Most tramlines have not been used since the 1960s and are recolonizing with native vegetation. Monitoring the colonization of the tramlines may provide insight into the succession of native plant species.

Estimated Cost: $1,000-2,000/acre
Applicable Objectives: RBNERR OBJ 2.7
CCGMP-Cons. OBJ 1.1

9.5.4 Water Quality: Management of the Preserve should include long-term physical data on the amount of water, timing of water and flow rates. In conjunction with the physical data collection, there should be a water quality monitoring program to examine nutrients and pesticides entering the watershed with an attempt to determine the sources and stop the input.

Estimated Cost: $50,000
Applicable Objectives: RBNERR OBJ 2.16
CCGMP-Cons. OBJ 2.2, 2.3 and 7.3

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APPENDIX A

Pesticides Used On Golf Courses Within The Watershed

Pesticide Use on Golf Courses within the Watershed			
Number and Region	**Insecticides**	**Fungicides**	**Herbicides**
1. Belle Meade Area (S)	-amdro -dursban -oftanol -orthene -nemacur	-alganax -Cleary's 3336 -subdue -triple action	-basagran -2,4-D -image -kerb -MSMA
2. Belle Meade (SW)	-orthene -proax -turcam granules	-Cleary's 3336 -fore	-basagran -Scott's DMC -illoxan -MSMA
3. Belle Meade (S)	-astrol -dipel -dursban -mole cricket bait -kelthane -mavrik -nemacur -orthene -oftanol -permanone -proax -slugfest -triumph -turcam -vector	-alliette -award -banrot -chipco -consan -fore -Lesco 4 FLBL -subdue -thalonil	-basagran -2,4-D -fusilade -gallery -garlon -illoxan -image -kerb -MSMA -roundup -rodeo -sencor -surflan -trimec
4. Belle Meade (S)	-dursban -orthene -nemacur	-daconil -manyx -subdue	-illoxan -MSMA -trimec
5. Water Management District 6 (N)	-dimension -gammamean -mavrik -oftanol -orthene -sevin	-arsenal -award -benomyl -chipco -daconil -dursban -subdue	-illoxan -MSMA -remedy -roundup -surflan -trimec -tordon

Number and Region	Insecticides	Fungicides	Herbicides
6. Water Management District 6 (N)	-dursban -orthene -pagent	-banall -daconil -subdue	-2,4-D -illoxan -MSMA
7. Water Management District 6 (SW)	-amdro -nemacur -sevin -sevin mole cricket bait	-bayleton -chipco -subdue	-barracade -basagran -2,4-D -illoxan -roundup
8. Water Management District 6 (W)	-dursban -gammamean -orthene -proax -turcam	-bayleton -daconil -rubigan -subdue	-basagran -illoxan -image -MSMA -sencor
9. Water Management District 6 (NE)	-astrol -dursban -orthene	-thalonil	-basagran -MSMA -roundup
10. Water Management District 6 (W)	-crusade -dursban -nemacur -orthene -triumph -turcam -vector	-daconil -mancozeb -subdue -thalonil	-basagran -gallery -kerb -illoxan -Lesco 3-way -MSMA -roundup
11. Water Management District 6 (N)	-amdro -mavrik -nemacur -orthene -triumph -turcam	-alliette -award -banall -banner -bayleton -coban -daconil -subdue	-barricade -basagran -Scott's BMC -gallery -illoxan -MSMA -roundup -sencor -surflan -trimec

Number and Region	Insecticides	Fungicides	Herbicides
12. Water Management District 6 (N)	-dursban -orthene -talstar -tempo	-alliette -daconil -mancozeb -subdue	-asulox -basagran -illoxan -MSMA -sencor

