106th Congress, 1st Session – – – – – – – – – – – – – House Document 106–150

LOWER CUMBERLAND AND TENNESSEE RIVERS, KENTUCKY LOCK ADDITION

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS)

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY, DATED JUNE 1, 1992, SUBMITTING A REPORT TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS

OCTOBER 28, 1999.— Referred to the Committee on Infrastructure and Transportation and ordered to be printed

106th Congress, 1st Session – – – – – – – – – – – – – House Document 106–150

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U.S. GOVERNMENT PRINTING OFFICE
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LETTER OF TRANSMITTAL

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

REPLY TO
ATTENTION OF

[illegible] JUN 1999

Honorable J. Dennis Hastert
Speaker of the House
of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

Section 101(a)(13) of the Water Resources Development Act of 1996 authorized an additional navigation lock at the Kentucky Lock and Dam on the Tennessee River, Kentucky. The Secretary of the Army supports the authorization and plans to implement the project through the normal budget process.

The authorized project is described in the report of the Chief of Engineers dated June 1, 1992, which includes other pertinent reports and comments. These reports are in final response to a resolution adopted by the Senate Committee on Public Works on October 2, 1972. They are also in partial response to a resolution adopted by the Senate Committee on Environment and Public Works on September 9, 1982.

The views of the Commonwealth of Kentucky and State of Tennessee; the Departments of the Interior, Transportation, and Energy; and the Environmental Protection Agency are set forth in the enclosed communications.

The authorized project modifies the existing Kentucky Lock and Dam by providing for a new 110-foot-wide by 1,200-foot-long lock chamber. The plan also provides for improved traffic management before and during construction of the new lock. The existing 600-foot-long lock chamber at Kentucky Lock and Dam will be used as an auxiliary lock, thereby allowing for the reduction in the operation and maintenance cost of the existing 800-foot-long Barkley Lock, located nearby on the Cumberland River which operates together with Kentucky Lock as a system. The project requires relocation of the Paducah and Louisville Railroad Bridge, modification of the highway bridge carrying U.S. Routes 62 and 641, and modification of the existing hydroelectric power generation and transmission facilities. The project is economically justified based on inland waterway transportation cost savings and reduction in the cost of operating and maintaining the existing navigation facilities. Fish and wildlife mitigation features include establishment of riparian and aquatic habitats and construction of a fish passage facility. The existing Taylor Park Campground will be relocated.

Based on October 1998 price levels, the total first cost of the authorized project is estimated at about $422,000,000. In accordance with Section 102 of the Water Resources Development Act of 1986, construction will be funded one-half from amounts appropriated from the general fund of the Treasury, and one-half from the Inland Waterways Trust Fund. The Federal government will be responsible for operation, maintenance, repair, rehabilitation, and replacement of the project.

The Office of Management and Budget advises that there is no objection to the submission of this report to the Congress. A copy of its letter is enclosed in the report.

Sincerely,

Joseph W. Westphal
Assistant Secretary of the Army
(Civil Works)

Enclosure

COMMENTS OF THE OFFICE OF MANAGEMENT AND BUDGET

WASHINGTON, D.C. 20503

The Honorable John H. Zirschky
Acting Assistant Secretary of the
Army for Civil Works
Pentagon - Room 2E570
Washington, D.C. 20310-0108

Dear Dr. Zirschky:

As required by Executive Order 12322, we have completed our review of former Assistant Secretary Lancaster's recommendation for the report on the construction of an additional navigation lock at the Kentucky Lock and Dam on the Tennessee River, enclosed with his letter of April 29, 1997.

Our review concluded that the recommendation for this project is consistent with the policies and program of the President. The Office of Management and Budget does not object to your submitting this report to Congress.

Sincerely,

Kathy Peroff
Deputy Associate Director
Energy and Science

COMMENTS OF THE COMMONWEALTH OF KENTUCKY

OFFICE OF THE GOVERNOR
DEPARTMENT OF LOCAL GOVERNMENT
FRANKFORT, KENTUCKY 40601-8204

BRERETON C. JONES
GOVERNOR

BRUCE FERGUSON
COMMISSIONER

March 6, 1992

Mr. Donald A. Banashek, Director
Washington Level Review Center
Corps of Engineers, Department of the Army
ATTN: CEWRC-WLR-E (SA)
Kingman Building
Fort Belvoir, Virginia 22060-5576

Dear Mr. Banashek:

RE: EIS-Lower Cumberland & Tennessee Rivers Final Feasibility Study, Kentucky Lock Addition SAI# KY920306-0220

The Kentucky State Clearinghouse, which has been officially designated as the Commonwealth's Single Point of Contact pursuant to Presidential Executive Order 12372, has completed its evaluation of the Lower Cumberland and Tennessee Rivers Final Feasibility Study, Kentucky Lock Addition. The following state agencies were given the opportunity to review the final Environmental Impact Statement:

1. Kentucky Natural Resources and Environmental Protection Cabinet:
   a. Division of Water
   b. Division of Waste Management
2. Department of Fish and Wildlife Resources
3. Kentucky Heritage Council/The State Historic Preservation Office
4. State Archaeologist, University of Kentucky
5. Transportation Cabinet

Attached to this correspondence are letters sent to Kentucky's State Environmental Review Officer, Ms. Valerie Hudson, from the Natural Resources and Environmental Protection Cabinet, Division of Water, Department of Fish and Wildlife Resources, respectively, which identify areas of concern that should be appropriately considered by the Corps of Engineers. Inasmuch as the issues raised in these letters relate to compliance with pertinent federal and state regulations, the State Clearinghouse assumes the Corps of Engineers will comply with these dictates, as appropriate.

The Commonwealth of Kentucky appreciates the opportunity to participate in the evaluation of this document.

Sincerely,

Ronald W. Cook

Ronald W. Cook, Manager
Kentucky State Clearinghouse

Attachments

cc: Valerie Hudson
Don R. McCormick
Tim Kuryla
Colonel James P. King

PHILLIP J. SHEPHERD
SECRETARY

BRERETON C. JONES
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

MEMORANDUM

TO: Valerie A. Hudson
State Environmental Review Officer
Office of the Commissioner

FROM: Timothy Kuryla TK
EIS Coordinator
Division of Water

DATE: February 26, 1992

RE: FEIS, and MRFS, Additional Lock at Kentucky Dam, Tennessee River (Livingston County), EIS 92-01

Attached are the Division of Water comments on the Final Environmental Impact Statement and Main Report Final Study regarding an additional lock at Kentucky Dam on the Tennessee River (Livingston County).

cc: Sam Call, Ecological Support Section
Jeff Pratt, Floodplain Management Section
Jeff Grubbs, Ecological Support Section
William Sampson, Nonpoint Source Pollution Section

The Division of Water concerns will be raised in the Division's responses to the:

- Corps of Engineers Public Notice.
- Corps of Engineers Request for Water Quality Certification.

Timothy Kuryla
Timothy Kuryla **EIS Coordinator** **Division of Water** 02/26/92 **Date**

NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET

ENVIRONMENTAL REVIEW

Division of Water | Project Number: 92-01

Project Title: FEIS & MRFS, Additional Lock at Kentucky Dam, Tennessee River (Livington County)

The Division of Water has reviewed this Final Environmental Impact Statement and Main Report Final Study and compared it to the Draft Environmental Impact Statement and Main Report Interim Study (EIS 91-19). The Division of Water finds its DEIS and MRIS comments have been addressed, for the most part, in the FEIS and MRFS. However, the Division has continued concerns and additional comments regarding aquatic habitat.

AQUATIC HABITAT

Response 4 — **Page EIS-78**
Response 7 — **Page EIS-79**

The EIS and MRS preparers in response to the Division of Water DEIS and MRIS comments state the dredged material disposal site is placed upland. While the Division is pleased with that, the Division asks if Responses 4 and 7 supersede the discussions in 6.23, placing dredged materials at the right bank Tennessee River Mile 19.7, and in 6.24 stone straining dike, if needed (MRFS page 74, MRIS page 85). (See also 4.5 FEIS page EIS-44, DEIS page EIS-42.) From a water quality perspective, the Division is concerned about the use of dredge materials for slough prevention and for a training dike.

Given each location and purpose plus the stream current, the dredged materials will probably not stay in place. Extensive testing must be done aforehand to insure the materials are not toxic. Such testing is not discussed in both the FEIS and MRFS as well as the DEIS and MRIS.

Because of both the right bank's and the training dike's locations, the Division of Water doubts that either site could become a mussel habitat. Even if both are implemented, a new habitat would not be created; the existing habitat would be exchanged for it.

The Division of Water iterates its EIS 91-19 recommendations that the mussels be moved, before construction, to an unAffected area of the sanctuary and that the moving be done by an entity, such as the Tennessee Valley authority, familiar with mussel relocating.

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF FISH AND WILDLIFE RESOURCES
DON R. McCORMICK, COMMISSIONER

February 10, 1992

Mrs. Valerie Hudson
Department for Environmental Protection
18 Reilly Road
Frankfort, KY 40601

RE: Public Notice No. 92-01, Final Environmental Impact Statement, Lower Cumberland and Tennessee Rivers Final Feasibility Study: Kentucky Lock Addition - Nashville District Corps of Engineers.

Dear Mrs. Hudson:

Members of my staff have reviewed the above-referenced public notice. Accordingly, we offer the following comments and recommendations.

The Kentucky Department of Fish and Wildlife Resources (KDFWR) has been involved with this proposal for several years. Members of my staff have had several meetings with the staff of the Nashville District Corps of Engineers to discuss this project, its potential impacts, and mitigation measures to off-set those impacts. The cooperation of the Nashville District staff has been beneficial and greatly appreciated.

KDFWR concurs with all of the mitigation measures outlined in the report (creation of mussel habitat, enhancement of the tailwater fishery, upgrading of the left bank boat launching facilities, etc.) and recommends they be constructed at the earliest possible time period during construction. The other only recommendation is that if the project is physically modeled, all of the environmental mitigation features should be included in the model and evaluated. This will help to insure the features will perform as planned and afford the opportunity to experiment with changes that may provide additional mitigation of impacts and enhancements to the fish and wildlife resources.

KDFWR would also like to express its appreciation to Messrs. Joe Cathy and Richard Tippit of the Nashville District staff for their cooperation during this project. We look forward to working with them during the final design of all of the mitigation measures.

Arnold L. Mitchell Bldg. #1 Game Farm Road Frankfort, Ky 40601
An Equal Opportunity Employer M/F/H

If you or your staff should have any questions, please feel free to contact members of my Environmental Section staff.

We appreciate the opportunity to comment.

Sincerely,

Don R. McCormick
Commissioner

DRM/WLD/kh

cc: Peter W. Pfeiffer, Director, Division of Fisheries
Edwin F. Crowell, Asst. Director, Division of Fisheries
William N. McLemore, Western Fishery District Biologist
Lee A. Barclay, USFWS, Cookeville, TN
Jack Wilson, Director, KY Division of Water
Environmental Section Files

COMMENTS OF THE STATE OF TENNESSEE

TENNESSEE STATE PLANNING OFFICE
307 JOHN SEVIER STATE OFFICE BUILDING
500 CHARLOTTE AVENUE
NASHVILLE, TENNESSEE 37243-0001
(615) 741-1676

NED McWHERTER
Governor

JIM HALL
Executive Director

February 18, 1992 25 FEB REC'D

92-0696

Mr. Donald A. Banashek
Dept. of the Army, Washington Level
Review Center, Kingman Building
Fort Belvoir, Virginia 22060-5576

SUBJECT: CHTN021892-009 Lower Cumberland-Tennessee Rivers Below Barkley Canal, Kentucky, Interim Reasibility Report - 12047A

Dear Mr. Banashek:

In accordance with Presidential Executive Orders 12372 and 12416 and with Gubernatorial `xecutive Order 58, this office serves as the designated State Clearinghouse for federal :tivities and grants review.

State and local government evaluation of submitted materials has indicated no conflicts .th existing or planned activities. Therefore, we are recommending that this proposal be pproved based on the descriptive information made available to us. However, should additional information come to the attention of this office, we may wish to comment further.

This letter should be attached to the application and become a permanent part of the project file. Any involved federal agency should respond in writing to this office if there are problems in complying with this approval. The above State Clearinghouse Identification Number should be placed in the appropriate block on the federal application form.

The appropriate funding agency will now be reviewing our recommendation. If we can be of further assistance, please do not hesitate to contact us.

Sincerely,

Charles W. Brown

Charles W. Brown
Director, State Clearinghouse

"WB:mcp

cc: Dan Sherry, Bob Bay, Wetlands Unit
Joe Richardson, Robert Baker

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
NASHVILLE, TENNESSEE 37219

February 5, 1992

Mr. Charles Brown
Director of Grant Review
Tennessee State Clearinghouse
John Sevier State Office Building
Room 309
Nashville, Tennessee 37243-0001

SUBJECT: A-95 Notification: CH# 92-0696

Dear Mr. Brown:

We have reviewed the subject project in regard to any possible conflict it may have upon the Department's plans.

The Department's Office of Rail and Water Transportation has reviewed the subject project and strongly supports the U.S. Army Corps of Engineers' recommendations to improve navigation on the Tennessee River. (see attached letter dated January 30, 1992)

Please provide our Office of Rail and Water Transportation a copy of your response to the applicant.

If you should need any additional information concerning this matter, please advise.

Sincerely,

Lonnie Porter

for N.E. Christianson, III
Transportation Manager II
Program Operations Office

NEC/jes

cc: Mr. Dave Fulton

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
NASHVILLE, TENNESSEE 37243-0325

January 30, 1992

MEMORANDUN

TO: N.E. Christianson, Transportation Manager II
Program Operations Office

FROM: Dave Fulton, Administrator
Office of Rail and Water Transportation

SUBJECT: CH# 92-0696

The Office of Rail and Water Transportation, Tennessee Department of Transportation strongly supports the U.S. Army Corps of Engineers' recommendations to improve navigation on the Tennessee River by construction of a new 110 foot by 1,200 foot lock chamber at the Kentucky Dam, continued use of the existing 100 foot by 600 foot lock chamber, and other measures as necessary to improve traffic management, reduce traffic delays, and enhance safety.

With the opening of the Tennessee-Tombigbee Waterway in 1985, the economic contribution made by barge transportation in Tennessee has grown significantly. If that growth is to be sustained, every effort must be made to improve safety and accessibility to the waterway by improving the locking capability of the dams located on the Tennessee River. Addition of a new lock at Kentucky Dam will complete a crucial step in improving access to the waterway.

The Office of Rail and Water Transportation, Tennessee Department of Transportation appreciates the opportunity to comment on this most important proposal. We request that our office be kept informed as to the State of Tennessee's response to the Department of the Army by the Tennessee State Planning Office.

DF:es

COMMENTS OF THE DEPARTMENT OF THE INTERIOR

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

MAR 3 1 1992

ER 92/53

Mr. Donald Banashek
Director
Washington Review Level Center
ATTN: CEWRC-WLR-E (SA)
Kingman Building
Fort Belvoir, Virginia 22060-5576

Dear Mr. Banashek:

We have reviewed the proposed report of the Chief of Engineers and the final feasibility report for the Lower Cumberland and Tennessee Rivers, Kentucky Lock Addition, Livingston and Marshall Counties, Kentucky. Several comments are provided for your consideration.

The Fish and Wildlife Service has been closely involved with this project throughout the early planning stages by way of the Fish and Wildlife Coordination Act process and Endangered Species Act consultation. These reports have identified significant fish and wildlife resources, evaluated potential impacts, and provided recommendations for avoidance and/or mitigation of impacts. In addition, the Corps of Engineers (Corps) has fully complied with its obligations under Section 7 of the Endangered Species Act. A biological opinion was issued on March 28, 1991, addressing impacts to federally endangered and threatened species, and providing the opinion that the proposed project is not likely to jeopardize the continued existence of those species, provided that the Corps agrees to implement the recommendations presented.

We have only one concern remaining with regard to this project. The Corps is apparently still considering the possibility of constructing a training dike along the left margin of the new navigation channel. This structure could have significant adverse impacts on aquatic resources, including several endangered species. The Corps has been made aware of our concern and if plans for the dike are subsequently included as part of the project, the Corps will need to evaluate its impacts to fish and wildlife resources, reinitiate formal Section 7 consultation, and prepare a supplement to the Feasibility Study/Environmental Impact Statement.

Thank you for the opportunity to comment on this proposal.

Sincerely,

Jonathan P. Deason
Director
Office of Environmental Affairs

COMMENTS OF THE DEPARTMENT OF TRANSPORTATION

U.S. Department of Transportation
United States Coast Guard

Commandant
U.S. Coast Guard

2100 Second Street S.W.
Washington, DC 20593-0001
Staff Symbol: G-MEP-3
Phone (202) 267-0500

16004
MAR 6 1992

Mr. Donald A. Banashek
Director
Washington Level Review Center
ATTN: CEWRC-WLR--E (SA)
Kingman Building
Fort Belvoir, Virginia 22060-5576

Dear Mr. Banashek:

This is in response to your letter of January 7, 1992, in which you transmitted the proposed report of the Chief of Engineers, the report of the district engineer, and final environmental impact statement (FEIS) on Lower Cumberland and Tennessee Rivers below Barkley Canal, Kentucky. We have reviewed the reports and FEIS and have no comments to offer.

Thank you for providing the opportunity for review of these reports.

Sincerely,

Janice C. Jackson
for W. ST. J. CHUBB
Commander, U.S. Coast Guard
Chief, Environmental
Coordination Branch
By direction of the Commandant

COMMENTS OF THE DEPARTMENT OF ENERGY

Department of Energy
Southeastern Power Administration
Elberton, Georgia 30635

February 19, 1992

Lieutenant Colonel Stephen M. Sheppard
District Engineer
U.S. Army Engineers District, Nashville
Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202

Dear Colonel Sheppard:

We have reviewed the Lower Cumberland and Tennessee Rivers Feasibility Report, May, 1991. The report recommends adding a new 110-foot wide by 1200-foot long lock at the Kentucky Project to solve navigation problems on the lower Cumberland and Tennessee Rivers.

The report points out that to continue to operate without adding the additional lock at the Kentucky Project would result in changes in the water release pattern at the Barkley Project. In addition, water would be diverted through the canal from the Barkley Project to the Kentucky Project to support navigation.

The changes in the release pattern at the Barkley Project and the diversion of water from Barkley to the Kentucky Project required with a continuation of the present lock at Kentucky would significantly reduce the power output of the Barkley project. Southeastern Power Administration, therefore, strongly supports the Corps' recommended plan to add a new and larger lock at the Kentucky Project. This appears to be the course of action which will better preserve the power values of the Barkley Project. The Corps' report states the recommended action will also meet the requirements of the National Economic Development (NED) plan.

Southeastern appreciates the opportunity to comment on this study and would be glad to participate in meetings that may be held to discuss further courses of action.

Jim B. Lloyd, P.E.
Director,
Power Resources Division

COMMENTS OF THE ENVIRONMENTAL PROTECTION AGENCY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV
345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

MAR 1 7 1992

Washington Level Review Center
ATTN: CEWRC-WLR-I
Kingman Building
Fort Belvoir, VA 22060-5576

Subject: Final Environmental Impact Statement (EIS) for the Kentucky Lock Addition, Lower Cumberland and Tennessee Rivers

Dear Sir:

Pursuant to Section 309 of the Clean Air Act and Section 102 (2)(C) of the National Environmental Policy Act, EPA, Region IV has reviewed the subject document. The major environmental impacts of the selected alternative result from direct construction activities associated with the new lock and attendant supporting facilities. The new 1200-foot lock will require building a replacement bridge downstream of the dam and raising portions of US Highway 62/641 across the locks.

Environmental impacts of this action will adversely affect several mussel beds. This loss is significant due to the presence of at least two federally endangered species. However, consultation with the U.S. Fish and Wildlife Service via the Section 7 process yielded a "no jeopardy" opinion. The details of this consultation are in the final EIS. Mitigation of what is deemed to be an unavoidable impact will be accomplished via creation of replacement habitat downstream. After construction monitoring will be conducted to determine the effectiveness of this mitigation.

Unavoidable adverse impacts on the various wetland types in the vicinity of the lock have been greatly minimized. Ultimate resolution will be accomplished by planting appropriate wetland species and monitoring to determine success. As previously noted, we were pleased that the 25 acres of hardwood habitat cleared during project construction will also be restored.

On the basis of our review it appears that the issues which we raised on the draft document have been satisfactorily resolved. If we can be of further assistance regarding this project, please contact Dr. Gerald Miller of my staff at 404-347-3776.

Sincerely yours,

Heinz J. Mueller
Chief, Environmental Policy Section
Federal Activities Branch

LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

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

REPLY TO
ATTENTION OF:

CECW-PM (10-1-7a) June 1, 1992

SUBJECT: Lower Cumberland and Tennessee Rivers Kentucky Lock Addition

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on navigation improvements at Kentucky Lock and Dam on the Tennessee River. It is accompanied by the reports of the Board of Engineers for Rivers and Harbors and the District and Division Engineers. These reports are in final response to a 2 October 1972 resolution of the Committee on Public Works of the United States Senate which requested that the U.S. Army Corps of Engineers investigate the advisability of navigation improvements on the Cumberland and Tennessee Rivers, generally below the connecting Barkley Canal. These reports are also an interim response to a 9 September 1982 resolution by the Committee on Environment and Public Works of the United States Senate, which requested that the U.S. Army Corps of Engineers evaluate the entire Tennessee River with a view to determining whether any modifications to improve navigation are advisable.

2. The District and Division Engineers recommend that the Kentucky-Barkley navigation system be modified for the purposes of reducing lock delays and improving navigation. The recommended modifications include a new 110-foot by 1,200-foot lock chamber at the existing Kentucky Lock and Dam, continued use of the existing 110-foot by 600-foot chamber, traffic management, as needed, and other such measures as necessary to maintain safe navigation on the Lower Cumberland River. The plan also includes relocation of a Paducah-Louisville Railroad bridge and approaches, elevating a section of U.S. Route 62/641, and relocation of electrical transmission lines. This proposed plan of improvement is the national economic development plan. The plan would reduce transportation costs to the Nation, provide safe and dependable navigation, and preserve the environmental resources of the area.

3. Washington level review indicates that the proposed project to construct an additional navigation lock on the Tennessee River is technically sound, economically justified, and environmentally acceptable.

4. The Board of Engineers for Rivers and Harbors concurs with the findings and recommendation of the reporting officers. The Board recommends that the existing Federal navigation project for Kentucky Lock and Dam be modified to provide for construction of a second and main lock chamber 110 feet wide and 1,200 feet long in accordance with the plan described in the District Engineer's report. Based on October 1991 prices, the estimated cost of the proposed plan is $448,000,000, of which one-half or $224,000,000 would be funded from the Inland Waterways Trust Fund and the remaining $224,000,000 would be borne by the Federal Government. Average annual charges, reflecting a 50-year period of economic analysis and an 8-1/2 percent interest rate, are $31,900,000. Average annual benefits are estimated at $53,800,000, and the benefit-cost ratio is 1.7.

5. I concur in the findings, conclusions, and recommendation of the Board.

6. The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the recommendations may be modified before it is transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, interested States, Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

H. J. HATCH
Lieutenant General, USA
Chief of Engineers

REPORT OF THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

DEPARTMENT OF THE ARMY
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
KINGMAN BUILDING
FORT BELVOIR, VIRGINIA 22060-5576

REPLY TO
ATTENTION OF:

CEBRH (10-1-7a) 8 May 1992

SUBJECT: Lower Cumberland-Tennessee Rivers Below Barkley Canal, Kentucky, Interim Feasibility Report - 12047A

Chief of Engineers
Department of the Army
Washington, DC 20314-1000

SUMMARY OF BOARD ACTION

The board concurs in the reporting officers' plan for construction of a second lock at the Kentucky Dam, lower Cumberland and Tennessee Rivers. The board finds that this improvement to the inland navigation system is technically feasible, economically justified, and environmentally and socially acceptable. The new lock would be 110 feet wide by 1,200 feet long with a 56-foot lift. The plan also includes constructing a new railroad bridge immediately downstream of the project and elevating a short section of highway. The new larger lock at the Kentucky Dam would lower river transportation costs by allowing increased navigation use of the more efficient lower Tennessee River as opposed to use of the longer route on the lower Cumberland River with its inherent navigational difficulties. Construction of the new lock would also result in lower system lock maintenance costs and avoidance of reduced hydropower releases necessary to accommodate increased navigational use on the Cumberland River. Based on October 1991 price levels, the first cost of the recommended plan is $448,300,000. The benefit-cost ratio is 1.7.

1. AUTHORITY. This report is in response to a resolution adopted 2 October 1972 by the Committee on Public Works of the United States Senate and in partial response to a second resolution adopted 9 September 1982 by the Committee on Environment and Public Works of the United States Senate. The 1972 resolution requested an investigation of the advisability of navigation improvements on the Cumberland and Tennessee Rivers, generally below Barkley Canal. The 1982 resolution requested evaluation of the entire Tennessee River to determine whether any modifications

to improve navigation are advisable. A final report in response to the 1982 resolution will be submitted at a later date.

2. DESCRIPTION OF THE STUDY AREA. The Cumberland and Tennessee Rivers are the Ohio River's largest tributaries. A total of 13 multipurpose lock and dam projects and related navigation improvements on the Cumberland and Tennessee Rivers provide over 1000 miles of 9-foot deep navigable waterway. Navigation also extends up the Clinch River about 60 miles and up both the Hiwassee and Little Tennessee Rivers about 20 miles. In addition, with completion of the Tennessee-Tombigbee waterway, the Tennessee River forms part of the connection of the Ohio River near Paducah, Kentucky, with the Gulf of Mexico at Mobile, Alabama. The primary study area is the Kentucky-Barkley navigation system extending downstream to the Ohio River from the Barkley Canal, which connects Kentucky Lake and Lake Barkley. This system is comprised of the sections of Barkley and Kentucky Lakes from the Barkley Canal downstream to their respective dams, the 30.6-mile segment of the Cumberland River downstream of Barkley Dam to the Ohio River, Barkley Lock and Dam, the 22.4-mile segment of the Tennessee River downstream of Kentucky Dam to the Ohio River, and Kentucky Lock and Dam. The Ohio River links the study area to the Upper Ohio Basin and on to the Mississippi River and tributary area which further links the study area to the Illinois and Missouri Rivers and essentially the upper Midwest and the Great Lakes.

3. ECONOMIC DEVELOPMENT. The contributing economic study area for the Kentucky-Barkley navigation system includes 170 counties in 5 states covering an area of about 76,500 square miles. The Cumberland-Tennessee Rivers linkage to the Ohio River and the connecting national inland waterway system is the backbone of commerce and economic development of the study area. In fact, in 1988, 20 states shipped or received waterborne commerce which passed through either Kentucky or Barkley Locks. The study area's manufacturing-based economy developed around its natural resources of water, coal, timber, limestone, and nonferrous metal ores and the demands of a larger regional economic emphasis on textile and furniture industries. Since its inception in the 1930's, the Tennessee Valley Authority (TVA) has been a major factor in the economic development of the study area. TVA's low-cost electric power development has attracted energy-intensive industries to the Tennessee Valley, in particular aluminum smelting. Regional timber product industries include paper and furniture making and manufacturing of synthetic fibers. All of the major industrial facilities in the study area use coal directly or indirectly. Grain processors, some of which are

relatively new in the region, serve three major markets: the poultry feed markets of north Georgia, Alabama, and South Carolina; the southeastern market for corn sweeteners and vegetable oils; and a growing export feed market. Waterside locations allow the grain processors to economically source midwestern grains and serve the export market in New Orleans.

4. EXISTING CUMBERLAND AND TENNESSEE RIVERS NAVIGATION SYSTEMS. Modern 9-foot-deep river channel navigation started in 1927 with Federal construction of Wheeler Lock and Dam, the first of nine locks and dams on the Tennessee River. Commercial navigation is available on the entire 652-mile length of the Tennessee River to about the City of Knoxville, Tennessee. Kentucky Lock and Dam is located at river mile 22.4 and is the first structure upstream from the mouth of the Ohio River. Kentucky Lock, which opened to commercial traffic in 1942, and the next five upstream locks all have lock chambers 110 feet wide and 600 feet long, with the exception of Pickwick Lock, the next lock upstream from Kentucky Lock, which has a 1000-foot-long chamber. The 600-foot locks are capable of passing an 8-barge tow in one lockage. Pickwick Dam and lake behind the dam also forms the south-bound entrance to the Tennessee-Tombigbee Waterway. With the exception of Kentucky Lock, the remaining five of the lower six locks all have both a main and auxiliary lock chamber. The five auxiliary lock chambers are 60 or 110 feet wide and vary in length from 300 to 600 feet. The three remaining upstream Tennessee River locks all have single-lock chambers 360 feet long by 60 feet wide.

5. In 1946, Congress authorized construction of a 9-foot-deep navigation channel from the mouth of the Cumberland River to the City of Nashville, Tennessee. The existing Cumberland River navigation project consists of four locks and dams and a short navigation canal between the Cumberland and Tennessee Rivers. The two lower locks, Barkley and Cheatham, have single chambers 800 feet long by 110 feet wide and are capable of passing a modern 11-barge tow in one lockage. Barkley lock was opened to traffic in 1964. The upper two locks have single chambers 400 feet long by 84 feet wide.

6. Barkley Canal connects the two lakes and provides flexibility with respect to navigation, flood control, hydropower generation, and recreation. The canal allows barge tows to bypass the lower portion of the Cumberland River, which is narrow and winding, in favor of the lower Tennessee River, which is broad and straight. The land area between the Cumberland and Tennessee Rivers is known as Land Between the Lakes and is a national recreation area operated by TVA.

7. WATERBORNE COMMERCE. Most of the tonnage shipped on the Cumberland and Tennessee Rivers moves inbound from or outbound to the Ohio River. The Kentucky-Barkley navigation system reached an all-time high level of traffic in 1988 of 37.3 million tons. This high level of traffic, however, was directly related to drought conditions present throughout most of the Nation that year. Return to a more normal hydrological condition in 1989 and 1990 resulted in lower Kentucky-Barkley traffic, 33.3 and 31.9 million tons, respectively. Since the Kentucky-Barkley system was completed in 1967, a steady growth in waterborne commerce has occurred with tonnages increasing from 13 to 34 million tons or about a 5.2 percent growth rate. Coal is the major commodity moved on the system accounting for about 47 percent of total tonnage. About 85 percent of the coal moves upbound, destined for steam powerplants along the Tennessee and Cumberland Rivers. Aggregate and grain traffic account for about 22 and 13 percent of the total system tonnage, respectively. Kentucky-Barkley traffic demand is projected to increase at about the same rate as the Ohio River navigation system for the next 60 years or at a rate of about 1.4 percent annually.

8. PROBLEMS AND NEEDS. The Kentucky-Barkley system is unique in that, with the construction of the Barkley Canal, it gives users a choice of how to reach their destinations. Historically, most users have chosen to reach their destinations via the Kentucky Lock for primarily economic reasons. The cost differential of about $0.50 per ton exists because the physical characteristics of the river are so different. The lower Tennessee River is like an interstate highway, broad and straight with relatively stable currents. The lower Cumberland River is comparable to a rural road. It is narrow and contains numerous curves and sharp bends. The narrowness of the channel contributes to swift currents and intensifies the adverse effects of fog and hydropower releases making the river very hazardous to navigate at times. Barkley's current hydropower operations interfere with industry's ability to use the lower Cumberland and Barkley Lock during periods of peak power generation or about 40 percent of the time for the majority of the towing industry. To accommodate the high level of traffic projected to use the lower Cumberland River under the without-project condition, safety improvements would be made and hydropower discharges at Barkley would be modified resulting in an average annual loss of $14.9 million in hydropower revenues. Given the preference to use Kentucky Lock, in 1988 Kentucky Lock reached 86 percent of its capacity while Barkley Lock reached only 20 percent. As the demand for Kentucky Lock increases, the average time a tow is delayed will increase forcing traffic to either shift to the higher cost Barkley Lock and the lower

Cumberland River or overland transportation. This situation is magnified during lock maintenance closures with annual system capacities estimated at 42 million tons when Barkley Lock is closed and 37.9 million tons when Kentucky Lock is closed. With projected traffic in the year 2000 estimated at 46.5 million tons, this far exceeds the capacity of the system when either lock is closed. By the year 2006, Kentucky Lock will have been in operation 64 years. The lock has been experiencing daily wear and tear on the concrete and wall armor. Condition surveys and engineering judgement have led to the conclusion that the concrete and wall armor must be rehabilitated before 2010. The lock is expected to be out of service for 13 consecutive weeks between years 2006 and 2009. Water and air piping is also deteriorating rapidly and will be replaced at the same time as well as painting of the miter gates. During these closures, delays at Barkley Lock are projected to range from 85 to 93 hours per tow.

9. IMPROVEMENTS DESIRED. Navigation interests desire a new 110- X 1200-foot lock at the Kentucky project in order to eliminate delay and congestion problems in the Kentucky-Barkley navigation system. The 1200-foot lock will also eliminate the need for helper boats and avoid the modification of hydropower operations at Barkley powerplant. The new lock, in combination with the existing locks, will efficiently accommodate all traffic projected to move on the Kentucky-Barkley navigation system for the period of analysis to include years in which major closures are scheduled.

10. ALTERNATIVES CONSIDERED. A number of operational alternatives were considered; and where they were economically feasible, they were considered to be implemented under the future without-project condition. Various new lock alternatives were considered as well as bendway modifications to the Cumberland River and the imposition of congestion fees. The optimal location of any new lock alternative as well as the optimal sizing was determined. Alternative lock sizes investigated were: 110- X 1200-foot chamber; 110- X 800-foot chamber; and 110- X 600-foot chamber.

11. PLAN OF IMPROVEMENT. The recommended plan provides an additional lock 110 feet wide and 1200 feet long. The lock is sited immediately landward of the existing Kentucky Lock with its upper miter sill about 300 feet downstream of the existing upper miter sill. The plan calls for using the existing chamber at Kentucky as an auxiliary and reducing the operation and maintenance of Barkley after construction of the new lock. The proposed lock will be a concrete gravity structure with walls similar to the existing lock. A section of the Paducah and

Louisville Railroad tracks will require relocation. Currently the track crosses the existing lock downstream of the chamber and has adequate vertical clearance. The existing track would, however, cross the chamber of the proposed lock, and vertical clearance would not be sufficient. The need for slight ascending and descending grades dictates relocating the railroad to a crossing about 0.3 mile downstream of the dam. Elevating a portion of US Highways 62 and 641 is also required. The horizontal alignment of the roadway will be similar to the existing roadway with major changes in vertical grades. Relocating the highway eliminates existing access to the powerhouse and switchyard; therefore, a new access road and a high-level bridge will be provided just upstream of the relocated railroad bridge. A new 500-foot section of Ferry Landing Road is also required by the recommended plan. In addition, 13 transmission lines must be raised to provide the minimum 140-foot vertical clearance above the new lock. Four buildings will replace existing facilities displaced by the new lock. In-river dredging of the lower lock approach will directly impact a small portion of the right bank tailwater mussel bed. Portions of the area to be dredged support dense populations of mussels, and relocating mussels from the area to other sites is planned. The dredged material will be placed in an open-water site in the lower Tennessee to create replacement habitat.

12. ECONOMIC EVALUATION. Based on October 1991 price levels, first costs of the recommended 110- X 1200-foot lock are \$448.3 million. The investment cost is \$570.7 million. Total incremental annual costs reflecting a 50-year period of economic analysis and a 8 1/2 percent interest rate are \$31.9 million. The average annual benefits are \$53.8 million including unemployment benefits. The benefit-cost ratio is 1.7, and the net benefits are \$21.9 million.

13. PROJECT EFFECTS. The recommended plan for providing an additional lock adjacent to the existing Kentucky Lock is economically justified and will insure a reliable and efficient Kentucky-Barkley navigation system that meets the needs for the entire period of analysis. The improvement will eliminate costly traffic delays as traffic continues to increase on the system and will avoid major traffic disruptions and additional transportation costs when existing locks must be closed for necessary maintenance and rehabilitation. Without-project O&M costs, helper boat costs, and hydropower costs as a result of reduced hydropower production will be eliminated or significantly reduced with the project. Minor temporary adverse environmental impacts will occur during the construction period. Major adverse

environmental impacts have been avoided and unavoidable impacts will be mitigated through sound environmental planning and the application of environmental engineering and design concepts.

14. RECOMMENDATION OF THE REPORTING OFFICERS. The district engineer recommends that an additional 110- X 1200-foot lock be located adjacent to the existing 110- X 600-foot Kentucky Lock and be authorized for construction as a Federal project, with such modifications as in the discretion of the Chief of Engineers may be advisable. The division engineer concurs.

REVIEW BY THE BOARD OF ENGINEERS FOR RIVERS AND HARBORS

15. GENERAL. The board's review encompassed the overall technical, economic, social, institutional, environmental, and policy aspects involved in the formulation of alternative plans of improvement and in the findings, conclusions, and recommendations of the reporting officers. The board considered the results of the consolidated Washington level review and the conformance of the recommended plan with essential elements of the U.S. Water Resources Council's Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation Studies. The board also considered the views of interested parties, including Federal, State, and local agencies. Particular attention was given to: (1) traffic projections; (2) the timing of estimated future without-project maintenance closures of the existing Kentucky and Barkley Locks; and (3) the relationship of these factors to the construction schedule for the proposed new lock.

16. RESPONSES TO THE DIVISION ENGINEER'S PUBLIC NOTICE. The division engineer issued a public notice on 20 December 1991 advising interested parties that they may provide comments to the Washington Level Review Center (WLRC). Fifteen letters were received from shippers, marine transportation companies, area development associations, the Governor of Kentucky, the four Senators from Tennessee and Kentucky, and the Congressman from Kentucky in whose district the proposed facility is located. Fourteen letters expressed support for the project and encouraged expedited processing of the report. One letter of opposition was received from a barge line that accounts for 25 percent of the traffic in the Kentucky-Barkley navigation system. This letter did not support the construction of a new lock at this time and stressed the need to allocate trust fund dollars to other projects that are of greater benefit to the inland waterway system and the Nation. This letter provided detailed comments on current depressed traffic levels, the need for non-structural

alternatives, the need for Cumberland River bendway improvements, and concern over excessive maintenance closures.

17. 90-DAY STATE AND AGENCY REVIEW. The 90-day State and agency review was initiated on 7 January 1992. WLRC has received favorable responses from the States of Kentucky and Tennessee, the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Transportation. The Southeastern Power Administration responded with strong support for the U.S. Department of Energy. The U.S. Departments of Agriculture and Commerce have indicated no comment. The U.S. Department of the Interior (DOI) expressed concern for the possible impacts of a potential training dike on endangered species and the need for additional section 7 coordination if this feature is included in the final plan. The inclusion of the training dike is dependent upon the results of model studies to be accomplished during PED.

18. FINDINGS AND CONCLUSIONS. The Board of Engineers for Rivers and Harbors concurs in the plan of improvements recommended by the reporting officers and in the results of the consolidated Washington level review. The board finds that the recommended additional lock and related improvements, identified as the national economic development (NED) plan, are economically justified, engineeringly sound, and environmentally and socially acceptable. The board believes that the additional lock at Kentucky Lock will significantly modernize the Kentucky-Barkley system and eliminate significant future traffic delays.

19. The board notes that normally traffic congestion problems are the primary reason for justification of additional locks. In this case, traffic is being delayed at Kentucky Lock but the alternative of Barkley Lock is currently being underutilized due to navigation inefficiencies on the lower Cumberland River with its narrowness in combination with numerous curves and sharp bends. However, the adverse economic consequences of major maintenance lock closures in addition to the inefficiencies of operating on the Cumberland River-Barkley Lock route, under the future without-project condition, result in sufficient benefits to justify construction of an additional lock adjacent to the existing Kentucky Lock.

20. The board notes that the NED plan identified by the reporting officers has net benefits that are approximately 3 percent or about $500,000 greater than the less costly 800-foot lock alternative. Current planning guidance indicates where two cost effective plans produce no significantly different levels of net benefits, the less costly is to be the NED plan. While the

difference in net benefits between the two alternative lock size plans is small, the board concurs in the conclusions of the reporting officers. In addition, the board notes there are other reasons for selecting the 1,200-foot alternative versus the less costly 800-foot alternative. These include: (a) the fact that Ohio River locks are 1,200 feet and the upstream Pickwick Lock is 1,000 feet; (b) placing a smaller lock in the middle of a system of larger locks would be inefficient, constrain tow sizes, and require helper boats in later years; (c) the additional 10 percent cost (about $50 million) results in a 50 percent gain in chamber capacity; and (d) traffic will not be constrained in the later years of the period of analysis causing pressures for an additional lock.

21. The board notes that the Water Resources Development Act of 1986 created an eleven member Inland Navigation Users Board to oversee the Inland Waterways Trust Fund and provide recommended investment priorities in an annual report to the Secretary of the Army and to the U.S. Congress. The board further notes that the U.S. Army Corps of Engineers works closely with the Users Board to provide project specific information and an investment priorities analysis to assist the Users Board in making their recommendations concerning investment priorities. The board is aware that the Users Board is not questioning the economic feasibility of the project. However, the optimal program identified by the Users Board places a lower priority on the new Kentucky Lock project, which given the limited Trust Fund monies, could cause a construction start to be delayed. This position was not unanimous, however, and a minority position was provided by 4 of the 11 members. The board concludes that while the Users Board priorities are important, many uncertainties still exist that could impact the current investment priorities analysis and the recommendations by the Users Board for future construction priorities. The board further concludes that since the new Kentucky Lock has been demonstrated to be feasible, authorization of the project should proceed at this time. Priorities of the Users Board can be assessed and taken into consideration when a construction decision is needed.

22. The board notes that the optimal timing of a construction investment decision is sensitive to the without-project assumptions concerning major maintenance closures at Kentucky Lock starting in year 2006. If construction of the new lock is delayed and major closures to the existing Kentucky Lock occur prior to construction completion, then benefits currently claimed for the additional transportation costs during closure years would not be realized. While this would lower the benefit-cost

ratio from 1.7 to 1.1, the board notes that the project would still be feasible. However, since the project justification becomes marginal and recognizing that future traffic projections may be higher or lower than estimated, the board concludes that if major maintenance occurs prior to new lock completion, the feasibility of the recommended project should be reanalyzed prior to initiation of construction.

23. The board notes that American Commercial Barge Line Company, an existing user of the Kentucky-Barkley system that accounted for 7.7 million tons or about 25 percent of the system traffic, has written a letter in opposition to construction of the proposed project at this time. The company believes that the limited dollars from both the Federal budget and Trust Fund should be spent on those projects which offer the greatest benefit to the inland waterway system and the Nation. The board notes that the specific technical concerns expressed in this letter of opposition have been considered in the analysis of this project. The board further notes that given the best information available at this time, the recommended plan is economically feasible. The board concludes that the proposed project should proceed to authorization and that the Users Board should continue to be looked to for advice on study and construction priorities for Kentucky Lock as well as the rest of the inland navigation system.

24. PUBLIC LAW 99-662. In accordance with section 102 of Public Law 99-662 and Public Law 99-88, one-half of the construction costs of the recommended project are to be paid from appropriations from the general fund of the United States Treasury and one-half from the Inland Waterways Trust Fund. Operation, maintenance, and replacement costs (with the exception of major rehabilitation costs which are cost-shared similar to new construction) are 100 percent Federal.

25. RECOMMENDATION. The board recommends that the existing Federal commercial navigation project for Kentucky Lock and Dam be modified to provide for construction of a second and main chamber lock 110 feet wide and 1200 feet long. The improvements include railroad relocations, highway alterations, traffic management, and other measures as needed to maintain traffic on the lower Cumberland River. All of the improvements are to be generally in accordance with the plan of the district engineer, with such modifications as in the discretion of the Chief of Engineers are advisable. Based on October 1991 price levels the first cost is estimated to be $448.3 million. This recommendation is subject to cost-sharing, financing, and other applicable

requirements of Public Law 99-662, as amended and otherwise provided by law.

26. The board's recommendation reflects the information available at this time and current departmental policies governing formulation of individual projects. The recommendation does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before being transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

FOR THE BOARD:

C. E. EDGAR III
Major General, USA
Chairman

REPORT OF THE DIVISION ENGINEER

[First Endorsement]

CEORD-PE-PN
SUBJECT: Lower Cumberland and Tennessee Rivers Final Feasibility Study, Kentucky Lock Addition

DA, Ohio River Division, Corps of Engineers, P.O. Box 1159, Cincinnati, OH 45201-1159

FOR CDRUSACE (CEWRSC-WLR), Kingman Building, #2593, Ft. Belvoir, VA 22060-5580

I concur in the recommendations of the District Commander.

ALBERT J. GENETTI, JR.
Brigadier General, USA
Commanding

REPORT OF THE DISTRICT ENGINEER

Lower Cumberland and Tennessee Rivers, Kentucky and Tennessee - Kentucky Lock Addition Project

Limited Reevaluation Report (LRR) - Supplement

20 November 1995

1. ***PURPOSE***. The purpose of this supplement is to provide information to document the resolution of two policy issues identified by the Office of the Assistant Secretary of the Army (Civil Works) (OASA(CW)) during review of the final LRR for the proposed lock addition at the Kentucky Lock and Dam project.

2. ***BACKGROUND***. The LRR for the Kentucky Lock Addition project was completed by the Nashville District on 20 June 1994. The preparation of this LRR report was directed by HQUSACE using $500,000 appropriated in the Energy and Water Development Appropriations Act of 1993 (Public Law No. 102-377). The initial Washington level policy review was completed on 5 August 1994 and numerous issues and concerns were identified. Written comments were transmitted to ORD in a memorandum dated 31 January 1995 (these comments were discussed with OASA(CW) on 11 January 1995 and J. Smyth cleared release of this memorandum on 24 January 1995). A copy of the Washington level comments is attached (see Attachment 1). The responses to these comments were provided by ORD on 2 June 1995. The Washington level policy review of ORD's responses was completed on 11 July 1995, and the LRR was submitted to the Office of the Secretary of the Army (Civil Works) for review and approval on 21 July 1995. At the request of OASA(CW), a meeting was held between OASA(CW) - J. Smyth and H. Shoudy and CECW-AR - Robert McIntyre to discuss and resolve policy review comments on 1 November 1995.

3. ***ISSUES***. As indicated above, following completion of the Washington level policy review and HQUSACE approval of the LRR, the report package was submitted to OASA(CW) for review and approval. In a memorandum, dated 14 September 1995 (see Attachment 2), OASA(CW) - Harry Shoudy identified two unresolved concerns which he indicated needed further explanation and/or policy determinations. The first concern involved traffic forecasts and the impact of closing the Pride Terminal Transloader facility. The second major area of concern involved the optimal timing for construction of the additional 1,200-foot lock project.

The final resolution of these two issues is discussed below:

(A). Pride Terminal Transloader.

OASA(CW) Comment: Response 2c indicates the possibility of the Pride Transloader closure is reflected in the November 1994 waterway traffic forecasts. How is the possibility of something occurring reflected in a traffic forecast? I could understand it being analyzed in a sensitivity analysis and the most probable future without project condition being selected. Further clarification is needed.

RESOLUTION: Pride Terminal's diminished importance to Kentucky-Barkley lock traffic was first noted in response to Project Guidance Memorandum Comment 3.a.(1), with references to Comment A.4 and Comment B.2. Kentucky-Barkley traffic destined for Pride Terminal, and ultimately Southern Company's Wansley and Yates power plants in Georgia, was projected to be 2.0 million tons in 1990, but actual traffic reached only 0.3 million tons. However, in the response it was demonstrated that unexpected traffic losses at Kentucky-Barkley were balanced by expected traffic gains from coal moving to other power plants.