APPENDIX B

Management And Storage Of Surface Water Permits Issued Within The Watershed

Water Management District Permits						
Permit #	Permittee	Location S-T-R	Acreage	Retention Acreage	25 yr storm discharge (cfs)	Receiving Water Body
75	Thomas Bros.	10-51-28	160	12	10.1	n/a
76 and 97	6Ls	51-27	2737	n/a	173	US 41 Canal
79	West Fla Aqua	4-51-28	105	95	31	US 41 Canal
85	Collier Dev. Corp.	31-50-26	640	n/a	40.4	n/a
95	N.T. Gargiulo	10-51-28	1965	n/a	124	Tidal Marsh
116	Carl Gran	6-51-27	174	n/a	11	US 41 Canal
144	Double B Farms	4-51-27	265	n/a	18.9	Henderson Creek
201	K. Smits and Sons	25-50-26	640	n/a	40	Henderson Creek
124	Riverwood	10-51-27	n/a	infiltration trench	n/a	n/a
137	Del-Meade Park	11-51-27	56.5	infiltration with overflow	n/a	n/a
191	Naples Isles	17-51-27	207	41	11	US 41 Canal
194	Quail Roost	11-51-27	53	12.9	38.7	Henderson Creek
203	Sander's Quarry	20-50-27	83.6	61.6	10	Henderson Creek

Permit #	Permittee	Location S-T-R	Acreage	Retention Acreage	25 yr storm discharge (cfs)	Receiving Water Body
204	Eagle Creek	4-51-27	324	n/a	n/a	Henderson Creek
240	Imperial Wilderness	13-51-26	n/a	7.8	30	Tidal Marsh
331	Rinker Quarry	11-50-26	330	n/a	n/a	n/a
368	Landfill	36-49-26	307	34	54	Henderson Creek
450	Woodfield Lake	3-51-27	75	21.5	9	Tidal Marsh
544	Tall Oaks	33-50-26	57.6	7.4	3	Henderson Creek
685	Mass. Mutual	24-51-26	950	n/a	n/a	Tidal Marsh

APPENDIX C

Volume Of Fill Required For South Golden Gate Estates Canals

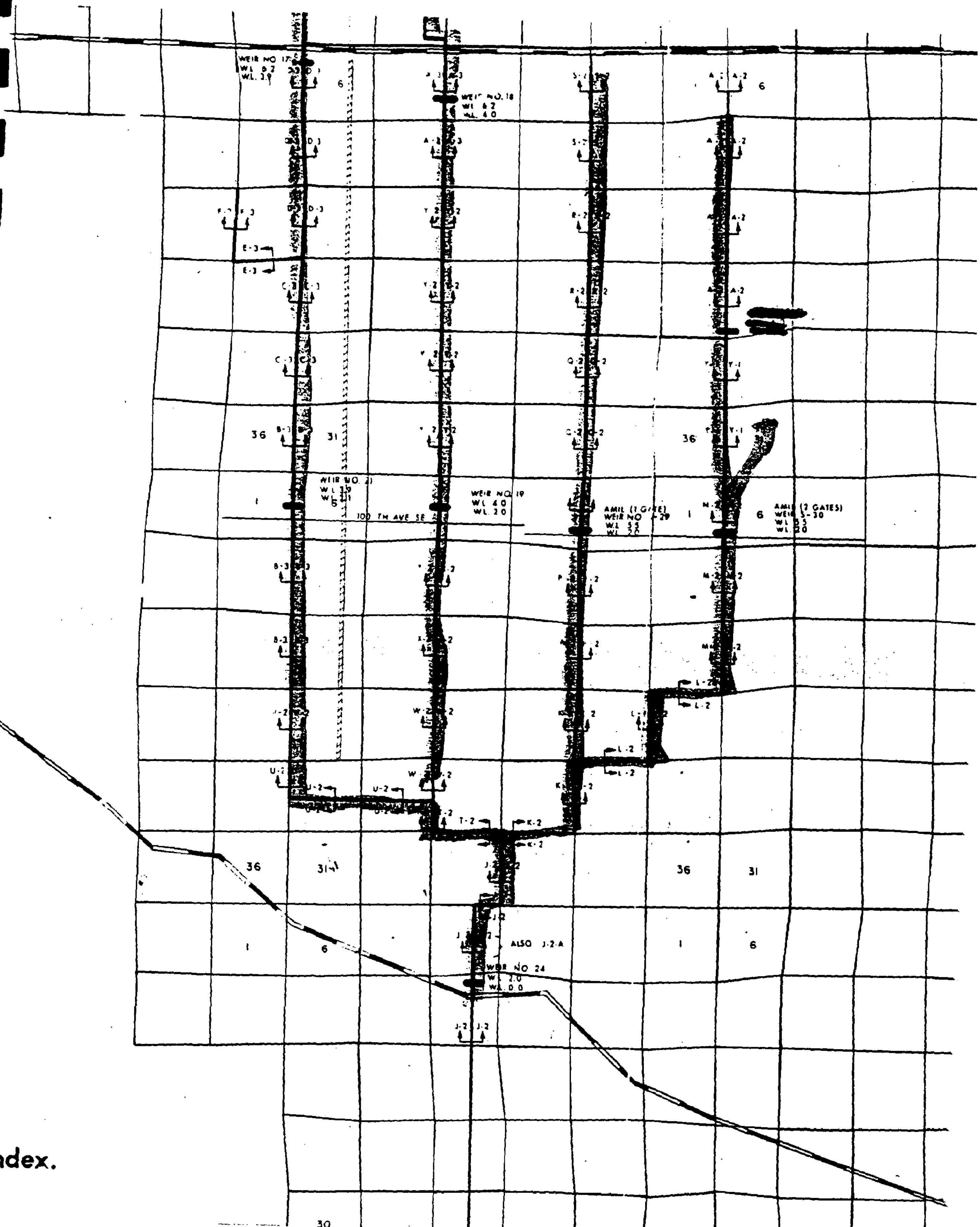

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Figure A. South Golden Gate Estates Canal Cross-sections.

South Golden Gate Canals		
Canal	**Cross-Section**	**Volume (yd³ per 60 ft. length)**
MILLER	D-3	4,950
	C-3	7,280
	B-3	8,340
	V-2	8,210
	U-2	10,220
FAKA UNION	A-3	17,150
	Y-2	20,000
	X-2	20,850
	W-2	24,440
	T-2	53,330
MERRITT	S-2	1,690
	R-2	3,890
	Q-2	5,500
	P-2	11,460
	K-2	14,080
PRAIRIE	A-2	1,450
	Y-1	2,670
	N-2	3,320
	M-2	3,500
	L-2	5,500

APPENDIX D

Water Quality Standards For The State Of Florida

APPENDIX D

Water Quality Standards For The State Of Florida

Parameter	Units	Class I: Potable Water Supply	Class II: Shellfish Propagation or Harvesting	Class III: Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife		Class IV: Agricultural Water Supplies	Class V: Navigation, Utility and Industrial Use
				Predominantly Fresh Waters	Predominantly Marine Waters		
1. alakalinity	milligrams/l as $CaCO_3$	shall not be depressed below 20		shall not be depressed below 20		≤600	
2. aluminum	milligrams/l		≤1.5		≤1.5		
3. ammonia (unionized)	milligrams/l as NH_3	≤0.02		≤0.02			
4. antimony	micrograms/l	≤14.0	≤4,300	≤4,300	≤4,300		
5a. arsenic (total)	micrograms/l	≤50	≤50	≤50	≤50	≤50	≤50
5b. arsenic (trivalent)			≤36		≤36		

Parameter	Units	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
6. bacteriological quality (fecal coliform bacteria)	number per 100 ml (most probable number (MPN) or membrane filter (MF))	MPN or MF counts shall mot exceed a monthly average of 200, nor exceed 400 in 10% of the samples. Monthly averages shall be expressed as geometric means based on a minimum of 5 samples taken over a 30 day period.	MPN shall not exceed a median value of 14 with not more than 10% of these samples exceeding 43	MPN or MF counts shall not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on a miniimum of 10 samples taken over a 30 day period.	MPN or MF counts shall not exceed a monthly average of 200, nor exceed 400 in 10% of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on a miniimum of 10 samples taken over a 30 day period.		
7. bacteriological quality (total coliform bacteria)	number per 100 ml (most probable number (MPN) or membrane filter (MF))	≤1,000 as a monthly avg., nor exceed 1,000 in more than 20% of the samples examined during any month, nor exceed 2,400 at any time, using either MPN or MF counts.	median MPN shall not exceed 70, and not more than 10% of the samples shall exceed an MPN of 230.	≤1,000 as a monthly avg., nor exceed 1,000 in more than 20% of the samples examined during any month; ≤2,400 at any time. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period,using either MPN or MF counts.	≤1,000 as a monthly avg., nor exceed 1,000 in more than 20% of the samples examined during any month; ≤2,400 at any time. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period,using either MPN or MF counts.		