The adequacy of the traffic forecasts was brought-up again in HQUSACE's - LRR comments (Attachment 1), specifically Comment 1. and Comment 2. Response 2.a. presented actual traffic from 1986 to 1994 and compared it with three sets of projections: (1) the May 1990 projections used in the Feasibility Report and in the LRR; (2) the November 1994 projections; and (3) the preliminary results of the traffic projection update scheduled for completion in the fall of 1995. In the response to HQUSACE comments, it was shown that actual traffic continued to track the traffic projections used in the Feasibility Report and the LRR. Expectations for future traffic levels were also re-examined for this response. A 1993 survey of electric utilities formed the basis for the November 1994 traffic projections. At the time of this survey, Southern Company, the sole user of the Pride Transloader, indicated that closure of Pride was a possibility, but that the transportation and supply arrangements that would lock-in this decision had not yet been finalized. The November 1994 projections took into account Southern Company's uncertain response by routing only 0.2 million tons of traffic through Kentucky-Barkley to Pride Terminal in the year 2000, an amount which grows to 0.3 million tons in the year 2050.

A survey of electric utilities was completed in the summer of 1995 and will form the basis for a set of traffic projections to be completed in the fall of 1995. Results of this survey indicate that the Pride Transloader has indeed closed, but that Kentucky-Barkley traffic lost as a result of this closure is out-weighed by the addition of traffic to other power plants. Actual traffic is expected to closely track the May 1990 projections used in the Feasibility Report and the LRR, and future traffic is expected to equal or slightly exceed the projected levels used in these two reports.

(B). <u>Optimal Timing for Project Construction</u>.

OASA(CW) Comment: Comment 4, of the HQUSACE comments (Attachment 1), required a determination of the year of maximum net benefits during the time period 2008 to 2022, with each year as the starting year for the 50-year evaluation period. Response to this comment is particularly critical as this office did not support authorization of the subject project in WRDA 92. At that time, this office concluded that there was no immediate need for a new larger lock at Kentucky Lock and Dam and the existing Kentucky Lock and Barkley Lock, acting as a system, have the capability to handle traffic for many years to come. The LRR, indicates that recent traffic at Kentucky-Barkley is tracking well with the traffic projections used in the feasibility report. However, that level of traffic was not expected to challenge the existing system capacity of 62.4 million tons ....optimum timing of this project is critical to a decision for budgetary support of this project, at this time. The optimum timing is sensitive to the timing of major maintenance closures. The district was directed to vary the base year of the project in order to determine the relative impact of transportation savings from traffic growth versus the benefits from rehabilitation of the existing locks. The district response is based on a base year of 2005 and varying the project on-line date. The response also does not

provide the benefits by benefit category. This response, therefore, does not respond to the HQUSACE comment or provide the necessary information relative to the year of optimum project timing.

RESOLUTION: Four sub-issues are raised in this OASA(CW) comment as summarized below: (1) the system capacity is sufficient to meet future traffic demands for the foreseeable future; (2) optimum timing of the recommended plan is tied to the timing of the major maintenance closure in the without project condition; (3) varying base years will correctly indicate the optimum timing for the recommended plan; and (4) the district did not provide benefits by category.

Each of these 4 issues is addressed separately below:

Issue 1. The system capacity is sufficient to meet future traffic demands for the foreseeable future.

Issue 1. RESOLUTION. Physical capacity in the Kentucky-Barkley system is not a problem at Kentucky-Barkley locks until sometime around 2025, given the traffic projections used in the LRR. However, capacity at Kentucky is being challenged right now, with delays averaging over 3.5 hours per tow over the last ten years and over 4.0 hours per tow the last three years. Meanwhile, delays at Barkley averaged just about 30 minutes per tow. This disparity reflects the high cost of using Barkley lock, costs which make it a poor substitute for Kentucky Lock. As capacity at Kentucky is reached, towing companies will incur further delays and costs at Kentucky and will, with increasing regularity, use the more costly Barkley option. The Feasibility Report documented the factors which make the Lower Cumberland through Barkley route less efficient: greater travel times, higher fuel consumption, spikes in flows caused by hydropower releases, sharp bends in a narrow channel, and the need to use smaller tows. All of these factors contribute to the estimated differential of $0.50 per ton for tows using the Lower Cumberland route versus tows using the Lower Tennessee River route through Kentucky Lock.

During closures when a single lock handles the entire Kentucky-Barkley system's traffic, the capacity of the individual lock is critical. With Kentucky closed, Barkley has the ability to handle only 40.9 million tons of traffic. Likewise, with Barkley closed, a slowly degrading Kentucky has the ability to handle only 35.2 million tons of traffic. Neither lock has the capacity to efficiently handle system demands in the absence of the other, a situation Barkley is most likely to face. Between the years 2000 and 2025, Kentucky is scheduled for over 400 days of closure, and Barkley is scheduled for 126 days of closure.

Issue 2. Optimum timing of the recommended plan is tied to the timing of the major maintenance closure in the without project condition.

Issue 2. DISTRICT/DIVISION RESPONSE. The response to HQUSACE LRR Comment 4, the LRR presented a timing analysis for a project condition which did not include the two nineteen week closures in 2009 and 2010 for rehabilitation of the existing lock at Kentucky. This project condition, referred to as the base case, reflects an indefinite deferral of the lock's rehabilitation and the resulting slow deterioration of physical and operating conditions

at the project. The base condition was meant to represent a project condition that would occur in the absence of a major rehabilitation of the aging 600 foot existing lock at Kentucky. Because the base condition did not include the major rehabilitation closure, it was used to demonstrate that this major closure did not predetermine the optimum timing of the replacement of the lock. The table presented in the LRR response to Comment 4 (Table 1 in this Supplement) indicates that foregoing the major maintenance closure of Kentucky Lock still results in an optimum on-line date of 2009 for an additional, new lock at Kentucky.

This base condition does not address any of the identified problems or needs of the Kentucky-Barkley system and offers lower system benefits than the revised without project condition. System benefits associated with the base condition and the revised without project condition are presented in the Table 3, page 13 of the LRR. The analysis in this table shows the rehabilitation work included as part of the without project condition is incrementally justified. The without project condition is the appropriate reference point for measuring the incremental benefits of the recommended plan.

ISSUE RESOLUTION: Presented in Table 2 of this supplement, is a display of the net loss ($1,000s) from deferring construction of the new 1,200 foot lock chamber from 2009 (economic base year) through the year 2054. As indicated in this table, if the new lock is "on-line" in the year 2009, the net economic loss is minimized with at $84,681,000.

Issue 3. Varying base years will correctly indicate the optimum timing for the recommended plan.

Issue 3. DISTRICT/DIVISION RESPONSE. Table 3 of this supplement presents a timing analysis for a Kentucky Lock addition given the without project condition, which includes a major maintenance closure at Kentucky. This table corresponds to Table 13 in the LRR. In order to correctly allow for direct comparison of project economics in differing years, the base year was held at 2005, the interest rate at 8.0%, and the price level at October 1993. The period of analysis was held constant as well. Again, the optimum on-line date is in the year 2009. Changing the base year will not change the ranking of optimum on-line dates. Keeping the same base year allows us to compare different investment streams that flow from differing on-line dates for the recommended plan.

Varying base years and changing the period of analysis will yield spurious results if opportunity costs and the time-value of money are not taken into account. It is true that postponing an investment will allow, at least in the case of our benefit streams which generally rise on the strength of growing traffic, the investor to tap into larger benefits in later years. However, the investor has been suffering considerable penalty in the form of ever-increasing transportation costs in the years preceding the investment. A prudent investor recognizes these opportunity costs when timing an investment decision. Additionally, the investor must decide today among investment alternatives. To do so, investment costs and benefits need to be expressed in common terms from a common reference point. Discounting to a set base year and presenting costs and benefits in present worth terms makes alternative investments comparable. The Principles and Guidelines recognize this in ER 1105-2-100, Chapter 6, Paragraph 3 by directing that NED benefits and costs be compared at a common point in time and that the same period of analysis be used for all alternative plans.

Issue 3. RESOLUTION. The district developed four additional tables to present the summary of navigation benefit streams and incremental benefits by category for a base year of 2009 and an on-line date of 2009 and also a base-year and on-line date of 2017. These tables are shown as Attachment 3. Table 2, shown earlier in this supplement, presents the net loss of deferring construction from 2009 through 2054.

Issue 4. Comment. The district did not provide benefits by category.

Issue 4. DISTRICT/DIVISION RESPONSE. Table 3 above displays benefits by category by on-line date.

Issue 4. RESOLUTION. The district provided the benefit category breakdown.

Table 1

Summary of Navigation Benefits by Category and On-line Dates
Measured Against the Base Case 1/
(All Benefits & Costs are in Millions of $October 1993 Discounted to Year 2005)

ONLINE DATES	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
INCREMENTAL SAVINGS																					
NORMAL OPERATIONS	37.4	35.6	33.9	32.4	31.0	29.7	28.5	27.4	26.3	25.3	24.4	23.5	22.7	21.9	21.2	20.5	19.9	19.3	18.7	18.1	17.5
PERIODIC MAINT.	7.6	6.2	6.2	6.2	6.2	6.2	4.5	4.5	3.9	3.9	3.9	3.3	3.4	2.8	2.8	2.8	2.0	2.1	2.1	2.1	2.1
MAJOR MAINT.	5.6	5.6	5.6	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	1.8	1.8	1.8
TOTAL SAVINGS	50.6	47.3	45.7	41.8	40.4	39.1	36.2	35.1	33.4	32.4	31.5	30.1	29.3	27.9	27.2	26.5	25.2	24.6	22.5	21.9	21.4
COSTS	29.4	27.3	25.0	23.0	21.0	20.2	18.9	17.4	16.0	14.7	13.6	12.1	10.6	10.0	9.1	8.2	7.6	7.0	6.6	6.0	5.4
NET BENEFITS	21.2	20.0	20.7	18.8	19.4	18.9	17.3	17.7	17.4	17.7	17.8	18.0	18.7	17.9	18.1	18.3	17.6	17.6	15.9	15.9	16.0

1/ The Base Case represents indefinate deferral of the rehabilitation of Kentucky Lock. This condition would result in degraded operating conditions at Kentucky. Towboat operators are assumed to exercise greater caution in order to avoid contact with deteriorating lockwall concrete and armor which could cause damage to their vessels, possibly causing barges to sink or discharge cargo.

(W/O PROJECT)

TABLE 2

9 NOV. 1995

1,200-foot lock construction costs

interest rate used in ς LRR

1	2	3	4	5	6	7	8	9	10	11
						2+3/6	4+5/6	Σ7	Σ8	
			458,000			0.08				
	Incremental Savings	Costs Avoided 1/	Interest earned deferred construction	O&M & Other Costs 2/	Discount Factor	Present Worth Savings	Present Worth Interest Earned	Accumulated Present Worth benefits foregon	Accumulated Present Worth Interest Earned	Net Loss from deferral
2009	110,495	23,700	36,640	6,100	1.08	124,255	39,574	124,255	39,574	84,681
2010	143,589	23,700	36,640	6,100	1.1664	143,423	36,643	267,678	76,217	191,461
2011	22,370	23,700	36,640	6,100	1.25971	36,672	33,928	304,250	110,145	194,105
2012	32,322	23,700	36,640	6,100	1.36049	41,178	31,415	345,428	141,560	203,867
2013	22,899	23,700	36,640	6,100	1.46933	31,714	29,088	377,142	170,648	206,494
2014	22,614	23,700	36,640	6,100	1.58687	29,186	26,933	406,328	197,582	208,746
2015	35,235	23,700	36,640	6,100	1.71382	34,388	24,938	440,716	222,520	218,196
2016	22,970	23,700	36,640	6,100	1.85093	25,214	23,091	465,930	245,611	220,319
2017	38,929	23,700	36,640	6,100	1.999	31,330	21,381	497,260	266,992	230,268
2018	24,222	23,700	36,640	6,100	2.15892	22,197	19,797	519,457	286,789	232,669
2019	24,487	23,700	36,640	6,100	2.33164	20,667	18,330	540,124	305,119	235,005
2020	50,593	23,700	36,640	6,100	2.51817	29,503	16,973	569,627	322,092	247,535
2021	24,440	23,700	36,640	6,100	2.71962	17,701	15,715	587,328	337,807	249,520
2022	98,658	23,700	36,640	6,100	2.93719	41,658	14,551	628,986	352,359	276,627
2023	26,212	23,700	36,640	6,100	3.17217	15,734	13,473	644,720	365,832	278,888
2024	26,899	23,700	36,640	6,100	3.42594	14,711	12,475	659,431	378,308	281,124
2025	50,295	23,700	36,640	6,100	3.70002	19,999	11,551	679,430	389,859	289,571
2026	26,704	23,700	36,640	6,100	3.99602	12,614	10,696	692,043	400,554	291,489
2027	49,892	23,700	36,640	6,100	4.3157	17,052	9,903	709,096	410,458	298,638
2028	28,647	23,700	36,640	6,100	4.66096	11,231	9,170	720,326	419,628	300,699
2029	29,134	23,700	36,640	6,100	5.03383	10,496	8,491	730,822	428,118	302,704
2030	65,425	23,700	36,640	6,100	5.43654	16,394	7,862	747,216	435,980	311,236
2031	28,791	23,700	36,640	6,100	5.87146	8,940	7,279	756,156	443,259	312,897
2032	65,921	23,700	36,640	6,100	6.34118	14,133	6,740	770,289	449,999	320,290
2033	32,600	23,700	36,640	6,100	6.84848	8,221	6,241	778,510	456,240	322,270
2034	33,593	23,700	36,640	6,100	7.39635	7,746	5,779	786,256	462,018	324,238
2035	64,101	23,700	36,640	6,100	7.98806	10,992	5,350	797,248	467,369	329,879
2036	32,045	23,700	36,640	6,100	8.62711	6,462	4,954	803,709	472,323	331,386
2037	65,244	23,700	36,640	6,100	9.31727	9,546	4,587	813,255	476,910	336,345
2038	37,565	23,700	36,640	6,100	10.06266	6,088	4,247	819,344	481,158	338,186
2039	38,558	23,700	36,640	6,100	10.86767	5,729	3,933	825,072	485,090	339,982
2040	238,816	23,700	36,640	6,100	11.73708	22,366	3,641	847,439	488,732	358,707
2041	235,165	23,700	36,640	6,100	12.67605	20,422	3,372	867,860	492,104	375,757
2042	95,088	23,700	36,640	6,100	13.69013	8,677	3,122	876,537	495,226	381,312
2043	67,057	23,700	36,640	6,100	14.78534	6,138	2,891	882,676	498,116	384,559
2044	76,266	23,700	36,640	6,100	15.96817	6,260	2,677	888,936	500,793	388,143
2045	102,060	23,700	36,640	6,100	17.24563	7,292	2,478	896,228	503,271	392,957
2046	87,579	23,700	36,640	6,100	18.62528	5,975	2,295	902,203	505,566	396,637
2047	125,295	23,700	36,640	6,100	20.1153	7,407	2,125	909,610	507,691	401,919
2048	112,902	23,700	36,640	6,100	21.72452	6,288	1,967	915,898	509,658	406,240
2049	122,070	23,700	36,640	6,100	23.46248	6,213	1,822	922,111	511,480	410,631
2050	207,608	23,700	36,640	6,100	25.33948	9,128	1,687	931,239	513,166	418,073
2051	121,806	23,700	36,640	6,100	27.36664	5,317	1,562	936,556	514,728	421,828
2052	148,988	23,700	36,640	6,100	29.55597	5,843	1,446	942,399	516,174	426,225
2053	131,239	23,700	36,640	6,100	31.92045	4,854	1,339	947,253	517,513	429,740
2054	131,239	23,700	36,640	6,100	34.47409	4,494	1,240	951,747	518,753	432,994

NOPV of the net losses from lock construction

Accumulated NOPV to do with project benefits and avoided costs

Accumulated NOPV of existing O&M and interest that could be earned on the funds needed to construct the new lock

Revised based on H. Shoudy telephone call 11/9/95:

Footnotes:

1/ *Costs Avoided:*
Existing O&M - $5.7M (600' Lock)
Helper Boats - 2.6M "
Hydropower Impacts - 15.4M "
$23.7M

2/ *w/Project (O&M & Annual Costs):*
O&M w/project (1200') = $4.7M (1200' lock)
Impacts to transp./highway = $1.4M
$6.1M

KENTUCKY LOCK ADDITION

SUMMARY OF NAVIGATION BENEFIT STREAMS AND INCREMENTAL BENEFITS BY CATEGORY
(BASE YEAR 2009, ON-LINE DATE 2009, THOUSANDS OF OCTOBER 1993 DOLLARS)

YEAR	W/O PROJECT CLOSURE SCHEDULE KENT. CLOSED	BARK. CLOSED	TOTAL TRANSPORTATION SAVINGS WITHOUT	WITH	INCREMENTAL SAVINGS BY CATEGORY NORMAL	CLOSURE	TOTAL	CUMULATIVE SAVINGS NOMINAL	DISCOUNTED
2009	130	0	3,561,653	3,672,147	23,315	87,179	110,495	110,495	102,310
2010	130	28	3,558,573	3,702,162	23,231	120,358	143,589	254,083	225,414
2011	0	0	3,706,640	3,729,009	22,370	0	22,370	276,453	243,172
2012	14	0	3,723,534	3,755,856	22,634	9,688	32,322	308,775	266,929
2013	0	0	3,759,805	3,782,704	22,899	0	22,899	331,674	282,514
2014	0	0	3,786,387	3,809,001	23,164	-549 [1]	22,614	354,288	296,765
2015	0	14	3,800,590	3,835,825	23,428	11,807	35,235	389,523	317,324
2016	0	0	3,839,552	3,862,523	23,693	-723 [1]	22,970	412,494	329,734
2017	21	0	3,851,163	3,890,093	23,958	14,972	38,929	451,423	349,209
2018	0	0	3,892,717	3,916,940	24,222	0	24,222	475,646	360,429
2019	0	0	3,919,300	3,943,787	24,487	0	24,487	500,133	370,931
2020	0	28	3,920,042	3,970,634	24,752	25,841	50,593	550,725	391,022
2021	0	0	3,986,426	4,010,865	25,239	-799 [1]	24,440	575,165	400,008
2022	90	0	3,953,491	4,052,149	25,726	72,932	98,658	673,823	433,597
2023	0	0	4,067,512	4,093,725	26,212	0	26,212	700,036	441,861
2024	0	0	4,108,055	4,134,755	26,699	0	26,699	726,735	449,654
2025	0	21	4,125,482	4,175,777	27,186	23,109	50,295	777,030	463,247
2026	0	0	4,189,142	4,215,846	27,673	-969 [1]	26,704	803,734	469,930
2027	21	0	4,207,768	4,257,660	28,160	21,732	49,892	853,626	481,490
2028	0	0	4,270,229	4,298,876	28,647	0	28,647	882,273	487,636
2029	0	0	4,310,772	4,339,906	29,134	0	29,134	911,407	493,424
2030	0	28	4,315,511	4,380,936	29,621	35,804	65,425	976,832	505,458

[1]/ Closure events occur in the with project condition for periodic maintenance of the new 1200' lock and major rehabilitation of the old 600' chamber at Kentucky, causing very slight reductions in with project system benefits. When these closures occur in the absence of without project closures, the result is a small, negative closure benefit to the with project condition.

Attachment 3 (Pg. 1)

KENTUCKY LOCK ADDITION

SUMMARY OF NAVIGATION BENEFIT STREAMS AND INCREMENTAL BENEFITS BY CATEGORY
(BASE YEAR 2017, ON-LINE DATE 2017, THOUSANDS OF OCTOBER 1993 DOLLARS)

	W/O PROJECT CLOSURE SCHEDULE		TOTAL TRANSPORTATION SAVINGS		INCREMENTAL SAVINGS BY CATEGORY			CUMULATIVE SAVINGS	
YEAR	KENT. CLOSED	BARK. CLOSED	WITHOUT	WITH	NORMAL	CLOSURE	TOTAL	NOMINAL	DISCOUNTED
2017	21	0	3,851,163	3,890,093	23,958	14,972	38,929	38,929	36,046
2018	0	0	3,892,717	3,916,940	24,222	0	24,222	63,152	58,813
2019	0	0 .	3,919,300	3,943,787	24,487	0	24,487	87,639	76,251
2020	0	28	3.920,042	3,970,634	24,752	25,841	50,593	138,232	113,438
2021	0	0	3,986.426	4,010.865	25,239	-799 [1]	24,440	162.671	130.072
2022	90	0	3,953,491	4,052,149	25,726	72.932	98,658	261,329	192,243
2023	0	0	4,067,512	4,093.725	26,212	0	26,212	287,542	207,538
2024	0	0	4,108,055	4,134.755	26,699	0	26,699	314,241	221,962
2025	0	21	4,125,482	4,175.777	27,186	23.109	50,295	364,536	247,122
2026	0	0	4,189,142	4,215.846	27,673	-969 [1]	26,704	391,240	259.492
2027	21	0	4,207,768	4,257.660	28,160	21.732	49.892	441,133	280,890
2028	0	0	4,270,229	4,298.876	28,647	0	28,647	469.779	292.266
2029	0	0	4,310,772	4.339.906	29,134	0	29,134	498.913	302.978
2030	0	28	4,315,511	4.380.936	29.621	35,804	65,425	564.338	325,253
2031	0	0	4,383,875	4.412,666	30,614	-1,823 [1]	28,791	593.129	334,329
2032	28	0	4,381,775	4.447,696	31,607	34.314	65.921	659.050	353,570
2033	0	0	4,448,996	4.481.595	32,600	0	32.600	691,649	362,381
2034	0	0	4,481,556	4,515,148	33,593	0	33.593	725,242	370,788
2035	0	21	4,484,595	4,548,696	34,586	29.515	64.101	789.343	385,641
2036	0	0	4,546,676	4,578,721	35,579	-3,534 [1]	32,045	821.388	392,516
2037	21	0	4,550,206	4,615,450	36,572	28,672	65,244	886,632	405,477
2038	0	0	4,611,796	4,649,361	37,565	0	37,565	924,197	412,387
2039	0	0	4,644,356	4,682,914	38,558	0	38,558	962,755	418,954
2040	0	130	4,477,652	4,716,467	39,551	199,265	238,816	1,201,571	456,615
2041	0	130	4,499,119	4,734,283	48,720	186,445	235,165	1,436,736	490,953
2042	28	0	4,664,182	4,759,270	57,889	37,199	95,088	1,531,823	503,809

[1]/ Closure events occur in the with project condition for periodic maintenance of the new 1200' lock and major rehabilitation of the old 600' chamber at Kentucky, causing very slight reductions in with project system benefits. When these closures occur in the absence of without project closures, the result is a small, negative closure benefit to the with project condition.

Attachment 3
(Pg. 2)

Table 3

Summary of Navigation Benefits by Category and On-line Dates
Measured Against the Revised Without Project Condition 1/
(All Benefits & Costs are in Millions of $October 1993 Discounted to Year 2005)

ONLINE DATES	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
RATE SAVINGS																					
NORMAL OPERATIONS	27.8	26.0	24.3	22.8	21.4	20.1	18.9	17.8	16.8	15.9	15.0	14.2	13.4	12.7	12.0	11.4	10.8	10.3	9.7	9.2	8.8
PERIODIC MAINT.	7.9	6.4	6.4	5.5	5.5	5.5	3.9	3.9	3.5	3.5	3.5	3.0	3.1	2.6	2.6	2.6	2.0	2.0	2.0	2.0	2.0
MAJOR MAINTENANCE	13.0	13.0	13.0	13.0	13.0	8.1	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	2.1	2.1	2.1
TOTAL	48.6	45.4	43.7	41.3	39.9	33.8	26.4	25.3	23.9	22.9	22.1	20.8	20.1	18.9	18.2	17.6	16.4	15.9	13.8	13.4	12.9
INCREMENTAL COSTS	29.4	27.3	25.0	23.1	21.1	20.4	18.9	17.4	16.0	14.7	13.6	12.1	10.6	10.0	9.1	8.2	7.6	7.0	6.6	6.0	5.4
NET BENEFITS	9.8	8.7	9.3	18.2	18.8	13.4	7.5	7.9	7.9	8.2	8.5	8.7	9.5	8.9	9.1	9.4	8.8	8.9	7.2	7.4	7.5

1/ The revised without project condition is presented in the LRR and is summarized on page 18 of that report.

DRAFT

LOWER CUMBERLAND AND TENNESSEE RIVERS

LIMITED REEVALUATION REPORT

KENTUCKY LOCK ADDITION

U.S. ARMY CORPS OF ENGINEERS

NASHVILLE DISTRICT

NASHVILLE, TENNESSEE

FEBRUARY 1994

DRAFT

LOWER CUMBERLAND AND TENNESSEE RIVERS
LIMITED REEVALUATION REPORT
KENTUCKY LOCK ADDITION

LIST OF TABLES

LIST OF EXHIBITS

APPENDICES

LOWER CUMBERLAND AND TENNESSEE RIVERS
LIMITED REEVALUATION REPORT
KENTUCKY LOCK ADDITION

SECTION 1 - THE STUDY AND REPORT

SCOPE OF STUDY

1.01 The District completed the feasibility report investigating improvements to the Kentucky-Barkley navigation system in March 1992. The feasibility report recommended the addition of a 1200-foot by 110-foot lock chamber to the Kentucky Project. Since this project was not among the projects authorized by the Water Resources and Development Act of 1992, the District was directed to prepare a Limited Reevaluation Report (LRR) addressing several issues and concerns (Exhibit 1). This LRR will investigate these issues and confirm the validity of the conclusions of the March 1992 feasibility report.

AUTHORITY OF STUDY

1.02 An October 2, 1972 resolution, adopted by the U.S. Senate Committee on Public Works, requested the Corps of Engineers to investigate the advisability of navigation improvements on the Cumberland and Tennessee rivers, generally below the connecting Barkley Canal. The feasibility study responded to the 1972 resolution and was an interim or partial response to another resolution adopted on September 9, 1982 by the U.S. Senate Committee on the Environment and Public Works. This resolution requested the Corps of Engineers to evaluate the entire Tennessee River with a view to determining whether any modifications to improve navigation are advisable. This Limited Reevaluation Report should be viewed as a continuation of the feasibility report.

FEASIBILITY STUDY

1.03 This report is a continuation of the March 1992 feasibility report. As such, it is assumed that the reader is already familiar with that report. This report will not reiterate the details of the feasibility report. However, a brief summary of the conclusions of the feasibility report is presented below.

1.04 The "without-project condition" is defined as the most likely condition expected to exist in the future in absence of any federal improvements. Benefits and costs relative to the without-project condition serve as the baseline against which incremental costs and benefits of alternatives are measured. The without-project condition described in the feasibility report includes the following key features: (1) modified hydropower operations at the Barkley Powerplant to allow safe passage of high volumes of traffic on the lower Cumberland River; (2) the most efficient lockage policy along with helper boats at Kentucky Lock by the year 2000 to maximize system capacity; and (3) routine, periodic, and major maintenance performed at both locks as needed to insure continued safe and dependable operation of the system.

1.05 The recommendation of the feasibility report was to add a 110-foot wide, 1200-foot long lock at the Kentucky Project. The plan includes constructing a new railroad bridge immediately downstream of the project and elevating a short section of the highway. The initial project cost was estimated to be $448 million at October 1991 prices. The incremental average annual benefits and costs were estimated at $53.8 million and $31.9 million, respectively, resulting in net benefits of $21.9 million and a benefit to cost ratio of 1.7.

DESCRIPTION OF STUDY AREA

1.06 The Cumberland and Tennessee rivers are the Ohio River's largest tributaries. The 13 multipurpose projects on the Cumberland and Tennessee rivers provide more than 1,037 miles of nine-foot deep navigable waterway. This report focuses on the Kentucky-Barkley portion of this navigation network. The 1967 construction of Barkley Canal connected the Cumberland and Tennessee rivers immediately upstream of the Kentucky and Barkley projects creating the Kentucky-Barkley navigation system. The system is comprised of the 30.6 mile segment of the Cumberland River below Barkley Dam, Barkley Lock, the sections of Lake Barkley and Kentucky Lake immediately above the dams including Barkley Canal, the 22.4 miles of the Tennessee River below the Kentucky Project, Kentucky Lock, and the intervening section of the lower Ohio River - Smithland to Paducah, Kentucky.

CONTENTS OF REPORT

1.07 This report is organized into major topical sections addressing the issues and concerns delineated in Exhibit 1. Section 2 describes the without project condition as refined in response to the LRR study items. Section 3 presents an analysis of recent traffic trends and investigates the validity of the feasibility report traffic projections. Section 4 examines the need for a downstream training dike. Section 5 reanalyzes the economic effects of the recommended plan. Finally, Section 6 discusses the conclusions and recommendations based on our findings.

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
WASHINGTON, D.C. 20314-1000

REPLY TO ATTENTION OF:

CECW-PE

13 NOV 1992

MEMORANDUM FOR COMMANDER, OHIO RIVER DIVISION ATTN: CEORD-PE-PN

SUBJECT: Lower Cumberland and Tennessee Rivers, KY & TN - Kentucky Lock Addition Project - Fiscal Year 1993 Preconstruction Engineering and Design (PED) Activities

1. Reference Fiscal Year 1993 - Initial Work Allowance dated 4 November 1992 for the subject project.

2. Funding amounting to $500,000 was appropriated in the Fiscal Year 1993 - Energy and Water Development Appropriations Act and this legislation directed the continuation of PED for the Kentucky Lock addition project. The Act language reads as follows:

> "Provided further, That using $500,000 of the funds appropriated herein, the Secretary of the Army, acting through the Chief of Engineers, is directed to continue preconstruction engineering and design for the Kentucky Lock, Kentucky project in accordance with the Report of the Chief of Engineers dated June 1, 1992."

2. Because this project was not among the projects authorized by the Water Resources Development Act of 1992, the district should prepare, within the $500,000 appropriation for Fiscal Year 1993, a Limited Reevaluation Report (LRR) addressing the following issues and concerns relating to the project:

a. Major Maintenance Closures - The District should reanalyze the duration, timing and need for maintenance closures. In addition, major rehabilitation of both Kentucky and Barkley Locks should be evaluated in terms of "reliability analysis" in accordance with the latest major rehabilitation program guidance.

b. Lock Capacity/Utilization - Major commodity projections should be reviewed and historical, current and projected traffic demand should be reanalyzed.

c. Economics - The economic sensitivity of major maintenance closures (issue 2a above) should be analyzed and the project economics including costs and benefits should be updated.

d. Environmental - The District should reevaluate the need for the tailwater training dike and reassess the mussel impacts.

EXHIBIT 1

SECTION 2 - WITHOUT-PROJECT CONDITION

GENERAL

2.01 The most critical issues and concerns detailed in Exhibit 1 pertain to the without-project condition defined in the feasibility report. Specifically, this section evaluates the need, duration and timing of major and periodic maintenance closures and reevaluates management measures for efficient utilization of Barkley Lock during closures of Kentucky Lock. This section examines these issues and concerns and presents a refined without-project condition based on a more detailed analysis.

FEASIBILITY REPORT WITHOUT-PROJECT CONDITION

2.02 As summarized earlier, the without-project condition as defined in the feasibility report includes: (1) modified hydropower operations at the Barkley Powerplant to allow safe passage of high volumes of traffic on the lower Cumberland River; (2) the most efficient lockage policy along with helper boats at Kentucky Lock; (3) routine, periodic, and major maintenance performed at both locks as needed; and (4) the congressionally authorized replacement of locks and/or dams at Gallipolis L&D, Olmstead L&D, McAlpine L&D, Winfield L&D, Point Marion L&D, and Gray's Landing L&D assumed to be in-place.

2.03 **HYDROPOWER MODIFICATION**. Pool fluctuations caused by hydropower discharges are a major impediment to navigating the lower Cumberland River. Barkley's current hydropower operations interfere with industry's ability to use the lower Cumberland River and Barkley Lock during periods of peak power generation (when the amount of water being discharged is changed rapidly) and when discharges are greater than 40,000 cubic feet per second (cfs). This equates to Barkley Lock being "down" or unavailable to a vast majority of the towing industry about 40 percent of the time.

2.04 Under the feasibility report without-project condition, the minimum continuous hydropower release would be increased to 9,000 cfs, while the maximum release would be limited to 40,000 cfs. Some of the flow that would go through Barkley's turbines under current conditions would be diverted to Kentucky under the without-project condition. The major change in hydropower operations involves limiting the rate of discharge to 6,000 cfs in a 6-hour period.

2.04 **LOCKAGE POLICIES**. The feasibility study evaluated five lockage policies at Kentucky Lock. The first-in-first-out (FIFO) policy represents existing conditions and serves as the basis for comparing the other policies. Two policies, one-up-one-down (1UP-1DN) and three-up-three-down (3UP-3DN), are almost identical in terms of capacity. Both provide slightly less capacity than FIFO when analyzed

e. <u>Lower Cumberland Traffic Management Plan</u> - Reevaluate management measures for efficient utilization of Barkley Lock during closures of Kentucky Lock. Reanalyze hydropower releases at Barkley Dam and effects on navigation on the lower Cumberland River and Barkley Lock.

4. With a portion of the funds provided in reference 1, the district should immediately prepare a plan of study with associated costs and schedule for completing the LRR. In addition to addressing the above mentioned issues, the LRR should include a reanalysis of the project justification and determination of the optimal timing of construction and a recommended PED schedule. The plan of study for the LRR should be furnished to CECW-PE by 14 December 1992 for review and approval.

FOR THE DIRECTOR OF CIVIL WORKS:

Hugh E. Wright / for

JIMMY F. BATES
Chief, Policy and Planning Division
Directorate of Civil Works

alone, but when analyzed in combination with helper boat plans, they produce capacity gains. However, 3UP-3DN is preferred by lock personnel and is, therefore, part of the without-project condition.

2.05 **HELPER BOAT SCHEMES**. Three helper boat schemes were evaluated using the best of the lockage policies - 3UP-3DN. Under normal operations, the first cut of a double lockage is removed from the lock chamber by a tow haulage unit. The unit holds the first cut on the wall until the second cut is processed. The tow is remade on the wall.

2.06 Helper boat Scheme C was determined to be the best helper boat plan because it reduced lockage times the most and, therefore, allowed for the maximum increase in lock capacity. Scheme C requires constructing two mooring cells above and two cells below Kentucky Lock. The helper boat pulls the first cut out of the chamber and takes it to the new mooring cells. The lock is turned-back immediately after the first cut clears the chamber. The second cut is then locked through and the chamber turned back immediately for the next tow. Tows are reconfigured on the mooring cells. This scheme minimizes the amount of time each cut spends in the chamber and approaches.

2.07 **MAINTENANCE**. The feasibility report called for a continuation of the District's 5-year periodic maintenance cycle. The feasibility report also called for four 13-week outages from 2006-2009 at Kentucky to rehabilitate the concrete and wall armor and to paint the miter gates. Table 1 shows the maintenance schedule for Kentucky and Barkley over the period of analysis.

2.08 **SUMMARY**. In summary, the feasibility report without-project condition includes maintaining Kentucky and Barkley Locks in accordance with current policies and procedures, modifying hydropower operations at Barkley Locks to allow safe navigation of the lower Cumberland under high traffic conditions, and implementing helper boat Scheme C concurrently with a 3UP-3DN lockage policy.

Table 1

Periodic and Major Maintenance Closures - Kentucky and Barkley Locks
Feasibility Report Without-Project Condition

YEAR	PROJECT	LENGTH OF CLOSURE (WEEKS)	COST OF REPAIR (1,000s)	MAJOR ITEMS TO BE REPAIRED
2005	BARKLEY	3	675	REHABILITATE TOW HAULAGE UNIT; REPLACE ALL WATER AND AIR PIPING
2006	KENTUCKY	13	7,000	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK; REPLACE AIR/WATER PIPING; PAINT GATES
2007	KENTUCKY	13	4,865	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2008	KENTUCKY	13	4,865	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2009	KENTUCKY	13	4,865	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2010	BARKLEY	4	520	UPGRADE MAIN POWER CIRCUITS; REPLACE INTAKE SCREEN
2012	KENTUCKY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2015	BARKLEY	2	415	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2017	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2020	BARKLEY	4	1,140	REPLACE MOORING BITTS; REHABILITATE UPPER EMERGENCY DAM
2022	KENTUCKY	8	14,145	REPLACE MITER GATES, VALVES, OPERATING MACHINERY AND MOORING BITTS
2025	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2027	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2030	BARKLEY	4	730	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2032	KENTUCKY	4	1,145	REPLACE FLOATING GUARD BOOM TIMBER AND INTAKE SCREEN
2035	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2037	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2038	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2039	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2040	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2041	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2042	KENTUCKY	4	780	REPLACE INTAKE SCREENS
2045	BARKLEY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2047	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2050	BARKLEY	8	14,145	REHAB/REPLACE GATES, VALVES & MACHINERY
2052	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED

2.09 **MITER GATES**. The Kentucky Lock miter gates are horizontally framed, double skin gates. The downstream gates have 23 horizontal girders and the upstream gates have 11 girders. The upstream gates are identical to the top portion of the downstream gates. The lower gate leaves are 92 feet tall weighing 650 tons each. These gates, being double skin plated, make access to the inside of the gate very difficult, if not impossible, to clean, repaint and maintain. The miter gates at Kentucky Lock have been a continual maintenance problem for the last 20 years due to their size and double skinplate construction. Painting contractors were hired for each of the last three maintenance unwaterings to spot clean and repaint the interior of the gates. Time during the unwaterings has only allowed the worst areas to be worked on. These paint contracts have only been able to remove loose paint and re-coat over what paint is left due to difficulties performing blasting or surface removal work inside of gates. This inability to get back to bare metal renders the new coating only marginally effective at protecting the gate.

2.10 **LOCKWALL CONCRETE AND EMBEDDED METALS**. Kentucky Lock is 50 years old and sustains very heavy usage. Deterioration of concrete and structural steel components is caused by time, weather, and friction. The constant frictional wear is caused by horizontal and vertical rubbing of towboats and barges passing through the lock. The concrete is worn away in places as much as 2-inches deep. The edges of embedded metals are exposed and metals themselves are well-worn from the effects of traffic. Armor around many recesses has been torn away from its anchorage. The armor in these areas is exposed on the ends, is cracked, and the concrete behind the steel has been broken away. This damage is worse around upper and lower ends of the lock where tows bump to line up with the chamber. Armor around edges of line hooks, floating bits and gate recesses are exposed where concrete has worn away. Tows have torn pieces of this armor away leaving rough steel edges.

2.11 The wall armor at Kentucky Lock has been patched, re-anchored, and built-up at every periodic maintenance unwatering and most unscheduled maintenance periods for the last 20 years. Over the years, virtually all major armor areas have been repaired at one time or another. We are now seeing most of the previously repaired areas in need of additional repair at every periodic closure, damaged worse than before, and the damage is accelerating. We expect this trend to continue as the concrete anchorage behind the metals breaks down and the metal armor wears through or breaks upon impact.

MAJOR MAINTENANCE

2.11 As described earlier, the feasibility report without-project condition called for four 13-week major maintenance closures from 2006-2009 to rehabilitate the concrete and wall armor and to paint the miter gates at Kentucky. This section reexamines the need for and timing of this major maintenance. The results obtained for Kentucky will be applied to Barkley to reformulate the without-project condition.

2.12 Four alternatives were examined: (1) base case (do not perform major maintenance); (2) rehabilitate concrete and wall armor and paint miter gates as described in the feasibility report; (3) repaint or replace the miter gates only; and (4) rehabilitate the concrete and wall armor only.

2.13 **MITER GATES**. The miter gates are the only lock feature that has established reliability analysis methodologies, severe economic consequences of unreliable performance, and serious concern for its long term condition. The reliability analysis of Kentucky Lock miter gates is different than has been performed in the past. The reliability methodology pertains to gates proven to be currently unreliable. For our analysis, we are applying this methodology to the expected future condition of the miter gates by 2005. A complete description of the reliability analysis is contained in Appendix A -- Engineering Analysis of Existing Kentucky Lock.

2.14 Table 2 displays the economic analysis of replacing the miter gates. The benefits of replacing the miter gates are derived from the probabilities of unsatisfactory performance obtained from the reliability analysis and the economic consequences of gate failure to the navigation industry. The costs of replacing the gates are the construction costs plus the costs to the navigation industry associated with a 90 day closure to accomplish the work. The total cost of gate rehabilitation in 2005 is $76.7 million. The present value in 2005 of the benefits of gate rehabilitation for the 50 year period from 2005-2054 is just a little over $1,000. Clearly, based on the current reliability methodology, rehabilitating the miter gates is not warranted in the 2005-2009 timeframe. Rehabilitating the miter gates in the 2005-2009 timeframe is not justified as a stand alone alternative or in conjunction with the lockwall armor and concrete rehabilitation as described in the feasibility report.

Table 2
Kentucky Lock Miter Gates Rehabilitation Analysis

Expected Cost of Failure

Hazard Function = (Gamma/Theta) * (Time/Theta) ^(Gamma -1)
Gamma 3.43703
Theta 1207.06
Time Years since 1977

Costs
104 day closure cost = sum of short term fixes + new gates + cost to navigation
90 day closure cost = sum of new gates + cost to navigation
Gates 22,581,441
Shortfix 250,000
Navigation see below

		Benefits of Gate Rehabilitation					Cost of Gate Rehabilitation	
Year	Time	Hazard Failure rate	104 day close Nav. Cost	Total Cost of a Failure w/ 104 day close	Expected Cost w/ 104 day closure = Hazard*Cost	Present Value	90 day closure Nav. Cost	Total Cost of a Replaceme w/ 90 day close
2005	28	2.9577E-07	62,588,930	85,420,371	25.26	25.26	54,163,500	76,744,941
2006	29	3.2218E-07	63,572,598	86,404,039	27.84	25.78	55,014,752	77,596,193
2007	30	3.4993E-07	64,556,266	87,387,707	30.58	26.22	55,866,004	78,447,445
2008	31	3.7904E-07	65,539,934	88,371,375	33.50	26.59	56,717,256	79,298,697
2009	32	4.0953E-07	66,523,602	89,355,043	36.59	26.90	57,568,508	80,149,949
2010	33	4.4142E-07	67,507,270	90,338,711	39.88	27.14	58,419,760	81,001,201
2011	34	4.7473E-07	67,900,763	90,732,204	43.07	27.14	58,760,282	81,341,723
2012	35	5.0948E-07	68,294,256	91,125,697	46.43	27.09	59,100,804	81,682,245
2013	36	5.4569E-07	68,687,749	91,519,190	49.94	26.98	59,441,326	82,022,767
2014	37	5.8337E-07	69,081,242	91,912,683	53.62	26.82	59,781,848	82,363,289
2015	38	6.2254E-07	69,474,735	92,306,176	57.46	26.62	60,122,370	82,703,811
2016	39	6.6323E-07	69,868,228	92,699,669	61.48	26.37	60,462,892	83,044,333
2017	40	7.0544E-07	70,261,721	93,093,162	65.67	26.08	60,803,414	83,384,855
2018	41	7.4919E-07	70,655,214	93,486,655	70.04	25.75	61,143,936	83,725,377
2019	42	7.9450E-07	71,048,707	93,880,148	74.59	25.39	61,484,458	84,065,899
2020	43	8.4140E-07	71,442,200	94,273,641	79.32	25.01	61,824,980	84,406,421
2021	44	8.8988E-07	75,710,607	98,542,048	87.69	25.60	65,518,794	88,100,235
2022	45	9.3998E-07	79,979,014	102,810,455	96.64	26.12	69,212,608	91,794,049
2023	46	9.9170E-07	84,247,421	107,078,862	106.19	26.57	72,906,422	95,487,863
2024	47	1.0451E-06	88,515,828	111,347,269	116.36	26.96	76,600,236	99,181,677
2025	48	1.1001E-06	92,784,235	115,615,676	127.19	27.29	80,294,050	102,875,491
2026	49	1.1568E-06	97,052,642	119,884,083	138.68	27.55	83,987,864	106,569,305
2027	50	1.2151E-06	101,321,049	124,152,490	150.86	27.75	87,681,678	110,263,119
2028	51	1.2752E-06	105,589,456	128,420,897	163.77	27.89	91,375,492	113,956,933
2029	52	1.3370E-06	109,857,863	132,689,304	177.41	27.98	95,069,306	117,650,747
2030	53	1.4006E-06	114,126,270	136,957,711	191.82	28.01	98,763,120	121,344,561
2031	54	1.4658E-06	115,252,642	138,084,083	202.41	27.37	99,737,865	122,319,306
2032	55	1.5329E-06	116,379,014	139,210,455	213.39	26.71	100,712,610	123,294,051
2033	56	1.6017E-06	117,505,386	140,336,827	224.77	26.05	101,687,355	124,268,796
2034	57	1.6723E-06	118,631,758	141,463,199	236.57	25.39	102,662,100	125,243,541
2035	58	1.7447E-06	119,758,130	142,589,571	248.77	24.72	103,636,845	126,218,286
2036	59	1.8189E-06	120,884,502	143,715,943	261.40	24.05	104,611,590	127,193,031
2037	60	1.8949E-06	122,010,874	144,842,315	274.47	23.38	105,586,335	128,167,776
2038	61	1.9728E-06	123,137,246	145,968,687	287.97	22.72	106,561,080	129,142,521
2039	62	2.0526E-06	124,263,618	147,095,059	301.93	22.05	107,535,825	130,117,266
2040	63	2.1342E-06	125,389,990	148,221,431	316.33	21.40	108,510,570	131,092,011
2041	64	2.2177E-06	117,619,784	140,451,225	311.48	19.51	101,786,354	124,367,795
2042	65	2.3031E-06	109,849,578	132,681,019	305.58	17.72	95,062,138	117,643,579
2043	66	2.3904E-06	102,079,372	124,910,813	298.59	16.03	88,337,922	110,919,363
2044	67	2.4796E-06	94,309,166	117,140,607	290.47	14.44	81,613,706	104,195,147
2045	68	2.5708E-06	86,538,960	109,370,401	281.17	12.94	74,889,490	97,470,931
2046	69	2.6639E-06	78,768,754	101,600,195	270.65	11.54	68,165,274	90,746,715
2047	70	2.7590E-06	70,998,548	93,829,989	258.87	10.22	61,441,058	84,022,499
2048	71	2.8560E-06	63,228,342	86,059,783	245.79	8.98	54,716,842	77,298,283
2049	72	2.9550E-06	55,458,136	78,289,577	231.35	7.83	47,992,626	70,574,067
2050	73	3.0561E-06	47,687,930	70,519,371	215.51	6.75	41,268,410	63,849,851
2051	74	3.1591E-06	47,687,930	70,519,371	222.78	6.46	41,268,410	63,849,851
2052	75	3.2641E-06	47,687,930	70,519,371	230.19	6.18	41,268,410	63,849,851
2053	76	3.3712E-06	47,687,930	70,519,371	237.74	5.91	41,268,410	63,849,851
2054	77	3.4804E-06	47,687,930	70,519,371	245.43	5.65	41,268,410	63,849,851

Present Value from 2005-2054 1,086.87

2.15 The reliability analysis contained in Appendix A predicts relatively low hazard for the miter gates under normal operating conditions. It should be noted that this hazard was calculated for pool elevations corresponding to historically observed normal operating conditions. These conditions represent an average head of only 48 feet in contrast to the flood head of 78 feet for which the miter gates were originally designed. In this context, it is appropriate to examine the integrity of the miter gates with continued corrosion under the design flood conditions. Such an examination indicates that in the year 2004 the allowable stresses under current design criteria would, in fact, be exceeded. At that time, the miter gates will possess a smaller margin of safety than was intended in the design of the Kentucky Lock and Dam project. The recent 1993 flooding on the Upper Mississippi River System dramatizes the importance of flood control structures performing their intended functions during extreme hydrological events.

2.16 Based on the above analysis, rehabilitating the miter gates are removed from the 2006-2009 major maintenance closure as described in the feasibility report. However, due to dam safety concerns, it is reasonable to assume that the miter gates will need to be replaced sometime in the period of analysis. In the revised without-project condition, the miter gates will be replaced in the year 2022. By moving the miter gate replacement out to this date, it no longer has any bearing on the optimum timing analysis for adding a new lock to Kentucky.