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
8. barium	milligrams/l	≤1					
9. benzene	micrograms/ l	≤1.18	≤71.28 annual avg.	≤71.28 annual avg.	≤71.28 annual avg.		
10. beryllium	micrograms/ l	≤0.0077 annual avg.	≤0.13 annual avg.	≤0.13 annual avg.	≤0.13 annual avg.	≤100 in waters with a hardness in mg/l of $CaCO_3$ of less than 250 and shall not exceed 500 in harder waters	

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
11. biological integrity	percent reduction of Shannon-Weaver Diversity Index	The Index for benthic macroinvert-ebrates shall not be reduced to less than 75%of background levels as measured using organisms retained by U.S. standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15m² area each, incubated for a period of four weeks.	The Index for benthic macroinvert-ebrates shall not be reduced to less than 75%of background levels as measured using organisms retained by U.S. standard No. 30 sieve and collected and composited from a minimum of three natural substrate samples, taken with Ponar type samplers with a minimum sampling area of 225 cm².	The Index for benthic macroinvert-ebrates shall not be reduced to less than 75%of background levels as measured using organisms retained by U.S. standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15m² area each, incubated for a period of four weeks.	The Index for benthic macroinvert-ebrates shall not be reduced to less than 75%of background levels as measured using organisms retained by U.S. standard No. 30 sieve and collected and composited from a minimum of three natural substrate samples, taken with Ponar type samplers with a minimum sampling area of 225 cm².	≤4.42 annual avg.	
12. BOD (biochemical oxygen demand)		Shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions.					

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
13. boron	milligrams/l					≤0.75	
14. bromates	milligrams/l		≤100		≤100		
15. bromine (free molecular)	milligrams/l		≤0.1		≤0.1		
16. cadmium	micrograms/l	$Cd \le e^{(0.7852[\ln H]-3.49)}$; 10 max	≤9.3	$Cd \le e^{(0.7852[\ln H]-3.49)}$	≤9.3		
17. carbon tetrachloride	micrograms/l	≤0.25 annual avg.; 3.0 max	≤4.42 annual avg.	≤4.42 annual avg.	≤4.42 annual avg.		
18. chlorides	milligrams/l	≤250	Not increased more than 10% above normal background. Normal daily and seasonal fluctuations shall be maintained.		Not increased more than 10% above normal background. Normal daily and seasonal fluctuations shall be maintained.		In predominantly marine waters, not increased more than 10% above normal background. Normal daily and seasonal fluctuations shall be maintained.
19. chlorine (total residual)	milligrams/l	≤0.01	≤0.01	≤0.01	≤0.01		
20a. chromium (trivalent)	micrograms/l	Cr (III)$\le e^{(0.819[\ln H]+1.561)}$	≤673,000	Cr (III)$\le e^{(0.819[\ln H]+1.561)}$	≤673,000	Cr (III)$\le e^{(0.819[\ln H]+1.561)}$	In predominantly freshwaters, $\le e^{(0.819[\ln H]+1.561)}$. In predominantly marine waters, ≤673,000

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
20b. chromium (hexavalent)	micrograms/ l	≤11	≤50	≤11	≤50	≤11	In predominantly freshwaters, ≤11. In predominantly marine waters, ≤50.
21 chronic toxicity (see definition in Section 17-302.200(3), F.A.C and also see below "Substances in concentrations which...")							
22. color, etc. (see also minimum criteria, odor, phenols, etc.)	color, odor and taste producing substances and other deleterious substances, including other chemical compounds attributable to domestic wastes, industrial wastes and other wastes					Only such amounts as will not render the waters unsuitable for agricultural, irrigation, livestock watering, industrial cooling, industrial process water supply purposes, or fish survival	