2.17 **LOCKWALL CONCRETE AND EMBEDDED METALS**. From an Engineering reliability standpoint, the deterioration of the lockwall concrete and armor does not pose a wall stability, miter gate operation or floating mooring bit operation hazard until a significant amount of concrete is lost such that corners of tows could contact the ends of gates or damage a floating bit. Currently, the Corps does not have methods of projecting wall deterioration due to impacts and abrasion. For these reasons, the analysis of wall deterioration and the need for rehabilitation of the lockwall armor and concrete must be investigated from a lock operating efficiency standpoint.

2.18 Lock operating personnel believe that if the lockwall armor and concrete are not rehabilitated, damage to tows by loose armor is an increasing possibility that can result in minimal to fairly major consequences. Should a barge impact a partially embedded section of steel armor, exposed against the barge's direction of travel, the mass of the barge would create sufficient force to drive the steel plate through the barge's steel skin. The barge could then sink, invert, and/or discharge its cargo into the lock chamber or approaches. The lock would be immediately closed until the cargo could be unloaded and the barge floated, requiring a closure of several days. If the barge inverts and spills its cargo into the lock, the barge would have to be righted and the cargo removed. Depending on the cargo, this could require unwatering the lock for a week or more. A barge sank at Guntersville Lock in 1979 after a repaired area of its skinplate came loose during lockage, possibly due to rubbing rough spots on the wall. Although the barge did not invert, unwatering of the lock was necessary to make repairs and refloat the barge.

2.19 The wall armor at Kentucky Lock is patched, re-anchored, and built-up at every periodic maintenance closure. In the past, these patch jobs have held up fairly well. We are now beginning to see wall armor problems develop before the next periodic closure is scheduled. Kentucky Lock was closed in 1992 for a periodic closure in which wall armor repair was one of the major work items addressed. In 1993, a 10-foot section of wall armor came loose on an area that had been thought to be secure. In a case such as this, the lock operation is changed allowing tows to only go through 2 barges wide to allow our lock personnel to cut off the armor and remove the hazard until it can be patched at the next periodic closure.

2.20 Lock operating personnel have observed that some towing companies are approaching Kentucky Lock more cautiously resulting in slower lock processing times due to the deteriorated wall armor conditions. In the absence of lockwall armor and concrete rehabilitation, tows will have to be more cautious during entry and exit in order to avoid a potential accident and expensive repairs to their equipment. The increased lockage time would translate directly into reduced lock efficiency and lower navigation benefits for the existing project.

2.21 Appendix B contains a report from the ORD Navigation Planning Center estimating and comparing the transportation rate savings of the base case (no rehabilitation) with the rate savings for rehabilitating the lockwall armor and concrete.

2.22 Appendix C -- Detailed Cost Estimates contains the cost estimate and construction duration for the lockwall armor and concrete rehabilitation. The miter gate reliability analysis showed that the miter gate rehabilitation was not justified either as a stand alone alternative or in conjunction with the lockwall armor and concrete rehabilitation. Addressing the lockwall armor and concrete as a separate rehabilitation alternative resulted in some efficiencies as compared to the feasibility report without-project condition. Instead of four 90-day closures, the lockwall armor and concrete can be rehabilitated in two 130-day closures. Eliminating the miter gates from consideration allows us to perform the lockwall armor and concrete rehabilitation off of floating plant reducing the overall length of lock closure.

2.23 Table 3 below displays the economic analysis of rehabilitating the lockwall armor and concrete. The timing of the lockwall armor and concrete rehabilitation was determined to be the years when the benefits obtained offset the costs of the rehabilitation. This occurs in the years 2009-2010.

Table 3
Kentucky Lock Lockwall Armor and Concrete Rehabilitation Analysis
(Millions of October 1993 Dollars)

Item	Base Case	Revised Without Project*	Difference
Average Annual Benefits	$3,951.3	$3,853.2	$1.9
Average Annual Costs	----	0.6	0.6

* Revised Without-Project Condition includes two 130-day closures in 2009-2010 to rehabilitate lockwall armor and concrete at Kentucky.

2.24 **CONCLUSION**. The results of our more detailed analysis shows that the major maintenance described in the feasibility report is not justified. The miter gates do not need to be rehabilitated early in the period of analysis. The rehabilitation of the lockwall armor and concrete is justified, but it does not require the lock to be closed for as long or occur as early as described in the feasibility report. The results for Kentucky were applied to Barkley as well to develop a revised without-project condition. The closure schedule for the revised without-project condition is shown in Table 4.

Table 4

Periodic Maintenance Closures - Kentucky and Barkley Locks

Revised Without-Project Condition

YEAR	PROJECT	LENGTH OF CLOSURE (WEEKS)	COST OF REPAIR ($1,000s)	MAJOR ITEMS TO BE REPAIRED
1995	BARKLEY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
1997	KENTUCKY	2	365	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2000	BARKLEY	2	365	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2002	KENTUCKY	5	1,250	REHABILITATE TOW HAULAGE UNIT; ADD PROGRAMMABLE CONTROLLER SYSTEM; REPLACE GUARDBOOM CONNECTION & MOORING BITTS; UPGRADE MAIN POWER CIRCUITS
2005	BARKLEY	3	675	REHABILITATE TOW HAULAGE UNIT; REPLACE ALL WATER AND AIR PIPING
2007	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2009	KENTUCKY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2010	KENTUCKY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2010	BARKLEY	4	520	UPGRADE MAIN POWER CIRCUITS; REPLACE INTAKE SCREEN
2012	KENTUCKY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2015	BARKLEY	2	415	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2017	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2020	BARKLEY	4	1,145	REPLACE MOORING BITTS; REHABILITATE UPPER EMERGENCY DAM
2022	KENTUCKY	12	23,000	REPLACE MITER GATES, VALVES, OPERATING MACHINERY AND MOORING BITTS; CONCRETE AND WALL ARMOR REPAIRS
2025	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2027	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2030	BARKLEY	4	730	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2032	KENTUCKY	4	1,145	REPLACE FLOATING GUARD BOOM TIMBER & INTAKE SCREEN
2035	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2037	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2040	BARKLEY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2041	BARKLEY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2042	KENTUCKY	4	780	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2045	BARKLEY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2047	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2050	BARKLEY	12	23,000	REPLACE MITER GATES, VALVES, OPERATING MACHINERY AND MOORING BITTS; CONCRETE AND WALL ARMOR REPAIRS
2052	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2055	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED

PERIODIC MAINTENANCE

2.25 The Nashville District has a policy of dewatering locks for inspection and repair on a five year periodic schedule. The rationale for this policy is contained in Exhibit 2. This section examines the impact of an alternative dewatering cycle on without-project condition transportation rate savings.

2.26 One alternative scenario is to not make periodic repairs and institute a policy of "don't fix it until it breaks". This was thrown out of this analysis. Exhibit 2 clearly documents several cases in the District where our periodic dewatering program saved lengthy closures. Additionally, IWR Report 93-R-11 "National Operation and Maintenance Program Plan of Improvement" dated August 1993 recommends: "that the dewatering of locks should be accomplished on a regular schedule, and that HQUSACE should develop a policy to establish dewatering schedules for maintenance and inspection of navigation locks at regular intervals".

2.27 Based on the above, it is clear that periodic maintenance closures are warranted. However, it is not clear that 5 years is the appropriate timeframe. Exhibit 3 displays a letter from TVA which states that it is their policy to dewater Kentucky Lock every 5 years as required by TVA's Dam Safety Program which is in concurrence with the "Federal Guidelines for Dam Safety" issued by the Federal Emergency Management Agency in 1979. For our analysis, we compared current policy (performing periodic maintenance every 5 years) to a 10-year periodic maintenance policy. Ten years was chosen as the alternative periodic scenario to take advantage of the 5-year inspection cycle as required by TVA. In other words, do we perform periodic maintenance at every dewatering and inspection or do we defer maintenance to every other dewatering and inspection. Table 5 displays the 10-year periodic maintenance schedule used in this analysis.

2.28 Transportation rate savings for the two periodic maintenance scenarios are displayed in Table 6. The 5-year periodic schedule yields slightly higher average annual rate savings compared to the 10-year cycle. Although not quantified, the 10-year schedule increases the likelihood of unscheduled emergency closures making this scenario even less desirable. Given the insignificant difference in average annual rate savings and the District's successful track record with the 5-year cycle, it is determined that the current dewatering cycle is appropriate as part of the without-project condition.

Table 5
Periodic Maintenance Closures - Kentucky and Barkley Locks
Revised Without-Project Condition
10 Year Periodic Maintenance at Kentucky Lock

YEAR	PROJECT	LENGTH OF CLOSURE (WEEKS)	COST OF REPAIR ($1,000s)	MAJOR ITEMS TO BE REPAIRED
1995	BARKLEY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
1997	KENTUCKY	2	365	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2000	BARKLEY	2	365	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2002	KENTUCKY	1	210	INSPECT ONLY -- NO REPAIRS
2005	BARKLEY	3	675	REHABILITATE TOW HAULAGE UNIT; REPLACE ALL WATER AND AIR PIPING
2007	KENTUCKY	5	1,250	REHABILITATE TOW HAULAGE UNIT; ADD PROGRAMMABLE CONTROLLER SYSTEM; REPLACE GUARDBOOM CONNECTION & MOORING BITTS; UPGRADE MAIN POWER CIRCUITS
2009	KENTUCKY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2010	KENTUCKY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2010	BARKLEY	4	520	UPGRADE MAIN POWER CIRCUITS; REPLACE INTAKE SCREEN
2012	KENTUCKY	1	210	INSPECT ONLY -- NO REPAIRS
2015	BARKLEY	2	415	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2017	KENTUCKY	4	730	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2020	BARKLEY	4	1,145	REPLACE MOORING BITTS; REHABILITATE UPPER EMERGENCY DAM
2022	KENTUCKY	12	23,000	REPLACE MITER GATES, VALVES, OPERATING MACHINERY AND MOORING BITTS; CONCRETE AND WALL ARMOR REPAIRS
2025	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2027	KENTUCKY	1	210	INSPECT ONLY -- NO REPAIRS
2030	BARKLEY	4	730	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2032	KENTUCKY	4	1,300	REPLACE FLOATING GUARD BOOM TIMBER & INTAKE SCREEN
2035	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2037	KENTUCKY	1	210	INSPECT ONLY -- NO REPAIRS
2040	BARKLEY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2041	BARKLEY	19	5,925	CONCRETE AND WALL ARMOR REPAIRS TO 1/2 LOCK
2042	KENTUCKY	4	780	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2045	BARKLEY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2047	KENTUCKY	1	210	INSPECT ONLY -- NO REPAIRS
2050	BARKLEY	12	23,000	REPLACE MITER GATES, VALVES, OPERATING MACHINERY AND MOORING BITTS; CONCRETE AND WALL ARMOR REPAIRS
2052	KENTUCKY	6	750	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2055	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED

Table 6
Transportation Rate Savings for
5-Year and 10-Year Periodic Maintenance Scenarios
(Millions of October 1993 Dollars)

Scenario	Transportation Rate Savings
5-Year Periodic Maintenance	$3,853.2
10-Year Periodic Maintenance	$3,852.9

LOWER CUMBERLAND TRAFFIC MANAGEMENT

2.29 Exhibit 1 directed that the District: "Reevaluate management measures for efficient utilization of Barkley Lock during closures of Kentucky Lock. Reanalyze hydropower releases at Barkley Dam and effects on navigation on the lower Cumberland River and Barkley Lock".

2.30 The feasibility report called for modifying hydropower releases at Barkley to a maximum of 40,000 cfs and a minimum of 9,000 cfs. The rate of change in discharge would be limited to 6,000 cfs in a 6-hour period. These modifications were thoroughly reviewed by and coordinated with the towing industry at numerous navigation meetings. In the feasibility report this hydropower scheme was assumed to be in place both under normal operating conditions (both locks open) and when Kentucky is closed (only Barkley is open).

2.31 After the feasibility report was released, the District had an opportunity to test the without-project condition during the scheduled periodic closure of Kentucky Lock in September 1992. The District proposed to the towing industry that during this closure the hydropower releases at Barkley would be held to a maximum discharge of 40,000 cfs as called for in the without-project condition. The towing industry was opposed to this and strongly urged that the discharges at Barkley be limited to a maximum of 27,000 cfs as has been the policy during past closures of Kentucky Lock. Apparently, the towing industry views the lower Cumberland differently during closures of Kentucky when all traffic is forced to use the lower Cumberland compared to normal operating conditions when they have a choice of waiting at Kentucky versus navigating the winding lower Cumberland.

2.32 Accordingly, the revised without-project condition presented in this report calls for the more stringent discharge limit of 27,000 cfs during closures of Kentucky. The limit would remain at 40,000 cfs during normal operating conditions. This results in slightly higher average annual hydropower costs for the revised without-project condition ($15.4 million) compared to the feasibility report without-project condition ($15.0 million).

SUMMARY OF REVISED WITHOUT-PROJECT CONDITION

2.33 The refined without-project condition as reformulated in response to the issues and concerns raised in Exhibit 1 contains the following key features: (1) two 130-day closures of Kentucky in 2009-2010 to rehabilitate lockwall armor and concrete; (2) continuation of the District's 5-year periodic maintenance cycle; and (3) more stringent limit of 27,000 cfs placed on Barkley's hydropower releases during closures of Kentucky.

2.34 This refined without-project condition will be used as the baseline against which incremental costs and benefits of the recommended plan will be measured. The updated project economics is contained in Section 5 of this report.

CEORN-CO-W (1130)

3 January 1994
Midgett/ne/5607

MEMORANDUM FOR RECORD

SUBJECT: CEORN'S Reasons for Dewatering Locks on a Five Year Frequency

1. There are 18 navigation lock structures on the Cumberland and Tennessee Rivers operated and maintained by the Nashville Corps of Engineers. Some of these structures were constructed in the 1920's, 30's and 40's, and are still operating with an acceptable degree of effectiveness. This can be attributed to the district's long-standing emphasis on preventive maintenance which includes a five year dewatering program. This "Fix it Before it Breaks" approach has proven to be extremely cost effective to both the Corps and navigation interests.

2. The Tennessee Valley Authority owns 14 of the navigation locks and they are operated and maintained by the Corps. The TVA continues to remain involved through funding and construction of capital improvements and a rather ambitious dam safety program. The dam safety program requires lock dewatering for concrete and foundation inspections on a five year frequency. The Corps and TVA have jointly funded these dewaterings for over 20 years, and the arrangement has proven to be most effective and beneficial. The Nashville District also adopted the five year frequency for three of the four Cumberland River locks.

3. For the past 25 years most all the locks in the system have experienced major repair/revision. Significant improvements such as complete revisions to miter gate sealing arrangements and replacement of original quoin and miter locks have been accomplished with minimal lock outage time. This has been made possible through long range planning, taking full advantage of the outage periods, and close coordination with industry.

4. The very nature of a navigation lock allows for some major components to be continually submerged in water, some continually non-submerged and some exposed to fluctuating conditions. Deterioration normally occurs first on the submerged components, second on the areas with changing conditions, and last on the non-submerged portions. These three factors are most significant in developing long range plans for high lift lock repair and maintenance. Close monitoring of the variances of deterioration and wear make it possible to fairly accurately predict component repair/replacement requirements. A typical example is the quoin and miter blocks on an 80' tall miter gate. After the initial 15 to 20 years of operation the lower portion (approximately one-third) of all contact surfaces deteriorate and wear to the point that replacement is necessary. The intermediate portion (approximately one-third) develops some wear, but not to the extent that

EXHIBIT 2

replacement is necessary for several more years. The top portions show very little deterioration and will not require replacement for even a longer period. This situation allows for a three phase plan to be established for complete contact block replacement. A determination for the need of a component replacement program is made five years prior to the actual start of replacement. The determination is made during (or as a result of) a scheduled dewatering and based on various factors including rate of deterioration, projected use of the facility, and sound engineering judgement. Planning, budgeting, and material procurement will then take place during the next five years.

5. The first phase block replacement includes the bottom portion or the portion that is normally submerged. Complete dewatering of a lock, replacement of this amount of miter blocks, gate quoins and wall quoins, and returning the lock to operation requires approximately 14 days. The closure period is based on continuous work operation, (i.e., seven days per week, twenty four hours per day) and with maximum resource utilization. Once the critical path of work and closure duration is established, other work items are included in the plan. These additional items normally include work that will become necessary to accomplish within the next few years and require interruptions to operation of the lock to accomplish. Such items as other gate repairs, machinery repair, electrical component replacement, valve repair, concrete and wall armor repair and painting of various components are included with contact block replacement in the overall plan of work to be accomplished during the two week closure. Should these additional items be accomplished at times other than the scheduled dewatering, total lock outage time would be considerably greater. If a lock is not closed on a regular five year frequency as part of multiphase component replacement/repair program, other scheduled, as well as non-scheduled, closures will be necessary and most likely create more adversities to industry.

6. Upon completion of the first phase of contact block replacement, the planning process for phase two will begin. The same planning process is used for phase two and phase three that was used for phase one. The three phase example stated above encompassed three scheduled unwaterings of 14 days each and covered a period of 15 years. It is very likely that such a long range planning effort could cover a longer period of time with more lock closures, but of shorter individual duration. It is usually necessary to repeat many of the previous accomplishments after 15 to 20 years of service.

7. Although the five year frequency of closing locks for maintenance has proven to be most effective in maintaining the structural and operational integrity of our projects, another extremely important benefit has resulted. On several occasions unexpected situations have been detected during scheduled closures that would have resulted in extremely long unscheduled lock outages and great economic impact to both navigation interests and the Corps. The following are a few examples:

a. During a scheduled dewatering of Wilson Lock a horizontal crack was discovered in the land wall lower gate leaf monolith at sill elevation. The crack connected a vertical joint on the downstream side of the gate with a vertical crack on the upstream side of the gate. This situation resulted in the 600 ton gate leaf being supported by only a "pie" shaped portion of concrete and a small portion of the embedded gate anchorage that extended into sound concrete. Each time the lock cycled the severed mass of concrete moved and the movement got progressively worse as the lock continued to operate. Massive reinforcement of the entire monolith was necessary and started immediately. All reinforcement work was accomplished from suspension scaffolds and atop the lockwall resulting in minimal interference to navigation. Had the situation not been discovered, the probability of catastrophic failure is very high. If the gate leaf and loose concrete mass had fallen, a lock closure of at least one year would have resulted at a cost of several million dollars.

b. During a routine dewatering of Cheatham Lock, a condition was discovered on an upper gate leaf that would have resulted in loss of a gate leaf if it had not been detected and corrected. Approximately 75% of the fasteners connecting the pintle assembly to the gate leaf were missing. The remaining fasteners were badly deteriorated and loose, and the situation became progressively worse during each operation. The gate was only a few operations away from failure. There was no indication the problem existed during normal operations due to the quoin contact surfaces acting for the pintle and indicating proper mitering of the gate. Failure of the gate leaf was imminent and would have resulted in a two to three month lock closure with a cost in excess of 1 million dollars.

c. Inspection of valves at Wilson Lock during a scheduled dewatering revealed fatigue failure of several valve trunnion embedded anchorage assemblies. Each valve had some degree of anchorage loss with one having a 70% loss. Complete failure of the anchorage system was imminent within the upcoming weeks or months and would have resulted in extended closure of the lock. Loss of an emptying valve would have necessitated design, construction, and installation of some means of closing off the culvert discharge system, dewatering of the lock chamber, removal of the valve, and construction and replacement of the valve and all anchorage systems. Completion of the work would have required at least a four months closure and cost several million dollars. Even though correction of the detected problem was rather time consuming and costly, the work was accomplished by isolating individual valves and leaving the lock in operation.

d. A few years after Cordell Hull Lock went into operation a dewatering was performed to inspect all underwater features. This is normal procedure for any new project following the first year or so of operation. This inspection revealed that over 800' of stainless steel hydraulic piping that had been anchored to the lock floor and walls had become loose and was extremely vulnerable to breaking from water turbulence or being hung by a tow. Breakage would have resulted in hundreds of gallons of hydraulic oil being emptied into the river.

8. Although the first three examples are unique, they did occur and the possibility of discovering similar conditions exists each time a lock is dewatered and inspected. The last example is not so unique. It is very unusual for a lock to be dewatered and inspection not reveal at least one previously unknown condition such as the loose hydraulic piping which requires immediate attention to prevent significant problems.

HAROLD L. MIDGETT
Chief, Locks Management
Section

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902-1499

February 15, 1994

Mr. Richard J. Connor
Chief, Engineering Division
U.S. Army Corps of Engineers
Nashville District Office
Post Office Box 1070
Nashville, Tennessee 37202

Dear Mr. Connor:

This letter confirms the arrangement whereby TVA and the U.S. Army Corps of Engineers (Corps) perform joint inspections at each of the Tennessee River navigation system locks every five years.

As an integral part of TVA's multipurpose hydro projects, the locks require periodic inspections, along with the dams and other appurtenant structures, to verify their structural integrity. These inspections are part of TVA's Dam Safety Program which is in concurrence with the "Federal Guidelines for Dam Safety" issued by the Federal Emergency Management Agency in 1979. According to the guidelines, "Formal inspections should be made periodically at intervals not to exceed five years."

TVA and the Corps also found it prudent to use this 5-year interval prior to issuance of the federal guidelines. As a result, potentially significant conditions have been identified in their initial stages and early repairs or maintenance have minimized the impact of damage to the equipment and structures. This program has also minimized disruptions to navigation traffic due to unscheduled or lengthy lock outages caused by structural deficiencies or equipment failure.

TVA will continue to use the 5-year interval for its dam safety inspections at all its hydro projects; and these inspections will, by necessity, include the navigation locks. This schedule has contributed to our goal of ensuring the safe and efficient operation of the Tennessee River navigation system.

If you would like additional information about TVA's Dam Safety Program and its relationship to the navigation locks, you may contact Mike Huston at (615) 632-6204.

Sincerely,

M. Ted Nelson
Acting Vice President
Water Management

EXHIBIT 3

SECTION 3 - TRAFFIC PROJECTIONS

GENERAL

3.01 One of the critical issues raised in Exhibit 1 concerned the accuracy of the traffic projections used in the feasibility report -- "Major commodity projections should be reviewed and historical, current and projected traffic demand should be reanalyzed". This section of the report looks at recent traffic at Kentucky-Barkley to determine whether the feasibility traffic projections are still valid.

PERFORMANCE OF TRAFFIC PROJECTIONS

3.02 As with nearly every lock facility in the Ohio River Division, coal accounts for most of the traffic at Kentucky-Barkley. In 1986, coal accounted for 48.1 percent of traffic followed by aggregates with 22.4 percent, grains with 10.5 percent, and petroleum products, ores and minerals, chemicals, steel and miscellaneous commodities with the remaining 18.6 percent. Coal's dominance has eroded over the past six years. In 1992, coal accounted for just under 40.0 percent of traffic, aggregates 30.5 percent and grains 11.4 percent. These last two commodities combined now account for more traffic than coal at Kentucky-Barkley.

3.03 The graph displayed in Exhibit 4 tracks actual traffic since 1986 relative to the traffic projections presented in the May 1990 "Forecast of Future Ohio River System Traffic Demands, 1986-2050" (though published in 1990, the base year used in developing these forecasts was 1986). Since 1986, traffic through Kentucky-Barkley has briefly exceeded projections, then fallen considerably below projections for three years, and finally begun to recover toward trend in 1992. Actual traffic in 1992 was 1.9 million tons less than the projected level of 38.0 million tons. Lock Performance Monitoring (LPMS) data for 1993 shows 38.3 million tons, just 0.3 million tons shy of projected 1993 traffic.

3.04 Kentucky-Barkley's recent traffic recovery is directly related to the strong performance of aggregates traffic and a rebound in coal traffic (see Table 7). Most of the aggregates traffic is construction-grade material, though shipments of limestone for de-sulfurization, especially at power plants, is expected to become more important over time.

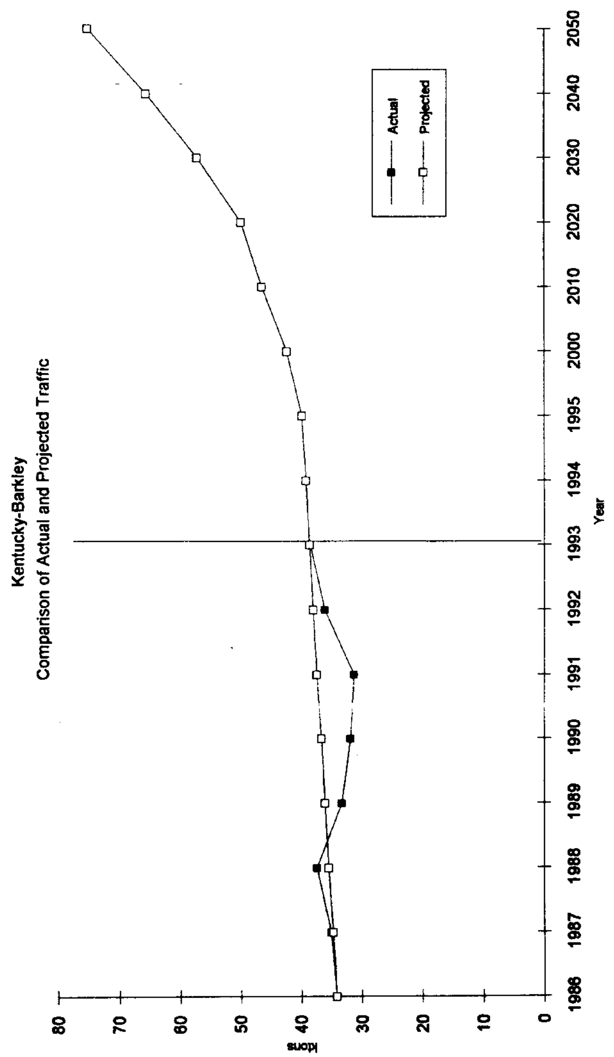
3.05 The rebound in coal traffic is not unexpected. Electric utilities that use Kentucky-Barkley experienced dramatically reduced shipments of coal during the 1989-1991 time period. Extended maintenance closures of coal-fired plants, unexpectedly high electric generation from other types of plants, and one-time decisions to reduce the target-level of coal stockpiles all combined to cause coal traffic to decline through these two locks. In 1993, coal traffic reached its highest level since 1988 with the upgrading of coal-fired plants, a now in-place stockpile strategy, and a return to expected levels of generation at key utilities.

Table 7
Kentucky-Barkley Locks and Dams Commodity Traffic, 1986-1993

	Historic								Projected	
Commodity	1986	1987	1988	1989	1990	1991	1992	1993	1993	Diff
Coal	16.0	15.4	16.2	12.5	11.4	11.5	14.4	15.8	17.6	-1.8
Petroleum	0.6	0.6	0.7	0.7	0.7	0.6	0.8	0.8	0.6	0.2
Aggregate	7.9	10.2	10.1	10.6	9.7	9.6	11.0	11.0	8.4	2.6
Grains	4.4	3.9	4.0	3.9	4.5	4.1	4.1	4.4	4.4	0.0
Chemicals	1.5	1.3	1.9	1.4	1.5	1.8	1.8	1.7	1.9	-0.2
Ores/Mins	0.4	0.4	0.8	0.8	0.7	0.7	0.7	0.8	1.2	-0.4
Steel	0.8	0.7	0.9	1.0	0.9	1.0	1.3	1.4	1.3	0.1
Others	2.4	2.6	2.8	2.5	2.4	2.2	2.1	2.4	3.2	-0.8
Total	33.9	35.1	37.4	33.3	31.9	31.3	36.1	38.3	38.6	-0.3

CONCLUSION

3.06 Based on the data presented above, recent traffic at Kentucky-Barkley is tracking well with the traffic projections used in the feasibility report. This reaffirms the validity of the feasibility report traffic projections and gives us confidence to use these projections for the analyses contained in this report.


Kentucky-Barkley
Comparison of Actual and Projected Traffic
ktons
Year
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Projected
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50
60
70
80
1986
1987
1988
1989
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1994
1995
2000
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2020
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2040
2050

EXHIBIT 4

SECTION 4 - DOWNSTREAM TRAINING DIKE

GENERAL

4.01 A major concern raised in Exhibit 1 pertained to the need for a tailwater training dike as a feature of the recommended project -- "The District should reevaluate the need for the tailwater training dike and reassess the mussel impacts".

DOWNSTREAM APPROACH CONDITIONS

4.02 A preliminary study was conducted to evaluate the effects of the magnitude and direction of currents from the powerhouse and spillway discharges on navigation in the downstream approach for the proposed new Kentucky Lock. A plan of the project and proposed new lock layout is shown on Exhibit 5. Prototype velocity measurements were made in the downstream approach during powerhouse discharges and the results are shown on Exhibit 5. Conditions were such that it was not possible to accurately determine the current direction. These low velocities should, however, not create difficult navigation conditions in the downstream approach. Conditions were such that it was not possible to make velocity measurements for spillway discharges, however, these values would probably be around 5-6 ft./sec. depending on the magnitude of discharge. Also, there is no data on current direction and eddies during spillway discharges. Hydraulic data on discharge, stage frequency, tailwater rating and duration curves is shown on Exhibit 6.

4.03 Based on a preliminary analysis of the sailing lines and flow conditions as shown on Exhibit 5 for the existing and proposed lock, it does not appear that navigation conditions during spillway and powerhouse discharges would be any worse for the new lock than the old lock location. Based on this finding, the cost for a downstream training dike is not an NED cost and is removed from the project cost estimate. In other words, if a training dike is needed, it is needed in the without-project condition as well.

4.04 Given that navigation conditions would not be any worse for the new lock than the old lock location, and that the old lock has been in operation for more than 50 years without any major problems in approach conditions, it is questionable whether a training dike is needed at all. Nevertheless, during PED a detailed physical model study will be used to determine the need for some type of training dike as shown on Exhibit 5. The model study will investigate the navigation conditions in the lock approach and will take into account not only the magnitude and frequency of discharge but the duration of discharge.

ENVIRONMENTAL CONCERNS

4.05 If it is determined that a downstream training dike is warranted, there are a number of environmental concerns that would need to be addressed. The dike would be located in an area of valuable fish and shellfish resources. These environmental concerns would be included in the detailed physical model study and would influence the design of the dike (if it is determined that a dike is needed) such that environmental impacts are minimized.

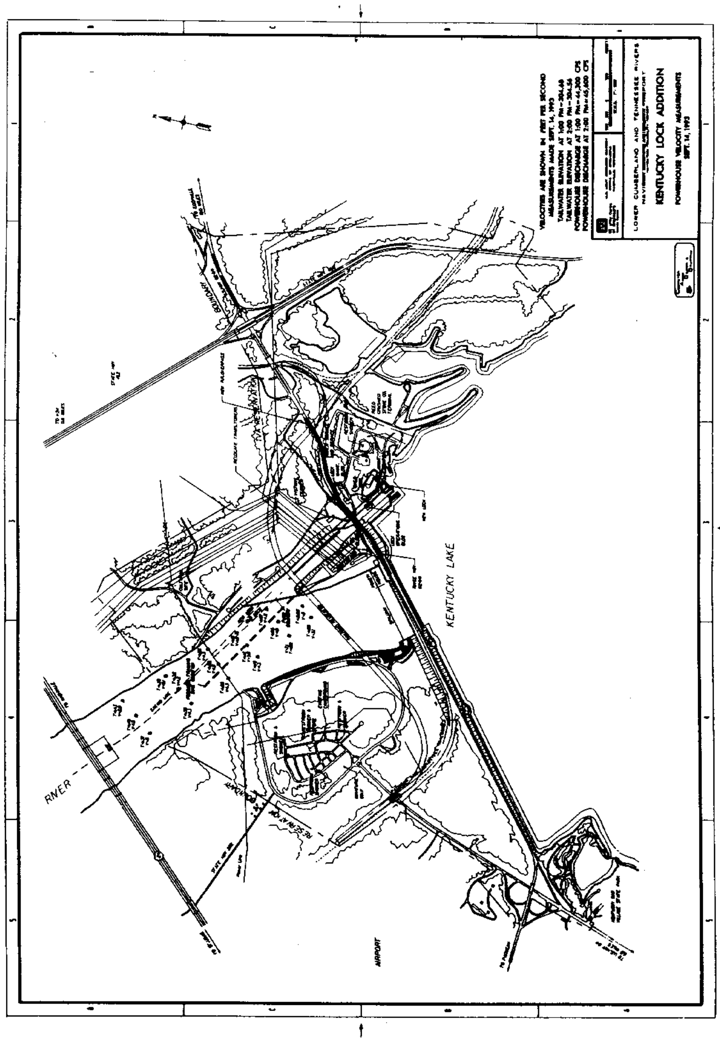
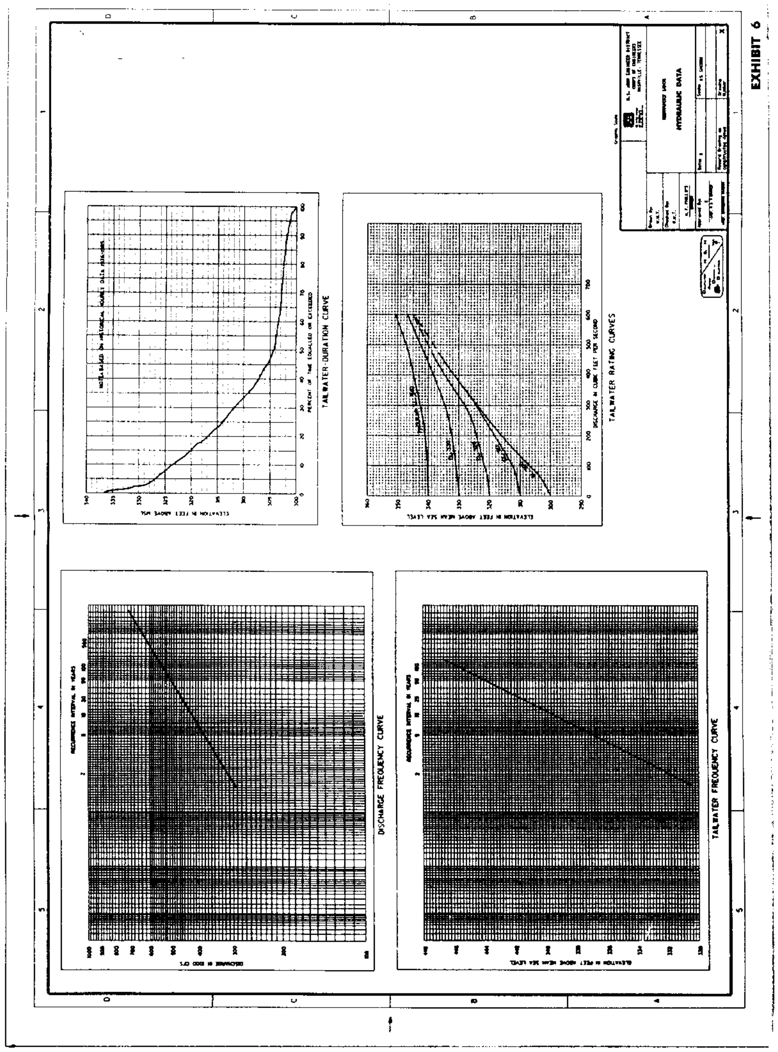

VELOCITIES ARE SHOWN IN FEET PER SECOND
MEASUREMENTS MADE SEPT. 14, 1993
TAILWATER ELEVATION AT 1:00 PM = 304.48
TAILWATER ELEVATION AT 2:00 PM = 304.54
POWERHOUSE DISCHARGE AT 1:00 PM = 44,300 CFS
POWERHOUSE DISCHARGE AT 2:00 PM = 45,600 CFS
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
POWERHOUSE VELOCITY MEASUREMENTS
SEPT. 14, 1993
KENTUCKY LAKE
RIVER
AIRPORT

EXHIBIT 5


TAILWATER-DURATION CURVE
TAILWATER RATING CURVES
DISCHARGE FREQUENCY CURVE
TAILWATER FREQUENCY CURVE
HYDRAULIC DATA
EXHIBIT 6

SECTION 5 - ECONOMIC EFFECTS OF RECOMMENDED PLAN

GENERAL

5.01 Exhibit 1 directed that: "The economic sensitivity of major maintenance closures should be analyzed and the project economics including costs and benefits should be updated". Based on the findings presented in Section 2 of this report, this section reanalyzes the economics of the recommended plan (additional 1200 ft lock) as compared to the revised without-project condition.

5.02 Summarized in this section are the benefits and costs for the recommended plan. The benefits and costs credited to the recommended plan represent the incremental differences between the with and revised without-project conditions. Both annual benefits and costs were estimated using a 50-year period and a base year of 2005. End of year discounting factors for an annual interest rate of 8 percent were used for the economic analysis presented below. All benefits and costs are expressed in October 1993 prices.

BENEFITS

5.03 The total incremental benefits for each of the final plans include benefits for the reduction of transportation costs, benefits for shifting movements from more costly modes of transportation, benefits for extending the useful life of the railroad bridge by early replacement, and benefits for the direct use of otherwise unemployed or underemployed labor resources during project construction. A summary of the average annual incremental benefits for the recommended plan is shown in Table 8 below.

Table 8
Summary of Average Annual Benefits for Recommended Plan
(Millions of October 1993 Dollars)

Item	Revised Without Project	Recommended Plan 1200 ft Lock
Transportation Rate Savings	$3,853.2	$3,901.8
Incremental Rate Savings		
Normal Operations	---	27.8
Periodic Maintenance Closures	---	7.8
Major Maintenance Closures	---	13.0

Total Incremental Savings	---	48.6
Advanced RR Bridge Replacement	---	0.1
Unemployment Benefits	---	3.8

Total Avg Ann Incremental Benefit	---	$52.5

COSTS

5.04 **CONSTRUCTION COSTS**. A summary of the construction costs for the recommended plan is shown in Table 9. The costs include contingencies which range from 20 to 25 percent. All estimated first costs are considered economic costs for the benefit-cost analysis.

5.05 **INVESTMENT COSTS**. Investment costs, shown in Table 10, are the sum of the construction expenditures and the accrued interest on those expenditures up to the time that plan benefits become available. Interest During Construction (IDC) was computed using an estimated sequence of construction expenditures and end-of-year discounting factors.

Table 9
Construction Cost of Recommended Plan
(Millions of October 1993 Dollars)

Item	Recommended Plan 1200 ft Lock
Real Estate	1.2
Relocations	
Roads	15.9
Railroads	40.9
Utilities	6.8
Espanade	0.9
Campground	1.5
Lock	322.4
Buildings, Project Operations	1.2
Recreation Facilities	0.6
Cultural Resources	0.5
Buildings, Grounds & Utilities	0.9

Subtotal	$392.8
Engineering and Design	46.1
Supervision & Administration	19.7

Total	$458.6

Table 10
Investment Costs of Recommended Plan
(Millions of October 1993 Dollars)
(8 Percent Discount Rate)

Item	Recommended Plan 1200 ft Lock
Construction Cost	$458.6
Interest During Construction	116.4

Total Investment Cost	$575.0

5.06 **TOTAL ANNUAL COSTS**. The total annual costs include investment costs, operation and maintenance (O & M) costs, helper boat and mooring cell costs (as needed), hydropower modification costs, and costs for detouring US62 and 641 traffic to Interstate 24 for several years during project construction. Average annual costs are summarized in Table 11 below.

Table 11
Average Annual Costs for Recommended Plan
(Millions of October 1993 Dollars)

Item	Revised Without Project	Recommended Plan 1200 ft Lock
Capital Costs	---	$47.0
O & M Costs	5.7	4.7
Helper Boat Costs	2.6	0.0
Hydropower Costs	15.4	0.0
Highway Traffic Detour Costs	0.0	1.4
	----	----
Total Annual Costs	$23.7	$53.2
Incremental Annual Costs		$29.4

SUMMARY

5.07 A summary of the total average annual benefits and average annual costs for the recommended plan and the corresponding net annual benefits and benefit-cost ratio is presented in Table 12. The recommended plan provides $23.1 million of net benefits and has a BCR of 1.8.

5.08 Unemployment benefits cannot be used to determine project feasibility. Without the unemployment benefits, the recommended plan yields net annual benefits of $19.3 million and a BCR of 1.7.

Table 12
Summary of Annual Benefits and Costs
(Millions of October 1993 Dollars)

Item	Recommended Plan 1200 ft Lock
Average Annual Incremental Benefits	$52.5
Average Annual Incremental Costs	$29.4
Net Annual Incremental Benefits	$23.1
Benefit-Cost Ratio	1.8

OPTIMUM PROJECT TIMING

5.09 The purpose of the optimum timing analysis is to determine the completion date that produces the maximum net annual benefits. The benefit analysis presented above is based on an additional lock being completed and available for use by the year 2005. Optimum replacement timing for the recommended plan was evaluated by estimating the average annual benefits and costs of completion dates ranging from 2005 to 2015 (see Table 13). The net benefits would be maximized with the project being on-line by 2009. This means that the project must be completed by 2008.

Table 13
Sensitivity of Net Annual Benefits to
Alternative Project Completion Dates
8 percent, 50-year Project Life
(Millions of October 1993 Dollars)

	Project On-Line Date						
Item	2005	2006	2007	2008	2009	2010	2015
Annual Benefits	48.7	45.8	44.4	42.3	41.1	35.2	23.6
Annual Costs	29.4	27.3	25.0	23.1	21.1	20.4	13.6
Net Benefits	19.3	18.5	19.4	19.2	20.0	14.8	10.0

NOTE: Annual Benefits do not include unemployment benefits. It is not appropriate to include unemployment benefits in the timing analysis.

SECTION 6 - RECOMMENDATIONS

6.01 Having carefully considered the environmental, social, economic, engineering, and public safety aspects of maintaining and modernizing commercial navigation facilities on the Kentucky-Barkley navigation system, I recommend that an additional 110 X 1200-foot lock be authorized for construction as a Federal project, with such modifications as, at the discretion of the Chief of Engineers, may be advisable. The recommendations also include traffic management as appropriate and such measures as necessary to maintain safe navigation on the lower Cumberland River.

6.02 The foregoing analysis of the issues and concerns raised in Exhibit 1 validates the recommendation of the feasibility report calling for an additional 110 X 1200-foot lock at the Kentucky project. The without-project condition was refined leading to the optimum project timing being slipped to a project completion date of 2008.

6.03 The total estimated first cost of this project, based on October 1993 prices and conditions, is $458 million. Annual operation and maintenance for the Kentucky and Barkley Locks and Dam, as modified by this recommendation, is estimated to be $4.7 million. Project financing is to be in accordance with Section 102 of the Water Resources Development Act of 1986 (Public Law 99-662), as amended.

J. David Norwood
LTC, Corps of Engineers
District Engineer

APPENDIX A

ENGINEERING ANALYSIS OF EXISTING KENTUCKY LOCK

Cumberland-Tennessee Rivers
Below Barkley Canal

Kentucky Lock Addition
Navigation Feasibility Report

Limited ReEvaluation Report Appendix A

Engineering Analysis of Existing Kentucky Lock

February 1994

Kentucky Lock
Limited ReEvaluation Report
Engineering Analysis

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LIST OF TABLES

LIST OF EXHIBITS

Kentucky Lock Addition
Navigation Feasibility Report

Limited ReEvaluation Report
Appendix A

Engineering Analysis of
Existing Kentucky Lock

1. GENERAL

A. Introduction

The need for a reliability analysis in a feasibility study for changes to an existing structure is to consider probabilities and economic consequences of different scenarios occurring. For major rehabilitation projects, the reliability analyses are intended to aid in the justification and prioritizing of rehabilitation investments. Feasibility studies involving the replacement or upgrade of structures utilize reliability analysis to understand the economic consequences of postponing or delaying the replacement. Recent studies have concentrated on making reliability degradation projections over time more accurate to aid in the determination of when projects are economically justified into the future. Kentucky Lock analysis is of this later type projecting existing lock reliability into future years.

This Appendix documents the methodology and scope of studies for engineering analysis of the major features of existing Kentucky Lock that potentially could cause major lock outage. The results of this analysis were utilized to formulate the base or "without project condition" for the recommended Kentucky Lock addition. It should be noted that the analysis conditions discussed in this appendix are projections many years into the future and that funding for rehabilitation work on the existing lock has not been requested. The most significant problem with the existing project is insufficient capacity.

B. Background

Kentucky Lock addition feasibility report was approved by the Board of Engineers for Rivers and Harbors in May 1992. Subsequent to this the lock addition did not receive full funding but received additional funds to continue PED on the project. Ohio River Division and Nashville District where asked to perform a more detailed analysis of several aspects of the feasibility report in this Limited ReEvaluation Report. The feasibility study "without new lock" base condition projected significant lock outages beginning in 2006 to rehabilitate the concrete wall and embedded metals to improve operational safety and efficiencies to take the lock beyond 100 year service life. Due to the length of this outage the miter gates, which are a continual maintenance concern, where projected to receive a complete sand blast and painting which can not be accomplished during routine major maintenance outages. Engineering-Planning Division were asked to investigate the long term maintenance needs of the existing lock in terms of new reliability methods. The engineering reliability analysis, where applicable, is included in this appendix.

C. Scope of Investigations

Subsequent to the request for a reliability analysis of existing lock maintenance projections a series of meetings was held between HQUSACE, OCE, Division and District personnel to determine an appropriate scope for the reliability assessment. It was determined that the concrete lock wall problems could not be analyzed by current engineering reliability methods due to the walls being principally safety and efficiency problems from wear. The culvert valves, mechanical systems and electrical systems could be assessed by reliability methods but due to the valves being kept in relatively good condition through routine maintenance, their low economic consequence of unreliable performance, and funding limitations it was decided these systems should only be assessed from a general nature. The miter gates were the only lock feature that had established reliability analysis methodologies, severe economic consequences of unreliable performance and serious concern for its long term condition. Reliability analysis for the miter gates is included as Part 3 of this appendix.

The reliability analysis of Kentucky Lock miter gates are different than has been performed in the past due to the gates currently performing reliably but we want to establish a reliability for the next 50 years. Reliability analysis performed to date by St. Louis District on miter gates is for gates proven to currently be unreliable. Additionally, reliability analysis of horizontally framed miter gates has not been performed previously. Currently St. Louis, Rock Island, St.Paul Districts, OCE and Waterways Experiment Station are refining reliability methods to better account for fatigue and corrosion effects on steel gates. Since Kentucky miter gates may be effected by both of these deterioration modes, Nashville District participated in discussions of this research. Subsequently the district contracted for assistance from JAYCOR, Vicksburg, MS and Structural Affiliates International, Nashville, TN to help apply these analysis methods to Kentucky Lock miter gates. General data for existing Kentucky Project is shown on Exhibit 1C-1.

KENTUCKY PROJECT

NAVIGATION LOCK

Authorized by Congress............................May 28, 1937
Construction Started..............................July 1, 1938
Lock Opened to Traffic...........................February 1942
Location....................................Right (east) bank
Lock Chamber Clear.............................110 by 600 ft.
Lift:
Maximum (el. 300 to el. 375).......................75 ft.
Normal (el. 303 to el. 359).........................56 ft.
Gate Sills................. Upper, el. 335.0; lower, el. 289.0
Minimum Depth Over Sills.............................11.0 ft.
Top of Upper Approach Walls..........................el. 382.0
Top of Chamber Walls.................................el. 382.0
Top of Lower Approach Walls..........................el. 342.0
Lock Gate Top...............Upper, el. 380.5; Lower, el. 380.5
Lock Gate Height.............Upper, 46.73 ft; lower, 92.73 ft.

SPILLWAY

Authorized by Congress............................May 28, 1937
Construction Started............................October, 1939
Construction Complete.........................August 30, 1944
Max. Height..206 ft.
Crest...el. 325.0
Roadway...el. 391.0
Control......................24-40'x50' fixed wheel lift gates

POWERHOUSE

Authorized by Congress............................May 28, 1937
Construction Started............................October, 1939
Construction Complete........................January 16, 1948
Number of units..5 Total
Capacity...175,000 KW

Exhibit 1C-1

2. ENGINEERING ASSESSMENT OF LOCK FEATURES

A. Culvert Valves

A1. General. The culvert valves at Kentucky Lock are segmental tainter type valves consisting of three horizontal girders spanning between side strut arms which rotate on a trunnion anchored to the lock wall. The skin plate is located on the downstream side with rubber side seals. Construction is of riveted structural steel weighing 57,600 pounds per valve. The valve is mechanically operated inside a 12 foot square culvert, one valve on each end of each of two culverts. Each valve has a bulkhead slot on the upstream and downstream side for maintenance unwatering.