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
23. conductance, specific	micromhos/ cm	shall not be increased more than 50% above background or to 1275, whichever is greater		shall not be increased more than 50% above background or to 1275, whichever is greater		shall not be increased more than 50% above background or to 1275, whichever is greater	shall not exceed 4,000
24. copper	micrograms/ l	Cu $\leq e^{(0.8545[\ln H]-1.465)}$	≤2.9	Cu $\leq e^{(0.8545[\ln H]-1.465)}$	≤2.9	≤500	≤500
25. cyanide	micrograms/ l	≤5.2	≤1.0	≤5.2	≤1.0	≤500	≤500
26. definitions (see Section 17-302.200, F.A.C)							
27. detergents	milligrams/l	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5
28. 1,1-dichloroethylene (1,1-dichloroethene)	microgrmas/ l	≤0.057 annual avg.; ≤7.0 max	≤3.2 annual avg.	≤3.2 annual avg.	≤3.2 annual avg.		
29. dichloromethane (methylene chloride)	micrograms/ l	≤4.65 annual avg.	≤1,580 annual avg.	≤1,580 annual avg.	≤1,580 annual avg.		
30. 2,4-dinitrotoluene	micrograms/ l	≤0.11 annual avg.	≤9.1 annual avg.	≤9.1 annual avg.	≤9.1 annual avg.		

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
31. dissolved oxygen	milligrams/l	shall not be less than 5.0. Normal daily and seasonal fluctuations above this level shall be maintained	shall not average less than 5.0 in a 24 hour period and shall never be less than 4.0. Normal daily and seasonal fluctuations above this level shall be maintained	shall not be less than 5.0. Normal daily and seasonal fluctuations above this level shall be maintained	shall not average less than 5.0 in a 24 hour period and shall never be less than 4.0. Normal daily and seasonal fluctuations above this level shall be maintained	shall not average less than 4.0 in a 24 hour period and shall never be less than 3.0	shall not be less than 0.3, fifty percent of the time on an annual basis for flows greater than or equal to 250 cubic feet per second and shall never be less than 0.1. Normal daily and seasonal fluctuations above this level shall be maintained
32. dissolved solids	milligrams/l	≤500 as a monthly avg.; ≤1,000 max					
33. fluorides	milligrams/l	≤1.5	≤1.5	≤10.0	≤5.0	≤10.0	≤10.0
34. "free froms" (see Minimum Criteria in Section 17-302.500, F.A.C.)							
35. "general criteria" (see Section 17-302.510, F.A.C. and individual criteria)							

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
36a. Halomethanes (total trihalomethanes) (total of bromoform, cholorodibromomethane, dichlorobromomethane and chloroform). Individual halomethanes shall not exceed b1. to b5. below	micrograms/l	≤100					
36b1. Halomethanes (individual): bromoform	micrograms/l	≤4.3 annual avg.	≤360 annual avg.	≤360 annual avg.	≤360 annual avg.		
36b2. Halomethanes (individual): chlorodibromomethane	micrograms/l	≤0.41 annual avg.	≤34 annual avg.	≤34 annual avg.	≤34 annual avg.		
36b3. Halomethanes (individual): chloroform	micrograms/l	≤5.67 annual avg.	≤470.8 annual avg.	≤470.8 annual avg.	≤470.8 annual avg.		
36b4. Halomethanes (individual): chloromethane (methyl chloride)	micrograms/l	≤5.67 annual avg.	≤470.8 annual avg.	≤470.8 annual avg.	≤470.8 annual avg.		

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
36b5. Halomethanes (individual): dichlorobromomethane	micrograms/l	≤0.27 annual avg.	≤22 annual avg.	≤22 annual avg.	≤22 annual avg.		
37. hexachlorobutadiene	micrograms/l	≤0.45 annual avg.	≤49.7 annual avg.	≤49.7 annual avg.	≤49.7 annual avg.		
38. imbalance (see nutrients)							
39. iron	milligrams/l	≤0.3	≤0.3	≤1.0	≤0.3	≤1.0	
40. lead	micrograms/l	Pb ≤ $e^{(1.273[\ln H]-4.705)}$; 50 max	≤5.6	Pb ≤ $e^{(1.273[\ln H]-4.705)}$; 50 max	≤5.6	≤50	≤50
41. manganese	milligrams/l		≤0.1				
42. mercury	micrograms/l	≤0.012	≤0.025	≤0.012	≤0.025	≤0.2	≤0.2
43. minimum criteria (see Section 17-302.500, F.A.C.)							
44. mixing zones (see Section 17-4.246, F.A.C.)							
45. nickel	micrograms/l	Ni ≤$e^{(0.846[\ln H]+1.1645)}$	≤8.3	Ni ≤$e^{(0.846[\ln H]+1.1645)}$	≤8.3	≤100	