A2. Present Condition. The valves are generally in good condition for 50 years of heavy traffic operation. They have had minor problems over the years and have only slight corrosion of the metals. In 1982 lock maintenance unwatering, the seals were repaired or replaced, the trunnion anchor nuts were found to be loose and subsequently retightened, and the trunnion bearings showed signs of wear. In 1986 maintenance unwatering the valves were removed from the culverts, sand blasted and repainted. The trunnion bearings were also replaced during this period. In 1992 maintenance unwatering the valves were inspected and no problems found.

A3. Reliability. Culvert valves are subjected to very high velocity flow with dynamic effects whenever the chamber is filled or emptied. This causes high fatigue loads on parts of the valve. Nashville District has found problems with valves in the past but typically has found and fixed the problems during the five year frequency maintenance unwaterings before they cause unscheduled lock outage. Many times during unwatering inspections valves have been found to have broken grease lines, loose anchorage, minor cracks around the strut arm and loose or missing seals. Occasionally a valve failure causes a valve to be taken out of service. This occurred at Cheatham Lock in Fall 1991 when cracked connections caused one valve to become inoperable and subsequently found similar problems on the other three valves. Similar problems have occurred at Pickwick Main Lock and others. Kentucky Lock culvert valves are 50 years old but have shown to be reliable in the past. The culvert valves are not included in this reevaluation reliability report for analysis due to the probability of unsatisfactory performance being low, the cost of unwatering and inspecting for study, and the consequences of unsatisfactory performance being relatively small.

A4. Consequences of Unsatisfactory Performance. The consequences of a valve performing unsatisfactorily can vary somewhat but normally for the case of a problem noticed by the lock operator, not during a maintenance inspection, the result is the same. The operator will take the lock out of service, call supervisors and maintenance personnel and try to determine the problem. An underwater inspection may be needed by divers to determine the problem. When it is determined the problem is serious enough that the valve must remain out of service the bulkheads will be set on both sides of the valve and the lock returned to service running on three valves. Dropping to one filling or one emptying valve will slow down operation slightly. This process should cause the lock to be out of service approximately one shift. The valve could then be dewatered and repaired while the lock remains in operation. The lock would be out of service another 4 hours after the valve is repaired to put it back into service. If the valve was damaged bad enough to need eventual replacement it would be procured and replaced at the next scheduled unwatering. Procuring one valve should cost approximately $250,000 which would not be considered major rehabilitation. Therefore the economic consequences of unsatisfactory performance of any one culvert valve does not justify the cost of doing a detailed analysis.

B. Mechanical Systems

B1. Miter Gate Machinery

<u>General Arrangement</u>. The miter gate machinery consists of: a two-speed electric motor with double extended output shafts, an electric-operated holding brake for one motor shaft extension, a primary reducer for the other motor shaft extension, a drive shaft with flexible couplings, a secondary reducer, a sector/pinion spur gear set, and associated items such as, sector arm, strut arm assembly, babbitt bearings and limit switches. Lubrication of the reducers is by pressure feed of synthetic oil and the sector/pinion spur gear set is by brush-application of heavy-duty open spur gear grease and lithium soap plain bearing grease. This design is standard for most locks designed by the Tennessee Valley Authority and has been proven to be reliable.

<u>Machinery Condition</u>.

(a.) Electric Motors. The motors appear to be in excellent condition. They operate without excessive noise and do not show signs of damage or wear. The motor brakes are disc type and operate smoothly, relative to most disc brakes.

(b.) Gear Reducers. Both the primary and secondary reducers appear to be well maintained. They do not show signs of excessive oil leakage which would indicate such things as bad gaskets, shaft seal failure, or worn bearings. Their internal components are examined monthly by lock personal and are reported to be in good condition. The output shaft of one secondary reducer is beginning to develop excessive vertical play and is presently being evaluated.

(c.) Sector and Pinion Gears. These spur gear sets show evidence of lubrication failure. This type of failure shows signs of surface scarring of both meshing gear surfaces and a distinctive ridge along the pitch line. Lubrication failure is typical for large gears that are exposed to the weather and are lubricated with brushed on grease.

(d.) Appurtenance Equipment. This equipment includes oil pumps, closed bladder type breathers, guards and limit switches. The flow pattern provided by the primary and secondary reducers oil pumps are examined monthly to check for blocked oil passages. The closed bladder type breathers are in good condition and are well maintained. The breathers are provided with a desiccant dryer to remove the moisture from inside the reducers. The desiccant is changed regularly to maintain its maximum effectiveness. The limit switches are rotary cam types and appear to be in good condition.

History of Repairs.

(a.) Motors. Motors and brakes on the miter gate were replaced in 1986. The original shoe brakes were replaced with the fast acting disc brakes. Brake pad wear is inspected monthly and is negligible.

(b.) Reducers. The primary and secondary reducers were rebuilt in 1986. The reducers bearings and seals were replaced and all excessively worn gears were reworked or replaced. After the rebuild the reducers were filled with synthetic oil and had closed bladder type breathers added to them.

(c.) Sector and Pinion Gears. The sector and pinion have not required any maintenance other than being greased monthly.

(d.) Appurtenance Equipment. Closed bladder type breathers were added to the primary and secondary reducers in 1982. The controls were replaced in 1982. The new controls included soft-start, soft-stop and rotary cam limit switches.

Reliability. The "Beta" factor reliability index for this machinery is beyond the scope of this report. The life expectancy of the equipment can be estimated from the maintenance history of the equipment. The gear reducers have been rebuilt on a ten year basis. The last rebuild was in 1986, therefore it can be assumed they may require rebuilding again in 1996. The sector and pinion gears have never been replaced and appear to have a minimum of 20 more years of service.

Consequences of Miter Gate Machinery Failure. Any failure of a miter gate machinery spur gear, bearing or shaft would result in complete closure of the lock until repair or replacement. Since spur gears should be replaced in sets, any replacement or rehabilitation, such as tooth surface weld repair and reshaping, should be preformed on both gears of a set. This procedure will probably result in at least a seven calendar day closure of the lock, based upon previous experience in weld repair of cast gear teeth.

B2. Culvert Valve Machinery

General Arrangement. The valve machinery consists of: a two-speed electric motor with double extended output shafts, and electric-operated holding brake for one motor shaft extension, a parallel shaft high speed reducer to the other motor shaft extension, a drive shaft with flexible coupling connecting the high speed reducer to the low speed reducer, a parallel shaft low speed reducer, a pinion gear, a sector gear with a sector arm attached, a spring loaded strut arm, and associated items such as gear guards, babbitt bearings and limit switches. Lubrication of reducers is by pressure feed of synthetic oil and the pinion/sector gear is by brush-application of heavy-duty open spur gear grease or lithium soap plain bearing grease.

Machinery Condition.

(a.) Electric Motors. The motors appear to be in excellent condition. They operate without excessive noise and do not show signs of damage or wear. The motor brakes are disc type and operate smoothly, relative to most disc brakes.

(b.) Gear Reducers. Both the primary and secondary reducers appear to be well maintained. They do not show signs of excessive oil leakage which would indicate such things as bad gaskets, shaft seal failure, or worn bearings. Their internal components are examined monthly by lock personal and are reported to be in good condition.

(c.) Sector and Pinion Gears. This spur gear set shows evidence of advanced lubrication failure. This type of failure exhibits signs of surface scarring of both meshing gear surfaces and a distinctive ridge along the pitch line. Lubrication failure is common for large gears that are exposed to the weather and are lubricated with brushed on grease.

(d.) Appurtenance Equipment. This equipment includes oil pumps, closed bladder type breathers, guards and limit switches. The oil flow pattern provided by the primary and secondary reducers oil pumps are examined monthly to check for blocked oil passages. The closed bladder type breathers are in good condition and are well maintained. The breathers are provided with a desiccant dryer to remove the moisture from inside the reducers. The desiccant is changed regularly to maintain its maximum effectiveness. The limit switches are rotary cam types and appear to be in good condition.

History of Repairs.

(a.) Motors. Motors and brakes on the segmental valves and the miter gate machinery were replaced in 1986. The original shoe brakes were replaced with the fast acting disc brakes. Brake pad wear is inspected monthly and is negligible.

(b.) Reducers. The primary and secondary reducers were rebuilt in 1986. The reducers bearings and seals were replaced and all excessively worn gears were reworked or replaced. After the rebuild the reducers were filled with synthetic oil and had closed bladder type breathers added to them.

(c.) Sector and Pinion Gears. Due to excessive wear the sector and pinion gears were replaced in 1973.

(d.) Appurtenance Equipment. Closed bladder type breathers were added to the primary and secondary reducers in 1982. The controls were replaced in 1982. The new controls have rotary cam limit switches.

Reliability. The "Beta" factor reliability index for this machinery is beyond the scope of this report. The life expectancy of the equipment can be estimated from the maintenance history of the equipment. The gear reducers have been rebuilt on a ten year basis. The last rebuild was in 1986, therefore they may require rebuilding again in 1996. The sector and pinion gears are replaced every 20 years. The gears were replaced in 1973 and should be replaced again in 1994.

Consequences of Machinery Failure. Any failure of a single culvert valve machine spur gear, bearing or shaft would result in reduced capacity of the lock until repair or replacement. It would take a failure of both filling (upstream) culvert valves or both emptying (downstream) culvert valves, simultaneously, to cause complete closure of the lock. Since only one filling and one emptying valve is required to minimally operate the lock, two of the machines can be used as spare parts for the other two machines. However, in the case of two valves serving the same function, such as filling, one of the remaining emptying valves must be taken out of service to supply spare parts. The actual removal and installation from one machine to the other will require lock closure. The lock will then operate at reduced capacity until spare or repaired parts are procured and installed at the appropriate locations. Since spur gears should be replaced in sets, any replacement should be performed by attempting to use both gears of the donating set. This procedure will probably result in at least a two day closure of the lock, based upon previous experience in gear replacement by hired labor. If three or more machines fail simultaneously, at the same device (gear, shaft, bearing), then lock closure could be up to seven calendar days.

C. Electrical Systems

C1. Present Condition. Present condition of the electrical systems is generally good.

(a.) Existing power service feeders from the TVA Kentucky Power Plant to Kentucky Locks are scheduled to be replaced by the end of the calendar year 1994. Secondary service feeders on the locks are in good condition.

(b.) Electric motors for miter gates and culvert valves are in good condition, having been replaced in 1986. There have been some problems with the operation of the motor disc brakes, which will require corrective action. The brakes are functional.

(c.) Other motors on the project for pumps and miscellaneous operations are in good condition.

(d.) The present Motor Control Center was installed in 1981 and is in good condition.

(e.) Motor Control Center spare parts are available from local vendors. The electrical control system was installed in 1981. It is in good operating condition, except for the timers in the miter gates and culvert valve controls. These items needs to be replaced within the next two years.

(f.) The lock's lighting system was installed in 1986 and is in good condition.

(g.) The tow haulage system is in need of service, but is operational.

C2. Reliability. The "Beta" factor reliability index for the electrical systems is beyond the scope of this report. The life expectancy of the electrical systems equipment can be estimated from the maintenance history of the equipment. A computerized preventive maintenance plan has been in use for 11 years. There have been no major failures of the electrical systems equipment during that time.

C3. Consequences. Failure of the electrical power supply from TVA Kentucky Power Plant could be replaced by supply of power from a standby diesel-electric generator in the maintenance building or by any other readily available standby generator. Since spare parts, lamps, and motors are on hand, failure of any other electrical system component can be corrected by repair or replacement of the component within a 48 hour lock closure. As a result, electrical system component failure could be limited to a two day closure.

D. Lockwall Concrete and Embedded Metals

D1. General. Kentucky Lock is 50 years old and sustains very heavy usage. The concrete is worn away in places as much as 2-inches deep. The edges of embedded metals are exposed and metals themselves are well-worn from the effects of traffic. Armor around many recesses has been torn away from its anchorage. The armor in these areas is exposed on the ends, is cracked, and the concrete behind the steel has been broken away. This damage is worse around upper and lower ends of the lock where tows bump to line up with the chamber. Armor around edges of line hooks, floating bits and gate recesses are exposed where concrete has worn away. Tows have torn pieces of this armor away leaving rough steel edges.

D2. Maintenance Problems. The wall armor at Kentucky Lock has been patched, re-anchored, and built-up at every major maintenance unwatering and most unscheduled maintenance periods for the last 20 years. In the past major maintenance unwaterings, wall repairs have been second priority to miter gate repairs, valve and culvert repairs, and other major operating equipment repairs that were essential for the lock to continue to function. During these maintenance periods only the worst of the areas were repaired at any single unwatering, generally working on 2-3 line hooks, a couple of vertical corners, a couple of horizontal armor areas and the short guardwalls at either end of the lock during an unwatering. Over the years virtually all major armor areas have been repaired at one time or another. We are now seeing most of the previously repaired areas in need of additional repair at every major maintenance period, damaged worse than before, and damage is accelerating. We do not expect this trend to lessen, in fact we expect it to get worse as the concrete anchorage behind the metals break down and the metal armor wears through or breaks upon impact. We expect the metals can continue to reasonably be repaired for another 3 to 4 major maintenance outages but beyond this period we will have no more existing armor or anchorage concrete behind the metals for repairs.

When the lock walls reach this level of deterioration our only choices will be to let the tows grind away at the lock walls without armor protection and take the risks and damage associated with this option, schedule a wall rehabilitation period and replace wall areas with new concrete and metals, or to extend every major maintenance period several weeks and gradually replace areas of wall with new concrete and metals over a period of decades. The last option is not preferred to the first because you are letting some areas severely deteriorate before schedules allow these to be repaired which still has the damage and risk potential of doing nothing.

Many of the damaged areas extend from the miter gate and maintenance bulkhead recesses to the end of the lock walls. These areas are difficult to work on during normal lock maintenance periods because of other work being performed in the area. Damaged areas beyond the maintenance bulkheads are impossible to unwater by normal methods or during short closures. Repairs to these areas must either be accomplished underwater or by building localized unwatering cofferdams which is both difficult, time consuming and expensive.

To more permanently repair a wall area in lieu of a major wall surface replacement it is necessary to remove the damaged concrete and metal areas with cutting torches, jack hammers or power saws, then align and anchor prefabricated metals to the wall and pour concrete, grout or epoxy solidly behind the metals. The fresh pour then must cure 4-7 days minimum before being returned to service. This process must be repeated in 10-20 foot sections up the wall. This type of repair would take longer than is typically available for periodic maintenance outage.

D3. Reliability. From an Engineering reliability standpoint the deterioration of the lockwall concrete or armor does not pose a wall stability, miter gate operation or floating mooring bit operation hazard until a significant amount of concrete is lost such that corners of tows could contact the ends of gates or damage a floating bit. Currently the Corps does not have methods of projecting wall deterioration due to impacts and abrasion. Most research has concentrated on the freeze/thaw deterioration experienced in northern waterways. For these reasons the wall deterioration must be investigated for lock operating efficiency and noting safety concerns of damaged walls. The damage to maintenance closure recesses is a concern due to not being able to repair these areas during maintenance unwaterings when the recess is in use. Additional damage to these areas could interfere with our ability to unwater the lock for maintenance or emergency repairs.

D4. Consequences. Operating personnel believe damage to tows by loose armor is an increasing possibility that can result in minimal to fairly major consequences, the least of which is interruption of traffic. Should a barge impact a partially embedded section of steel armor, exposed against the barges direction of travel, the mass of the barge would create sufficient force to drive the steel plate through the steel skin.

The barge could then sink, invert, and/or discharge its cargo into the lock chamber or approaches.

The least consequence of a barge/armor accident would be the temporary closure of the lock while damaged armor is removed from the lock wall or a damaged barge is taken out of service awaiting dry-dock repairs.

Of more major consequence would be the rupturing of a barge's skin resulting in the barge sinking. The lock would be immediately closed until the cargo could be unloaded and the barge floated, requiring a closure of several days. If the barge inverts and spills its cargo into the lock the barge would have to be righted and the cargo removed. Depending on the cargo, whether dry/bulk, aggregate or otherwise, this could require unwatering the lock for a week or more. A barge sank at Guntersville Lock in 1979 after a repaired area of its skinplate came loose during lockage, possibly due to rubbing rough spots on the wall. Although the barge did not invert, unwatering of the lock was necessary to make repairs and refloat the barge.

The worst consequence of a barge sinking in the lock, other than loss of life, would result from a barge carrying hazardous material, chemicals, petroleum products, chlorine or contaminants. This could cause wide-spread pollution, fish and aquatic kills, contamination of local water supplies and would probably shut down the lock until the contaminants could be removed or dissipated.

3. RELIABILITY ANALYSIS OF MITER GATES

A. Description of Miter Gate

The Kentucky Lock miter gates are horizontally framed, double skin, gates. The downstream gates have 23 horizontal girders and the upstream gates have 11 girders. The upstream gates are identical to the top portion of the downstream gates. Gate construction is of ASTM A7 steel using riveted plate girder construction. The lower gate leaves are 92 feet tall weighing 650 tons each. These gates, being double skin plated, make access to the inside of the gate very difficult, if not impossible, to clean, repaint and maintain. The inside compartments of the gates are small and separated by diaphragms which make working inside the gate very hard. Lighting and respirator problems further compound the problems of working on the inside. Therefore the inside of the gates are experiencing corrosion and this is one area that is addressed in this reliability analysis. At one time pigeons were getting inside the upper portions of the gate and their droppings caused the corrosion of the gate to accelerate. Wire screens were eventually installed on the gates to keep the pigeons out. Also, these gates are over 50 years old and have undergone many load cycles. This prompted us to investigate the fatigue as part of the reliability analysis.

B. Maintenance History and Problems

The miter gates at Kentucky lock have been a continual maintenance problem for the last 20 years due to their size and double skinplate construction. Nashville District has hired painting contractors for each of the last three maintenance unwaterings to spot clean and repaint the interior of the gates. Time during the unwaterings has only allowed the worst areas to be worked on. These paint contracts have only been able to remove loose paint and re-coat over what paint is left due to difficulties performing blasting or surface removal work inside of gates. This inability to get back to bare metal renders the new coating only marginally effective at protecting the gate.

On numerous occasions during cleaning operations the contractor had to be stopped to repair deteriorated areas that were found when loose coating was removed. In 1982 the paint contractor had to be pulled off the job because his chisels that were being used to remove built-up coating actually punched thru the rusted horizontal girder webs inside the gate. These webs and many supporting angles and rivets had to be built-up before letting the contractor return to work and putting gates back in service. We do not know what impacts the expected Zebra mussel infestation will have to these gates. We have found Zebra mussels in the gates and believe it will be nearly impossible to remove build-ups of mussels inside the gate compartments. A partial list of gate maintenance records is shown on Exhibit 3B-1.

MITER GATE MAINTENANCE RECORDS

The Following Records were exerted from Maintenance records of Kentucky Lock. Unfortunately records prior to approximately 1980 were not well documented.

Maintenance Required	Date
Broken Strut Arm Repaired	Mar 1962
Broken Strut Arm Repaired	Nov 1973
Spot Painting Inside Gates by Operating Personnel	1977
Exterior Painting Below Waterline	Sep 1982
Vertical Seal at Pintles Replaced	Sep 1982
Gate Fenders Replaced	Sep 1982
Seal Welds Near Miter Casting Broken, Repaired	Sep 1982
Lower Seals Repaired or Replaced	Sep 1982
Added Safety Railing and Stepdown to Access Hatch	Feb 1983
Added Rainwater Drain Pipes from Top Girder to Outside of Gate	Feb 1983
Added Hinged Screens to All Downstream Skin Vents	Feb 1983
Web Plates of Lower Gates Built up with Plate at Corroded Areas	Feb 1983
Rivets Replaced with Bolts, Approximately 300	Feb 1983
Misc. Web Stiffener Angles Built up with New Plate	Feb 1983
Interior Access Ladders Replaced 8 Sections	Feb 1983
Removed Misc. Loose Paint Inside Gates	Feb 1983
Overall Spot Blast and Painting Interior Above Waterline	Feb 1983
Reinforced Strut Arm Connections	Jul 1986
Replaced Strut Arm Springs	Jul 1986
Replaced Strut Arm	Jul 1986
Web Plates Built Up with New Plate	Jul 1986
Rivets Replaced with Bolts	Jul 1986
Web Stiffeners Built up with New Plate	Jul 1986
Miter Post Weld Cracks Repaired	Jul 1986
Mitering Device on Lower Gate Repaired	Jul 1986
Miter and Quoin Contact Blocks Replaced	Jul 1986
Overall Spot Blast and Painting Interior Below Waterline	Jul 1986
Splash Zone Inside Gates Spot Painted	Sep 1992
Gate Fenders Replaced	Sep 1992

Exhibit 3B-1

Postponement of a good surface preparation and painting of the Kentucky lock miter gates several years will lead to further deterioration and reduced strength of the gate structure. This along with other gate problems could cause premature replacement of the four gate leaves amounting to 3.7 million pounds of fabricated steel.

C. Performance Modes

C1. Design Load Cases vs Historical Loads. The original design of Kentucky Lock in 1939 checked several load cases for adequacy of the structures. The lock was designed to operate both during normal pool elevations and to maintain operation during rare flood events which the reservoir was sized to hold. The design pool elevations are as follows:

Maximum Extreme Headwater	Elev. 380.0
Maximum Normal Headwater	Elev. 375.0
Normal Summer Pool	Elev. 359.0
Normal Winter Pool	Elev. 354.0
Minimum Tailwater	Elev. 302.0

The load cases that the gates were designed for are as follows:

Load Case I - Dead Load Gate Swinging
Dead load of gate thru full swing unwatered.

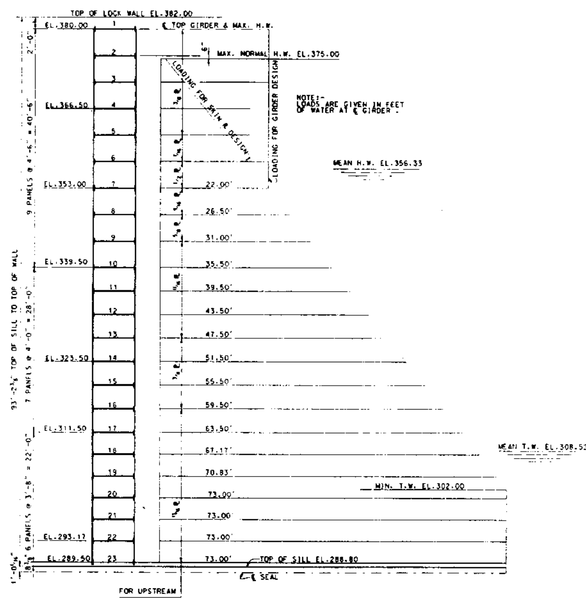
Load Case II - Gate Mitered With Normal Head
Dead load of gate in mitered position with normal head of headwater elev. 375 and tailwater elev. 302.

Load Case III - Gate Mitered, Normal Head plus Earthquake
Dead load of gate in mitered position with normal head of headwater elev. 375 and tailwater elev. 302 plus earthquake of acceleration 0.10 g times the gate weight plus water hammer effects per Westergaard's theory.

Load Case IV - Gate Mitered with Extreme Head
Dead load of gate in mitered position with extreme head of headwater elev. 380 and tailwater elev. 330.

A 25% overstress was allowed for Load Cases III and IV.

Historical pools at Kentucky Lock were investigated for input into the reliability analysis. Headwater data was gathered for the life of the lock and tailwater data was only available since 1976. Analysis of this data shows maximum pool elevation of 369.95 and mean headwater of elevation 356.33. Tailwater data shows minimum and maximum elevations of 299.16 and 340.39 respectively with a mean of elevation 308.52. The mean and standard deviations of these pools are used in the reliability analysis as a variable. Design pools and the last seven years pool data are shown on Exhibits 3C-1 and 3C-2.



LOWER GATE
LOADING DIAGRAM
SCALE: 3/16"=1'-0"

Exhibit 3C-1

Kentucky Lock Pool Data

HW Max = 359.95 HW Min = 345.28 HW Mean = 356.33 HW Std D = 2.27
TW Max = 340.39 TW Min = 299.18 TW Mean = 308.52 TW Std D = 8.80

Day	1986 Headwater	1986 Tailwater	1987 Headwater	1987 Tailwater	1988 Headwater	1988 Tailwater	1989 Headwater	1989 Tailwater	1990 Headwater	1990 Tailwater	1991 Headwater	1991 Tailwater	1992 Headwater	1992 Tailwater
1-Jan	354.29	301.00	354.53	312.71	356.82	316.48	356.34	316.94	354.98	303.55	359.54	339.64	354.67	308.78
2-Jan	354.38	301.87	354.69	308.84	356.50	314.41	355.84	315.80	355.34	311.58	358.79	339.00	354.65	310.37
3-Jan	354.41	302.14	354.70	307.12	356.07	312.64	355.64	314.30	355.41	314.10	359.02	338.89	354.23	312.19
4-Jan	354.17	301.88	354.09	306.24	355.38	310.38	355.55	312.95	355.32	315.58	358.30	338.67	354.36	313.04
5-Jan	354.45	301.82	354.87	306.05	355.31	309.05	355.48	312.06	355.37	316.89	358.68	338.54	354.44	315.80
6-Jan	354.37	302.06	354.47	304.30	355.07	308.17	355.19	311.38	355.38	317.80	358.05	338.64	354.41	316.34
7-Jan	354.25	302.50	354.11	304.08	354.88	306.41	355.14	311.70	355.26	319.39	357.89	338.37	354.27	315.85
8-Jan	354.39	301.97	354.14	303.52	354.91	301.34	355.45	312.32	355.00	319.88	357.98	337.83	354.17	315.40
9-Jan	354.48	301.85	354.22	303.10	355.04	300.48	355.84	313.22	354.75	319.88	357.80	337.78	354.02	314.07
10-Jan	354.38	302.24	354.35	301.35	355.18	301.04	355.48	315.37	354.71	318.50	357.84	337.69	354.28	311.70
11-Jan	354.50	301.55	354.88	302.82	355.33	301.22	355.24	316.10	354.32	317.13	357.29	337.58	354.22	310.93
12-Jan	354.22	301.66	354.88	302.46	354.81	302.27	355.12	321.87	354.35	314.77	357.08	337.18	353.90	310.27
13-Jan	354.65	301.57	354.66	303.56	354.77	303.13	355.25	326.55	354.09	313.85	357.06	336.80	353.81	307.00
14-Jan	354.47	301.58	354.47	303.56	354.88	301.50	356.30	326.54	354.84	313.44	356.54	335.97	354.12	304.29
15-Jan	354.47	301.71	353.86	304.24	355.02	301.60	356.89	331.17	354.37	313.03	355.92	335.16	354.39	304.84
16-Jan	354.57	301.50	354.02	301.78	355.18	301.14	357.02	332.18	354.30	309.53	356.15	334.29	355.34	307.32
17-Jan	354.48	301.62	354.16	301.17	354.80	303.39	357.20	330.81	354.51	306.90	354.58	332.56	355.38	308.78
18-Jan	354.61	301.43	354.28	301.45	355.16	302.32	357.02	330.06	354.30	308.44	354.32	330.78	355.27	308.81
19-Jan	354.63	301.76	353.97	303.70	356.47	304.28	358.65	329.31	354.17	310.10	354.38	329.14	355.12	308.23
20-Jan	354.73	302.03	354.12	305.03	356.48	317.30	358.14	327.63	354.41	312.50	354.00	327.84	354.69	307.26
21-Jan	354.78	302.18	354.45	308.88	356.72	320.72	355.71	328.82	354.39	314.30	354.17	326.87	354.58	304.10
22-Jan	354.57	301.67	354.42	310.53	357.04	321.80	354.97	325.45	354.30	317.10	354.32	324.75	354.40	303.54
23-Jan	354.47	301.81	354.61	311.14	357.14	319.70	354.75	321.70	354.39	318.15	354.38	323.22	354.27	302.84
24-Jan	354.55	302.99	354.64	312.38	356.89	318.39	354.63	314.34	354.35	319.32	354.37	321.87	354.50	302.39
25-Jan	354.43	304.06	354.46	312.71	356.53	318.44	354.66	308.07	354.25	318.76	354.76	319.38	354.42	302.39
26-Jan	353.73	305.70	354.72	313.61	356.17	318.87	354.70	305.85	354.52	319.38	354.87	317.28	354.82	303.12
27-Jan	354.42	306.77	354.62	312.19	355.78	317.40	354.82	304.87	354.36	318.86	354.80	315.00	354.34	305.80
28-Jan	354.54	306.87	354.88	310.18	355.84	311.80	355.01	304.77	354.32	317.89	354.35	313.12	354.20	306.47
29-Jan	354.28	306.15	354.67	309.08	356.06	308.20	355.22	304.72	354.48	317.15	353.94	311.25	354.25	306.25
30-Jan	354.40	304.67	354.63	308.87	356.47	303.92	355.52	304.80	354.42	318.43	354.14	309.85	354.38	303.88
31-Jan	354.58	303.04	354.74	308.48	356.27	303.88	355.75	304.84	354.47	318.82	354.68	309.35	354.33	303.81
1-Feb	354.59	300.59	354.55	306.82	355.70	304.75	355.58	305.40	354.89	320.12	354.72	306.37	354.46	302.48
2-Feb	354.93	300.34	354.47	305.31	355.57	311.95	355.38	305.90	355.04	323.08	354.60	308.31	354.61	300.65
3-Feb	355.18	306.50	354.55	306.05	355.40	315.05	355.93	309.05	355.80	326.69	354.41	308.11	354.59	300.13
4-Feb	355.18	307.48	354.67	305.38	355.27	315.54	356.43	310.83	355.77	331.18	354.44	308.08	354.28	302.91
5-Feb	355.08	309.30	354.84	307.42	355.17	318.92	358.41	312.11	356.23	332.19	354.88	306.66	354.29	303.28
6-Feb	354.94	313.14	354.72	307.72	355.57	317.63	356.00	314.58	356.98	332.22	355.23	310.81	354.30	303.12
7-Feb	354.85	315.07	354.90	307.32	355.25	318.38	355.83	315.43	357.21	332.02	355.23	312.30	354.17	303.25
8-Feb	354.88	318.58	354.43	307.30	355.03	318.89	355.38	315.83	357.31	330.55	356.53	313.87	354.36	301.87
9-Feb	354.58	318.00	354.84	306.71	354.79	318.44	355.56	315.10	357.08	330.39	356.37	315.32	354.43	302.03
10-Feb	354.54	318.00	354.80	305.85	354.55	319.68	355.55	312.85	357.27	331.75	354.84	316.72	354.53	301.90
11-Feb	354.80	319.35	354.61	305.21	354.15	318.54	355.57	309.06	357.33	332.39	355.12	316.87	354.42	302.16
12-Feb	354.52	319.82	354.33	304.77	354.44	317.71	355.56	307.88	357.56	332.84	354.91	317.53	354.59	301.59
13-Feb	354.73	320.30	354.43	304.23	354.84	314.44	355.85	312.22	357.54	332.58	354.37	318.63	354.60	301.81
14-Feb	354.54	320.41	354.45	303.80	354.98	310.23	356.24	320.49	357.31	332.37	354.52	318.88	355.11	302.12
15-Feb	355.11	318.82	354.32	303.00	355.38	308.33	356.51	327.10	357.89	333.85	355.41	318.55	354.90	302.58
16-Feb	355.24	318.22	354.25	303.25	355.70	307.48	357.06	327.13	357.55	334.67	356.03	318.61	354.70	301.90
17-Feb	355.24	318.50	354.29	303.12	355.58	307.78	358.03	325.53	357.34	335.18	356.36	319.30	354.88	301.23
18-Feb	355.51	318.73	354.52	303.18	355.46	307.27	358.69	325.83	356.78	335.67	357.18	322.08	354.80	302.30
19-Feb	355.83	318.89	354.58	303.50	355.48	307.18	358.66	326.27	356.60	334.69	356.80	329.89	354.83	303.41
20-Feb	355.77	319.53	354.87	304.10	355.11	307.12	358.81	327.50	356.87	334.47	356.26	333.92	355.29	303.39
21-Feb	355.73	319.20	354.67	304.45	355.50	305.13	359.28	330.21	357.22	334.55	356.53	335.62	355.08	305.52
22-Feb	355.28	319.48	354.73	304.80	355.34	305.88	358.62	334.48	357.12	334.81	357.01	335.93	354.78	305.97
23-Feb	354.70	320.08	354.71	307.51	354.87	308.48	358.78	335.63	357.17	334.80	357.40	338.45	354.80	304.22
24-Feb	354.44	318.78	354.84	308.88	354.84	307.61	359.63	333.90	356.80	334.18	357.36	336.22	354.96	305.85
25-Feb	354.77	318.04	355.02	308.60	354.89	308.41	359.84	333.45	356.67	333.58	357.38	335.43	354.86	306.44
26-Feb	354.74	317.67	354.88	312.70	354.56	307.78	359.23	333.04	356.18	332.64	357.05	335.18	355.87	306.58
27-Feb	354.28	317.49	354.40	318.01	354.40	306.70	358.66	333.13	355.39	331.43	358.57	334.88	358.18	309.51
28-Feb	354.53	316.79	354.59	324.28	354.55	304.90	358.01	332.69	354.80	326.81	358.00	334.30	355.94	311.54
29-Feb					354.52	304.00							356.20	312.62
1-Mar	354.89	313.84	354.62	328.07	354.70	302.20	357.22	332.88	354.44	328.55	355.45	333.57	356.07	313.29
2-Mar	354.89	311.80	354.99	327.22	354.85	300.80	356.71	331.78	354.80	322.19	354.62	331.83	355.82	313.81
3-Mar	354.83	308.80	354.78	327.61	354.86	299.80	356.42	330.67	354.76	318.00	354.28	328.00	355.43	313.94
4-Mar	354.80	308.41	354.89	326.13	355.21	300.62	355.61	328.91	355.05	318.85	354.48	326.69	355.03	313.06
5-Mar	354.50	309.11	355.28	323.98	355.43	302.48	355.40	329.64	354.91	317.10	354.80	323.87	354.77	310.83
6-Mar	354.82	306.20	355.60	323.17	355.80	305.71	355.21	330.30	354.88	316.68	354.30	322.01	354.77	307.42
7-Mar	354.88	304.86	355.81	322.82	355.77	308.28	355.41	330.41	354.54	318.10	354.46	321.23	354.59	306.26
8-Mar	354.98	302.54	355.45	322.58	355.77	311.63	355.67	330.82	354.43	316.68	354.63	320.84	354.29	304.47
9-Mar	354.93	301.66	354.96	321.24	355.35	313.22	356.34	328.44	354.39	314.63	354.33	321.38	354.20	305.17
10-Mar	354.48	302.40	354.73	319.52	355.47	313.58	356.96	328.89	354.52	313.83	354.27	321.82	354.72	311.58
11-Mar	354.86	302.22	354.42	317.29	355.26	313.30	357.20	327.72	354.56	313.30	354.32	321.36	355.84	315.87
12-Mar	355.13	303.97	354.33	313.60	355.07	310.22	357.20	327.20	354.58	313.19	354.42	321.19	356.15	317.82
13-Mar	355.67	307.57	354.70	310.98	355.29	306.82	357.12	327.22	354.41	313.21	354.28	320.10	356.17	318.66
14-Mar	356.27	312.52	354.66	310.27	355.31	306.85	357.12	328.50	354.47	311.08	354.37	319.89	355.64	318.87
15-Mar	356.57	314.94	354.32	309.83	355.32	306.48	356.82	325.80	354.40	311.10	354.54	319.22	355.01	318.90
16-Mar	356.40	318.76	354.39	307.17	355.39	305.97	356.34	324.66	354.46	315.19	354.59	319.12	354.89	316.58
17-Mar	355.96	319.32	354.43	306.02	355.38	306.17	356.11	322.34	354.56	317.67	354.82	319.38	354.21	315.36
18-Mar	355.82	319.12	354.44	305.06	355.10	306.58	355.70	319.26	354.53	320.30	354.52	318.82	354.32	314.87
19-Mar	355.36	319.74	354.38	303.87	355.48	302.54	355.35	316.15	354.69	320.44	354.51	318.13	354.58	314.88
20-Mar	355.06	320.06	354.32	303.87	355.53	300.75	354.32	314.25	354.64	321.76	354.40	318.10	354.85	314.56
21-Mar	355.33	319.80	354.38	303.60	355.44	300.16	354.55	312.43	354.72	321.40	354.58	317.96	354.81	315.54
22-Mar	355.57	319.48	354.47	302.88	355.52	300.17	354.98	313.30	354.78	320.98	355.04	318.98	354.48	316.42
23-Mar	355.43	319.64	354.50	303.15	356.45	302.15	355.22	314.82	354.80	320.83	355.31	320.15	354.78	318.15
24-Mar	355.38	319.88	354.23	304.12	355.83	301.93	355.50	315.91	355.00	320.44	355.50	321.43	354.92	318.96
25-Mar	355.21	317.66	354.18	302.93	355.86	301.98	355.51	318.66	354.96	318.37	355.50	323.02	354.96	318.97
26-Mar	355.02	315.72	354.34	301.94	355.83	302.38	355.51	317.40	354.92	314.65	355.47	323.87	354.85	318.72
27-Mar	355.03	312.23	354.64	301.42	355.75	302.17	355.38	317.68	354.97	311.12	355.03	324.81	354.84	315.16
28-Mar	355.11	309.33	354.75	301.64	355.94	300.68	355.37	317.67	354.97	308.18	355.12	326.37	354.90	312.70
29-Mar	355.06	307.24	354.39	301.65	355.83	300.80	355.48	318.16	354.96	308.85	354.70	326.73	355.09	309.11
30-Mar	355.17	305.45	354.47	301.45	355.95	301.74	355.28	318.31	355.17	308.39	355.57	327.51	354.86	308.18
31-Mar	355.23	303.76	354.88	303.06	356.19	303.86	356.42	318.80	355.39	308.14	356.57	328.17	354.80	308.95
1-Apr	355.09	302.66	354.79	305.60	356.47	305.17	357.00	316.87	355.54	307.08	357.54	328.35	354.63	311.33
2-Apr	355.25	301.03	355.05	307.74	357.13	306.03	357.27	317.70	354.96	306.68	358.41	329.08	354.94	311.60

Exhibit 3C-2
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Kentucky Lock Pool Data

HW Max = 363.95 TW Max = 340.39
HW Min = 345.28 TW Min = 299.18
HW Mean = 356.33 TW Mean = 306.52
HW Std D = 2.27 TW Std D = 8.80

Day	1986 Headwater	1986 Tailwater	1987 Headwater	1987 Tailwater	1988 Headwater	1988 Tailwater	1989 Headwater	1989 Tailwater	1990 Headwater	1990 Tailwater	1991 Headwater	1991 Tailwater	1992 Headwater	1992 Tailwater
3-Apr	355.33	300.05	355.16	308.16	357.70	306.10	357.71	320.27	356.51	305.81	358.96	327.80	355.21	311.28
4-Apr	355.32	299.67	355.11	310.73	358.03	306.70	357.96	323.18	355.73	304.69	359.19	326.93	355.51	309.52
5-Apr	355.36	299.40	355.36	310.50	358.22	308.04	358.46	325.83	356.00	303.39	359.16	325.83	355.85	308.39
6-Apr	355.37	300.27	355.30	310.60	358.09	309.89	358.53	327.22	356.57	303.09	358.68	324.53	356.09	307.52
7-Apr	355.42	301.17	355.56	310.23	358.20	310.96	358.96	327.23	357.03	302.50	358.21	321.41	356.21	306.42
8-Apr	355.14	301.51	355.78	309.78	358.36	311.62	359.56	328.81	357.23	302.07	357.78	317.76	356.48	304.77
9-Apr	355.67	301.29	355.88	308.38	358.33	312.24	360.58	326.57	357.61	301.64	357.39	315.23	356.89	303.27
10-Apr	355.82	301.67	355.87	308.74	358.22	312.42	361.30	326.70	357.47	303.56	357.39	312.39	356.90	301.86
11-Apr	355.81	301.60	356.20	310.57	358.34	312.04	361.47	327.57	357.85	304.60	357.66	311.50	357.10	300.40
12-Apr	356.03	301.80	356.18	311.89	358.44	312.00	361.41	327.74	358.31	305.69	357.82	311.33	357.30	299.92
13-Apr	356.19	301.36	356.50	312.66	358.72	312.12	361.24	327.41	358.63	306.58	357.87	311.80	357.52	301.35
14-Apr	356.11	301.75	356.85	314.13	358.74	311.64	360.86	328.20	358.59	306.76	357.95	314.85	357.63	302.25
15-Apr	356.12	301.76	357.21	315.80	358.67	308.87	360.58	325.11	358.63	307.17	357.81	318.81	357.86	302.37
16-Apr	356.40	301.31	357.49	318.24	358.74	306.65	360.04	323.07	358.66	307.56	358.18	320.46	357.97	302.00
17-Apr	356.58	301.47	357.51	319.59	358.75	304.32	359.42	319.70	358.63	306.44	358.55	321.64	358.19	302.13
18-Apr	356.72	301.41	357.89	318.02	358.89	303.47	358.77	315.92	358.87	306.31	358.54	322.79	358.39	302.44
19-Apr	356.92	301.18	358.42	318.73	359.02	303.44	358.73	311.66	359.13	307.34	358.37	323.15	358.56	300.87
20-Apr	357.10	301.59	358.91	318.58	359.04	303.39	358.69	308.20	359.19	306.07	358.63	321.77	358.64	302.80
21-Apr	358.91	299.87	359.39	319.08	359.00	302.22	358.79	305.86	359.30	306.22	359.12	321.21	358.72	304.90
22-Apr	357.26	300.34	359.56	319.33	359.05	301.31	358.88	304.48	359.60	307.55	359.31	320.37	358.75	306.80
23-Apr	357.48	300.56	359.52	319.23	358.57	301.85	358.82	304.17	358.76	309.12	359.07	318.69	358.94	307.80
24-Apr	357.61	300.70	359.53	318.84	358.81	300.05	358.99	303.62	358.57	308.68	358.84	317.87	358.78	309.19
25-Apr	357.77	300.77	359.43	316.90	358.86	301.77	359.06	303.45	358.32	310.32	358.69	315.38	358.78	310.17
26-Apr	357.82	300.84	359.06	313.89	358.83	302.57	359.17	302.09	359.23	309.81	358.90	312.94	358.78	310.79
27-Apr	358.12	300.70	358.78	309.62	358.84	301.85	358.27	300.49	359.22	308.98	358.75	310.26	358.90	311.53
28-Apr	358.20	300.80	359.17	307.98	358.81	301.58	359.43	301.23	358.37	307.70	358.84	309.55	358.86	311.34
29-Apr	358.29	299.60	359.21	306.91	358.97	301.66	359.28	302.50	358.31	305.87	359.00	311.58	358.98	311.02
30-Apr	358.37	300.98	359.12	306.48	358.98	302.18	358.20	304.40	358.22	304.28	358.94	313.84	358.83	308.40
1-May	358.42	300.80	359.08	309.73	358.87	301.66	358.10	306.93	358.25	303.32	358.87	313.82	358.90	307.22
2-May	358.48	301.25	359.19	306.64	358.93	301.74	359.22	308.50	358.41	302.72	358.83	313.61	358.93	305.63
3-May	358.73	301.12	359.18	307.08	359.03	301.64	359.02	310.28	358.41	303.54	358.94	308.66	358.98	303.90
4-May	358.85	301.35	359.27	305.17	358.96	301.55	358.82	313.00	358.52	306.03	359.00	308.93	358.89	302.75
5-May	358.98	301.54	359.24	304.02	358.94	301.81	358.72	314.14	359.62	305.14	358.83	308.46	358.69	302.04
6-May	358.94	301.60	359.08	303.72	358.97	301.74	358.88	311.74	359.61	307.25	358.98	311.00	358.82	301.22
7-May	359.00	301.50	358.91	303.21	358.98	301.45	359.01	312.35	359.44	310.10	359.00	311.46	358.85	301.28
8-May	359.07	301.34	359.01	302.15	358.87	301.84	359.05	312.73	358.23	312.07	359.06	311.58	358.91	301.04
9-May	359.12	301.35	358.89	301.22	359.01	301.98	359.03	313.09	359.16	312.94	359.07	312.23	358.92	300.43
10-May	359.20	301.41	358.94	300.38	358.95	302.21	359.21	313.26	359.35	311.70	359.12	311.18	358.96	300.08
11-May	359.34	301.37	358.93	300.05	358.92	302.41	359.04	313.80	359.32	311.00	358.33	310.80	359.01	300.82
12-May	359.33	301.55	358.99	301.88	358.96	302.58	358.86	314.56	359.39	309.45	359.29	313.55	359.13	302.34
13-May	359.40	301.87	359.04	302.33	358.95	302.15	358.82	314.88	359.41	308.45	359.53	316.06	359.25	302.64
14-May	358.27	301.37	359.07	302.70	358.93	301.43	358.89	315.30	359.56	307.39	358.66	314.71	359.29	301.89
15-May	359.62	299.87	359.15	302.75	358.86	301.75	358.64	315.80	359.33	308.14	359.64	314.56	359.29	302.25
16-May	359.54	304.15	359.17	301.97	358.81	301.79	358.76	315.46	359.13	311.19	359.54	313.39	359.48	301.46
17-May	359.48	304.60	359.15	302.00	358.84	301.86	358.74	315.80	359.55	314.85	359.50	310.10	359.40	302.79
18-May	359.23	303.99	359.13	301.98	358.81	301.71	358.98	315.50	359.44	317.97	358.25	309.30	358.39	303.52
19-May	359.41	302.75	359.12	302.06	358.78	301.73	358.80	315.52	359.42	320.61	359.08	309.03	359.57	302.29
20-May	359.37	301.79	359.13	301.87	358.72	301.00	359.02	313.94	359.01	322.33	358.17	307.35	359.80	302.23
21-May	359.36	301.73	359.24	302.00	358.70	301.18	358.48	312.80	358.64	322.17	358.19	306.67	358.68	302.69
22-May	359.39	302.60	359.29	302.06	358.70	301.30	359.64	313.05	361.10	322.00	359.03	305.85	358.62	302.90
23-May	359.32	304.11	359.23	302.18	358.91	301.71	359.47	313.76	362.14	322.13	359.14	305.90	359.42	302.22
24-May	359.48	305.34	359.17	302.05	358.86	301.99	359.50	312.80	362.87	322.20	358.98	305.36	359.27	302.28
25-May	359.68	305.90	359.22	303.07	358.77	301.87	359.27	311.42	363.30	322.62	358.91	305.47	358.16	301.64
26-May	359.72	307.05	359.24	303.33	358.91	301.81	359.06	310.80	363.33	322.67	358.92	310.12	358.98	302.07
27-May	359.55	307.27	359.31	302.98	358.92	301.93	359.48	309.70	363.44	322.32	359.10	318.98	358.96	301.33
28-May	359.38	306.73	359.20	302.84	358.83	302.07	358.55	310.33	363.30	323.12	358.84	327.82	359.09	301.34
29-May	359.27	307.78	359.07	303.29	358.89	302.11	358.45	311.45	363.19	323.06	358.56	329.01	359.36	302.21
30-May	359.37	307.37	359.29	300.93	358.82	301.33	358.31	312.00	363.14	322.82	359.06	322.84	359.51	301.82
31-May	359.41	306.68	359.20	301.27	358.88	301.67	359.06	312.35	363.37	322.41	358.75	316.14	358.50	302.30
1-Jun	359.43	304.53	359.17	300.61	358.77	301.44	359.00	311.40	363.51	322.48	358.72	311.22	358.46	302.65
2-Jun	359.37	303.69	359.12	300.47	358.70	301.60	358.96	310.71	363.19	323.37	358.77	307.61	359.36	302.60
3-Jun	359.48	303.00	358.92	300.73	358.67	302.08	359.01	308.12	362.75	323.67	358.79	306.53	359.42	302.64
4-Jun	358.50	301.50	358.01	300.86	358.69	301.48	359.39	306.15	362.30	323.68	358.79	305.89	358.63	302.50
5-Jun	359.58	300.87	359.00	300.57	358.68	301.37	359.47	305.06	362.00	323.67	358.94	303.76	358.92	302.27
6-Jun	358.83	300.73	359.02	300.06	358.67	301.26	359.51	306.53	361.71	322.88	360.00	302.87	358.94	301.88
7-Jun	359.80	303.20	358.92	299.98	358.59	301.40	358.52	307.17	361.29	321.87	359.01	302.44	358.84	302.46
8-Jun	358.72	303.85	358.87	302.67	358.61	301.50	359.28	308.26	360.87	320.43	359.01	301.84	358.73	302.83
9-Jun	360.02	305.80	358.87	301.85	358.41	301.54	359.23	308.30	360.37	318.82	358.94	300.55	359.68	302.82
10-Jun	358.68	309.72	359.07	302.23	358.40	301.52	359.22	308.25	359.81	317.42	358.87	299.98	358.66	303.42
11-Jun	359.49	308.80	358.98	302.07	358.36	301.23	359.32	308.35	358.39	315.69	358.89	300.29	358.69	303.80
12-Jun	359.38	307.78	359.08	302.08	358.28	301.40	358.88	309.80	358.14	314.22	358.36	300.64	359.62	306.40
13-Jun	359.37	307.00	359.16	302.51	358.28	301.22	358.80	313.20	358.12	313.43	358.62	301.06	359.52	306.72
14-Jun	359.38	306.25	359.32	302.58	358.29	301.14	358.60	316.40	359.04	313.46	358.56	303.62	358.32	303.57
15-Jun	359.38	305.21	359.24	302.36	358.25	301.04	359.36	318.10	359.08	313.06	359.47	303.33	359.15	302.25
16-Jun	359.27	304.84	359.25	302.39	358.18	301.08	359.07	321.20	359.15	310.14	358.55	302.81	359.27	303.39
17-Jun	358.09	304.62	359.28	302.20	358.15	300.85	358.91	321.87	359.37	307.87	358.50	303.66	358.21	303.76
18-Jun	358.97	303.61	358.21	302.17	358.18	301.08	358.78	321.37	359.41	307.45	358.17	303.38	359.18	303.81
19-Jun	358.96	301.64	358.25	303.29	358.11	301.06	358.57	321.81	359.40	308.90	358.89	303.89	359.37	302.54
20-Jun	358.94	300.70	358.43	302.10	358.05	300.89	358.50	322.52	359.21	308.34	358.86	302.50	359.07	305.89
21-Jun	358.94	300.23	358.80	302.20	358.09	301.05	358.59	323.04	359.22	307.07	358.12	302.45	358.08	305.66
22-Jun	358.93	299.49	358.32	303.08	358.18	301.06	358.71	323.86	359.30	306.89	358.32	303.89	358.01	304.17
23-Jun	358.82	301.49	359.19	302.84	358.13	301.01	358.86	323.84	359.32	304.94	358.81	303.38	358.82	303.44
24-Jun	358.86	301.49	359.06	302.80	358.38	301.02	359.07	323.80	359.29	305.38	358.79	303.12	359.21	300.55
25-Jun	358.97	301.29	359.00	301.82	358.27	300.93	359.22	323.30	359.31	305.50	358.68	303.22	359.28	301.66
26-Jun	359.06	301.50	358.11	302.05	358.00	301.14	359.28	322.82	359.02	306.33	358.59	303.58	359.39	302.28
27-Jun	359.08	301.62	358.14	302.36	358.08	301.72	359.21	321.28	358.97	306.00	358.35	303.89	359.37	303.62
28-Jun	359.02	301.63	359.08	302.34	358.04	301.98	359.05	320.80	359.03	305.19	358.28	303.30	358.57	301.85
29-Jun	358.95	301.41	359.00	302.06	358.04	302.14	359.04	319.30	359.12	305.17	358.27	303.19	358.52	301.23
30-Jun	359.04	301.94	359.00	302.40	358.08	302.13	359.02	317.70	359.10	303.81	359.27	302.60	359.62	302.35
1-Jul	358.98	301.84	358.95	301.86	356.00	302.12	358.73	317.81	359.02	303.64	359.21	302.88	359.41	303.71
2-Jul	358.93	301.31	359.00	302.00	359.07	302.18	358.63	320.65	358.87	302.84	358.85	303.39	359.39	302.59
3-Jul	358.97	299.98	359.18	301.95	358.08	302.30	358.83	320.10	358.85	302.28	358.81	303.38	359.47	304.04
4-Jul	359.08	300.99	359.33	302.03	358.14	302.10	359.36	319.52	358.82	302.45	359.05	303.50	358.82	302.87