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
46. nitrate	milligrams/l as N	≤10 or that concentration that exceeds the nutrient criteria					
47. nuisance species		substances in concentrations which result in the dominance of nuisance speciess: non shall be presen					
48a. nutrients		The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Sections 17-302.300, 17-302.700 and 17-4.242, F.A.C.					
48b. nutrients		In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural popuations of aquatic flora or fauna.					
49 odor (also see color, minimum criteria, phenolic compounds, etc.)	threshold odor number		shall not exceed 24 at 60 degrees C as daily average				Odor producing substances: only in such amounts as will not unreasonably interfere with the use of the water for the designated purpose of this classification.
50a. oils and greases	milligrams/l	dissolved or emulsified oils and greases shall not exceed 5.0	dissolved or emulsified oils and greases shall not exceed 5.0	dissolved or emulsified oils and greases shall not exceed 5.0	dissolved or emulsified oils and greases shall not exceed 5.0	dissolved or emulsified oils and greases shall not exceed 5.0	dissolved or emulsified oils and greases shall not exceed 10.0
50b. oils and greases		No undissolved,or visible oil defined as irridescence, shall be present so as to cause taste or odor, or otherwise interfere with the beneficial use of waters.					

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
51. pesticides and herbicides							
51a.2,4,5-TP	micrograms/l	≤10					
51b. 2,4-D	micrograms/l	≤100					
51c. aldrin	micrograms/l	≤0.00013 annual avg.; 3.0 max	≤0.00014 annual avg.; 1.3 max	≤0.00014 annual avg.; 3.0 max	≤0.00014 annual avg.; 1.3 max		
51d. betahexacholocyclohexane (b-BHC)	micrograms/l	≤0.014 annual avg.	≤0.046 annual avg.	≤0.046 annual avg.	≤0.046 annual avg.		
51e. chlordane	microgram/l	≤0.00058 annual avg.; 0.0043 max	≤0.00059 annual avg.; 0.004 max	≤0.00059 annual avg.; 0.004 max	≤0.00059 annual avg.; 0.004 max		
51f. DDT	micrograms/l	≤0.00059 annual avg.; 0.001 max	≤0.00059 annual avg.; 0.001 max	≤0.00059 annual avg.; 0.001 max	≤0.00059 annual avg.; 0.001 max		
51g. demeton	micrograms/l	≤0.1	≤0.1	≤0.1	≤0.1		
51h. dieldrin	micrograms/l	≤0.00014 annual avg.; 0.0019 max	≤0.00014 annual avg.; 0.0019 max	≤0.00014 annual avg.; 0.0019 max	≤0.00014 annual avg.; 0.0019 max		
51i. endosulfan	micrograms/l	≤0.056	≤0.0087	≤0.056	≤0.0087		

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
51j. endrin	micrograms/l	≤0.0023	≤0.0023	≤0.0023	≤0.0023		
51k. guthion	micrograms/l	≤0.01	≤0.01	≤0.01	≤0.01		
51l. heptachlor	micrograms/l	≤0.00021 annual avg.; 0.0038 max	≤0.00021 annual avg.; 0.0036 max	≤0.00021 annual avg.; 0.0038 max	≤0.00021 annual avg.; 0.0036 max		
51m. lindane (g-benzene hexachloride)	micrograms/l	≤0.019 annual avg.; 0.08 max	≤0.063 annual avg.; 0.16 max	≤0.063 annual avg.; 0.08 max	≤0.063 annual avg.; 0.16 max		
51n. malathion	micrograms/l	≤0.1	≤0.1	≤0.1	≤0.1		
51o. methoxychlor	micrograms/l	≤0.03	≤0.03	≤0.03	≤0.03		
51p. mirex	micrograms/l	≤0.001	≤0.001	≤0.001	≤0.001		
51q. parathion	micrograms/l	≤0.04	≤0.04	≤0.04	≤0.04		
51r. toxaphene	micrograms/l	≤0.0002	≤0.0002	≤0.0002	≤0.0002		
52a. pH (Class I and Class IV Waters)	standard units	Shall not vary more than one unit above or below natural background provided that the pH is not lowered to less than 6 units or raised above 8.5 units. If natural background is less than 6 units, the pH shall not vary below natural background or vary more than one unit above natural background. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below background.					