Exhibit 3C-2
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Kentucky Lock Pool Data

HW Max = 369.95 | HW Min = 345.28 | HW Mean = 356.33 | HW Std D = 2.27
TW Max = 340.39 | TW Min = 299.18 | TW Mean = 308.52 | TW Std D = 8.80

Day	1986 Headwater	1986 Tailwater	1987 Headwater	1987 Tailwater	1988 Headwater	1988 Tailwater	1989 Headwater	1989 Tailwater	1990 Headwater	1990 Tailwater	1991 Headwater	1991 Tailwater	1992 Headwater	1992 Tailwater
5-Jul	359.05	302.32	359.27	300.74	358.05	302.00	359.51	319.59	358.88	301.61	359.15	303.22	358.82	302.37
6-Jul	358.89	303.10	359.34	302.81	358.08	301.90	359.30	319.00	358.97	301.13	359.12	302.79	359.71	304.78
7-Jul	358.77	303.81	359.17	305.13	358.18	302.21	359.17	317.36	358.97	300.29	358.91	303.34	358.72	303.78
8-Jul	358.73	303.01	358.98	306.32	358.22	301.86	358.92	318.50	358.93	300.08	358.93	303.08	358.63	303.21
9-Jul	358.70	300.03	359.04	306.45	358.32	301.90	358.71	314.98	358.93	300.25	358.98	302.73	358.70	302.13
10-Jul	358.78	299.24	358.94	306.43	358.29	301.88	358.56	314.24	358.70	302.12	358.87	303.70	358.68	304.06
11-Jul	358.86	300.10	358.89	305.13	358.31	301.98	358.55	312.89	358.90	300.76	358.87	301.66	358.39	304.12
12-Jul	358.72	300.81	358.77	303.88	358.47	302.00	358.51	312.44	358.90	301.28	358.79	301.46	358.89	302.88
13-Jul	358.55	302.17	358.51	303.13	358.85	301.81	358.45	312.28	358.73	302.87	358.64	301.28	358.67	302.87
14-Jul	358.53	303.65	358.58	302.60	358.70	302.10	358.47	311.38	358.80	304.10	358.57	301.78	358.60	301.16
15-Jul	358.45	305.27	358.55	302.18	358.98	302.10	358.38	311.13	358.82	303.12	358.34	303.48	358.41	301.19
16-Jul	358.41	305.74	358.41	302.00	359.04	302.08	358.09	310.96	358.82	304.67	358.29	302.56	358.30	301.14
17-Jul	358.48	305.88	358.29	302.15	359.17	302.12	358.16	306.03	358.59	306.65	358.19	302.13	358.28	302.85
18-Jul	358.62	304.98	358.40	301.29	359.29	302.32	358.11	304.08	358.88	307.14	358.18	302.12	358.40	302.95
19-Jul	358.55	303.94	358.30	303.00	359.48	302.24	358.11	303.46	358.85	307.42	358.10	302.68	358.26	304.35
20-Jul	358.22	303.18	358.27	301.52	359.43	301.81	358.09	303.78	358.93	308.12	358.13	302.30	358.04	305.00
21-Jul	358.18	301.82	358.10	303.28	359.47	301.71	358.15	303.50	358.91	307.79	358.39	301.31	358.15	305.40
22-Jul	358.06	300.34	357.93	302.89	359.50	301.97	358.18	302.85	358.80	307.50	358.41	301.91	358.30	304.89
23-Jul	358.07	299.66	357.91	302.47	359.88	302.05	358.02	303.05	358.17	305.28	358.32	302.14	358.30	304.81
24-Jul	358.12	299.38	357.81	302.90	359.72	301.91	357.83	303.73	358.37	303.97	358.26	303.01	358.18	304.81
25-Jul	358.13	301.23	358.00	302.50	359.73	301.80	357.83	302.80	358.38	303.87	358.25	302.22	358.10	304.85
26-Jul	358.11	301.48	358.04	301.51	359.83	302.24	357.81	302.18	358.38	304.52	358.32	302.06	357.96	305.70
27-Jul	357.83	301.48	358.01	302.47	359.70	302.25	357.88	302.20	358.38	304.42	358.42	301.80	357.85	305.85
28-Jul	357.85	301.53	357.97	301.92	359.89	302.03	357.74	302.71	358.28	304.89	358.43	301.80	357.84	307.30
29-Jul	357.77	301.60	357.95	302.83	360.01	301.96	357.68	303.98	358.05	303.78	358.15	302.25	357.88	308.70
30-Jul	357.73	301.48	357.85	302.21	359.96	301.63	357.83	303.80	357.86	302.27	358.15	302.60	357.96	308.80
31-Jul	357.63	301.78	357.88	303.38	359.90	301.50	357.50	302.68	357.81	300.87	358.00	301.89	357.97	310.18
1-Aug	357.65	301.32	357.71	303.85	359.90	301.80	357.61	302.67	357.82	302.60	357.94	302.00	358.11	310.43
2-Aug	357.68	301.35	357.58	303.88	359.96	302.09	357.42	302.55	357.79	303.03	357.88	302.26	358.17	310.22
3-Aug	357.39	301.31	357.68	302.08	359.98	302.21	357.45	302.18	357.79	302.85	357.81	301.93	358.23	309.42
4-Aug	357.31	301.88	357.60	302.40	359.89	302.24	357.48	303.40	357.78	302.64	357.84	302.46	358.32	308.90
5-Aug	357.35	300.95	357.58	302.56	359.90	302.65	357.40	304.04	357.75	302.75	358.00	302.21	358.41	308.57
6-Aug	357.35	300.90	357.48	301.98	359.89	302.00	357.28	304.08	357.60	303.19	357.85	303.26	358.41	308.05
7-Aug	357.45	301.24	357.40	302.54	359.87	301.67	357.32	302.92	357.52	302.94	357.82	301.83	358.38	306.80
8-Aug	357.48	301.32	357.44	302.60	359.82	301.91	357.35	303.30	357.48	303.11	357.82	302.20	358.11	304.33
9-Aug	357.41	301.80	357.19	302.37	359.88	302.32	357.10	304.60	357.39	303.25	357.78	302.06	357.97	303.61
10-Aug	357.30	301.84	357.17	301.78	360.01	302.25	357.08	303.80	357.48	303.25	357.93	302.60	357.88	306.50
11-Aug	357.19	301.78	357.12	302.54	360.05	302.45	357.10	301.80	357.39	302.80	358.03	302.53	357.59	304.12
12-Aug	357.13	301.48	357.12	302.32	360.04	302.50	357.08	302.94	357.20	303.17	358.04	302.12	357.47	304.05
13-Aug	357.20	301.45	357.14	302.14	359.92	302.58	357.07	302.15	357.32	303.12	357.98	302.03	357.29	302.88
14-Aug	357.30	301.52	357.14	301.76	359.77	302.50	356.89	303.43	357.16	302.58	357.94	302.33	357.37	302.56
15-Aug	357.46	301.35	357.18	301.72	359.77	302.47	356.86	304.56	357.09	302.67	357.98	301.79	357.45	300.44
16-Aug	357.48	301.61	357.10	302.32	359.84	302.42	356.83	303.60	357.18	303.12	358.15	303.03	357.15	299.95
17-Aug	357.40	301.85	357.00	302.29	359.80	302.88	356.85	302.81	357.15	303.14	358.07	302.53	356.97	299.86
18-Aug	357.29	301.63	356.86	302.57	359.93	302.70	356.83	302.49	357.21	303.00	358.02	303.47	356.92	300.80
19-Aug	357.17	301.69	356.79	302.68	360.11	302.59	357.01	301.62	356.81	303.18	357.87	302.63	356.75	303.09
20-Aug	357.09	302.35	356.70	302.40	359.98	302.45	357.01	302.08	356.64	302.17	357.87	302.93	356.51	302.58
21-Aug	357.06	302.03	356.61	301.95	359.89	302.08	356.93	304.51	356.68	303.17	357.78	303.25	356.55	301.52
22-Aug	357.08	301.58	356.44	302.20	359.81	302.30	356.93	304.27	356.60	303.32	357.67	302.61	356.57	301.11
23-Aug	357.00	301.82	356.23	302.43	359.63	302.37	356.92	303.92	356.65	301.73	357.54	302.61	356.52	301.13
24-Aug	356.87	302.09	356.16	301.99	359.59	302.48	356.71	302.71	356.53	301.87	357.35	303.18	356.30	302.10
25-Aug	356.87	301.22	356.18	301.60	359.50	302.30	356.63	301.72	356.60	300.66	357.15	303.43	356.07	303.61
26-Aug	356.87	302.06	356.14	302.04	359.35	301.85	356.80	301.35	356.47	300.81	357.12	302.92	355.98	302.80
27-Aug	356.61	301.65	356.11	301.67	359.26	302.20	356.91	302.51	356.42	301.37	357.11	303.06	355.81	303.19
28-Aug	356.59	301.66	356.25	301.68	359.14	302.04	356.94	303.00	356.46	300.65	357.11	302.73	356.04	303.83
29-Aug	356.62	302.48	356.25	302.43	359.13	302.05	356.78	304.88	356.36	300.34	357.11	302.38	356.13	303.10
30-Aug	356.56	301.67	356.19	301.92	358.93	302.23	356.81	302.08	356.35	302.30	357.05	302.58	356.12	302.71
31-Aug	356.50	301.30	356.10	301.90	358.77	302.06	356.87	301.87	356.34	302.81	357.11	302.30	355.93	303.83
1-Sep	356.39	301.92	356.12	301.51	358.73	301.85	356.85	302.10	356.34	301.75	357.08	303.05	355.84	303.91
2-Sep	356.35	301.69	356.02	302.01	358.76	302.18	356.71	302.65	356.28	302.35	357.12	302.63	356.04	302.21
3-Sep	356.37	301.36	355.86	301.61	358.82	302.70	356.62	302.60	356.36	302.17	357.10	302.25	355.86	301.13
4-Sep	356.26	304.06	355.88	301.33	358.71	302.50	356.63	302.20	356.34	302.33	357.08	302.38	355.83	302.81
5-Sep	356.27	303.85	355.91	301.54	358.61	302.78	356.50	303.48	356.37	302.11	357.15	302.83	355.86	302.73
6-Sep	356.24	303.34	355.72	301.94	358.61	302.38	356.40	303.10	356.12	304.82	357.13	302.76	356.00	302.85
7-Sep	355.97	303.38	355.68	301.86	358.60	302.30	356.35	303.95	356.00	303.39	357.13	302.39	356.13	303.83
8-Sep	355.93	303.20	355.59	301.50	358.52	302.22	356.30	304.43	356.18	300.73	357.08	302.69	355.97	303.93
9-Sep	355.87	302.07	355.56	302.36	358.54	302.40	356.31	302.48	356.20	301.86	357.03	302.30	356.00	303.28
10-Sep	355.84	301.38	355.54	302.10	358.53	302.51	356.33	301.83	356.12	303.40	357.03	303.05	355.83	303.84
11-Sep	355.82	301.88	355.69	302.16	358.53	302.21	356.21	303.11	356.06	304.37	356.86	303.03	355.87	304.06
12-Sep	356.04	301.50	355.81	302.08	358.54	302.06	356.18	302.48	356.00	301.84	356.80	303.12	355.80	303.83
13-Sep	355.89	301.83	355.82	301.98	358.57	302.43	356.13	303.79	356.01	302.78	356.86	302.33	355.90	303.58
14-Sep	355.84	301.81	355.98	301.80	358.75	302.62	355.85	303.74	355.98	303.05	356.59	302.30	355.85	303.37
15-Sep	355.85	302.08	356.00	302.20	358.94	302.90	355.84	302.48	355.92	302.50	356.46	303.17	355.81	303.63
16-Sep	355.86	302.28	356.04	302.10	359.20	302.10	355.92	304.18	355.92	302.19	356.35	302.58	355.83	303.81
17-Sep	355.75	302.41	355.72	302.01	359.34	301.84	356.00	306.10	355.87	302.62	356.35	302.40	356.00	303.48
18-Sep	355.82	301.63	355.62	301.84	359.18	301.84	356.00	306.94	355.84	302.61	356.18	302.35	356.06	303.18
19-Sep	356.05	301.53	355.62	302.00	359.30	302.48	355.80	307.10	355.84	302.85	356.17	302.01	356.11	302.75
20-Sep	356.02	301.87	355.50	301.85	359.34	302.87	355.52	307.82	355.95	302.29	356.18	302.13	356.07	303.25
21-Sep	355.80	301.86	355.40	301.80	359.40	302.76	355.35	307.70	356.02	302.78	356.19	301.75	356.13	303.56
22-Sep	355.86	302.05	355.32	302.30	359.42	302.40	355.29	308.24	355.89	302.19	355.92	301.94	356.25	303.45
23-Sep	355.78	302.04	355.38	302.40	359.50	302.84	355.09	305.83	355.93	302.19	355.85	301.19	356.53	303.30
24-Sep	355.73	302.01	355.38	302.40	359.39	302.76	355.38	305.72	355.93	301.83	355.78	301.67	356.87	302.19
25-Sep	355.70	302.10	355.40	301.52	359.26	302.96	355.42	308.21	355.85	302.26	355.85	301.94	357.15	303.88
26-Sep	355.80	301.47	355.25	302.08	359.15	302.80	355.29	307.44	355.70	302.53	355.86	302.66	356.97	305.36
27-Sep	355.74	301.01	355.16	301.82	359.04	302.74	355.35	308.18	355.67	302.30	356.06	301.90	356.54	305.52
28-Sep	355.67	300.47	355.09	301.66	358.91	302.74	355.30	307.87	355.61	302.26	356.00	301.90	356.86	304.87
29-Sep	355.53	300.84	354.90	302.21	358.88	302.88	355.24	308.08	355.40	301.80	355.78	301.96	355.86	303.82
30-Sep	355.47	300.84	354.98	301.86	358.84	302.50	355.19	308.08	355.31	301.47	355.73	302.34	355.86	303.22
1-Oct	355.42	301.07	355.14	301.86	358.73	302.19	355.05	311.02	355.29	301.40	355.77	302.58	355.64	302.06
2-Oct	355.55	301.83	354.83	301.38	358.52	302.27	355.07	317.68	355.17	301.54	355.77	302.90	355.57	301.11
3-Oct	355.66	302.36	355.20	301.40	358.45	302.32	354.90	318.80	355.64	301.80	355.87	301.96	355.45	301.52
4-Oct	355.36	304.68	355.13	301.71	358.41	302.49	355.66	315.50	355.64	302.23	355.92	301.89	355.10	303.32
5-Oct	355.41	306.61	354.95	302.24	358.51	302.51	355.72	318.42	355.77	302.44	355.71	302.38	355.00	302.88

Exhibit 3C-2
3 of 4

Kentucky Lock Pool Data

HW Max = 363.95   HW Min = 345.28   HW Mean = 356.33   HW Std D = 2.27
TW Max = 340.39   TW Min = 298.16   TW Mean = 308.52   TW Std D = 8.80

	1986		1987		1988		1989		1990		1991		1992	
Day	Headwater	Tailwater	Headwater	Tailwater	Headwater	Tailwater	Headwater	Tailwater	Headwater	Tailwater	Headwater	Tailwater	Headwater	Tailwater
6-Oct	355.39	306.84	355.01	302.41	358.60	302.40	355.53	316.53	355.75	302.84	355.58	301.87	355.06	301.96
7-Oct	355.29	310.41	354.96	302.07	358.08	302.60	355.25	316.27	355.65	303.12	355.45	302.13	355.27	302.17
8-Oct	355.08	311.80	355.13	301.85	358.61	302.68	354.90	315.25	355.70	302.80	355.39	302.62	355.28	302.22
9-Oct	355.08	311.83	355.07	301.64	358.39	302.80	354.61	312.84	355.55	302.83	355.34	301.83	355.34	302.82
10-Oct	355.23	312.01	354.78	302.48	358.27	302.51	354.38	310.17	355.57	301.28	355.34	302.04	355.18	303.32
11-Oct	355.46	311.76	354.83	301.85	358.02	302.60	354.58	306.73	355.52	300.86	355.31	302.04	355.18	301.87
12-Oct	355.24	311.55	354.94	301.97	357.98	302.46	354.55	306.08	355.38	300.73	355.17	301.32	355.14	301.64
13-Oct	355.30	311.02	354.89	302.13	357.89	302.45	354.64	303.00	355.34	299.75	355.10	301.22	355.36	301.80
14-Oct	355.43	310.40	355.04	301.38	357.92	302.87	354.56	302.83	355.14	300.28	355.08	301.14	355.37	302.14
15-Oct	355.40	308.64	355.03	301.87	357.79	302.88	354.52	302.60	355.12	302.50	355.04	301.28	355.37	302.07
16-Oct	355.44	306.10	355.13	301.40	357.54	302.87	354.55	304.06	355.15	304.10	355.16	301.89	355.29	302.37
17-Oct	355.44	306.37	355.02	301.58	357.52	302.55	354.47	304.80	355.28	306.31	355.28	301.17	355.30	303.73
18-Oct	355.37	306.10	354.89	301.59	357.14	301.98	354.74	306.20	355.20	306.23	355.35	301.14	355.12	302.51
19-Oct	355.25	307.28	354.84	301.70	357.15	302.23	355.28	306.16	355.30	304.90	355.36	301.60	355.13	302.84
20-Oct	355.15	306.85	354.72	301.12	357.20	301.98	355.48	307.98	355.44	303.52	355.31	301.54	355.21	303.09
21-Oct	355.20	305.83	354.81	301.41	357.23	301.80	355.33	308.84	355.28	303.13	355.27	301.58	355.30	302.98
22-Oct	355.28	305.43	355.02	301.34	357.25	302.45	355.14	311.43	355.27	303.60	355.30	302.01	355.31	302.87
23-Oct	355.42	304.58	355.10	301.54	357.04	302.42	354.87	311.89	355.36	304.00	355.34	301.86	355.35	303.12
24-Oct	355.72	303.85	355.00	301.84	357.08	302.43	354.77	312.50	354.75	306.18	355.40	302.09	355.34	301.89
25-Oct	355.72	304.80	355.02	301.72	357.02	302.39	354.59	312.21	355.01	305.73	355.37	302.08	355.25	303.04
26-Oct	355.63	304.88	354.94	302.26	357.13	302.43	354.57	310.41	355.06	305.29	355.44	301.85	355.12	302.82
27-Oct	355.40	305.07	355.04	302.12	357.31	302.51	354.80	306.70	355.00	305.10	355.58	302.38	355.03	302.87
28-Oct	355.42	303.30	355.17	301.88	357.18	302.54	354.62	304.85	354.94	306.06	355.80	302.56	355.27	302.77
29-Oct	355.26	303.88	355.28	301.74	357.20	302.00	354.42	303.60	354.88	306.16	355.91	302.44	355.50	302.87
30-Oct	355.35	304.18	355.30	301.80	357.08	301.92	354.48	302.24	354.83	304.80	355.85	302.50	355.57	302.56
31-Oct	355.41	303.81	355.30	301.70	357.14	301.66	354.40	302.00	354.88	302.11	356.16	302.58	355.88	302.35
1-Nov	355.53	303.33	355.28	302.38	357.18	301.56	354.40	303.62	354.85	298.80	356.09	302.50	355.47	303.64
2-Nov	355.51	303.23	355.18	302.20	357.50	302.10	354.24	303.70	354.87	300.80	355.92	302.50	355.25	303.10
3-Nov	355.42	303.28	355.20	302.10	357.54	301.78	354.41	303.98	354.87	301.55	355.80	303.50	354.91	303.64
4-Nov	355.44	303.11	355.07	302.40	357.50	302.13	354.57	302.26	354.86	302.11	355.81	302.37	355.14	303.69
5-Nov	355.47	302.63	355.10	302.40	357.40	302.40	354.55	301.76	354.64	302.58	355.73	301.80	355.25	303.60
6-Nov	355.54	302.68	355.25	302.18	357.58	302.03	354.53	303.12	354.68	302.80	355.84	301.82	355.30	303.51
7-Nov	355.73	302.76	355.27	301.64	357.92	302.13	354.82	303.80	354.80	302.55	355.37	302.84	355.35	304.11
8-Nov	355.95	304.34	355.07	302.47	357.90	302.90	354.44	303.73	354.78	302.26	355.55	302.10	355.31	304.30
9-Nov	355.83	309.15	354.87	302.13	358.18	303.65	355.00	304.53	354.64	303.33	355.87	301.10	355.31	303.32
10-Nov	356.08	311.94	355.04	302.88	357.83	303.48	355.20	303.40	355.28	303.11	355.59	301.60	355.30	303.23
11-Nov	356.41	314.08	355.09	302.87	357.97	303.36	355.43	304.18	355.53	303.02	355.55	302.00	355.48	303.62
12-Nov	355.85	315.41	355.18	301.81	357.80	303.80	355.58	304.56	355.44	301.44	355.54	302.12	355.14	304.61
13-Nov	356.04	316.40	355.27	302.08	357.69	303.66	355.56	305.21	355.41	302.56	355.57	302.63	355.04	304.76
14-Nov	355.89	316.06	355.28	302.07	357.88	303.34	355.50	305.28	355.38	303.03	355.52	302.06	354.89	305.80
15-Nov	355.62	315.37	355.41	302.04	358.02	302.84	354.94	306.80	355.30	302.62	355.46	302.31	354.94	306.19
16-Nov	355.29	314.17	355.48	302.17	357.23	303.16	354.86	310.68	354.83	302.32	355.35	301.54	355.00	307.80
17-Nov	354.85	311.87	355.04	301.84	357.19	303.14	355.08	312.17	355.00	301.73	355.08	303.17	354.90	308.80
18-Nov	354.57	308.04	354.92	302.56	357.49	303.16	355.02	312.90	354.78	301.18	355.08	302.08	354.87	308.62
19-Nov	354.92	305.98	354.98	302.37	358.20	303.23	354.94	313.82	354.55	302.60	355.09	301.89	354.76	308.27
20-Nov	354.58	304.63	354.78	302.34	358.65	310.50	354.51	314.62	354.62	302.89	355.11	301.92	354.69	308.30
21-Nov	354.87	303.86	355.16	301.35	359.00	314.00	354.36	315.21	354.77	302.88	355.21	303.06	354.28	308.02
22-Nov	355.36	302.32	355.37	300.92	359.14	314.20	354.02	314.33	354.83	303.12	355.32	303.18	354.14	307.85
23-Nov	354.74	304.80	355.14	302.01	358.80	314.85	354.51	313.48	354.84	303.18	355.02	301.97	354.16	310.05
24-Nov	354.50	307.76	355.32	302.18	358.34	316.58	354.72	312.60	354.57	302.59	354.69	302.30	354.34	313.12
25-Nov	354.78	306.12	355.11	302.36	358.03	314.42	354.48	311.28	354.37	300.81	354.62	303.23	354.37	314.84
26-Nov	354.87	313.86	355.20	301.95	357.51	318.03	354.30	310.40	354.40	301.22	354.75	302.80	354.55	315.27
27-Nov	355.02	317.15	355.17	302.08	357.14	314.90	354.18	309.30	354.81	300.31	354.64	300.50	355.17	314.86
28-Nov	355.10	320.70	355.44	302.37	358.68	313.08	353.96	308.45	354.46	300.87	354.87	300.60	355.73	314.81
29-Nov	354.84	322.38	355.20	302.30	358.35	310.78	354.24	308.30	354.62	301.22	354.86	301.58	356.17	314.79
30-Nov	354.48	322.98	355.01	301.97	358.07	308.21	354.20	308.40	354.81	301.28	354.13	303.70	356.17	315.69
1-Dec	354.76	320.60	355.19	302.12	358.03	305.67	354.33	307.20	354.81	301.75	354.37	309.10	355.87	318.23
2-Dec	354.80	320.44	355.32	302.02	358.18	304.38	353.70	307.17	354.90	302.14	354.84	316.93	355.37	315.32
3-Dec	354.87	320.40	354.88	302.93	358.12	303.15	354.32	306.97	354.57	304.72	355.34	323.30	355.08	314.15
4-Dec	354.88	319.03	355.22	302.60	355.80	302.92	354.29	305.38	355.03	307.30	356.36	327.10	354.43	310.60
5-Dec	355.06	318.02	355.22	302.50	355.71	302.80	354.24	304.85	355.35	309.56	357.21	329.50	354.67	308.16
6-Dec	355.32	317.72	355.16	302.16	355.38	302.43	353.86	304.14	355.12	310.20	357.12	330.90	354.37	306.37
7-Dec	355.57	317.88	355.18	301.90	355.03	304.01	354.01	302.12	355.38	310.86	357.26	329.77	354.22	305.37
8-Dec	355.41	318.89	355.28	301.50	355.05	304.26	354.08	303.30	355.18	311.14	357.45	329.48	354.46	304.93
9-Dec	355.80	319.58	355.00	301.84	355.39	304.06	354.45	303.30	354.79	310.29	357.72	328.58	354.81	304.37
10-Dec	356.73	321.44	355.02	301.84	355.48	302.32	354.50	303.25	354.28	310.06	357.92	329.11	354.61	304.17
11-Dec	357.86	321.10	354.93	301.55	355.40	303.10	354.15	304.90	354.19	307.63	357.86	326.62	354.73	303.81
12-Dec	358.18	320.89	354.92	301.62	355.40	304.33	354.20	305.00	354.34	306.10	357.66	323.80	354.73	303.82
13-Dec	358.48	321.12	354.84	301.70	355.44	303.06	354.10	304.80	354.55	303.12	357.23	323.66	354.44	304.40
14-Dec	356.45	321.25	355.50	301.20	355.11	302.92	354.17	303.15	355.01	301.89	356.75	323.06	354.59	303.37
15-Dec	357.93	322.77	354.87	301.92	354.82	302.80	354.13	302.91	354.82	301.05	356.26	322.87	354.37	304.45
16-Dec	357.25	323.34	354.87	301.86	355.06	302.90	354.34	302.96	354.89	301.35	355.89	322.60	354.26	304.72
17-Dec	356.56	322.90	355.06	301.60	355.36	301.56	354.35	302.80	355.47	302.85	355.07	322.00	354.10	305.87
18-Dec	355.97	321.85	355.26	301.58	355.58	301.48	354.33	303.60	356.38	311.14	354.47	320.56	354.25	308.66
19-Dec	355.57	317.82	355.78	301.85	355.86	301.86	354.18	303.71	356.57	318.54	354.33	317.75	354.35	309.88
20-Dec	354.98	315.17	355.24	302.32	355.50	301.83	354.23	303.76	356.44	321.39	354.32	315.22	354.32	311.83
21-Dec	354.35	313.55	355.35	302.19	355.65	302.47	353.84	303.58	356.58	324.76	354.43	312.28	354.10	314.90
22-Dec	353.92	311.10	355.41	301.80	355.98	302.93	354.11	303.30	356.89	330.50	354.36	311.17	354.39	316.50
23-Dec	353.95	308.59	355.57	302.44	356.32	304.91	354.28	302.97	355.14	334.47	353.97	307.50	354.37	317.34
24-Dec	354.22	309.33	355.81	300.92	357.43	303.67	354.38	303.03	355.08	335.01	354.40	307.46	355.67	317.48
25-Dec	354.51	308.31	357.01	311.53	358.29	307.20	354.46	303.16	356.32	337.04	354.48	307.66	356.39	317.27
26-Dec	354.81	308.62	357.68	320.25	358.73	311.23	354.53	302.91	356.86	336.73	354.52	308.27	356.86	318.05
27-Dec	355.00	310.58	357.65	322.44	357.85	316.74	354.88	302.74	356.50	337.04	354.55	308.07	356.75	319.41
28-Dec	355.08	311.62	356.96	323.57	357.83	319.19	354.69	302.75	357.21	338.28	354.56	307.91	356.41	319.27
29-Dec	355.08	312.84	357.01	319.18	357.52	319.90	354.52	302.66	357.83	339.20	354.38	307.32	356.14	319.10
30-Dec	354.95	313.43	357.50	316.85	357.21	318.71	354.43	302.66	358.44	339.80	354.40	309.66	355.94	319.22
31-Dec	354.81	313.35	356.99	317.02	356.72	318.06	354.45	303.00	359.02	340.39	354.52	309.21	355.41	317.00
Max.	360.02	323.34	359.60	327.61	360.11	321.90	361.47	336.63	363.51	340.39	358.84	330.64	359.94	319.41
Min.	353.73	299.24	353.86	299.96	354.15	299.60	353.70	300.46	354.17	299.75	353.84	299.96	353.61	299.66
Average	356.47	306.34	356.38	304.87	357.60	304.64	356.77	311.99	356.85	310.60	356.89	311.46	356.48	306.99
Std. D	1.52	5.46	1.64	4.03	1.42	3.69	1.67	7.46	1.84	9.40	1.50	8.61	1.60	3.89

Exhibit 3C-2
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To date Kentucky Lake has not been filled to the design pool of elevation 375.0. From guide curves for the lake this elevation equates to just greater than a 500 year frequency flood for the Tennessee River which we have not had. When you combine this pool with the design tailwater to produce load case II the frequency of this event is greater than a 1000 year flood. This load case was not analyzed in the reliability analysis due to the low probability of it happening and the consequences being essentially the same as the normal pool unsatisfactory performance. It should be noted however that for dam safety concerns the lake and lock must be capable of withstanding this flood event at any time.

The original design of the miter gates (1939) precedes most of our current guidance on design of hydraulic steel structures. The original design of the ASTM A7 steel (33,000 psi yield) used an allowable working stress of 18,000 psi which is higher than our current basic allowable stress of 16,500 psi. Also a much lower effective width of skinplate was allowed as part of the composite girder section properties than is now used. To investigate the effects of these differences the governing load case II was analyzed in combination with corrosion projections, current allowable stress guidelines, and full skin plates to center of girder spacing effective with composite girder. The result of this analysis is that in approximately the year 2004 the lower girders of the lower miter gate are over allowable design stress of 16,500 psi. This overstress will become increasingly higher as corrosion continues. This over stress is a Dam Safety concern for the project.

C2. Load Cycles and Fatigue Investigation. Early in the reliability analysis we had a concern for fatigue effects on the miter gates due to heavy traffic at the project. Kentucky Lock is somewhat different than many Corps of Engineers projects due to the influence of hydropower operations and flood control at the site. For these reasons Tennessee Valley Authority tracks water discharges thru the lock in terms of the number of times the lock chamber is emptied into tailwater regardless of how may tows passed thru the lock. Most Corps projects only track numbers of tows that pass thru the locks. It just happens that the number of times the lock chamber is filled and emptied is also the number of load cycles the structure is subjected to for fatigue effects. Tennessee Valley Authority was able to find records back to 1947 for lock chamber emptying cycles, which is only five years after the lock was opened to traffic. Traffic was less than 1000 cycles per year during these early years and was neglected for fatigue analysis. Lockage load cycles and projections are shown on Exhibit 3C-3. In order to project fatigue cycles into the future we needed to project lock filling/emptying cycles for the next 50 years. The ORD Navigation Center fit our historical cycles to the historical traffic and then projected the load cycles into the future

Kentucky Lock Cycles

Yearly and Total Times Emptied/Filled
(Since 1947)

Year	Actual * Emptied Cycles/Yr	Actual Cumulative Total
1947	839	839
1948	1020	1859
1949	1171	3030
1950	1306	4336
1951	1609	5945
1952	2210	8155
1953	1847	10002
1954	1865	11867
1955	1892	13759
1956	2021	15780
1957	2408	18188
1958	2452	20640
1959	2342	22982
1960	2449	25431
1961	2311	27742
1962	2481	30223
1963	2384	32607
1964	2611	35218
1965	3066	38284
1966	3534	41818
1967	3605	45423
1968	3614	49037
1969	4141	53178
1970	4212	57390
1971	4556	61946
1972	4463	66409
1973	4681	71090
1974	4607	75697
1975	4783	80480
1976	4077	84557
1977	4291	88848
1978	4538	93386
1979	4890	98276
1980	4876	103152
1981	4237	107389
1982	3942	111331
1983	4572	115903
1984	4895	120798
1985	4670	125468
1986	3760	129228
1987	5255	134483
1988	5375	139858
1989	5186	145044
1990	5476	150520
1991	5061	155581
1992	5326	160907

Year	Projected ** Emptied Cycles/Yr	Projected Cumulative Total
1993	5607	166514
1994	5653	172167
1995	5700	177867
1996	5747	183614
1997	5793	189407
1998	5840	195247
1999	5887	201134
2000	5933	207067
2001	5947	213014
2002	5960	218974
2003	5974	224948
2004	5987	230935
2005	6001	236936
2006	6014	242950
2007	6027	248977
2008	6041	255018
2009	6054	261072
2010	6068	267140
2011	6070	273210
2012	6073	279283
2013	6075	285358
2014	6078	291436
2015	6080	297516
2016	6083	303599
2017	6085	309684
2018	6088	315772
2019	6090	321862
2020	6093	327955
2021	6100	334055
2022	6108	340163
2023	6115	346278
2024	6123	352401
2025	6131	358532
2026	6138	364670
2027	6146	370816
2028	6154	376970
2029	6161	383131
2030	6169	389300
2031	6176	395476
2032	6182	401658
2033	6189	407847

Year	Projected ** Emptied Cycles/Yr	Projected Cumulative Total
2034	6196	414043
2035	6202	420245
2036	6209	426454
2037	6215	432669
2038	6222	438891
2039	6229	445120
2040	6235	451355
2041	6252	457607
2042	6270	463877
2043	6287	470164
2044	6304	476468
2045	6321	482789
2046	6338	489127
2047	6356	495483
2048	6373	501856
2049	6390	508246
2050	6407	514653

* Courtesy of TVA Water Resources

** Projections by ORD Navigation Center
Based on Traffic Projections

Exhibit 3C-3

using traffic projections for the site. From this data we find Kentucky Lock has the highest load cycles of any lock on the Cumberland or Tennessee Rivers with approximately 161,000 cycles thru 1992. With traffic projections of 5600 lock cycles per year, increasing with time, the lock is expected to be at 250,000 cycles in 2007 and 500,000 load cycles in 2047.

Nashville began investigating the structural components of the gates using fatigue methods developed for Mississippi River locks by Waterways Experiment Station. This was state-of-the-art reliability methods at the time, still under refinement, and was recommended by ORD and OCE. Some variations to the developed methods had to be made due to differences in gate configurations. The locks on the Mississippi River have vertically framed miter gates typically subjected to relatively low head with little flood control pool allowance. Kentucky Lock being slightly newer than these other locks with significantly higher head and a substantial flood pool has more typical horizontally framed miter gates. A reliability analysis had never been performed on a high head, riveted steel, horizontally framed gate. For fatigue to be considered a structural component must be subjected to cycles of fluctuating tensile stress in order for a fatigue crack to form and propagate thru the member to failure. The stress fluctuation range can extend into compression stress zone to produce a higher range of fluctuation but the concern is tensile stress.

What was found is that horizontally framed gates, particularly double skin-plated with no diagonals, have very few high tension stress components. Some of the load cases during swinging the leaf thru water and supporting of dead weight do produce tensile stresses but they do not amount to high magnitudes on girders designed for compression of high heads. At this point in the investigation the fatigue analysis methods were abandoned and analysis changed to more conventional Factor of Safety, yield stress, based reliability analysis, lessons learned. We do believe some components of the gate, particularly hanging and swinging top anchorage systems, may eventually be effected by fatigue but we did not investigate this in any detail.

C3. Seismic Considerations. The original design of the gate leaves (1939) included seismic considerations. Namely, the Westergaard equation was utilized to determine the seismic impact of the hydrostatic force, "water hammer", and the inertial forces due to the mass of the leaves were also considered. A seismic co-efficient of 0.1 (10 percent) was used for the determination of the static equivalent lateral force. The earthquake lateral force increased the total load on the most critical horizontal girder by approximately 15%, well within the 25% stress increase allowed then for earthquake load cases. The allowable steel stress was taken as 18.0 KSI. A Seismic Zone Map is shown on Exhibit 3C-4.

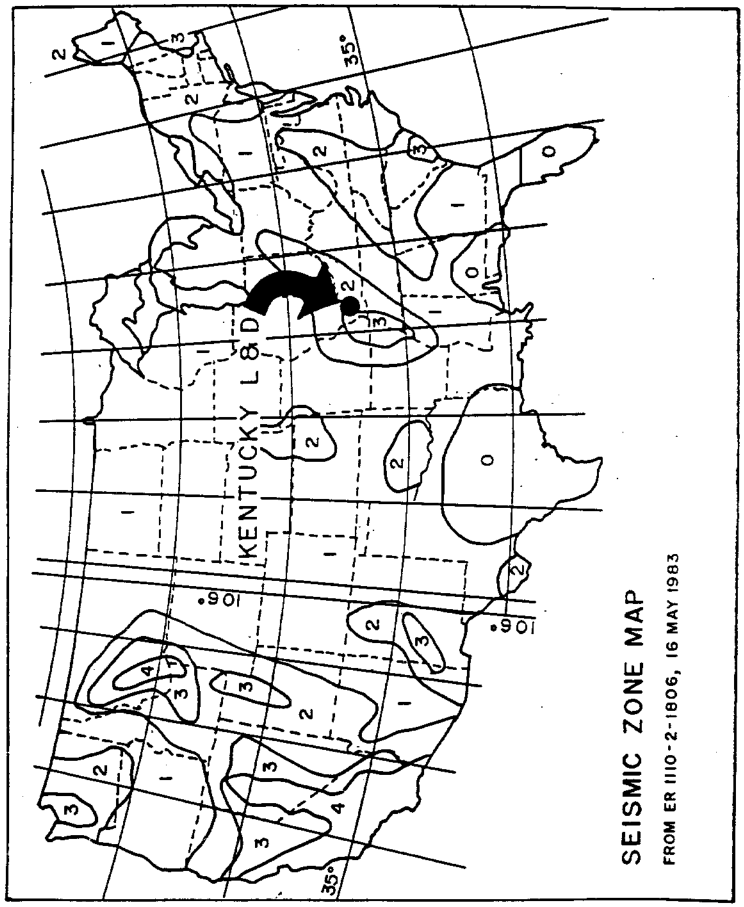

SEISMIC ZONE MAP
FROM ER 1110-2-1806, 16 MAY 1983
KENTUCKY L&D
35°
106°

Exhibit 3C-4

The current CORPS Engineering Manual (EM1110-2-2105) for the Design of Hydraulic Steel Structures (HHS) still utilizes the same Westergaard equation for the evaluation of the seismic effects of the hydrostatic force. Additionally, the effects of the inertial forces due to the mass of the leaves (being small compared to the water hammer) may be ignored, and the allowable stress increase is 33%. On the other hand, the allowable stress has been reduced to 0.83 times the AISC allowable, which for A7 material (Fy=33.0 KSI) would result in an allowable stress of 16.4 KSI. The net effects, of the differences in the design parameters discussed so far, result in approximately the same stress level (compared to allowable) for the 1939 and current design procedures.

Kentucky lock lies on the dividing line between seismic zone 2 and 3. If seismic zone 3 is selected then the seismic coefficient is 0.15 which will result in 50% higher earthquake forces than the original design. This force results in a slight overstress based on the static equivalent force method of the referenced EM. It should be noted, however, that due to the proximity of the lock to the New Madrid fault, a site specific geotechnical and seismological assessment would need to be performed so that the actual earthquake effects could be evaluated.

C4. Event Tree. The event tree investigated for Kentucky Lock miter gates contains several load condition branches with modes of performance for each major branch followed by consequences of that branch occurring. For a given branch to be analyzed economically the branch must be given both a probability of occurring and an economic consequence of the occurrence. In order to come up with the consequences of a branch the engineering analysis must be detailed enough to figure out what component of the gate system has the highest probability of performing unsatisfactorily and what will happen when it does.

After discussions with ORD and OCE about the many different loading conditions and performance modes that could take place it was decided due to time, cost, and probable outcome to not analyze several branches of the event tree. The following discussion addresses each branch of the event tree and why it was analyzed or not analyzed.

- Normal Pool Conditions. The normal pool branch of the event tree represents the condition of normal historical pool elevations at the project without any unusual loads, accidents or natural disasters occurring. This is the normal day-to-day operating condition of the lock. This branch of events was analyzed for continued operation of the project as it has historically been maintained.

The normal pool branch splits into three primary modes of performance. The first is the satisfactory performance of the system resulting in no unscheduled outage of the system. This branch assumes normal spot painting, contact block adjustments, strut adjustments, seals, inspections, etc. continue as has been done in the past predominantly at five year frequency major maintenance periods.

The main member unsatisfactory performance assumes a mode of performance has occurred whereby a major horizontal girder of the gate deteriorates to the point that it unexpectedly causes lock outage and an immediate repair to return the lock back to operation. Although this scenario could take many forms from minor maintenance problems to total collapse of the gate leaf we believe the most probable scenario is that the lock operator notices a problem with gate operation, alignment, or sealing and further investigation reveals a need for immediate repair to prevent further damage to the structure. A scenario of this happening will be described later.

The secondary member unsatisfactory performance assumes that a secondary member in the gate does not perform its intended purpose. This branch was not analyzed because it was felt the secondary members such as intercostals, stiffeners, seals contacts, etc. problems could be repaired without a major outage of the structure or would be found and repaired during major maintenance periods.

- Probable Maximum Flood Pools. The PMF pools branch of the event tree represents the occurrence of one of the flood pools that has not been put on the structure historically but that the structure was designed to hold for original load cases II and IV. Normally dam safety checks of a Corps structure would insure its capability of withstanding PMF pools and performing satisfactorily or the structure is brought up to current criteria to hold these loads. This branch was not analyzed due to the difficulties assigning probabilities of this flood event occurring. Hydraulics engineers indicated the probability of this load occurring was less than once every 1000 years. It was also felt that the mode and consequences of unsatisfactory performance for this load condition was similar to the normal load events.

- Impact Damage. The Impact damage branch represents the scenario of a tow boat bumping the gate. Tows bump miter gates often but normally only dent the fenders. Records are not well kept of impact damage to gates particularly when they only dent a fender. Other districts have more problem with this than Nashville. Possibly this can be partially explained by our high lift locks which have a tall concrete sill under the upper gate which eliminates the possibility of impacting the gate while locking a tow upstream. Also our high lift lock gates tend to be more substantial than other low lift gates which would make it more resistive to damage. We know the probability of this event branch occurring is not zero but a probability of a tow rendering a lock gate inoperable could not be estimated and the branch was therefore not analyzed for reliability. The consequences of impact damage to a gate could range from routine fender dents which must be replaced every few years to rendering a miter gate leaf totally inoperable depending on where and how hard the impact. The consequences of rendering one of our large high lift gates inoperable would be substantial because spare gate leaves are not available as is customary for Mississippi and Ohio river locks. It is possible a severe impact could cause unrepairable damage to a gate leaf and cause the lock to be out of service until a new leaf is fabricated and installed many months after the accident.

- Earthquake Zone II or III. The Earthquake loading branch represents the case of a seismic load affecting performance of the miter gate. Kentucky Lock is located on the edge of seismic zone III with the original zone II design loading probably under current criteria. This load condition was not analyzed for the reliability analysis due to difficulties assigning a probability of a particular magnitude earthquake occurring and assessing the most probable damage to the leaves. This analysis could be a significant study in itself and probably not worth the effort when probabilities are combined with economics. The worst consequence of a major earthquake load event would be the gates becoming unmitered with significant water head on it, or for the top anchorage of the gate leaf to break. Either occurrence would probably drop the gate leaf in the lock chamber and destroy the leaf. It is possible however that an earthquake loading would only cause minor damage to primary or secondary member of the gate due to increased heads of "water hammer".

C5. Consequences of Unsatisfactory Performance. Unsatisfactory performance of the miter gate could occur in many modes. Some of these are a fracture or warping of the main girders, anchorage problems at the top hinge, pintle problems, strut arm failure, or bearing area failure. Although some of these unsatisfactory performance modes could result in catastrophic collapse of the gate and an extended outage of the lock, we do not believe these are the most probable modes of performance. After investigating inspection reports and discussions with operating personnel the gate pintles, bearing areas and anchorage appear to be in relatively good condition. The most probable mode of unsatisfactory performance of the gate system, that would cause extended outage, would be a problem with main girders of the gate. This would be a significant problem due to the size, weight, and riveted construction of the gate leaf. No spare gates exist for Kentucky Lock and trying to replace a damaged girder in the gate would involve dismantling and rebuilding the leaf in place. This process would take many weeks of lock outage to accomplish and would be roughly equivalent to installing a new gate leaf. For these reasons we believe the most probable unsatisfactory performance consequence to be as follows:

1. The lock operator notices problems with a main girder in the gate due to operation problems, misalignment of the leaf or leakage at the contact blocks.

2. The lock is taken out of service to investigate the problem. Supervisors, maintenance personnel and area repair station are notified of a problem.

3. We assume for analysis that a main girder is found to have fractured or buckled components due to deterioration. The most probable location of this problem would be the lower girders of the lower gate at or below tailwater where stresses are the highest. When this is discovered the repair crews would begin mobilizing to the site.

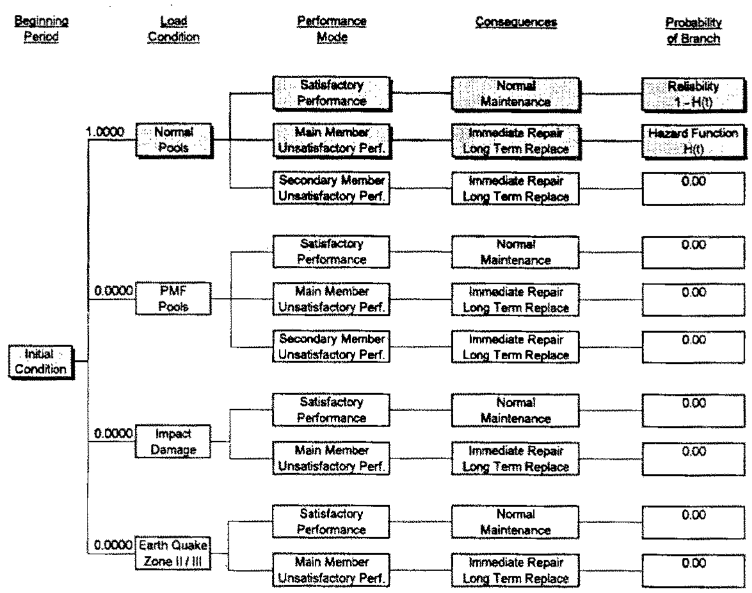
4. If the problem area is below tailwater the maintenance closure would have to be set and the lock chamber dewatered. This process would take less than a week before repairs are started.

5. Assuming that the girder is badly enough damaged that it needs major repair, due to lack of a spare gate leaf, the decision would likely be made to patch the girder however required to get it back into service pending further study and analysis. Engineering and Operations would come up with a temporary repair that would hold until long term resolution of the problem could be developed. This repair and rewatering of the lock to return it to service could easily exceed an additional week of outage.

6. After getting the lock back into operation an analysis of the problem solution would be performed. In the event that the damaged girder needs replacement, it is likely that other girders in the gate will have similar deterioration, and a study would be done to look into replacing the gate leaf. This could result in a reliability study due to the cost of leaf replacement exceeding rehabilitation spending limits. Then new gate leaves would be designed to eliminate maintenance problems, constructed and installed one to two years after the original outage.

The costs of this repair and replacement would be the initial two week outage and repair, costing approximately $250,000 in-house plus industry costs, plus the eventual gate replacement outage. The Event Tree showing possible loads, performance modes and consequences is shown on Exhibit 3C-5. This Event tree will be discussed in more detail later.

Kentucky Lock Miter Gates
Event Tree



- Primary Event Tree Branch

H (t) - Hazard function representing probability of unsatisfactory performance during any given year. Time "t" is in years since 1977 (ie, for 1993, t=16).
H (t) = .00285 * (t / 1207)^2.437 H(1993) = 7.6 x 10^-8

Exhibit 3C-5

D. Corrosion Investigation

D1. Field Investigation. To determine the extent of corrosion in the miter gates an extensive field inspection/measurement program was done. We knew from past reports that the gates had been spot sand blasted and painted several times resulting in questionable protective coating. The upper girders had experienced problems with bird droppings and standing rainwater deteriorating the paint and steel. The lower girders stay continuously wet and cannot be properly maintained. We attempted to get consultants to perform the field measurements, but problems with personnel safety in the confined enclosed gates and removal of bitumastic coatings resulted in them being hesitant to take the work on. Nashville District Waterways Maintenance personnel had to perform the field investigation, utilizing mobile cranes, ventilation equipment, special lighting, air tools and special ultrasonic measurement equipment. Hazardous tank entry procedures had to be used with safety inspectors outside the gate at all times. The upper gate fills with water and totally empties each time the lock chamber is filled and emptied. The lower gate fills with water only to tailwater elevation. This work was carried out with the lock in continuous operation so we had to be cautious that all personnel were out of the upper gate before lock operators could fill the chamber. This resulted in only being able to work in the upper gate while a tow was making a cut at tailwater elevation. Overall the Waterways Maintenance personnel did an excellent job and probably were better equipped for the work than a consultant would have been.

The miter gates are constructed of horizontal riveted plate girders 7.04 feet wide on varying spacing of 3.67 to 4.50 feet. Both sides of the gate are skin plated with small vents in the downstream side. The girders have full width vertical diaphragm plates at a spacing of 6.46 feet which effectively breaks the gate up into a series of small cubicles 6.5 ft. by 7.0 ft by approximately 4 feet high. Access from one cubicle to another is accomplished by crawling thru a small manhole 15 inches wide by 21 inches tall. Each girder has 10 of these cubicles across its length. The upper gate has 11 girders of five different configurations. The lower gate has 23 girders of eight different configurations. Each girder changes cross section three times from centerline to bearing area, with the girder symmetrical about centerline. In an effort to keep the total measurements required to a reasonable number we decided to take measurements of only the major components of the girder(upstream skin plate, 2 web, 2 connection angles) of one or two representative girders of each configuration. To get enough measurements of each girder configuration to statistically be meaningful each of the 10 cubicles was checked resulting in 50 measurements on each girder. Numbering from the top girder, girders 1, 2, 4, 6, 8, 10 and 11 (7 total) were checked on the upper gate and girders 1, 2, 4, 6, 9, 12, 15, 17, and 19 (9 total) were checked on the lower gate.

Kentucky Lock - Miter Gates

Girder No. : 6   Initials : DDS   Date : 6/24/93

[ ] Upper Gate
[X] Lower Gate

[X] Land Leaf
[ ] River Leaf

Notes : (B) U/S ANGLE 1 LEG RUST VERY BAD.

Location	Thrust Plate			Web		Adjacent U/S Web		Adjacent D/S Web	
	Nominal	Reading	Reading	Nominal	Reading	Nominal	Reading	Nominal	Reading
A Quoin	0.75	0.792	0.792	0.375	0.383	0.375	0.368 0.375	0.375	0.403 0.374

Location	Skin Plt. (1)		U/S Angle (2)		U/S Web (3)		D/S Web (4)		D/S Angle (5)	
	Nominal	Reading	Nominal	Reading	Nominal	Reading	Nominal	Reading	Nominal	Reading
B	0.438	0.43	0.375	0.263	0.375	0.358	0.375	0.365	0.375	0.359
C	0.438	0.437	0.375	0.35 0.364	0.375	0.348	0.375	0.349	0.375	0.341
D	0.438	0.428	0.375	0.363	0.375	0.353	0.375	0.34	0.375	0.352
E	0.438	0.433	0.375	0.356	0.375	0.356	0.375	0.36	0.375	0.34
F	0.438	0.432	0.375	0.368	0.375	0.379	0.375	0.326	0.375	0.357
G	0.438	0.442	0.375	0.364	0.375	0.32	0.375	0.327	0.375	0.378
H	0.438	0.429	0.375	0.379	0.375	0.358	0.375	0.361	0.375	0.388
I	0.438	0.425	0.375	0.369	0.375	0.36	0.375	0.36	0.375	0.314

Location	Thrust Plate			Web		Adjacent U/S Web		Adjacent D/S Web	
	Nominal	Reading	Reading	Nominal	Reading	Nominal	Reading	Nominal	Reading
J Miter	0.75	0.793	0.826	0.375	0.382	0.375	0.379 0.319	0.375	0.378 0.331

Exhibit 3D-1

Girders 20 to 23 were not accessible on the lower gate due to tailwater in the gate. Access to these would have required a major unwatering of the lock chamber.

To make the thickness readings a digital ultrasonic meter was utilized with a readout in .001 inches, and utilizes a small probe approximately 3/4 inch in diameter. To make the reading a small spot had to be cleaned to bare metal, on one side of the member, removing all mud, rust, and bitumastic coating. In places the bitumastic coating was 1/2 inch thick where it had been poured on originally and had the consistency of a hard epoxy. An air chisel laid on edge like a scraper was found to do an adequate job of removing about a 1 inch square of coating and mud to nearly bare metal. The meter would not read accurately on very rusty web plates so web readings were made on the underside where there was less rust. Rivet heads, angle stiffeners and the downstream skinplate were not checked. Flange cover plates on the outside of each girder where checked near the splash zone where they were not covered by steel fenders.

The readings indicated less material loss than originally thought, generally 1/16 to 1/8 inch or less, even in rusty areas. Surprisingly many of the thicker members of 3/4 inch thickness or more were found to be thicker than originally specified. Since we do not know what thickness any of the members were originally, we can only speculate that these thicker pieces were rolled on the high side of the mill tolerances. Mill tolerances at the time of gate construction, which vary by specified thickness, are minus .010 inches and approximately plus 3%-4% of thickness or for a 1/2 inch plate +.020 inches. We do not believe any of the members in the gate were thickened up during design or construction for corrosion allowance. The thicknesses specified on construction drawings are the same as were sized in computations.

D2. Projections. We next performed an analysis of the foregoing thickness measurements for Kentucky lock and dam. From this data, we have produced a set of representative measurements to describe the corrosion that has occurred at this project. From this representative set of data, statistical parameters for the site specific corrosion were determined, which lead to a power law to represent future corrosion. In addition, the power law was projected backwards in time to determine initial thicknesses of the elements which now have a greater thickness than the specified nominal.

This analysis addressed the girders of the downstream gates suffering the greatest deterioration. To determine the thickness loss to corrosion, the measured 1993 thickness of each element was subtracted from the 1942 nominal thickness. In many cases, however, this difference was negative indicating current thicknesses greater than the nominal. This aberration occurred most frequently for the thicker elements, i.e., the skin plate and the upstream angle. These thicknesses are shown in the included, Table D-1.

In order to isolate measurements that could be used in corrosion analysis, the distribution of corrosion loss for each member element was studied. In this investigation, we determined that 79% of the measurements of the skin plate were greater than the nominal value. In addition, 87% of the upstream angle measurements also generated negative thickness losses. In contrast, only 20% of the upstream web measurements, 8% of the downstream web measurements, and 4% of the downstream angle measurements were questionable. In isolating a usable set of data, all of the measurements of the skin plate and the upstream angle were rejected. From the data remaining, the negative corrosion losses were disregarded.

The remaining thickness losses were then divided by two to be compatible with the power law description of corrosion which gives thickness loss per surface. A histogram of the half thickness losses from the relevant measurements is shown in Figure D-1 . A statistical analysis of this subset of the measurements revealed a mean corrosion loss of 0.043" and a standard deviation of 0.051". When viewing this histogram, one can see that six of the computed losses are much greater than the other 41. These six values are responsible for elevating the mean loss and producing a standard deviation much greater than the mean value.

In order to quantify the effect of these six extreme numbers, a second subset of the data was produced excluding these measurements. The plot, Figure D-2, shows a histogram of the 41 remaining data points. This set of data has a mean corrosion loss of 0.016" and a standard deviation of 0.020". As shown in the histogram of the original data set, the mean value of the bin containing the higher thickness losses is 0.16" which is 7.5 standard deviations away from the mean of the bulk of the data. This distance from the mean statistically excludes these measurements as they are rare events.

The censored statistics are much more representative of the largest part of the data. The standard deviation is greater than the mean, and this represents the uncertainty inherent in the measurement of the thicknesses. This abbreviated set of data can now be used to determine a power law to describe corrosion at Kentucky lock and dam.

The power law representing corrosion is of the form

$$C = A\,t^{B} \qquad \text{D-1}$$

where C is the corrosion loss per surface in microns (meters x 10-6), t is the time of corrosion in years, and A and B are constants representing the specific corrosion case investigated. By taking the common logarithm of each side of the equation, a linear equation in logarithmic space is given by

$$\log C = \log A + B \log t. \qquad \text{D-2}$$

To fit the available data to this power law representation, the thickness losses are first converted to microns; and then the common log of these values is computed. A histogram of the logarithm of the thickness losses in microns is shown in Figure D-3 . The statistics of this distribution include a mean value of log C of 2.211 with a standard deviation of 0.67.

Since the girders in question are in a location where splash zone corrosion should govern, the previously developed expression for splash zone corrosion should be matched as closely as possible (ITl, 1993) . The equation for splash zone corrosion has been shown to be

$$\log C = \log 148.5 + 0.903 \log t. \qquad \text{D-3}$$

Either the intercept, log A, or the slope B may be kept the same as previous thus allowing for the computation of the other constant. In the case of splash zone corrosion, the most important parameter needed for projection of future corrosion is the slope B. Therefore, B retains its value of 0.903 and A is determined such that the computed value of the corrosion in 1993 matches the mean value of the measured data.

Records of Kentucky lock indicate that the project began operation in 1942 and received a protective bituminous coating to impede corrosion. Evidence of corrosion was first observed in 1977 which is herein estimated to be the first year of corrosion. With 1977 being the first year, the measurements in 1993 represent 16 years of corrosion. Knowing the time of corrosion, t, and letting B equal 0.903, the equation for corrosion at Kentucky lock is

$$\log C = \log A + 0.903 \log (16). \qquad \text{D-4}$$

Solving the equation for log A produces a value for the constant A of 13.3. Hence, the equation for corrosion at Kentucky lock and dam is

$$\log C = \log 13.3 + 0.903 \log t + \epsilon_c. \qquad \textbf{D-5}$$

The term e_c represents the uncertainty in the computation of the corrosion losses and is treated as a random variable. As the constant A was calculated to match the mean of the measurements, $E[\ e_c\ ] = 0$. Further, the standard deviation is simply the standard deviation of the measured values of log C, 0.67 .

In order to apply this corrosion function to all of the elements of the horizontal girder, the initial thicknesses of the elements whose present thickness is greater than the reported nominals must be determined. The elements in question are the nominal 0.75" skin plates, the 0.813" skin plates, the 0.75" upstream angles, and the 0.875" upstream angles. The first step in determining initial thicknesses is computing the mean value of the thicknesses recorded in 1993. For the thinner skin plate, the mean value is 0.7581" for the 0.813" skin plate, 0.8298". For the upstream angles, the mean thickness of the 3/4 inch angle is 0.7536"; and the mean thickness of the thicker angle is 0.8819".

Since these elements have experienced 16 years of corrosion, Equation D-4 can be used to compute the amount of thickness that should have been lost during this time. The equation for this loss is expressed as

$$\log C = \log 13.3 + 0.903 \log 16 \qquad \textbf{D-6}$$

which yields a value for C of 162.62 mm or 0.0064 inches. Adding twice this thickness loss to the mean current thickness measurements of the girder elements in question provides an indication of the initial thicknesses at the time of construction. Therefore, the initial thickness of the nominal 0.75" skin plate is 0.7709"; and the initial thickness of the 0.813" skin plate is 0.8426". For the upstream angles, the initial thickness of the 0.75" nominal angle is 0.7664" and the thickness of the 0.875" angle is 0.8947". Refer to Table D-1 for a summary.

Table D-1 Estimated Initial Thickness of Elements Measured to be Thicker Than Nominal

Element	Mean Thickness (in)	Corrosion Loss (in)	Initial Thickness (in)
.75" Skin Plate	0.7581	0.0128	0.7709
.813" Skin Plate	0.8298	0.0128	0.8426
.75" US Angle	0.7536	0.0128	0.7664
.875" US Angle	0.8819	0.0128	0.8947

The most important results of this analysis are the determination of the power law to represent corrosion at Kentucky lock and dam, and the determination of initial thicknesses of the large elements of the girder. By extracting meaningful data from the thickness measurements reported, a distribution of the corrosion loss was determined. This distribution gave rise to the applicable power law

$$\log C = \log 13.3 + 0.903 \log t + \epsilon_c \begin{bmatrix} \mu = 0.0 \\ \sigma = 0.67 \end{bmatrix}. \qquad \text{D-7}$$

Using this power law and the initial thicknesses of the girder elements, corrosion loss and element thickness can be projected to any time. With this projected degradation of the structure, the reliability functions can be computed at any time.

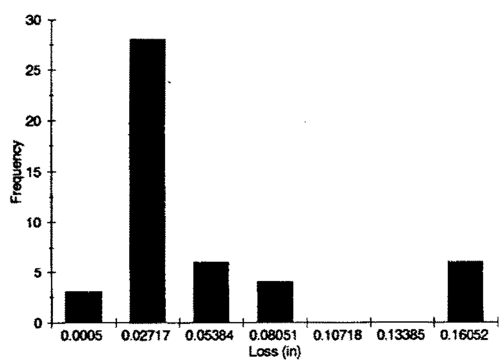


Figure D-1. Distribution of Thickness Lost to Corrosion.

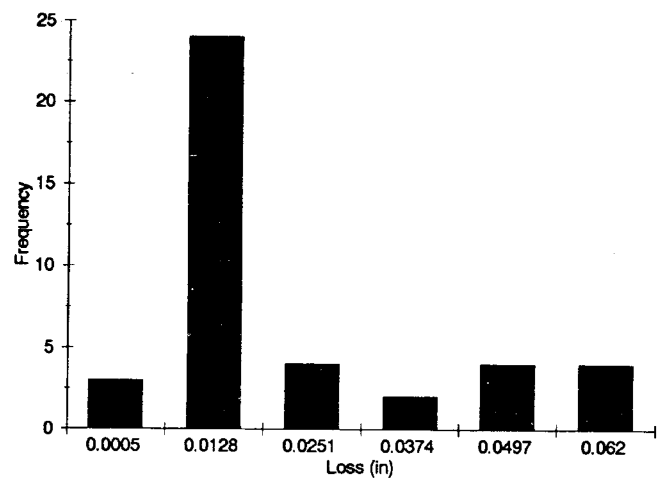


Figure D-2. Censored Distribution of Thickness Loss.

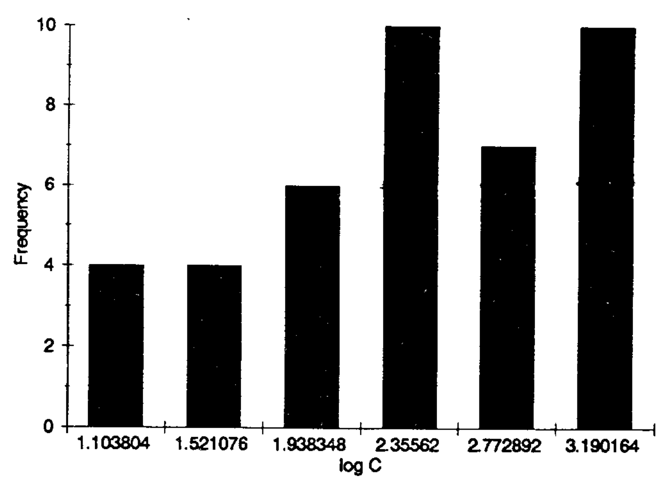


Figure D-3. Distribution of Logarithm of Thickness Loss.

E. Reliability Analysis

E1. Method of Analysis.

Reliability Index

In deterministic structural analysis and design, the proximity to a limiting state of performance is traditionally quantified through the factor of safety, F. This dimensionless measure is defined in general as the ratio of the capacity to resist, C, to the applied demand, D, i.e.,

$$F=\frac{C}{D} \tag{E-1}$$

Accordingly, a ratio greater than one represents a condition of satisfactory performance, while values less than one indicate an unacceptable condition.

Current probabilistic-based design codes recognize that through Equation (E-1), F is a function of a set of uncertain variables, X_i describing the geometric, material, and boundary conditions of a structure, i.e.,

$$F = F(X_i) \tag{E-2}$$

The factor of safety is therefore, a random variable with an associated probability density function as shown in Figure E-1 where μ and σ represent the mean and standard deviation of the distribution. The reliability of a structure, or its probability of satisfactory performance, is the area under this curve to the right of $\ln(F) = 0$. Therefore reliability depends not only on the mean factor of safety, but also on the distribution about this mean value. However in most practical situations the exact form of this distribution is unknown.

To circumvent this difficulty, the reliability index β can be used as a relative measure of satisfactory performance. While mathematically more rigorous definitions of β exist, the reliability index is here defined from only the mean $\mu_{\ln(F)}$ and standard deviation $\sigma_{\ln(F)}$ of the natural logarithm of the factor of safety as

$$\beta = \frac{\mu_{\ln(F)}}{\sigma_{\ln(F)}} \tag{E-3}$$

As shown in Figure E-1, β is the number of standard deviations from the limiting state (defined by $\ln(F)=0$) to the mean. Thus the reliability index increases as the mean factor of safety increases and as the standard deviation of the factor of safety decreases. Current load and resistance factor design codes achieve reliable structures by specifying load and resistance factors that have been calibrated using the means and standard deviations of the uncertain variables, to achieve reliability indexes of 3 to 4 (Ellingwood et al., 1980).

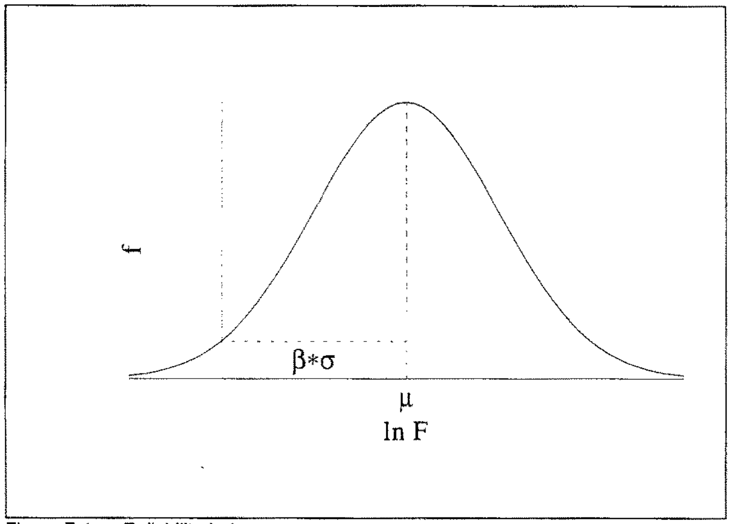


Figure E-1. Reliability Index

Now, the evaluation of an existing structure is dependent on the same uncertainties used in design. For design purposes, a target reliability index β is the basis for calculation of the resistance of the structure. Therefore, the reliability index β should be a good representation of the condition of an existing structure. In evaluation however, the reliability index β is explicitly estimated using Equation (E-3) from the capacity and demand of the existing structure.

Taylor Series - Finite Difference Estimation

The foregoing estimation of the reliability index requires the mean and the standard deviation of ln(F) associated with the limit state of interest. Usually these are unknown directly but information may be available about the means and standard deviations of the variables on which ln F functionally depends. A number of procedures exist to estimate the moments of such a function from those of its independent variables including Monte Carlo simulation, point estimation of probability moments, and Taylor series approximation. Based on a balanced consideration of rationality and practicality, a variation of the later method which we call Taylor Series - Finite Difference (TSFD) estimation has been found to be helpful in the evaluation of Corps projects.

This estimation employs a first order Taylor series expansion of Equation (E-2) as the basis for determining the mean and standard deviation of the factor of safety (Benjamin and Cornell 1970). Specifically, the mean and standard deviation of a function of random variables (lnF) can be estimated by expansion of a Taylor Series about the mean, truncated to linear terms. This procedure approximates the mean lnF through

$$E[\ln F] = \ln F(\mu_i) \qquad \textbf{(E-4)}$$

in which μ_i are the means of the random variables X_i that describe the limit state. If the random input variables are independent, the variance can be approximated by

$$Var\ [\ln F] = \sum \left(\frac{\partial \ln F}{\partial x_i} \sigma_i \right)^2 \qquad \textbf{(E-5)}$$

where σ_i are the standard deviations of these variables, and partial derivatives are evaluated at the mean μ_i . To complete the procedure, the partial derivatives are approximated by the finite difference expression

$$\frac{\partial \ln F}{\partial x_i} = \frac{\ln F_i^+ - \ln F_i^-}{2\sigma_i} \qquad \textbf{(E-6)}$$

in which

$$\ln F_i^+ = \ln F(\mu_1, \ldots, \mu_i + \sigma_i, \ldots, \mu_n) \qquad \textbf{(E-7)}$$

and

$$\ln F_i^- = \ln F(\mu_1, \ldots, \mu_i - \sigma_i, \ldots, \mu_n) \qquad \textbf{(E-8)}$$

are the values of ln(F) evaluated at one standard deviation above and below the mean of each independent variable, respectively. Substitution of Equations (E-6) through (E-8) into

Equation (E-5) gives

$$Var[\ln F] = \sum\left(\frac{\ln F_i^+ - \ln F_i^-}{2}\right)^2 \qquad \textbf{(E-9)}$$

which completes the estimation of the mean and standard deviation of lnF from the first and second moments of the random variables X_i .

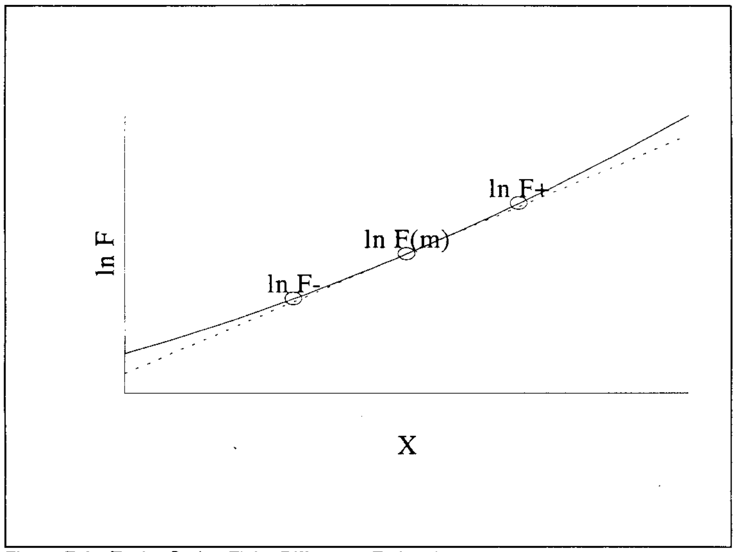


Figure E-2. Taylor Series Finite Difference Estimation

The Taylor Series Finite Difference (TSFD) estimation is depicted in Figure E-2 for ln F shown as a function of a single random variable X. The actual functional behavior is approximated by a line through ln F(μ) which parallels the chord between ln F^- and ln F^+. The exact moments of this linear approximation, Equations (E-4) and (E-9), then provide the estimates $\mu_{\ln F}$ and $\sigma_{\ln F}$. Accordingly, the method estimates these moments as accurately as the line approximates the function.

This procedure requires 1+2n deterministic calculations of the factor of safety, where n is the number of independent random variables in the limit state equation. The first calculation is Equation (E-4) at the mean values, while the other n pairs, Equations (E-8) and (E-9), measure the sensitivity to the uncertainties in each X_i. Equation (E-9) then synthesizes this information into a single value describing uncertainty in ln(F). Further, the individual terms in this sum indicate the contributions of each X_i to σ_{lnF}, thus quantifying the dependence of the uncertainty in factor of safety on each input variable.

Reliability Estimation

The index β can be used to further estimate the reliability of the underlying limit state. If one can assume that the underlying ln(F) is normally distributed, It then follows that

$$R = 1 - \Phi\left(\frac{0 - \mu_{\ln(F)}}{\sigma_{\ln(F)}}\right) = \Phi(\beta) \qquad \textbf{(E-10)}$$

in which $\Phi(\beta)$ is the cumulative function of the standardized normal distribution and represents the area under the curve to the right of ln(F)=0 in Figure E-1. Any reliability calculated from this equation represents an estimate which is as good as the assumption of normality for ln(F) and the moments estimated for this variable. Such reliabilities estimated from Equation (E-10) have been helpful in economic studies for the rehabilitation of Corps projects.

An approximation (Hastings, 1955) for the cumulative distribution function which is accurate to within 7.5×10^{-8} is

$$\Phi(x) = 1 - f(x)\,(b_1\tau + b_2\tau^2 + b_3\tau^3 + b_4\tau^4 + b_5\tau^5) \quad , \quad 0 \le x \qquad \textbf{(E-11)}$$

where $\Phi(x)$ is the cumulative distribution function, Z(x) is the probability density function and τ is a function of x. The functions Z(x) and τ are given by

$$Z(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} \qquad \textbf{(E-12)}$$

$$\tau = \frac{1}{1 + px} \qquad \textbf{(E-13)}$$

The constants in this polynomial approximation are

p =	0.2316419	b_3 =	1.781477937
b_1 =	0.319381530	b_4 =	1.821255978
b_2 =	-0.356563782	b_5 =	1.330274429

Reliability Functions

Due to deterioration of structural resistance, and perhaps an increase in service loading (demand), at some point in time a structural component will cease to perform its intended function. The time T at which this occurs is necessarily a random variable due to uncertainties in capacity and demand. The distribution of this variable is given by its cumulative distribution function

$$F(t) = P[T \le t] \quad \textbf{(E-14)}$$

This increases monotonically in time and is always between 0 and 1.

Figure E-3 shows an illustrative cumulative distribution function. This graph gives the probability of unsatisfactory performance sometime before the indicated number of years. For example, this probability is $F = 0.26$ for $t = 40$ years as indicated in the figure by the dotted lines.

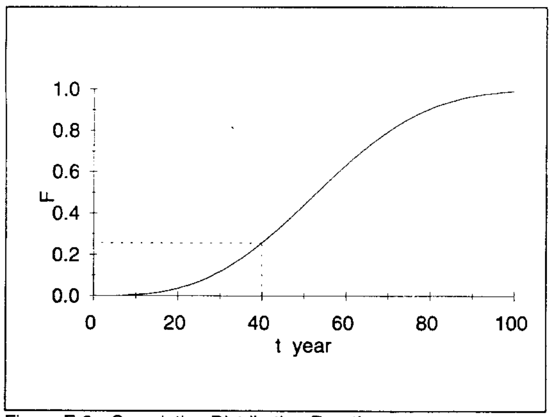


Figure E-3. Cumulative Distribution Function

The reliability of a system is the probability of performing its intended function. For systems whose capacity and demand are changing with the respect to time, this reliability R(t) is a time dependent function which is related to the cumulative distribution function of the time of unsatisfactory performance as follows:

$$R(t) = P[T \geq t] = 1 - F(t) \qquad \textbf{(E-15)}$$

It is important to emphasize that the value of the reliability function at a particular time is an instantaneous measure of its condition.

Figure E-4 is the reliability function corresponding to the cumulative distribution in Figure E-3. This plot indicates the probability of performing satisfactorily through a given number of years. For example, at t = 40 years R = 0.74. Note that R(40) + F(40) = 1 as required by Equation (E-15).

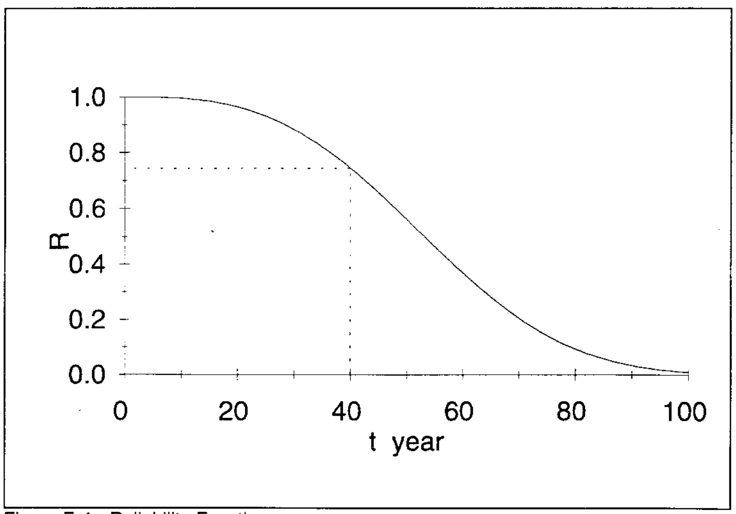


Figure E-4. Reliability Function

The time at which unsatisfactory performance occurs is also described by a probability density function f(t). This is related to the cumulative distribution function through

$$f(t) = \frac{dF}{dt} \qquad \textbf{(E-16)}$$

The unconditional probability of reaching unsatisfactory performance in a particular time interval can be found by integrating this probability density function over the interval of interest. Accordingly, probability density functions are always positive and the total area under their graphs is always equal to 1.

The probability density function corresponding to the cumulative distribution of Figure E-3 appears in Figure E-5. This indicates the unconditional rate of incurring unsatisfactory conditions in the corresponding year. For example f = 0.0165/year when t = 40 years. This is the slope of the cumulative function in Figure E-3 as dictated by Equation (E-16).

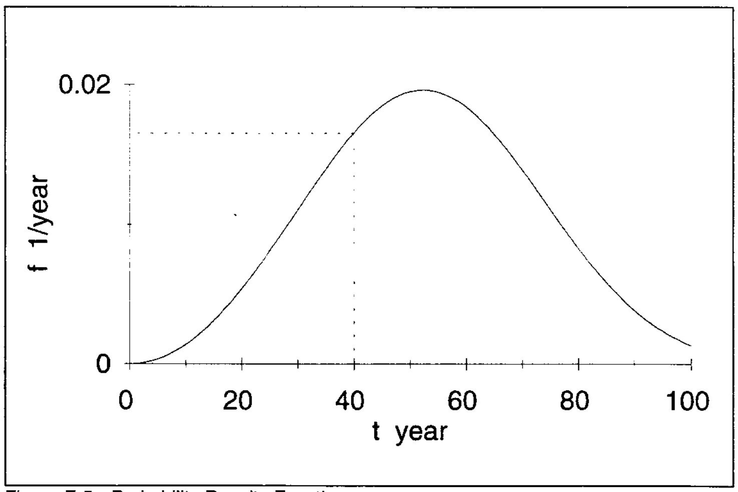


Figure E-5. Probability Density Function

The *hazard function* of a system is the instantaneous rate of incurring unsatisfactory conditions given that the system has performed satisfactorily through this time. It is thus given by

$$h(t) = \frac{f(t)}{R(t)} \qquad \textbf{(E-17)}$$

This conditional rate of reaching unsatisfactory performance is the engineering reliability input required by the economic simulations of rehabilitation alternatives. As the hazard function is an instantaneous probability per unit time, it must be multiplied by the time interval to determine the probability in this period.

Figure E-6 presents the hazard function corresponding to the distribution of time to unsatisfactory performance in Figure E-3. This represents the instantaneous rate given that the system has survived to date. For example at t = 40 years, h = 0.0222/year. Observe that this rate exceeds the unconditional rate f = 0.0165/year since h(40) = f(40)/R(40) in accordance with Equation (E-17).

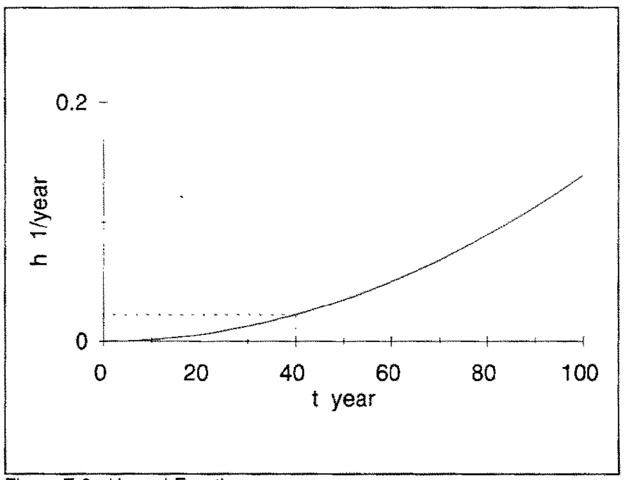


Figure E-6. Hazard Function

Thus, the time dependent reliability of a system is characterized by four functions which are inter-related so that knowledge of any one defines the other three. Two of these, F(t) and f(t) describe the distribution of the time of unsatisfactory performance. The reliability function R(t) indicates the instantaneous reliability of the system. The hazard function h(t) represents the instantaneous rate at which unsatisfactory conditions occur.

Weibull Model

The Weibull probability distribution has been applied broadly in engineering reliability. It was originally conceived to describe the strength of materials (Weibull, 1939). Recently it has been used to describe the wear out of generator stator windings in Corps hydropower projects.

The Weibull model is a two parameter distribution of the time of unsatisfactory condition, T, whose reliability is

$$R = e^{-\left(\frac{t}{\theta}\right)^{\gamma}} \qquad \textbf{(E-18)}$$

in which

θ = characteristic age at which R = 1/e = 0.37
γ = Dimensionless shape parameter

The corresponding hazard is simply

$$h(t) = \frac{\gamma}{\theta}\left(\frac{t}{\theta}\right)^{\gamma-1} \qquad \textbf{(E-19)}$$

Note that $\gamma > 1$ describes the increasing hazard associated with aging structures. Thus the Weibull model conveniently characterizes the time dependent reliability and hazard of a limit state through the two constants θ and γ. In particular the reliability functions in Figures E-3 through Figure E-6 are based on a Weibull model with θ = 60 years and γ = 3.

These parameters can be estimated by linear regression if reliability has been calculated at times in the period of interest. This is based on algebraically transforming Equation (E-18) to obtain

$$\ln\left[\ln \frac{1}{R}\right] = \frac{\gamma}{\ln\theta} + \gamma \ln t \qquad \textbf{(E-20)}$$

This represents a linear equation of the form

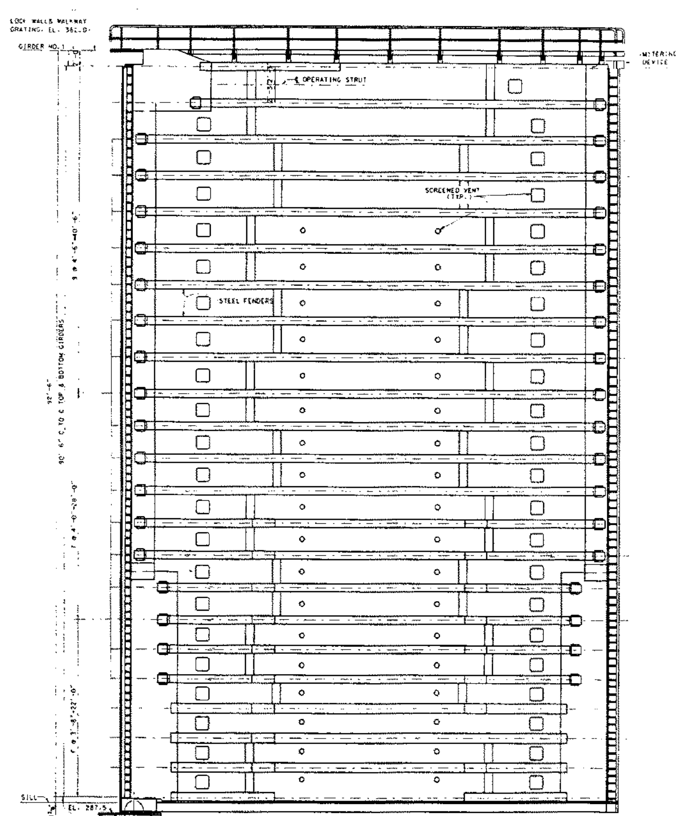
$$y = a + bx \qquad \textbf{(E-21)}$$

in which $y = \ln\left[\ln \frac{1}{R}\right]$, $x = \ln t$, $a = \frac{\gamma}{\ln \theta}$ and $b = \gamma$.

Thus a linear regression of the (x, y) calculated from the estimated (t, R) points will yield estimates of θ and γ through the coefficients a and b.

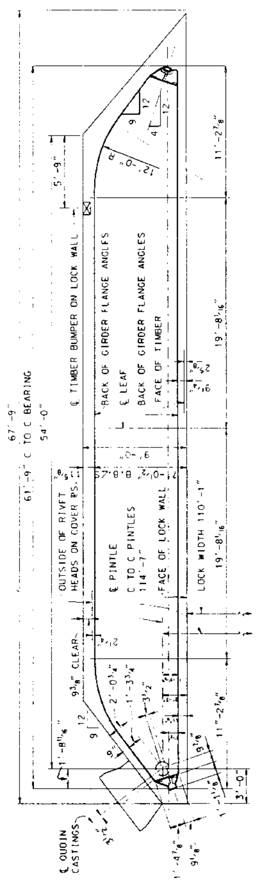
E2. Analysis Model. The gate analysis model investigated, considered each main horizontal girder as a main member loaded and supported as a three-hinge arch as described in EM 1110-2-2703, "Lock Gates and Operating Equipment". Various load cases were investigated but it was decided that none of these except the historical pool loads had enough probability of occurring to be used in the economic analysis. The main horizontal girders consist of riveted plates and angles to form an I-shape girder. A seven foot wide web is riveted to upstream and downstream skinplates using angles top and bottom of the web. The skin plate is sandwiched between exterior cover plates and the connection angles to form a riveted plate girder consisting of nine parts. Discussions of how much effective width of skinplate to consider as part of the girder section led to OCE and WES recommending that the maximum available be used center-to-center of girder spacing. This skinplate effective width is higher than typical of new design and higher than original design which results in stronger girder section properties. A sensitivity check of this change was performed but due to shifting of neutral axis this section analyzed almost identical stresses to typical design section properties. Exhibits 3E-1, 3E-2 and 3E-3 show gate leaf and girder details.

Corrosion loss thicknesses were calculated within the Taylor Series spreadsheet and then transferred to the section properties calculation. After calculation of resulting cross sectional area and moment of inertia these were transferred back to the Taylor Series and considered correlated with corrosion thickness losses. Because of this interrelation of corrosion section loss and section properties, all four variables related to cross section properties were correlated and stepped together in the analysis.



DOWNSTREAM ELEVATION

Exhibit 3E-1



GATE LEAF & RECESS OUTLINE

Exhibit 3E-2

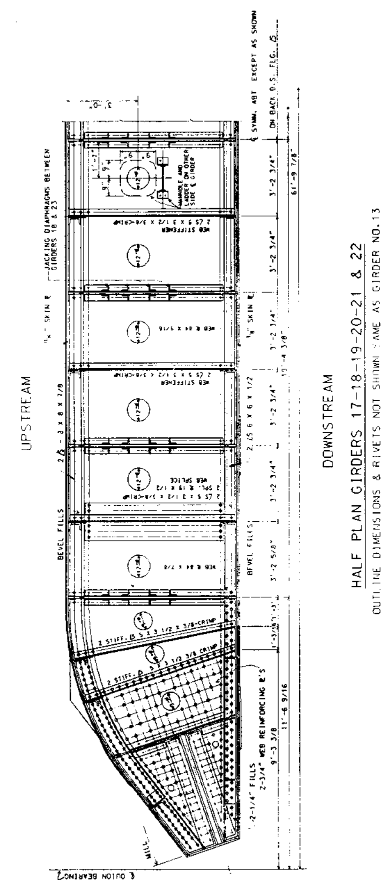

UPSTREAM
DOWNSTREAM
HALF PLAN GIRDERS 17-18-19-20-21 & 22
OUTLINE DIMENSIONS & RIVETS NOT SHOWN SAME AS GIRDER NO.13

Exhibit 3E-3

Girder analysis forces were calculated per the EM 1110-2-2703 resulting in water load per foot of girder, total water load on girder, axial force, and moment at location "x". From these forces and section properties axial compressive stress was calculated and maximum bending compressive stress. These were summed as the maximum compression stress and is considered to be the "Demand" portion of analysis. Sections at centerline and end area where the girder tapers down 8.66 feet from contacts were checked for maximum stress. Due to geometry of the neutral axis relationship to the axial thrust line, the end section resulted in higher stresses and is analyzed in the reliability assessment.

The reliability calculation of Beta and probability of unsatisfactory performance are performed using a Taylor Series in accordance with ETL 1110-2-532, Reliability Assessment of Navigation Structures. The random variables and constants used are described in following sections of this appendix. The number of load cycles shown in the Taylor Series are not used in the calculations, but are only for reference. The "Capacity" of the girder model is taken as the random variable "Yield" which is the yield stress of the ASTM A7 steel. The Factor of Safety "FS" shown is the result of:

$$FS=\frac{Capacity}{Demand}=\frac{Yield}{Ks*St}$$

Where Ks is the coefficient of actual stress to theoretical stress and St is the total compressive stress. The resulting Beta and probability of unsatisfactory performance show extremely good reliability of the structure when subjected to historical pools. Also shown in exhibits is the controlling design, load case II, pools for 1993 and projected to 2003 which shows the girder at allowable stress of 16.5 KSI in 2003 which will become a dam safety concern. This load case is a concern because it is the normal operating pool the lock was designed for with no overstress allowed and the structure should be capable of sustaining this load at any time with no damage. Exhibits 3E-4, 3E-5 and 3E-6 show reliability calculations for controlling girder 22, end section. Exhibits 3E-7 and 3E-8 show stress calculations for this same end section but with design pool loads for 1993 and projected to 2003.

E3. Constants of Analysis. The following parameters needed for the stress analysis and Beta calculation were treated as constants in the reliability analysis.

Time-- Time was treated as a constant because we could take snapshots in time and perform our analysis. Corrosion estimates are calculated as a function of time in years with corrosion beginning in 1977. At these given time intervals, we analyzed the condition of the gate.

NI--# cycles-- Based on available records of the number of load cycles the lock has experienced and the future prediction of traffic, we can predict the number of load cycles at any given time period. Therefore we chose to make this a constant. Since fatigue was dropped out of the analysis this constant is not used in calculations but is shown for reference only.

Gamma-- The unit weight of water was taken as a constant equal to 62.5 pounds per cubic foot. This constant can be found in numerous textbooks and was used to help calculate the horizontal loads acting on the miter gates.

s--Girder Spacing-- The girder spacing determines the amount of water load that is applied to each girder. We analyzed two sections per girder but for any particular girder, the girder spacing remains constant and was taken from the as built drawings.

Elevation-- The elevation of each girder determines how much load is applied to that girder. This is constant for each girder and the elevation was also taken from the drawings.

L--Girder Length-- The length of the each girder is from contact to contact points and is used in calculating the water loads and moments in the girders. This length was also taken from the drawings.

d--Girder Depth-- The depth of girder,(out to out of skin plates) is constant and was calculated from dimensions shown on the drawings. This depth is used in calculating the geometric properties and moment of inertia of the section being analyzed.

c--The distance from the centroid of the girder to the outside of the upstream skinplate is constant for each cross section. This distance is used in calculating water load and stresses in the girder.

a-- The distance from the centroid of the girder to the girder work line is constant and used in calculating water load and stresses in the girder per EM 1110-2-2703, Figure 2-1.

theta-- The angle of the gate leaf to a perpendicular from the wall is constant and is set by the miter gate geometry taken from design drawings.

t1-- The distance from the outside of skin plate to the work line at each cross section as used in EM 1110-2-2703.

t2-- For each cross section, the thickness of the upstream cover plate is constant. This thickness is used in calculating the area and moment of inertia of the section being analyzed and finally the bending stress at the upstream extreme fiber.

x-- The distance from the contact point to the analyzed section for moment calculations is constant.