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
52b. pH (Class II Waters)	standard units	Shall not vary more than one unit above or below natural background of coastal waters as defined in Section 17-302.520(3)(b), F.A.C. or more than two-tenths unit above or below natural background of open waters as defined in Section 17-302.520(3)(f), F.A.C., provided that the pH is not lowered to less than 6.5 units or raised above 8.5 units. If natural background is less than 6.5 units, the pH shall not vary below natural background or vary more than one unit above natural background for coastal waters or more than two-tenthsunit above natural background for open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of coastal waters or more than two-tenths below natural background of open waters.					
52c. pH (Class III Waters)	standard units	Shall not vary more than one unit above or below natural background of predominantly freshwaters and coastal waters as defined in Section 17-302.520(3)(b), F.A.C. or more than two-tenths unit above or below natural background of open waters as defined in Section 17-302.520(3)(f), F.A.C., provided that the pH is not lowered to less than 6 units in predominantly freshwaters, or less than 6.5 units in predominantly marine waters, or raised above 8.5 units. If natural background is less than 6 units, in predominantly freshwaters or 6.5 units in prdominantly marine waters, the pH shall not vary below natural background or vary more than one unit above natural background of predominantly freshwaters and coastal waters, or more than two-tenths unit above natural background of open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of predpminantly freshwaters and coastal waters, or more than two-tenths unit below natural background of open waters.					
52d. pH (Class V Waters)	standard units	Not lower than 5.0 nor greater than 9.5 except certain swamp waters which may be as low as 4.5.					
53a. phenolic compounds: total (ClassI, Class II, Class III, and Class IV)	micrograms/ l	Phenolic compounds as listed - total chlorinated phenols, including trichlorophenols, and chlorinated cresols, shall not exceed 1.0 except as set forth in b1. to b6. below or unless higher values are shown not to be chronically toxic. Such higher values shall be approved in writing by the Secretary. In addition, the compounds listed below shall not exceed the limits specified for each compound. Phenolic compounds other than those produced by the natural decay of plant material, listed or unlisted, shall not taint the flesh of edible fish or shellfish or produce objectionable taste or odor in a drinking water supply.					
53b1. phenolic compound: 2-chlorophenol	micrograms/ l	≤120	≤400	≤400	≤400	≤400	
53b2. phenolic compound: 2,4-dichlorophenol	micrograms/ l	≤93	≤790	≤790	≤790	≤790	

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
53b3. phenolic compound: 2,4-dinitrophenol	milligrams/l	≤0.0697	≤14.26	≤14.26	≤14.26	≤14.26	
53b4. phenolic compound: 2,4,6-trichlorophenol	micrograms/l	≤2.1 annual avg.	≤6.5 annual avg.	≤6.5 annual avg.	≤6.5 annual avg.	≤6.5 annual avg.	
53b5. phenolic compund: pentachlorophenol	micrograms/l	≤30 max; ≤0.28 annual avg.; $\leq e^{(1.005[pH]-5.29)}$	≤7.9	≤30 max; ≤8.2 annual avg.; $\leq e^{(1.005[pH]-5.29)}$	≤7.9	≤30	
53b6. phenolic compound: phenol	milligrams/l	≤21	≤4,600	≤4,600	≤4,600	≤4,600	

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
53c. phenolic compounds: total (Class V)							Phenolic compounds as listed: chlorinated phenols, including trichlorophenols; chlorinated cresols; 2-chlorophenol; 2,4-dichlorophenol; pentachlorophenol; and 2,4-dinitrophenol, shall not exceed 0.05. Phenol: shall not exceed 0.2. Phenolic compounds other than those produced by the natural decay of plant material, listed or unlisted, shall not taint the flesh of edible fish or shellfish.
54. phosphorus (elemental)	micrograms/l		≤0.1		≤0.1		
55. phthalate esters	micrograms/l	≤3.0		≤3.0			
56. polychlorinated biphenyls (PCBs)	micrograms/l	≤0.000044 annual avg.; 0.014 max	≤0.000045 annual avg.; 0.03 max	≤0.000045 annual avg.; 0.03 max	≤0.000045 annual avg.; 0.03 max		