E4. Analysis of Random Variables. The following parameters were treated as random and varied one standard deviation above and one standard deviation below the mean value for the particular parameter.

e'-- The residual of Log of corrosion thickness loss data was taken as a variable since the corrosion loss varies at each spot on the gate. This was verified by field measurements.

C-- The corrosion thickness loss was taken as a variable and the formula for calculating this was adjusted to match the field data.

Area-- The cross sectional area of the girder varies by location and corrosion projections and therefore was taken as a variable.

I-- The moment of inertia of the cross sections of the girder being analyzed is different at each location due to corrosion loss and therefore was taken as a variable.

Yield-- The yield stress of ASTM A7 steel used in fabrication of the gate has some uncertainty as supplied by the mill which affects the capacity of the structure directly. The stated steel manual stress is 33,000 pounds per sq. inch. From research done for load and resistance factor design (Ellingwood et al. 1980) this value has been found to have a mean value 5% over stated nominal yield stress and varies by +/- 10% from the mean value.

hu-- The headwater upstream elevation fluctuates with the time of year, amount of rainfall and runoff and for this reason was taken as a variable. Since the pool was first impounded, records of headwater and tailwater elevations were kept and were retrieved for use in this report.

hd-- The head downstream (tailwater) elevation fluctuates even more than the headwater due to it being open to the Ohio River pools, and it too was considered a variable. The elevation of the tailwater had the greatest effect on the standard deviation of the factor of safety of any of the variables. This elevation can fluctuate totally independent of upper pool depending on rainfall and pools of the Ohio River.

Ks-- The ratio of actual stress to calculated stress was treated as a variable. From field tests by strain gauge measurements, at other projects, it has been found that actual mean stresses are slightly lower than theoretical calculated values. This variable was recommended for inclusion by OCE and WES. This variable had the second greatest effect of any of the variables when we stepped one standard deviation above and one standard deviation below the mean value.

Kentucky Lock Miter Gate Reliability Study

Beam Properties Calculations

CEORN-EP-D
8-Feb-94

LOWER GATE

Girder # 19

Fy = 33 ksi

Cell B&I

Thkns Loss = 0.0128
Year = 1993 AVG

Upstream

Cover Plt. (in)
Y-Axis
High 17.00
Thk 0.6752

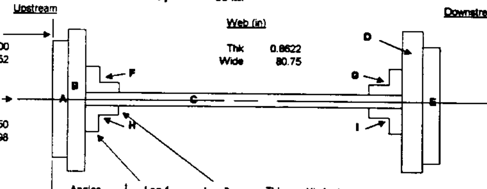
Skin Plt (in)
X-Axis
High 43.50
Thk 0.8298

Web (in)
Thk 0.8622
Wide 80.75

Downstream

Cover Plt (in)
High 13.00
Thk 0.3622

Skin Plt (in)
High 43.50
Thk 0.3622



Angles	Leg 1	Leg 2	Thk	Xb fm base
F	8.00	8.00	0.8819	2.33
G	6.00	6.00	0.4872	1.68
H	8.00	8.00	0.8819	2.33
I	6.00	6.00	0.4872	1.68

Leg 1 parallels Y-axis
Leg 2 parallels X-axis

Y-Y Axis Section Properties

	Plate	H (in)	Thk (in)	Area	X (in)	Area * X	d	A*d^2	Io	lbs/ft
	A	17.00	0.68	11.48	0.34	3.88	32.07	11804.84	0.44	39.06
	B	43.50	0.83	36.10	1.09	39.35	31.32	35401.14	2.07	122.83
	C	0.86	80.75	69.62	42.13	2933.20	-9.72	6582.04	37831.57	236.91
	D	43.50	0.36	15.76	82.94	1306.72	-50.53	40227.47	0.17	53.61
	E	13.00	0.36	4.71	83.30	392.22	-50.89	12194.97	0.05	16.02
Angles	F			13.30	3.83	51.01	28.57	10859.39	80.11	45.26
	G			5.61	81.07	454.75	-48.67	13285.41	19.46	19.09
	H			13.30	3.83	51.01	28.57	10859.39	80.11	45.26
	I			5.61	81.07	454.75	-48.67	13285.41	19.46	19.09
	Total		83.48	175.48		5686.88		154500.06	38033.44	597.13

Xu= 32.41 in

Xd = 51.07 in

Area = 175.5 in^2

Depth = 83.48 in

d (out-to-out skin plt) = 82.442 in

c (from edge of skin plt to CG) = 31.732 in

Iy = 192534 in^4
ry = 33.12 in
Syu = 5941.13 in^3
Syd = 3769.81 in^3

Weight = 597.13 Lb/Ft

Exhibit 3E-4

24-Jan-94
CEORN-EP-D

Kentucky Lock Miter Gate Horizontal Girder
Lower Gate - Girder No. 22 - End Area
Taylor Series - Finite Difference

1993 Condition

Constants	Time	NI	gamma	s	Elev	L	d	c	a	theta	t1	t2	x
	yrs	# cycles	lb/ft^3	in	ft	ft	in	in	in	deg	in	in	ft
	16	166514	62.50	44.00	293.17	61.824	82.442	31.732	45.835	18.435	77.57	0.675	8.660

Design Pools		Mean Pools	
375	302	356.33	308.52
		2.27	8.60

Variables	e'	C	Area	I	Yield	hu	hd	Ks
		in	in^2	in^4	ksi	ft	ft	
Mean	0.00	0.013	175.50	192534	34.65	356.33	308.52	0.88
StDv (+)	0.67	0.060	163.80	176707	3.47	2.27	8.60	0.14
(-)	-0.67	0.003	178.00	195913				

	e'	C	Area	I	Yield	hu	hd	Ks	w	W	P	Mx	Sa	Sb	St	FS
									k/ft	kip	kip	ft-k	ksi	ksi	ksi	
Mean	0.00	0.013	175.5	192534	34.65	356.33	308.52	0.88	10.96	677.4	1086.9	-1400.3	6.193	4.458	10.651	3.697
e' & C	0.67	0.060	163.8	176707	34.65	356.33	308.52	0.88	10.96	677.4	1086.9	-1400.3	6.635	4.857	11.492	3.426
Area & I	-0.67	0.003	178.0	195913	34.65	356.33	308.52	0.88	10.96	677.4	1086.9	-1400.3	6.106	4.381	10.487	3.755
Yield	0.00	0.013	175.5	192534	38.12	356.33	308.52	0.88	10.96	677.4	1086.9	-1400.3	6.193	4.458	10.651	4.067
	0.00	0.013	175.5	192534	31.19	356.33	308.52	0.88	10.96	677.4	1086.9	-1400.3	6.193	4.458	10.651	3.327
hu	0.00	0.013	175.5	192534	34.65	358.60	308.52	0.88	11.48	709.5	1138.5	-1466.8	6.487	4.669	11.156	3.529
	0.00	0.013	175.5	192534	34.65	354.06	308.52	0.88	10.44	645.2	1035.3	-1333.9	5.899	4.248	10.145	3.881
hd	0.00	0.013	175.5	192534	34.65	356.33	317.12	0.88	8.99	555.5	891.4	-1148.5	5.079	3.656	8.735	4.508
	0.00	0.013	175.5	192534	34.65	356.33	299.92	0.88	12.93	799.2	1282.4	-1652.2	7.307	5.259	12.566	3.133
Ks	0.00	0.013	175.5	192534	34.65	356.33	308.52	1.02	10.96	677.4	1086.9	-1400.3	6.193	4.458	10.651	3.190
	0.00	0.013	175.5	192534	34.65	356.33	308.52	0.74	10.96	677.4	1086.9	-1400.3	6.193	4.458	10.651	4.398

StDv-FSi				0.164	0.370	0.176	0.687	0.603
%				16.2%	36.4%	17.3%	67.7%	59.4%

Mean-FS	StDv-FS	Mean-lnFS	StDv-lnFS	Beta	Reliability
3.6970	1.0154	1.2712	0.2697	4.71	0.999988

Exhibit 3E-5

REL_93B.XLS

Index of Constants and Variables
Used in Taylor Series Analysis

a	Girder work line to centroid distance
Area	Cross sectional area of girder
Beta	Reliability index
c	Distance from centroid to outside u/s skinplate
C	Corrosion thickness loss formula fit to field data
	Log C = log(26.6) + .903*log(Time) +/- e'
d	Depth of girder, out to out skinplates
e'	Residual of Log of corrosion thickness loss data
Elev	Elevation of girder
gamma	Unit weight of water
hd	Downstream elevation of water
hu	Upstream elevation of water
I	Moment of inertia
Ks	Ratio of actual to calculated stress
L	Length of gate leaf
FS	Factor of safety
Mean-FS	FS at mean values
Mean-lnFS	Natural log mean FS
	= ln(MeanFS) - (StDv-lnFS^2)/2
Mx	Moment in horizontal girder @ x
	= .5 * w * (L * x - L * a / Tan(theta) + (t1-a)^2 - a^2 - x^2)
Nl	Number of load cycles (Not used in calculations)
P	Axial load on girder
	= .5 * W / Tan(theta) + t1 * w
R	Reliability
	= Area under normal distribution curve @ beta
s	Spacing between girders
Sa	Stress due to axial loading
	= P / Area
Sb	Stress due to bending moment
	= M * (c+cover plt.) / I (using c to downstream skin plt.)
St	Combined total stress on compression side
	= Sa + Sb
StDv-FS	Standard deviation of FS
StDv-FSI	Standard deviation of FS from random variable
	= Abs(Difference of FS's) / 2
StDv-lnFS	Standard deviation of lnFS from random variable
	= Sqrt(ln(1 + (StDv-FS/Mean-FS)^2))
t1	Distance from outside skinplate to work line
t2	Upstream cover plate thickness
theta	Angle of gate leaf from wall perpendicular
Time	Years of corrosion beginning in 1977
w	Head of water on girder
	= (differential head ft.) * gamma * girder spacing
W	Total water load on girder
	= w * L
Yield	Yield stress of ASTM A7 steel
x	Distance from contact to moment point

24-Jan-94
CEORN-EP-D

Kentucky Lock Miter Gate Horizontal Girder
Lower Gate - Girder No. 22 - End Area
Taylor Series - Finite Difference

1993 Condition

Constants	Time	NI	gamma	s	Elev	L	d	c	a	theta	t1	t2	x
	yrs	# cycles	lb/ft^3	in	ft	ft	in	in	in	deg	in	in	ft
	16	166514	62.50	44.00	293.17	61.824	82.442	31.732	45.835	18.435	77.57	0.675	8.660

Design Pools		Mean Pools	
375	302	356.33	308.52
		2.27	8.60

Variables	e'	C	Area	I	Yield	hu	hd	Ks
		in	in^2	in^4	ksi	ft	ft	
Mean	0.00	0.013	175.50	192534	34.65	375.00	302.00	0.88
StDv (+)	0.67	0.060	163.80	176707	3.47	0.00	0.00	0.14
(-)	-0.67	0.003	178.00	195913				

	e'	C	Area	I	Yield	hu	hd	Ks	w	W	P	Mx	Sa	Sb	St	FS
									k/ft	kip	kip	ft-k	ksi	ksi	ksi	
Mean	0.00	0.013	175.5	192534	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.421
e' & C	0.67	0.060	163.8	176707	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	10.131	7.416	17.547	2.244
Area & I	-0.67	0.003	178.0	195913	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.323	6.689	16.012	2.459
Yield	0.00	0.013	175.5	192534	38.12	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.663
	0.00	0.013	175.5	192534	31.19	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.179
hu	0.00	0.013	175.5	192534	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.421
	0.00	0.013	175.5	192534	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.421
hd	0.00	0.013	175.5	192534	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.421
	0.00	0.013	175.5	192534	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.421
Ks	0.00	0.013	175.5	192534	34.65	375.00	302.00	1.02	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.089
	0.00	0.013	175.5	192534	34.65	375.00	302.00	0.74	16.73	1034.3	1659.5	-2138.2	9.456	6.806	16.262	2.879
StDv-FSI				0.108	0.242	0.000	0.000	0.395								
%				22.6%	50.9%	0.0%	0.0%	83.1%								

Mean-FS	StDv-FS	Mean-lnFS	StDv-lnFS	Beta	Reliability
2.4213	0.4758	0.8654	0.1946	4.45	0.999974

Exhibit 3E-7

REL_93B.XLS

24-Jan-94
CEORN-EP-D

Kentucky Lock Miter Gate Horizontal Girder
Lower Gate - Girder No. 22 - End Area
Taylor Series - Finite Difference

2003 Condition

Constants	Time	NI	gamma	s	Elev	L	d	c	a	theta	t1	t2	x
	yrs	# cycles	lb/ft^3	in	ft	ft	in	in	in	deg	in	in	ft
	26	224948	62.50	44.00	293.17	61.824	82.428	31.643	45.910	18.435	77.55	0.668	8.660

Design Pools		Mean Pools	
375	302	356.33	308.52
		2.27	8.60

Variables	e'	C	Area	I	Yield	hu	hd	Ks	w	W	P	Mx	Sa	Sb	St	FS
		in	in^2	in^4	ksi	ft	ft		k/ft	kip	kip	ft-k	ksi	ksi	ksi	
Mean	0.00	0.020	173.70	190155	34.65	375.00	302.00	0.88								
StDv (+)	0.67	0.093	155.60	165546	3.47	0.00	0.00	0.14								
(-)	-0.67	0.004	177.60	195412												
Mean	0.00	0.020	173.7	190155	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.388
e' & C	0.67	0.093	155.6	165546	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	10.665	7.965	18.630	2.114
Area & I	-0.67	0.004	177.6	195412	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.344	6.748	16.092	2.447
Yield	0.00	0.020	173.7	190155	38.12	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.627
	0.00	0.020	173.7	190155	31.19	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.149
hu	0.00	0.020	173.7	190155	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.388
	0.00	0.020	173.7	190155	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.388
hd	0.00	0.020	173.7	190155	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.388
	0.00	0.020	173.7	190155	34.65	375.00	302.00	0.88	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.388
Ks	0.00	0.020	173.7	190155	34.65	375.00	302.00	1.02	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.060
	0.00	0.020	173.7	190155	34.65	375.00	302.00	0.74	16.73	1034.3	1659.5	-2148.6	9.554	6.934	16.488	2.840
StDv-FSI				0.167	0.239	0.000	0.000	0.390								
%				34.3%	49.1%	0.0%	0.0%	80.1%								

Mean-FS	StDv-FS	Mean-lnFS	StDv-lnFS	Beta	Reliability
2.3881	0.4866	0.8502	0.2017	4.22	0.999951

Exhibit 3E-8

REL_03B.XLS

E. Reliability

E5. Hazard of Unsatisfactory Performance. Based on the calculations and data in the foregoing section, a hazard function for the miter gates has been estimated. In all of these calculations, we assume that 1977 is the year in which corrosion began. At this point in time, there is no degradation of the structure due to corrosion. Figure E-7 shows the reliability index, β, versus time. The index values, like the relevant data, begins in 1977 and progresses to the year 2038. As seen in the graphic, the index begins with a value of 4.99 and concludes at a value of 3.77.

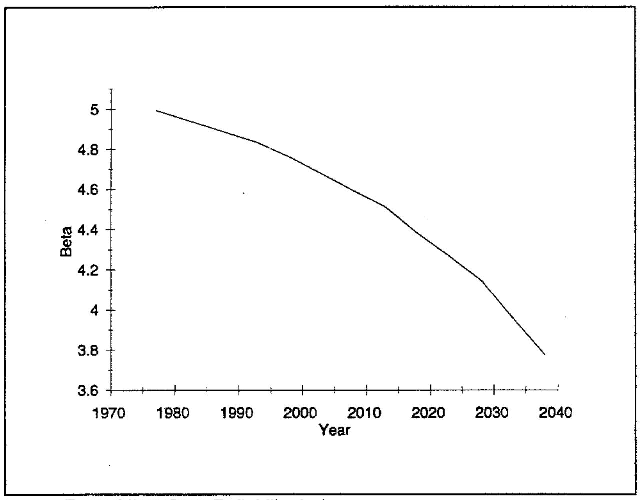


Figure E-7. Miter Gate Reliability Index.

Figure E-8 summarizes the computed values at a five-year increment from 1993 onward. Along the row of each year is given the reliability index, β, reliability, R, and time of corrosion, t. This time of corrosion equals to the difference in the given year and the first year of corrosion, 1977. Following these inputs are the calculations needed for the determination of the Weibull constants - the logarithm of t and the logarithm of the logarithm of the inverse of R.

First Year: 1977

Year	Beta	R	t	ln t	ln(ln(1/r))	R(t)	h(t)	lin	Regression Output:	
1977	4.99423	1.000000	0						Constant	-24.389
1993	4.831	0.999999	16	2.77259	-14.185	1.000000	7.6E-08	-14.86	Std Err of Y Est	0.5139
1998	4.75932	0.999999	21	3.04452	-13.828	0.999999	1.5E-07	-13.925	R Squared	0.9071
2003	4.677	0.999999	26	3.25810	-13.424	0.999998	2.5E-07	-13.191	No. of Observations	10
2008	4.59223	0.999998	31	3.43399	-13.015	0.999997	3.8E-07	-12.586	Degrees of Freedom	8
2013	4.5114	0.999997	36	3.58352	-12.632	0.999994	5.5E-07	-12.072		
2018	4.37978	0.999994	41	3.71357	-12.021	0.999991	7.5E-07	-11.625	X Coefficient(s)	3.43703
2023	4.26719	0.999990	46	3.82864	-11.511	0.999987	9.9E-07	-11.23	Std Err of Coef.	0.38889
2028	4.14541	0.999983	51	3.93183	-10.973	0.999981	1.3E-06	-10.875		
2033	3.95592	0.999962	56	4.02535	-10.165	0.999974	1.6E-06	-10.554	Gamma	3.43703
2038	3.77442	0.999919	61	4.11087	-9.4226	0.999965	2.0E-06	-10.26	Theta	1207.06

Figure E-8. Spreadsheet for Miter Gate Reliability

On the far right side of Figure E-8, the results of the linear regression, Equation (E-20), of the input parameters is shown. In this regression, ln t serves as the independent variable and ln(ln(1/R)) serves as the dependent. The regression is performed for the data beginning in 1993 and ending in 2038. After the determination of the slope and intercept of this line, the Weibull constants γ = 3.4 and θ = 1207 years are determined. The value R(t) indicates the reliability value computed using the Weibull approximation; and h(t), the hazard value determined from the Weibull constants through Equation (E-19).

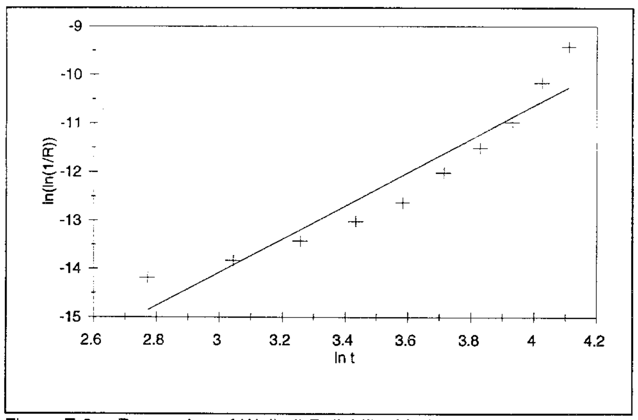


Figure E-9. Regression of Weibull Reliability Model.

Figure E-9 shows the linear approximation determined from the regression analysis of the input values. While some nonlinarity exists, the Weibull model explains 91% of the variability in the independent variable. This is quantified by the "R Squared" value in Figure E-8.

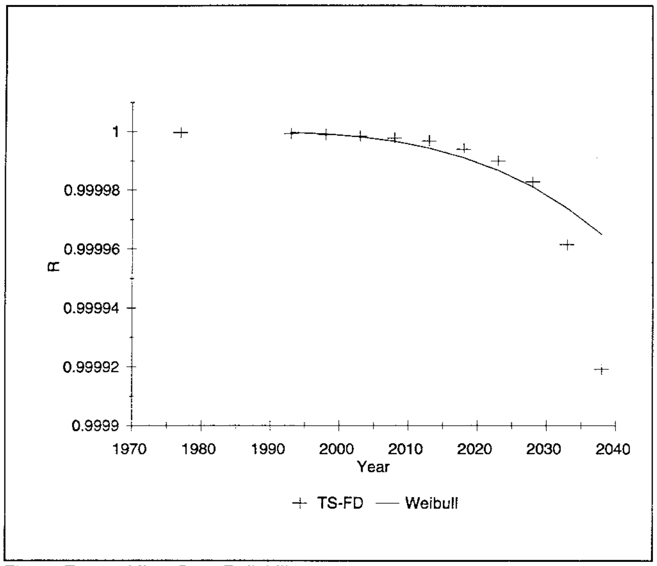


Figure E-10. Miter Gate Reliability.

Figure E-10 is a plot of reliability as determined by both the Taylor Series and the Weibull regression. Since the Weibull regression was begun with the 1993 data, it is only shown beginning in 1993. While the two curves diverge after the year 2028, the difference in magnitude is negligible.

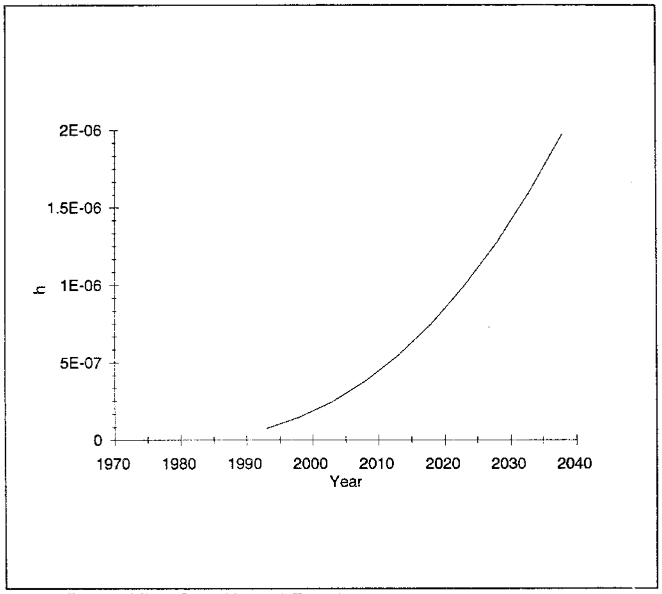


Figure E-11. Miter Gate Hazard Function.

Finally, Figure E-11 is the hazard function of the miter gates. Like the reliability calculations, the calculation of a hazard value is only shown beginning in 1993. Following 1993, the hazard function does increase as required by Equation (E-19). This increase is from 7.6×10^{-8} to 2×10^{-6}. This value of the hazard function in the year 2038 indicates 2 failures per million girders.

F. Summary

F1. Discussion of Results. The foregoing reliability analysis predicts relatively low hazard for the miter gates under normal operating conditions. As the continued corrosion of this structural element has been a matter of concern, this estimate warrants explanation. It should first be noted that this hazard has been calculated for pool elevations corresponding to historically observed normal operating conditions. These conditions represent an average head of only 48 feet in contrast to the flood head of 78 feet for which the miter gates were originally designed. Thus, even the corroded members have adequate resistance under normal loads. In addition, the District's aggressive program of inspection and maintenance of the gates has mitigated the effect of the continuing corrosion. While the estimated hazard is, in fact, the appropriate number for the economic simulation of repair alternatives, a number of other engineering considerations must be mentioned.

In this context, it is appropriate to examine the integrity of the miter gates with continued corrosion under the design flood conditions. Such an examination indicates that in the year 2004 the allowable stresses under current design criteria would, in fact, be exceeded. At that time, the miter gates will possess a smaller margin of safety than was intended in the design of the Kentucky Lock and Dam project. The recent 1993 flooding on the Upper Mississippi River System dramatized the importance of flood control structures performing their intended functions during extreme hydrological events.

As the Kentucky Lock and Dam project lies very close to the New Madrid fault zone, some consideration of the miter gates seismic resistance under continued corrosion is relavent. While the earthquake response of a miter gate is a complex structural and hydrodynamic phenomena, current practice assures their adequacy through a seismic coefficient analysis. Accordingly, less resistance would be provided by the deteriorated gates in the event of a major earthquake than is anticipated by current standards. The very recent earthquake in the San Fernando valley of California has underscored the importance of survivable lifelines in the reconstruction following devastating earthquakes. Some sources project a high probability of a major quake in the New Madrid area in the next 50 years.

Finally, it should be remembered that increasing traffic is going to eventually justify the construction of a second lock at the Kentucky Lock and Dam, and not the deterioration of the miter gates from corrosion by itself. Presently, the 600 foot chamber of this structure requires the inefficient and time consuming breaking of larger tows, which can transient the other locks on the waterways system in a single lockage. It is only a question of time when the delay costs associated with this short chamber will exceed the cost of another lock chamber at this bottleneck project. This is discussed in more detail in the sections of the reevaluation report dealing with economic considerations.

F2. Recommendations. Reliability and projected corrosion rates of the miter gates do not appear to justify lock outage for the sake of reducing the rate of corrosion. Corrosion rate projections are based on the current level of maintenance which should be continued. If the current level of maintenance is reduced it would be expected that the rate of gate corrosion would increase to approximately that experienced on the Mississippi River structures, which is roughly ten times higher than these gates. The reduced maintenance would lead to early replacement of the gates. When time to do surface preparation and painting is available during other lock outages an emphasis on quality workmanship should be stressed so areas worked on will not require additional work in a few short years.

In future years if a lock outage is required for other work which would allow adequate surface preparation and painting to stop corrosion, it should be performed so as to not interfere with the other work.

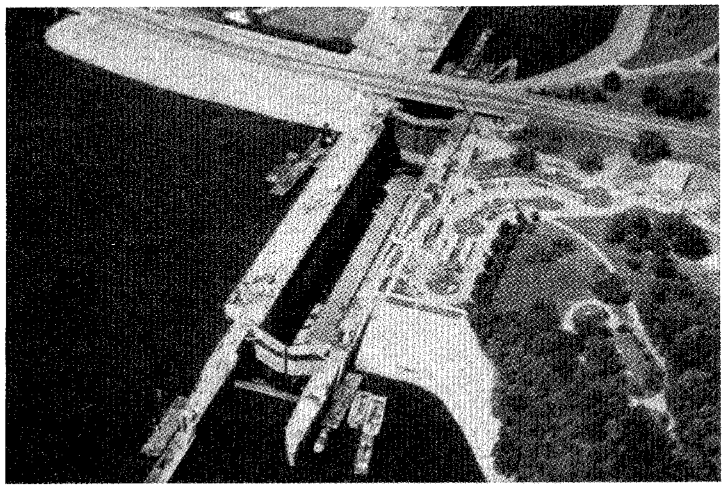
When the miter gates deteriorate to the state of being a dam safety concern they will likely have to be replaced. A second corrosion investigation prior to that time will probably be necessary to establish a better projection of deterioration than is available with a single investigation.

Routine maintenance of the electrical systems, mechanical systems and culvert valves appears to be satisfactory so as to cause minimal lock service disruptions.

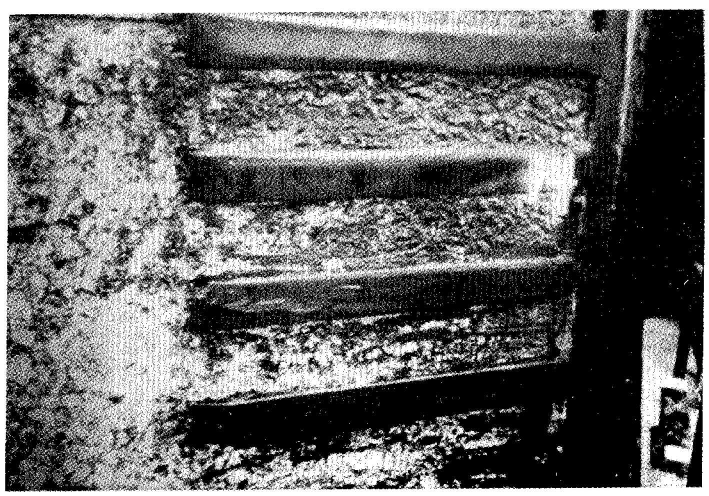
Lock walls and embedded metals are an operational concern and will continue to require routine repair work to correct safety problems. At some point in time the walls and metals will require a more substantial repair when operational efficiencies or protection of appurtenance features (gates, bits, line hooks or unwatering recesses), necessary to operate the lock, justify the work.

4. PHOTOGRAPHS

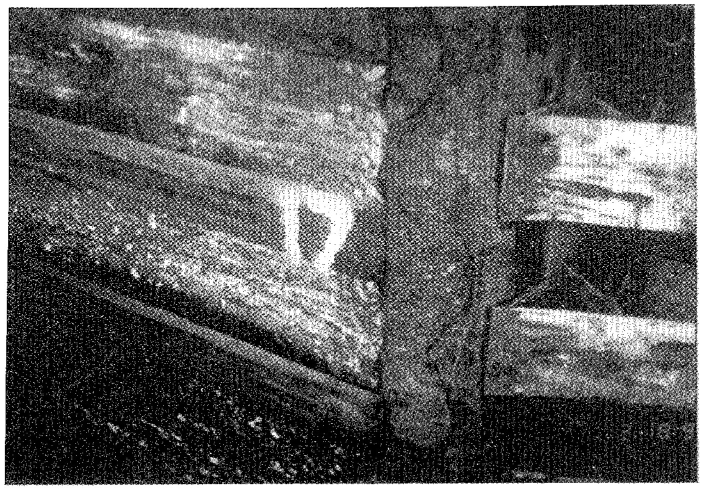
Following this page.



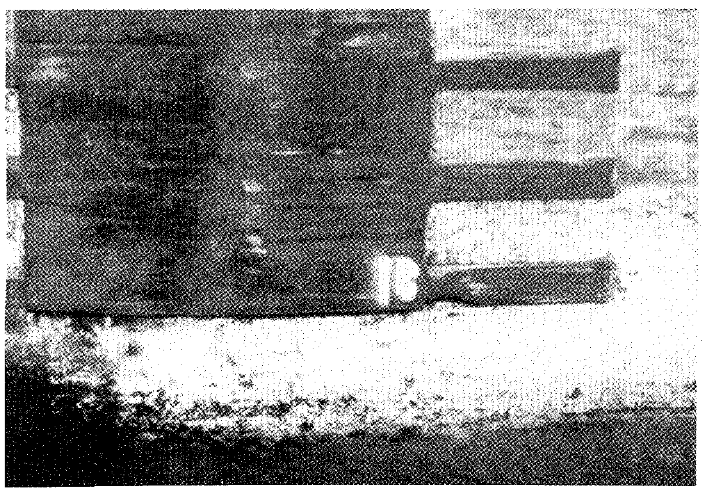
Aerial View of Kentucky Lock During Major Maintenance



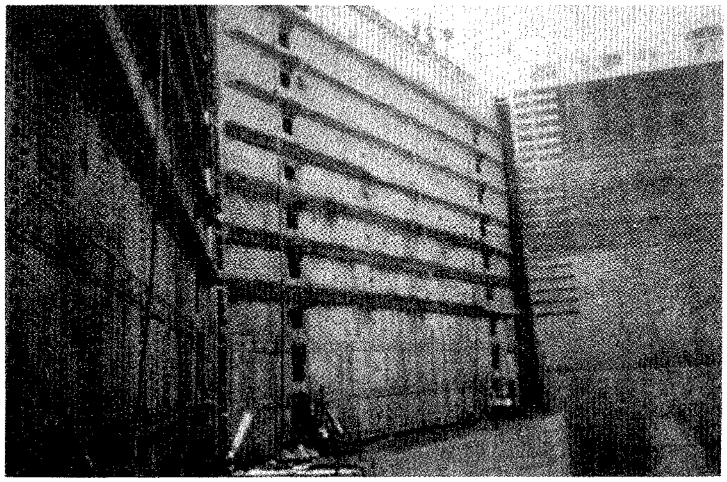
Typical Concrete and Armor Wear



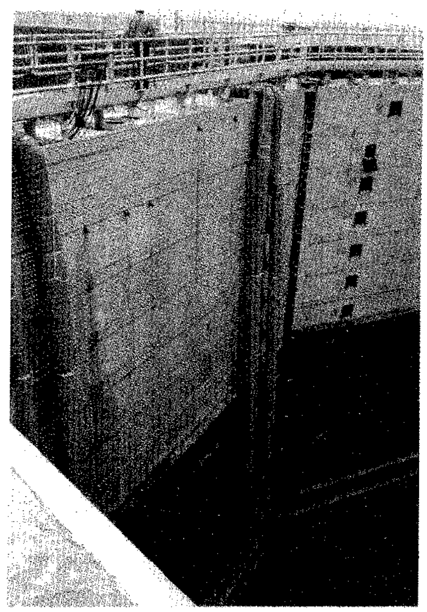
Damaged Concrete and Armor at Recess



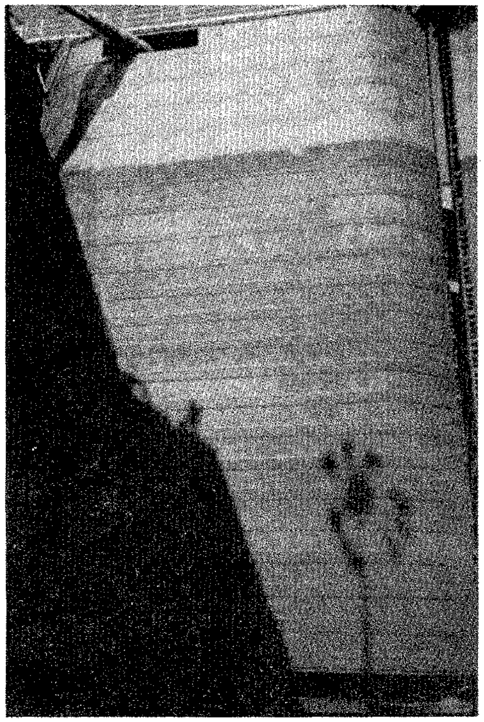
Damaged Concrete at Guard Walls



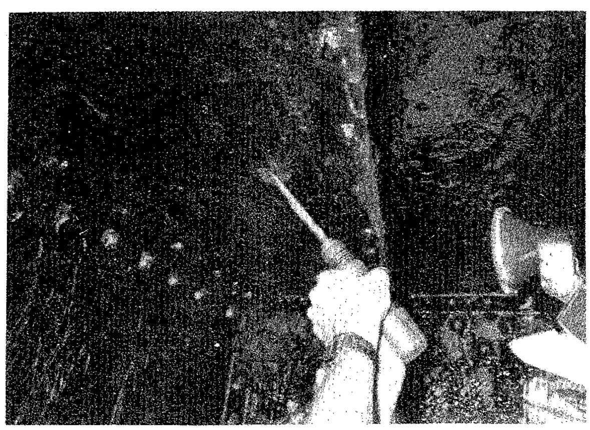
Upper Miter Gate, Downstream View
Fenders Under Repair



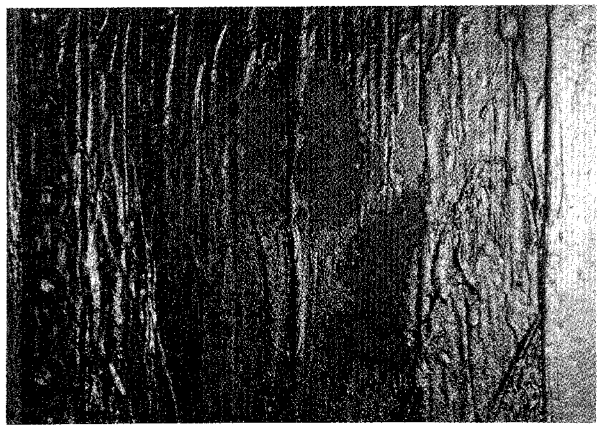
Lower Miter Gate
Downstream View
Ventilators in Use
For Work Inside Gate



Lower Miter Gate
Chamber Side
Unwatered During
Major Maintenance

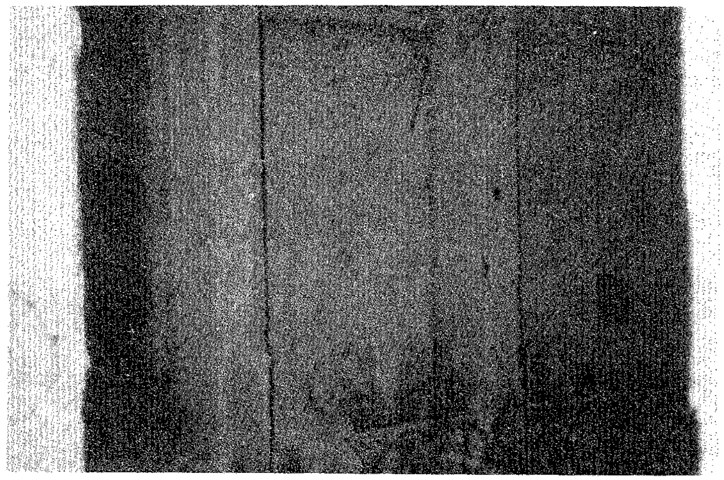


Inside Gate, Removing Bitumastic Coating
Underside of Web for Thickness Measurement



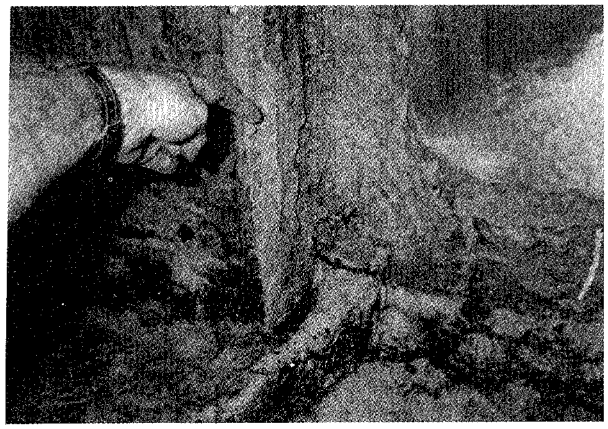
Inside Gate, Skin Plate Corrosion

Inside Gate, Web Corrosion

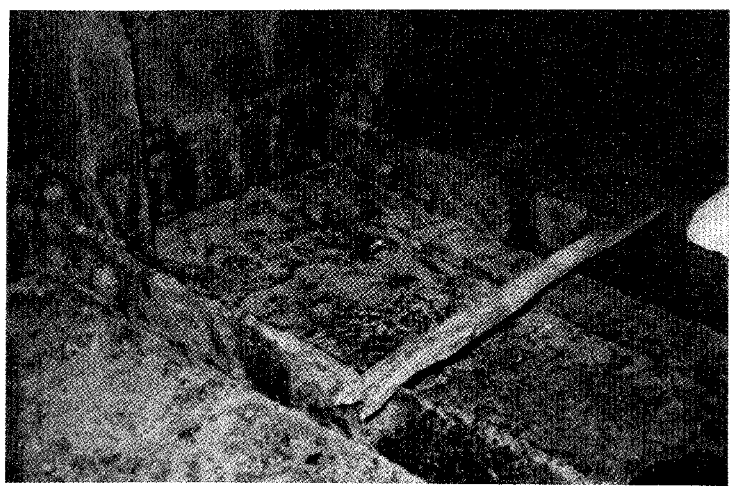


Inside Gate, Skin Plate and Intercostal Corrosion

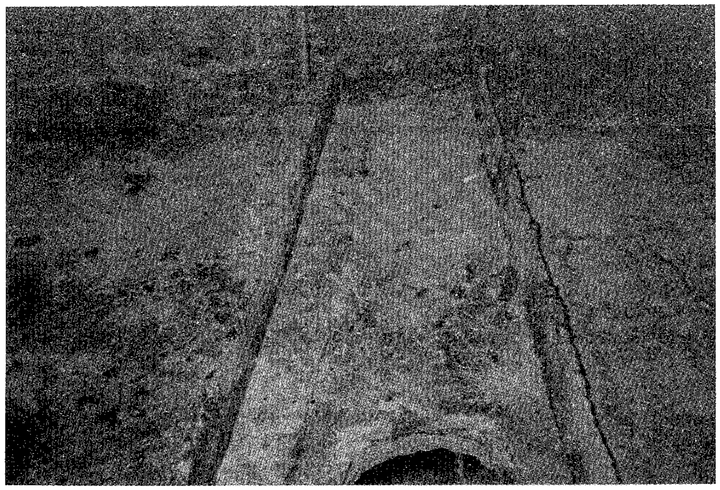
Inside Gate, Web Stiffener Angle
Corroded Thru



Inside Gate, General Corrosion



Inside Gate, Skin Plate, Web and Stiffener Corrosion



Inside Gate, Web and Stiffener Corrosion
at Miter End of Girder

Inside Gate, Rivet Heads
Protective Coating Gone and Heads Rusting Away

APPENDIX B

ORD NAVIGATION PLANNING CENTER REPORT

US Army Corps
of Engineers
Huntington District

Ohio River Division Navigation Planning Center

KENTUCKY LOCK ADDITION
LIMITED RE-EVALUATION REPORT

January 1994

KENTUCKY LOCK ADDITION
LIMITED RE-EVALUATION REPORT

1. INTRODUCTION

This report examines the impact of not rehabilitating the concrete and wall armor at Kentucky Lock as envisioned under the without-project condition defined in the feasibility report. In the absence of such rehabilitation, tows would have to be more cautious during entry and exit of the lock chamber in order to avoid a potential accident. The increased lockage time would translate directly into reduced lock efficiency and lower navigation benefits for the existing project. This new condition is referred to as the "base case condition" in this report. The magnitude of the economic effects are documented by comparing the performance of the Kentucky-Barkley system under the base case condition to the without-project condition presented in the feasibility report. Due to a change in the closure schedule for Kentucky, a revised without project condition was formed using the base case and the feasibility without project condition. This revised without project condition and its performance characteristics are discussed in this report.

2. IMPACT OF DECLINING LOCK EFFICIENCY

a. Methodology. The impacts of the declining lock efficiency were estimated by reanalyzing the capacity and tonnage-delay characteristics for Kentucky Lock in the absence of the rehabilitation. These revised curves were then used in the Equilibrium Model to estimate system traffic levels, lock delays and system transportation rate savings. All other data inputs were exactly the same as used in defining the without-project condition for the feasibility report.

b. Lock Capacity. Capacity and tonnage-delay characteristics of Kentucky Lock under the base case condition were developed using the Waterway Analysis Model (WAM). Revised lockage times were estimated by the Nashville District based on the degree of physical degradation of the concrete and wall armor. After discussion and direct observation of tows entering, locking, and exiting the lock, it was determined that a 30 percent increase in all lockage time components except the upbound long approach and the downbound long exit would be the result of damaged armor and concrete. The times for the upbound long approaches and the downbound long exits were based on an 1800-foot approach or exit. Only 600 feet of this distance is applicable to armor or concrete protection, the remaining 1200 feet is open water. This was taken into consideration by increasing these component times by 10 percent (one-third of 30). Additionally, the empty chamber turnback portion of the chambering time for double lockages was not increased. **TABLE 1** shows the mean lockage time components used in the capacity study.

WAM capacity-delay curves were developed for Kentucky Lock to reflect this degradation in service with Barkley open and Barkley closed. The capacity results and average processing times for the without-project and base case conditions with Barkley Lock open and closed are summarized in **TABLE 2**. **FIGURES 1 and 2** compare the old and new capacity-delay curves showing effects of degradation.

TABLE 1

Kentucky Lock Re-evaluation
Mean Lockage Time Components
(Minutes)

Lockage Type	Direction	Approach Long	Approach Short	Entry	Chamber	Exit Long	Exit Short
Without-Project Condition							
Single	Up	16.2	3.9	8.2	16.5	7.4	6.0
Single	Down	12.7	3.5	8.0	16.6	9.3	7.5
Double	Up	28.8	8.1	22.2	80.2	7.4	6.0
Double	Down	19.0	5.4	17.3	68.9	9.3	7.5
Base Case Condition							
Single	Up	17.8	5.1	10.7	21.4	9.6	7.9
Single	Down	16.5	4.5	10.4	21.6	10.3	9.7
Double	Up	31.6	10.5	28.8	102.5	9.6	7.9
Double	Down	24.7	7.1	22.5	85.6	10.3	9.7

TABLE 2

Kentucky Lock Re-evaluation
Capacities and Processing Times

Condition	Capacity (Million Tons)	Processing Times (Hours)
Barkley Open		
Without-Project	43.6	1.6
KY Base Case	35.2	2.0
Barkley Closed		
Without-Project	37.3	1.6
KY Base Case	30.1	2.0

FIGURE 1

Kentucky Lock Re-evaluation
Capacity-Delay Curves with Barkley Open

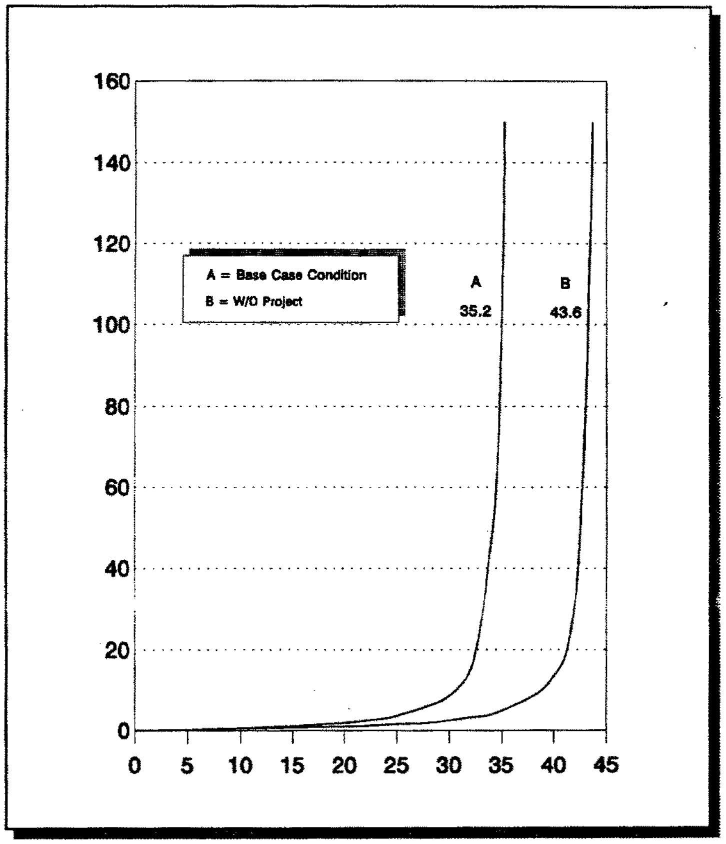
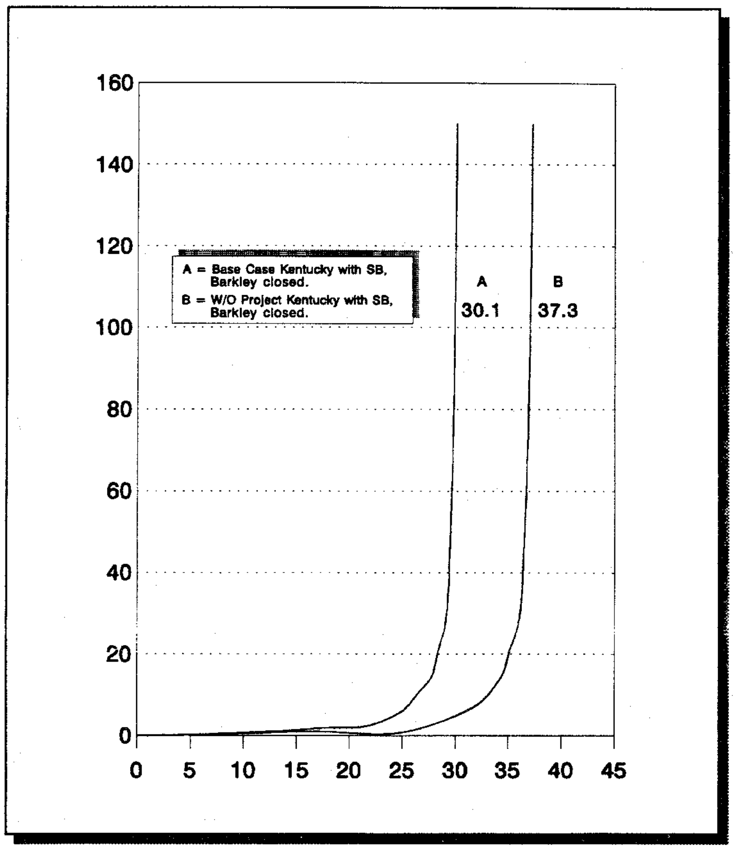


FIGURE 2

Kentucky Lock Re-evaluation
Capacity-Delay Curves with Barkley Closed



c. Traffic Accommodated. The volume of traffic that the Equilibrium Model indicates could move through the Kentucky-Barkley projects and on the Ohio River navigation system at a rate savings is shown in **TABLE 3**. Traffic levels for the base case condition, the without-project condition, the revised without-project condition and the recommended plan are presented for comparison purposes. The model shows no difference in traffic levels between the base case and without-project conditions until the year 2050, when 6.1 million tons of traffic would be diverted off the Kentucky-Barkley system under the base case. However, it is important to note that while the same level of traffic is accommodated from 2000 to 2040, there are significant shifts of traffic from Kentucky to Barkley because of the reduced capacity at Kentucky Lock.