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
57a. polycyclic aromatic hydrocarbons (PAHs). Total of: Aacenaphthylene; benzo(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(ghi)perylene; benzo(k)fluoranthene; chrysene; dibenzo(a,h)anthracene; indeno(1,2,3-cd)pyrene; and phenanthrene	micrograms/l	≤0.0028 annual avg.	≤0.031 annual avg.	≤0.031 annual avg.	≤0.031 annual avg.		
57b1. (individual PAHs): anthracene	milligrams/l	≤9.6	≤110	≤110	≤110		
57b2. (individual PAHs): fluorene	milligrams/l	≤1.3	≤14	≤14	≤14		
57b3. (individual PAHs): pyrene	milligrams/l	≤0.96	≤11	≤11	≤11		
57b4. (individual PAHs): fluoranthene	milligrams/l	≤0.3	≤0.370	≤0.370	≤0.370		

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
57b5. (individual PAHs): acenaphthene	milligrams/l	≤1.2	≤2.7	≤2.7	≤2.7		
58a. radioactive substances (combined radium 226 and 228)	picocuries/l	≤5	≤5	≤5	≤5	≤5	≤5
58b. radioactive substances (gross alpha particle activity including radium 226, but excluding radon and uranium)	picocuries/l	≤15	≤15	≤15	≤15	≤15	≤15
59. selenium	micrograms/l	≤5.0	≤71	≤5.0	≤71		
60. silver	micrograms/l	≤0.07	≤0.05	≤0.07	≤0.05		
61. specific conductance (see conductance, specific, above)							

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
62. substances in concentrations which injure, are chronically toxic to, or produce adverse physiological or behavioral response in humans, plants or animals		None shall be present.					
63. 1,1,2,2-tetrachloroethane	micrograms/l	≤0.17 annual avg.	≤10.8 annual avg.	≤10.8 annual avg.	≤10.8 annual avg.		
64. tetrachloroethylene (1,1,2,2-tetrachloroethene)	micrograms/l	≤0.8 annual avg.; ≤3.0 max	≤8.85 annual avg.	≤8.85 annual avg.	≤8.85 annual avg.		
65. thallium	micrograms/l	≤13	≤48	≤48	≤48		
66. thermal criteria (see Section 17-302.520)							
67. total dissolved gases	percent of the saturation value for gases at the existing atmospheric and hydrostatic pressures	≤110% of saturation value	≤110% of saturation value	≤110% of saturation value	≤110% of saturation value		

Parameter	Unit	Class I	Class II	Class III: Fresh	Class III: Marine	Class IV	Class V
68. transparency	dpeth of the compensation point for photosynthetic activity	shall not be reduced by more than 10% as compared to the natural background value	shall not be reduced by more than 10% as compared to the natural background value	shall not be reduced by more than 10% as compared to the natural background value	shall not be reduced by more than 10% as compared to the natural background value		
69. trichloroethylene (trichloroethene)	micrograms/l	≤2.7 annual avg.; ≤3.0 max	≤80.7 annual avg.	≤80.7 annual avg.	≤80.7 annual avg.		
70. 1,1,1-trichloroethane	milligrams/l	≤3.100	≤173	≤173	≤173		
71. turbidity	nephelometric turbidity units (NTU)	≤29 above natural background conditions	≤29 above natural background conditions	≤29 above natural background conditions	≤29 above natural background conditions	≤29 above natural background conditions	≤29 above natural background conditions
72. zinc	micrograms/l	Zn $\leq e^{(0.8473[\ln H]+0.7614)}$; ≤1,000	≤86	Zn $\leq e^{(0.8473[\ln H]+0.7614)}$; ≤1,000	≤86	≤1,000	≤1,000

Notes: (1) "annual avg." means the maximum concentration at average annual flow conditions (see Section 17-4.020(1), F.A.C.); (2) "max" means the maximum not to be exceeded at any time; (3) "lnH" means the natural logarithm of total hardness expressed as milligrams/l of $CaCO_3$.