TABLE 3

Kentucky Lock Re-evaluation
Waterway Traffic Accommodated
(Million Tons)

Year	Project(s)	Traffic Demand	Base-Case	Without Project	Revised Without Project	1200' Lock
2000	Kentucky	-----	31.1	37.7	31.1	43.6
	Barkley	-----	12.5	5.9	12.5	0.0
	Ky/Bk System	46.5	43.6	43.6	43.6	43.6
	ORS	288.4	276.1	276.1	276.1	276.1
2010	Kentucky	-----	31.4	38.9	31.4	47.9
	Barkley	-----	16.5	9.0	16.5	0.0
	Ky/Bk System	51.2	47.9	47.9	47.9	47.9
	ORS	321.4	304.4	304.4	304.4	304.4
2020	Kentucky	-----	31.6	39.2	39.2	51.4
	Barkley	-----	19.8	12.2	12.2	0.0
	Ky/Bk System	55.2	51.4	51.4	51.4	51.4
	ORS	347.6	325.3	325.3	325.3	325.3
2030	Kentucky	-----	33.0	39.9	39.9	59.6
	Barkley	-----	26.6	19.7	19.7	0.0
	Ky/Bk System	63.7	59.6	59.6	59.6	59.6
	ORS	400.0	370.0	370.0	370.0	370.0
2040	Kentucky	-----	33.9	40.5	40.5	66.9
	Barkley	-----	32.9	26.3	26.3	0.0
	Ky/Bk System	72.7	66.8	66.8	66.8	66.9
	ORS	447.8	406.0	406.0	406.0	406.0
2050	Kentucky	-----	34.9	42.2	42.2	75.7
	Barkley	-----	34.6	33.4	33.4	0.0
	Ky/Bk System	82.9	69.5	75.6	75.6	75.7
	ORS	501.2	439.2	445.3	445.3	445.3

d. Lock Delays. The projected lock delays under the base case condition, without project conditions and recommended plan are presented in **TABLE 4**. As would be expected, the shifts of traffic to the Barkley routing under the base case would result in increased delays at Barkley Lock and the lower Cumberland bends. In addition, the delays at Kentucky Lock would increase due to its' reduced capacity. In general, the decline in lockage efficiency under the base case would cause the without-project delay values to occur approximately ten years earlier.

TABLE 4

Kentucky Lock Re-evaluation
Tow Delays
(Hours per Tow)

Year	Project	Base-Case	Without Project	Revised Without Project	1200' Lock
2000	Kentucky	11.0	7.6	11.0	0.2
	Barkley	1.0	0.3	1.0	0.0
	LC Bends	1.0	0.5	1.0	0.0
2010	Kentucky	11.9	11.4	11.9	0.2
	Barkley	1.6	0.6	1.6	0.0
	LC Bends	1.3	0.7	1.3	0.0
2020	Kentucky	12.8	12.0	12.0	0.3
	Barkley	2.1	1.1	1.1	0.0
	LC Bends	1.6	1.1	1.1	0.0
2030	Kentucky	18.8	13.5	13.5	0.4
	Barkley	4.3	2.0	2.0	0.0
	LC Bends	1.8	1.6	1.6	0.0
2040	Kentucky	45.6	15.3	15.3	0.5
	Barkley	24.8	4.3	4.3	0.0
	LC Bends	2.3	1.7	1.7	0.0
2050	Kentucky	117.2	42.5	42.5	0.8
	Barkley	112.2	32.7	32.7	0.0
	LC Bends	2.5	2.4	2.4	0.0

e. System Rate Savings. System transportation savings for the base case, the feasibility report without-project condition, the revised without-project condition, and the recommended plan are presented in **TABLE 5**. Base case savings are less than the without-project conditions due to higher transportation costs that result from higher delays at Kentucky/Barkley and from the diversion of traffic to the lower Cumberland River.

The average annual values shown in the Table 5 are calculated by adjusting benefits during periods of normal operation to reflect the impact of periodic (routine) and major maintenance closures. The projected closure schedules are displayed in **Attachment A.** The major differences between closure schedules for the base case condition and the feasibility without-project condition, are the changes from four 91-day closures in 2006-2009 to one 56-day closure in 2007 and from four 98-day closures in 2038-2041 to two 130-day closures in 2040 and 2041. The major differences between closure schedules for the revised without-project condition and the base case condition are the same as those just mentioned except for the years 2006-2009 where four 91-day closures are replaced with two 130-day closures in 2009 and 2010. Benefits are annualized using standard discounting techniques, a 50 year project life, and a discount rate of 8.5 percent. Benefits are estimated over the 2005 through 2054 period with 2005 representing the base year for computing average annual equivalent benefits.

TABLE 5

Kentucky Lock Re-evaluation
System Rate Savings
(Million 1991 Dollars, 8.5 %)

Year	Base-Case	Without Project	Revised Without Project	1200' Lock
2000	3,222.0	3,227.6	3,222.0	3,245.0
2010	3,509.1	3,510.2	3,509.1	3,531.3
2020	3,761.9	3,763.7	3,763.7	3,787.3
2030	4,140.1	4,150.4	4,150.4	4,178.7
2040	4,389.6	4,461.0	4,461.0	4,498.7
2050	4,439.4	4,580.9	4,580.9	4,706.1
AAEB	3,659.5	3,656.6	3,660.3	3,706.2

3. UPDATED RATE SAVINGS

a. Interest Rate Adjustment. The average annual system savings for the base case condition, the without-project conditions and the recommended 1200-foot lock shown earlier in Table 5 are based on October 1991 prices and conditions and a discount rate of 8.5 percent. This is the price base and interest rate used in preparing the feasibility report. The discount rate dropped to 8.25 percent in FY 1993 and may fall again in FY 1994 to 8.0 percent. **TABLE 6** displays the average annual system savings at each of the three discount rates.

TABLE 6

Kentucky Lock Re-evaluated
Average Annual Benefits
(Million October 1991 Dollars)

Discount Rate	Base Case	Without-Project	Revised Without Project	1200' Lock
8.50%	3,659.5	3,656.6	3,660.3	3,706.2
8.25%	3,666.4	3,664.1	3,667.7	3,713.8
8.00%	3,673.5	3,671.8	3,675.3	3,721.7

b. Price Update. The benefits were updated to a 1993 price base using a transportation cost index[1] developed by WEFA. The index from 1991 to 1993 was calculated to be 1.0484. **TABLE 7** presents the updated values at discount rates of 8.5%, 8.25% and 8.0%.

TABLE 7

Kentucky Lock Re-evaluated
Average Annual Benefits
(Million 1993 Dollars)

Discount Rate	Base Case	Without-Project	Revised Without Project	1200' Lock
8.50%	3,836.6	3,833.6	3,837.5	3,885.6
8.25%	3,843.9	3,841.4	3,845.2	3,893.5
8.00%	3,851.3	3,849.5	3,853.2	3,901.8

1 US Long-Term Economic Outlook, WEFA, 3Q 1993.

KENTUCKY LOCK

LIMITED RE-EVALUATION REPORT

ATTACHMENT A

SCHEDULE OF MAINTENANCE CLOSURES

The following closure schedules were used to determine system benefits during periodic or routine maintenance closures and major rehabilitation closures. For this study, a major maintenance involves any chamber closed for 45 days or more. Periodic maintenance was defined as a closure of less than 45 days.

TABLE 1-A

Kentucky and Barkley Locks
Feasibility Without-Project Condition
Schedule of Periodic and Major Maintenance Closures

Year	Number of Days Closed: Existing Kentucky	Number of Days Closed: Existing Barkley
2000	0	14
2002	35	0
2005	0	21
2006	91	0
2007	91	0
2008	91	0
2009	91	0
2010	0	28
2012	14	0
2015	0	14
2017	21	0
2020	0	28
2022	56	0
2025	0	21
2027	21	0
2030	0	28
2032	28	0
2035	0	21
2037	21	0
2038	0	98
2039	0	98
2040	0	98
2041	0	98
2042	28	0
2045	0	14
2047	21	0
2050	0	56
2052	21	0
2055	0	21

Source: CEORN
Note: Years without major closures scheduled are not shown.

TABLE 2-A

Kentucky and Barkley Locks
Revised Without-Project Condition
Schedule of Periodic and Major Maintenance Closures

Year	Number of Days Closed	
	Existing Kentucky	Existing Barkley
2000	0	14
2002	35	0
2005	0	21
2006	0	0
2007	21	0
2008	0	0
2009	130	0
2010	130	28
2012	14	0
2015	0	14
2017	21	0
2020	0	28
2022	90	0
2025	0	21
2027	21	0
2030	0	28
2032	28	0
2035	0	21
2037	21	0
2038	0	0
2039	0	0
2040	0	130
2041	0	130
2042	28	0
2045	0	14
2047	21	0
2050	0	90
2052	21	0
2055	0	21

Source: CEORN
Note: Years without major closures scheduled are not shown.

TABLE 3-A

Kentucky and Barkley Locks
Base Case Condition
Schedule of Periodic and Major Maintenance Closures

Year	Number of Days Closed	
	Existing Kentucky	Existing Barkley
2000	0	14
2002	35	0
2005	0	21
2007	56	0
2010	0	28
2012	21	0
2015	0	14
2017	28	0
2020	0	28
2022	90	0
2025	0	21
2027	28	0
2030	0	28
2032	28	0
2035	0	21
2037	28	0
2038	0	0
2039	0	0
2040	0	130
2041	0	130
2042	28	0
2045	0	14
2047	28	0
2050	0	90
2052	28	0
2055	0	21

Source: CEORN
Note: Years without major closures scheduled are not shown.

TABLE 4-A

Kentucky and Barkley Locks
Additional 1200-Foot Lock Alternative
Schedule of Periodic and Major Maintenance Closures

Year	Number of Days Closed		
	Main Kentucky	Auxiliary Kentucky	Main Barkley
2000	0	0	14
2002	0	35	0
2005	0	0	21
2008	0	14	0
2014	0	130	0
2015	0	130	35
2016	14	0	0
2021	14	0	0
2022	0	90	0
2025	0	0	35
2026	14	0	0
2027	0	21	0
2031	21	0	0
2032	0	28	0
2035	0	0	21
2036	28	0	0
2037	0	21	0
2041	21	0	0
2042	0	28	0
2045	0	0	14
2046	21	0	0
2047	0	21	0
2051	21	0	0
2052	0	21	0

Source: CEORN
Note: Years without major closures scheduled are not shown.

APPENDIX C

DETAILED COST ESTIMATES

U.S. ARMY ENGINEER DISTRICT, NASHVILLE, TN 16-Feb-94
KENTUCKY LOCK, 110' X 1200'
MULTI-PORT FILLING & EMPTYING SYSTEM

PROJECT COST SUMMARY
ESCALATED TO OCTOBER 1, 1993 PRICE LEVEL

	ESTIMATED COST	CONTINGENCY	TOTAL COST
CONTRACT 1			
02.-.-.- RELOCATE CAMPING	1,283,503	256,701	1,540,204
CONTRACT 2			
01.-.-.- LAND ACQUISITION	978,880	244,720	1,223,600
CONTRACT 3			
18.-.-.- CULTURAL RESOURCES	425,600	106,400	532,000
CONTRACT 4			
06.-.-.- MUSSELL RELOCATION	85,120	21,280	106,400
CONTRACT 5			
02.-.-.- TOWER RELOCATION	4,622,727	2,128,000	6,750,727
CONTRACT 6			
02.1.-.- RELOCATE POWERHOUSE ACCESS	7,527,630	1,627,909	9,155,539
02.2.-.- RELOCATE RAILROAD	33,548,624	7,346,481	40,895,105
14.-.-.- BOAT RAMP & PARKING	357,190	71,438	428,628
CONTRACT 6 TOTAL	41,433,444	9,045,828	50,479,272
CONTRACT 7			
02.-.-.- RELOCATIONS	6,273,409	1,372,133	7,645,542
05.-.-.- LOCK CONSTRUCTION	266,991,667	56,471,406	323,463,073
14.-.-.- RECREATIONAL FACILITIES	126,777	25,355	152,132
19.-.-.- BLDGS, GROUNDS & UTILITIES	733,746	146,750	880,496
CONTRACT 7 TOTAL	274,125,599	58,015,644	332,141,243
TOTAL CONSTRUCTION COST	322,954,873	69,818,573	392,773,446
30.-.-.- ENGINEERING & DESIGN	37,178,330	8,967,073	46,145,403
31.-.-.- CONSTRUCTION MANAGEMENT	17,147,169	2,572,075	19,719,244
TOTAL PROJECT COST	$377,280,000	$81,360,000	$458,640,000

NOTE: This update deletes the cost of the training dike from the previous estimate.

Johnny E. Parham
Cost Engineer

Phil Mitchell 2/16/94
Phil Mitchell
Chief, Cost Engineering Branch

COST ESTIMATES
LIMITED REEVALUATION REPORT
KENTUCKY LOCK

GENERAL - The cost estimates for this report have been prepared as agreed to in the Revised Scope of Work. They also are prepared in accordance with EM 1101-2-1301 Revised, "Cost Estimates Planning and Design Stages". The cost account numbers in the estimate are in accordance with those prescribed in ER 11-2-240 and the standard code of accounts established in EC 1110-2-538 "Civil Works Project Cost Estimating-Code of Accounts". The price level base is October 1993.

The Estimates are for the following:

1. Cost to rehabilitate the interior of the existing lock wall using precast concrete panels anchored to the existing monoliths.

2. Cost to completely repaint the existing miter gates.

3. Cost to replace the existing miter gates with newly fabricated gates.

We determined it is not feasible to combine either gate project with the wall rehabilitation since the water level inside the lock will have to be constantly adjusted to most efficiently install the new panels from a floating plant.

Discussion of Wall Rehabilitation Estimate

This contract is assumed to be completed in two major sequences. Each sequence will rehabilitate half of each wall on opposite ends and opposite sides of the lock. This will allow for the greatest number of crews to work at one time as space will allow and minimize the time of each lock closure.

The first major item of work in each sequence is to drill the first 40 ft of lock wall. After drilling, the lock will have to be closed to traffic. The face of the first level is then blasted. The second level is drilled and blasted from a floating plant. After blasting is complete, the lock is dewatered and the base of the wall is dressed and the first two rows of precast panels are anchored and backfilled. The lock is then flooded and the remainder of the panels are placed from floating plant raising the water level as the rows of panels progress. The poured in place concrete is also formed and poured as the panels are put in place. After all panels are in place a floating plant using a clamshell loads all of the blast debris on a barge for disposal. The lock can be reopened after the debris is cleared.

Contingencies for the project are about 30%. The largest item of uncertainty is the final design of the panel system. The system used for this estimate is based on a design used for a lock with a shorter lift. The higher lift for this lock could affect the panel sizes, reinforcing, anchors etc. Additionally, the quantities of armor and other miscellaneous metals could change.

Discussion of Gate Painting Estimate

The painting estimate assumes there will be one painter working on the interior and exterior of each gate at all times. Since these gates are double skinned, it is not possible to safely have more than one person working in the gate at any time. This also necessitates the use of a spotter to keep air lines clear and monitor the worker in the gate at all times. We assumed the use of a three coat vinyl system for painting that has been successfully used in this area previously. Surface preparation will be a major problem for this job since the gates currently are coated with a thick bitumastic material that must be removed prior to application of the new system. We assumed one third of the surface area would have to be "air chiseled" to remove the bitumastic before sandblasting could begin. Sandblasting would then be to near white metal. Cleaning debris and blast material from the inside of the gates will also be slowed due to inaccessible vents for discharging the material.

Contingencies for this project are generally 30%. Major items affecting the contingency are uncertain production rates due to working in the confined spaces inside the gates and how much effort will be required to remove the above mentioned bitumastic material so the new paint system can be applied.

Discussion of Gate Replacement Estimate

Each set of gates will be replaced at separate times to insure no loss of pool in case of bulkhead failure during replacement. The gates will be fabricated and delivered in segments prior to closing the lock to traffic. The gate segments will be placed by a crane and floating plant operating from outside the bulkheads and one crane on each lock wall. The segments will be welded together as they are put in place. Placement of seals and adjustments will take place after the gate structure has been completed.

Contingencies for this project are generally 30%. The largest item of uncertainty is the final design of the gate. This will affect the cost from the fabricator because of weight changes and also greater or lesser weights will change the equipment required to install the gates.

CORPS OF ENGINEERS, U.S. ARMY
OHIO RIVER DIVISION

CEORN-EP-D Nashville District

COMPUTATION SHEET

PAGE 1 OF 3 PAGES

DATE 12/12/93

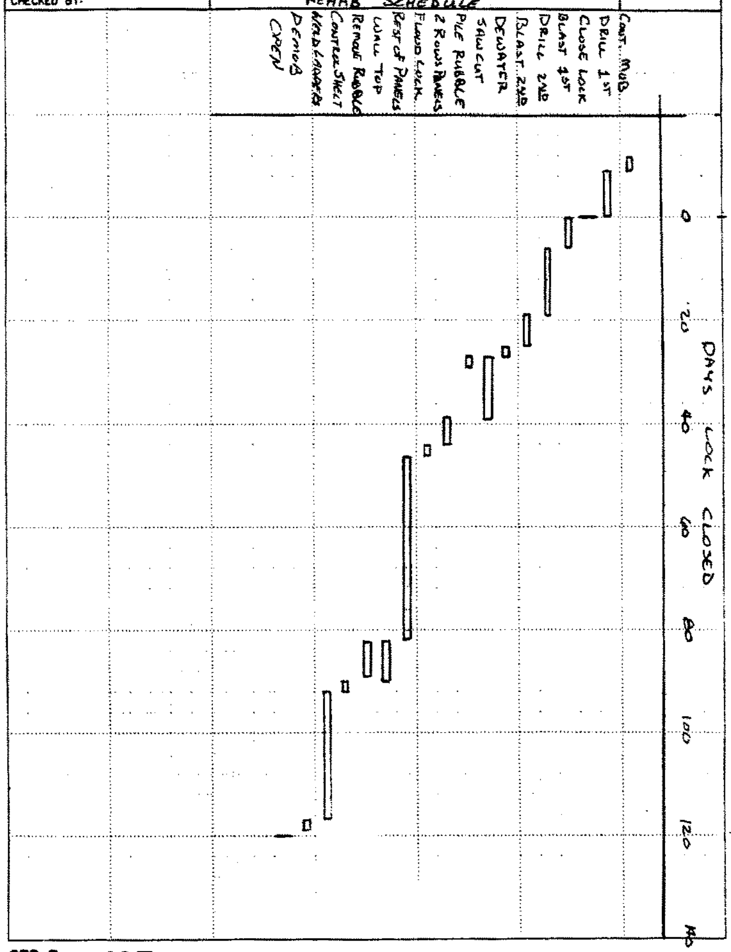
SUBJECT: KENTUCKY LOCK WALL REHAB

COMPUTED BY: JEP

CHECKED BY:

COMPUTATION: REHAB SCHEDULE

NUMBER



ORD Form 427
1 APR 83

CORPS OF ENGINEERS, U.S. ARMY OHIO RIVER DIVISION CEORN-EP-D Nashville District	COMPUTATION SHEET	PAGE 2 OF 3 PAGES DATE 12/17/93
	SUBJECT: KENTUCKY LOCK WALL REHAB	
COMPUTED BY: JEP	COMPUTATION: REHAB SCHEDULE	NUMBER
CHECKED BY:		

WORK ITEM	QUANTITY	PRODUCTION	TOTAL CREW TIME	CONTRACT DURATION
CONTRACTOR MOB	1			3 DAYS
DRILL 1ST LEVEL	32,800 LF	39.38 LF/HR	833 HRS	208 HRS (9 DAYS)
* CLOSE LOCK TO TRAFFIC				0
LOAD & BLAST 1ST LEVEL	32,800 LF	59 LF/HR	556 HRS	140 HRS (6 DAYS)
DRILL 2ND LEVEL	32,800 LF	30 LF/HR	1093 HRS	275 HRS (13 DAYS)
LOAD & BLAST 2ND LEVEL	32,800 LF	59 LF/HR	556 HRS	140 HRS (6 DAYS)
DEWATER LOCK				4 DAYS
SAWCUT BOTTOM	1200 LF	1.13/LF/HR	1062 HRS	265 HRS (12 DAYS)
STOCK PILE RUBBLE	6000 CY	40/CY/HR	150 HRS	40 HRS (2 DAYS)
SET 2 ROWS OF PANELS				5 DAYS
FLOOD LOCK				2 DAYS
PLACE REMAINING PANELS				35 DAYS
PLACE TOP OF WALL				178 HRS 8(DAYS)
REMOVE RUBBLE	6000 CY	20 CY/HR	300 HRS	150 HRS 7(DAYS)
REPLACE CONTROLS ETC				2 DAYS
WELD LADDERS & ARMOR	330,000 lbs	75 lb/HR	4400 HR	SAY 25 DAYS
DEMOB & TOUCHUP				2 DAYS
OPEN TO TRAFFIC				

ORD Form 427
1 APR 83

CORPS OF ENGINEERS, U.S. ARMY OHIO RIVER DIVISION	COMPUTATION SHEET	PAGE 3 OF 3 PAGES
CEORN-EP-D Nashville District	SUBJECT: KENTUCKY LOCK WALL REHAB	DATE 12/17/93
COMPUTED BY: JEP	COMPUTATION: REHAB SCHEDULE	NUMBER
CHECKED BY:		

TIME TO PLACE EACH ROW OF PANELS & FORM & POUR CIP CONCRETE

EACH CREW WILL PLACE 7 Panels /ROW

EACH ROW REQUIRES AVG OF 150 ANCHORS

DRILL & SET ANCHORS 150 @ 6/HR 25 HRS = 3.5 HR / PANEL

PLACE, LEVEL & WELD PANELS 7 @ 2 HR/EA 14 HRS

BACKFILL PANELS 1 HR/EA : 7 HRS

Assuming LAST 2 Panels Are Placed After Drilling

Total Time for Row is 25 HRS + 6 HRS = 31 HRS.

To FORM & POUR CIP Concrete and set Wall Armor & Ladders as each row goes up.

Forming from MCACES Production Requires 20 HRS /ROW

(Includes Armor Anchors)

Pour CIP Concrete 3 HRS / ROW

23 HRS / ROW

TOTAL = 54 HRS / ROW

SAY 2.5 DAYS PER ROW TO ALLOW FOR DELAYS

ORD Form 427
1 APR 83

Rehab KY Lock Wall
Limited Reevaluation
Report

Designed By: Nashville District, COE
Estimated By: Nashville District, COE

Prepared By: Johnny E. Parham

Date: 12/15/93

SUMMARY REPORTS SUMMARY PAGE

DETAILED ESTIMATE DETAIL PAGE

BACKUP REPORTS BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - LEVEL 4 **

		QUANTY UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
05 Locks							
05.01 Mob & Demob							
05.01. 1 Mob & Demob (Dewater Lock)							
	Mob & Demob (Dewater Lock)	2.00 EA	400,000	100,000	0	500,000	250000
05.01. 2 Mob & Demob (Contractor)							
	Mob & Demob (Contractor)	2.00 EA	200,000	50,000	0	250,000	125000
	Mob & Demob	2.00 EA	600,000	150,000	0	750,000	375000
05.63 Lock Structure							
05.63.03 Concrete							
05.63.03.01	Drill First Level	32800 LF	207,401	62,220	0	269,621	8.22
05.63.03.02	Remove Control Shelters etc.		733	220	0	953	
05.63.03.03	Load & Blast 1st Level		157,977	47,393	0	205,369	
05.63.03.04	Drill 2nd Level	32800 LF	303,754	91,126	0	394,881	12.04
05.63.03.05	Load & Blast 2nd Level		157,977	47,393	0	205,369	
05.63.03.06	Dress Face of Wall		41,019	12,306	0	53,325	
05.63.03.07	Stockpile Rubble in Pit Center	6000.00 CY	18,393	5,518	0	23,911	3.99
05.63.03.08	Set Concrete Anchors	9600.00 EA	435,667	130,700	0	566,367	59.00
05.63.03.09	Place Precast Panels	208.00 EA	1,826,204	547,861	0	2,374,065	11414
05.63.03.10	Form & Pour Mooring/Ladder Wells	520.00 CY	301,950	90,585	0	392,536	754.88
05.63.03.11	Pour Wall Top	250.00 CY	56,868	17,066	0	73,954	295.82
05.63.03.12	Remove Rubble	6000.00 CY	178,601	53,580	0	232,181	38.70
05.63.03.14	Replace Shelters etc.		733	220	0	953	
	Concrete		3,687,297	1,106,189	0	4,793,486	
05.63.05 Metals							
05.63.05.01	Replace Misc. Metals	300000 LBS	1,642,411	492,723	0	2,135,135	7.12
05.63.05.03	Install New Armor	330000 LBS	1,806,652	541,996	0	2,348,648	7.12
	Metals		3,449,064	1,034,719	0	4,483,783	
	Lock Structure		7,136,360	2,140,908	0	9,277,268	
	Locks		7,736,360	2,290,908	0	10,027,268	

	QUANTY	UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
30 Engineering & Design							
30. 1 Engineering & Design							
Engineering & Design			900,000	270,000	0	1,170,000	
Engineering & Design			900,000	270,000	0	1,170,000	
31 Supervision & Administration							
31. 1 Supervision & Administration							
Supervision & Administration			500,000	150,000	0	650,000	
Supervision & Administration			500,000	150,000	0	650,000	
Rehab KY Lock Wall			9,136,360	2,710,908	0	11,847,268	

Johnny E. Parham
Cost Engineer

1/3/94
Phil Mitchell
Chief, Cost Engineering Branch

		QUANTY UOM	DIRECT	OVERHEAD	PROFIT	BOND	TOTAL COST	UNIT
05 Locks								
05.01 Mob & Demob								
05.01. 1 Mob & Demob (Dewater Lock)								
	Mob & Demob (Dewater Lock)	2.00 EA	400,000	0	0	0	400,000	200000
05.01. 2 Mob & Demob (Contractor)								
	Mob & Demob (Contractor)	2.00 EA	200,000	0	0	0	200,000	100000
	Mob & Demob	2.00 EA	600,000	0	0	0	600,000	300000
05.63 Lock Structure								
05.63.03 Concrete								
05.63.03.01	Drill First Level	32800 LF	163,282	24,492	18,777	850	207,401	6.32
05.63.03.02	Remove Control Shelters etc.		577	87	66	3	733	
05.63.03.03	Load & Blast 1st Level		124,371	18,656	14,303	647	157,977	
05.63.03.04	Drill 2nd Level	32800 LF	239,138	35,871	27,501	1,244	303,754	9.26
05.63.03.05	Load & Blast 2nd Level		124,371	18,656	14,303	647	157,977	
05.63.03.06	Dress Face of Wall		32,294	4,844	3,714	168	41,019	
05.63.03.07	Stockpile Rubble in Pit Center	6000.00 CY	14,480	2,172	1,665	75	18,393	3.07
05.63.03.08	Set Concrete Anchors	9600.00 EA	342,990	51,448	39,444	1,785	435,667	45.38
05.63.03.09	Place Precast Panels	208.00 EA	1,437,725	215,659	165,338	7,481	1,826,204	8779.83
05.63.03.10	Form & Pour Mooring/Ladder Wells	520.00 CY	237,718	35,658	27,338	1,237	301,950	580.67
05.63.03.11	Pour Wall Top	250.00 CY	44,787	6,718	5,150	233	56,888	227.55
05.63.03.12	Remove Rubble	6000.00 CY	140,608	21,091	16,170	732	178,601	29.77
05.63.03.14	Replace Shelters etc.		577	87	66	3	733	
	Concrete		2,902,918	435,438	333,836	15,105	3,687,297	
05.63.05 Metals								
05.63.05.01	Replace Misc. Metals	300000 LBS	1,293,030	193,955	148,698	6,728	1,642,411	5.47
05.63.05.03	Install New Armor	330000 LBS	1,422,333	213,350	163,568	7,401	1,806,652	5.47
	Metals		2,715,363	407,304	312,267	14,129	3,449,064	
	Lock Structure		5,618,281	842,742	646,102	29,235	7,136,360	
	Locks		6,218,281	842,742	646,102	29,235	7,736,360	

	QUANTY UOM	DIRECT	OVERHEAD	PROFIT	BOND	TOTAL COST	UNIT
30 Engineering & Design							
30. 1 Engineering & Design							
Engineering & Design		900,000	0	0	0	900,000	
Engineering & Design		900,000	0	0	0	900,000	
31 Supervision & Administration							
31. 1 Supervision & Administration							
Supervision & Administration		500,000	0	0	0	500,000	
Supervision & Administration		500,000	0	0	0	500,000	
Rehab KY Lock Wall		7,618,281	842,742	646,102	29,235	9,136,360	
Contingency						2,710,908	
TOTAL INCL OWNER COSTS						11,847,268	

		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
05 Locks									
05.01 Mob & Demob									
05.01. 1 Mob & Demob (Dewater Lock)									
	Mob & Demob (Dewater Lock)	2.00	EA	0	0	0	400,000	400,000	200000
05.01. 2 Mob & Demob (Contractor)									
	Mob & Demob (Contractor)	2.00	EA	0	0	0	200,000	200,000	100000
	Mob & Demob	2.00	EA	0	0	0	600,000	600,000	300000
05.63 Lock Structure									
05.63.03 Concrete									
05.63.03.01	Drill First Level	32800	LF	29,572	42,269	91,440	0	163,282	4.98
05.63.03.02	Remove Control Shelters etc.			563	14	0	0	577	
05.63.03.03	Load & Blast 1st Level			30,452	8,043	85,877	0	124,371	
05.63.03.04	Drill 2nd Level	32800	LF	71,570	76,129	91,440	0	239,138	7.29
05.63.03.05	Load & Blast 2nd Level			30,452	8,043	85,877	0	124,371	
05.63.03.06	Dress Face of Wall			23,824	8,469	0	0	32,294	
05.63.03.07	Stockpile Rubble in Pit Center	6000.00	CY	10,572	3,908	0	0	14,480	2.41
05.63.03.08	Set Concrete Anchors	9600.00	EA	123,648	87,054	132,288	0	342,990	35.73
05.63.03.09	Place Precast Panels	208.00	EA	175,610	91,451	1,170,664	0	1,437,725	6912.14
05.63.03.10	Form & Pour Mooring/Ladder Wells	520.00	CY	131,579	9,679	96,460	0	237,718	457.15
05.63.03.11	Pour Wall Top	250.00	CY	20,746	429	23,612	0	44,787	179.15
05.63.03.12	Remove Rubble	6000.00	CY	34,026	70,582	0	36,000	140,608	23.43
05.63.03.14	Replace Shelters etc.			563	14	0	0	577	
	Concrete			683,177	406,084	1,777,658	36,000	2,902,918	
05.63.05 Metals									
05.63.05.01	Replace Misc. Metals	300000	LBS	253,980	5,550	1,033,500	0	1,293,030	4.31
05.63.05.03	Install New Armor	330000	LBS	279,378	6,105	1,136,850	0	1,422,333	4.31
	Metals			533,358	11,655	2,170,350	0	2,715,363	
	Lock Structure			1216535	417,739	3,948,008	36,000	5,618,281	
	Locks			1216535	417,739	3,948,008	636,000	6,218,281	

** PROJECT DIRECT SUMMARY - LEVEL 4 **

	QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
30 Engineering & Design								
30. 1 Engineering & Design								
Engineering & Design			0	0	0	900,000	900,000	
Engineering & Design			0	0	0	900,000	900,000	
31 Supervision & Administration								
31. 1 Supervision & Administration								
Supervision & Administration			0	0	0	500,000	500,000	
Supervision & Administration			0	0	0	500,000	500,000	
Rehab KY Lock Wall			1216535	417,739	3,948,008	2,036,000	7,618,281	
Prime Contractor's Overhead							842,742	
SUBTOTAL							8,461,023	
Prime's Profit							646,102	
SUBTOTAL							9,107,125	
Prime Contractor's Bond							29,235	
TOTAL INCL INDIRECTS							9,136,360	
Contingency							2,710,908	
TOTAL INCL OWNER COSTS							11,847,268	

05.01. Mob & Demob	QUANTY UOM CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
05. Locks							
05.01. Mob & Demob							
The Dewater cost will not receive overhead and profit because this will be accomplished by in-house personnel. Actual dewatering will occur after the second level of drilling occurs since it is assumed this will be accomplished from a floating plant in the lock pit.							
Mob & Demob (Dewater Lock)			0	0	0	400,000	400,000
Mob & Demob (Contractor)			0	0	0	200,000	200,000
Mob & Demob			0	0	0	600,000	600,000

05.63. Lock Structure	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST

05.63. Lock Structure

05.63.03. Concrete

05.63.03.01. Drill First Level

Assume holes are spaced 18 inches on center. A total of 800 holes will have to be drilled to a depth of 41 ft for the first level for a total of 32,800 lf.

	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
USR AA Rock Rem Drill f/Pre-Splitting					0.90	1.29	2.79	0.00	4.98
	32800	LF	CLADH	39.38	29,572	42,269	91,440	0	163,282
Drill First Level					29,572	42,269	91,440	0	163,282

05.63.03.02. Remove Control Shelters etc.

	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
MIL AA Small Tools					0.00	1.39	0.00	0.00	1.39
	10.00	HR	XMIXX020	1.00	0	14	0	0	14
MIL AA Outside Electrician					23.17	0.00	0.00	0.00	23.17
	1.70	HR	X-ELECTRN	1.00	39	0	0	0	39
MIL AA Outside Electrician					22.67	0.00	0.00	0.00	22.67
	10.00	HR	X-ELECTRN	1.00	227	0	0	0	227
MIL AA Outside Laborer					14.85	0.00	0.00	0.00	14.85
	20.00	HR	X-LABORER	1.00	297	0	0	0	297
Remove Control Shelters etc.					563	14	0	0	577

05.63.03.03. Load & Blast 1st Level

	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
MIL AA Blasting for Pre-Splitting					0.93	0.25	2.62	0.00	3.79
	32800	LF	CLADF	59.00	30,452	8,043	85,877	0	124,371
Load & Blast 1st Level					30,452	8,043	85,877	0	124,371

05.63.03.04. Drill 2nd Level

	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
USR AA Rock Rem Drill f/Pre-Splitting					2.18	2.32	2.79	0.00	7.29
	32800	LF	XKYWH	30.00	71,570	76,129	91,440	0	239,138
Drill 2nd Level					71,570	76,129	91,440	0	239,138

05.63. Lock Structure	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
05.63.03.05. Load & Blast 2nd Level									
MIL AA Blasting for Pre-Splitting					0.93	0.25	2.62	0.00	3.79
	32800	LF	CLADF	59.00	30,452	8,043	85,877	0	124,371
Load & Blast 2nd Level					30,452	8,043	85,877	0	124,371
05.63.03.06. Dress Face of Wall Will require sawcutting length of the base and airhammer any uneven faces left from blasting.									
USR AA Air Hammer Surface					6546.00	6962.88	0.00	0.00	13508.88
	1.00	LS	XKYWH	0.01	6,546	6,963	0	0	13,509
L MIL AA Saw Cut Plain Concrete Walls					14.40	1.26	0.00	0.00	15.65
	1200.00	LF	ULABE	1.13	17,278	1,506	0	0	18,785
Dress Face of Wall					23,824	8,469	0	0	32,294
05.63.03.07. Stockpile Rubble in Pit Center									
USR AA Stockpile Rubble					1.76	0.65	0.00	0.00	2.41
	6000.00	CY	XKYWJ	40.00	10,572	3,908	0	0	14,480
Stockpile Rubble in Pit Center					10,572	3,908	0	0	14,480
05.63.03.08. Set Concrete Anchors Anchors are placed at 2' centers horizontally for every 5' row of panels. Therefore, 1200' requires 600 anchors per row at 16 rows for a total of 9600 anchors. Each anchor is 2.5' deep so 24,000 ft of drilling is required.									
USR AA Drill & Grout Concrete Anchors					12.88	9.07	13.78	0.00	35.73
	9600.00	EA	XKYWI	6.00	123,648	87,054	132,288	0	342,990
Set Concrete Anchors					123,648	87,054	132,288	0	342,990
05.63.03.09. Place Precast Panels									
USR AA Place Precast Wall Panels					364.02	174.71	4293.00	0.00	4831.73
	208.00	EA	XKYWG	0.50	75,716	36,341	892,944	0	1,005,001
B MIL AA Concrete Backfill					24.77	13.66	63.60	0.00	102.03
	3200.00	CY	ALABG	5.00	79,255	43,724	203,520	0	326,499

05.63. Lock Structure	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
B MIL AA Grout Backfill					41.28	22.77	148.40	0.00	212.45
	500.00	CY	ALABG	3.00	20,639	11,387	74,200	0	106,226
Place Precast Panels					175,610	91,451	1,170,664	0	1,437,725
05.63.03.10. Form & Pour Mooring/Ladder Wells									
MIL AA Forms for Poured Concrete					2.37	0.08	1.33	0.00	3.77
	46000	SF	ACARL	37.50	108,850	3,643	60,950	0	173,443
B MIL AA Pour Conc Wall,Crane & Bkt					20.64	11.39	63.60	0.00	95.63
	520.00	CY	ALABG	6.00	10,732	5,921	33,072	0	49,725
MIL AA Wall Finishes,Break Ties & Patch					0.26	0.00	0.05	0.00	0.32
	46000	SF	ACMAA	67.50	11,997	115	2,438	0	14,550
Form & Pour Mooring/Ladder Wells					131,579	9,679	96,460	0	237,718
05.63.03.11. Pour Wall Top									
CIV AA Forms, 1 Use					6.65	0.11	1.61	0.00	8.37
	2600.00	SF	ACARA	3.75	17,278	299	4,189	0	21,766
MIL AA Gr 50 Resteel,Bm,Clmn,Wall,#8					231.41	3.02	414.46	0.00	648.89
	8.50	TON	SIWRC	0.31	1,967	26	3,523	0	5,516
M MIL AA Pour Conc, Dir Chute					6.00	0.42	63.60	0.00	70.02
	250.00	CY	ALABE	13.13	1,500	104	15,900	0	17,505
Pour Wall Top					20,746	429	23,612	0	44,787
05.63.03.12. Remove Rubble									
USR AA Load onto Barge					5.67	11.76	0.00	0.00	17.43
	6000.00	CY	XXRAA	20.00	34,026	70,582	0	0	104,608
USR AA Disposal					0.00	0.00	0.00	6.00	6.00
	6000.00	CY		0.00	0	0	0	36,000	36,000
Remove Rubble					34,026	70,582	0	36,000	140,608
05.63.03.14. Replace Shelters etc.									
MIL AA Small Tools					0.00	1.39	0.00	0.00	1.39
	10.00	HR	XMIXX020	1.00	0	14	0	0	14

05.63. Lock Structure	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
MIL AA Outside Electrician					23.17	0.00	0.00	0.00	23.17
	1.70	HR	X-ELECTRN	1.00	39	0	0	0	39
MIL AA Outside Electrician					22.67	0.00	0.00	0.00	22.67
	10.00	HR	X-ELECTRN	1.00	227	0	0	0	227
MIL AA Outside Laborer					14.85	0.00	0.00	0.00	14.85
	20.00	HR	X-LABORER	1.00	297	0	0	0	297
Replace Shelters etc.					563	14	0	0	577
Concrete					683,177	406,084	1,777,658	36,000	2,902,918
05.63.05. Metals									
05.63.05.01. Replace Misc. Metals									
USR AA Misc. Metals					0.85	0.02	3.45	0.00	4.31
	300000	LBS	XIWSD	75.00	253,980	5,550	1,033,500	0	1,293,030
Replace Misc. Metals					253,980	5,550	1,033,500	0	1,293,030
05.63.05.03. Install New Armor									
USR AA Lock Armor					0.85	0.02	3.45	0.00	4.31
	330000	LBS	XIWSD	75.00	279,378	6,105	1,136,850	0	1,422,333
Install New Armor					279,378	6,105	1,136,850	0	1,422,333
Metals					533,358	11,655	2,170,350	0	2,715,363
Lock Structure					1216535	417,739	3,948,008	36,000	5,618,281
Locks					1216535	417,739	3,948,008	636,000	6,218,281

30. 1. Engineering & Design	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
30. Engineering & Design									
Approximately 12% of Contract Cost									
Engineering & Design					0	0	0	900,000	900,000
Engineering & Design					0	0	0	900,000	900,000

31. 1. Supervision & Administration	QUANTY UOM CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
31. Supervision & Administration							
Approximately 6% of Contract cost							
Supervision & Administration			0	0	0	500,000	500,000
Supervision & Administration			0	0	0	500,000	500,000
Rehab KY Lock Wall			1216535	417,739	3,948,008	2,036,000	7,618,281

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	ACARA	1 B-carpnter + Small Tools		PROD =	100%			CREW HOURS =	1387
MIL	B-CARPNTERL	Carpenters	1.00 HR	19.84	1.00	19.84			19.84
MIL	B-CARPNTERF	Carpenters	0.25 HR	20.34	0.25	5.08			5.08
MIL	XMIXX020	E Small Tools	0.31 HR	1.39			0.31	0.43	0.43
	TOTAL				1.25	24.92	0.31	0.43	25.35
	ACARL	4 B-carpnter + Misc Power Tools		PROD =	100%			CREW HOURS =	2453
MIL	B-CARPNTERL	Carpenters	2.00 HR	19.84	2.00	39.67			39.67
MIL	B-CARPNTERF	Carpenters	1.00 HR	20.34	1.00	20.34			20.34
MIL	B-CARPNTERA	Carpenters	1.00 HR	15.87	1.00	15.87			15.87
MIL	B-LABORER L	Laborer (Semi-Skilled)	1.00 HR	12.86	1.00	12.86			12.86
MIL	XMIXX010	E Misc. Power Tools	0.32 HR	5.85			0.32	1.87	1.87
MIL	XMIXX020	E Small Tools	0.79 HR	1.39			0.79	1.10	1.10
	TOTAL				5.00	88.74	1.11	2.97	91.71
	ACMAA	1 B-cemtfinr + Small Tools		PROD =	100%			CREW HOURS =	1363
MIL	B-CEMTFINRF	Cement Finishers	0.25 HR	14.48	0.25	3.62			3.62
MIL	B-CEMTFINRL	Cement Finishers	1.00 HR	13.98	1.00	13.98			13.98
MIL	XMIXX020	E Small Tools	0.12 HR	1.39			0.12	0.17	0.17
	TOTAL				1.25	17.60	0.12	0.17	17.77
	ALABE	4 B-laborer + 2 Electric Concrete Vibrators		PROD =	100%			CREW HOURS =	38
MIL	B-CEMTFINRL	Cement Finishers	1.00 HR	13.98	1.00	13.98			13.98
MIL	B-LABORER L	Laborer (Semi-Skilled)	4.00 HR	12.86	4.00	51.44			51.44
MIL	B-LABORER F	Laborer (Semi-Skilled)	1.00 HR	13.36	1.00	13.36			13.36
MIL	C65WC002	E CONC VIB.,HI-FREQ,INT,2-1/2"HD	2.00 HR	1.50			2.00	3.01	3.01
MIL	XMIXX020	E Small Tools	0.68 HR	1.39			0.68	0.95	0.95
MIL	G10HO004	E GEN SET, 5.5 KW, PORTABLE	1.00 HR	1.52			1.00	1.52	1.52
	TOTAL				6.00	78.77	3.68	5.48	84.25
	ALABG	6 B-laborer + 2 Electric Concrete Vibrators		PROD =	100%			CREW HOURS =	1787
MIL	B-CEMTFINRL	Cement Finishers	1.00 HR	13.98	1.00	13.98			13.98
MIL	B-LABORER L	Laborer (Semi-Skilled)	5.00 HR	12.86	5.00	64.29			64.29
MIL	B-LABORER F	Laborer (Semi-Skilled)	1.00 HR	13.36	1.00	13.36			13.36
MIL	B-EQOPRCRNL	Eq Oper, Crane/Shovl	1.00 HR	21.20	1.00	21.20			21.20
MIL	C65MS005	E CONCRETE VIBRATOR, 6.0"	2.00 HR	2.10			2.00	4.20	4.20
MIL	C80LI007	E CRANE,HYD,TRKMTD, 60T W/110'BOO	1.00 HR	54.13			1.00	54.13	54.13
MIL	XMIXX020	E Small Tools	0.68 HR	1.39			0.68	0.95	0.95
MIL	B-EQOPROILL	Eq Oper, Oilers	1.00 HR	11.00	1.00	11.00			11.00
MIL	A15XX009	E AIR COMPR, 250 CFM, 100 PSI	1.00 HR	8.65			1.00	8.65	8.65
MIL	A20XX002	E AIR HOSE, 1", 50', HARDROCK	1.00 HR	0.40			1.00	0.40	0.40
	TOTAL				9.00	123.84	5.68	68.32	192.15

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO. UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	CLADF	2 B-powdermn + 1-3 Ton Flatbed Truck			PROD = 100%			CREW HOURS =	2224
MIL	B-LABORER	L Laborer (Semi-Skilled)	2.00 HR	12.86	2.00	25.72			25.72
MIL	B-POWDERMNL	Powderman	2.00 HR	12.86	2.00	25.72			25.72
MIL	B-POWDERMNF	Powderman	0.25 HR	13.36	0.25	3.34			3.34
MIL	T40XX012	E TRUCK OPT,FLATBED, 8' x 9.0'	1.00 HR	0.47			1.00	0.47	0.47
MIL	T50GM008	E TRK,HWY,4X2 3500 PICKUP, 8600GV	0.25 HR	9.12			0.25	2.28	2.28
MIL	T50GM012	E TRK, HWY, 2 AXLE, 24000 GVW, 4X	1.00 HR	11.72			1.00	11.72	11.72
	TOTAL				4.25	54.78	2.25	14.47	69.24
	CLADH	1 B-eqoprmed + 1 Air Compressor, 750 Cfm			PROD = 100%			CREW HOURS =	1666
MIL	A15XX013	E AIR COMPR, 750 CFM, 100 PSI	1.00 HR	21.26			1.00	21.26	21.26
MIL	B-LABORER	L Laborer (Semi-Skilled)	0.50 HR	12.86	0.50	6.43			6.43
MIL	B-POWDERMNF	Powderman	0.25 HR	13.36	0.25	3.34			3.34
MIL	B-EQOPRMEDL	Eq Oper, Medium	1.50 HR	17.15	1.50	25.73			25.73
MIL	D10SU002	E DRILL,AIR TRACK,2.5- 4"DIA,12'F	1.00 HR	22.55			1.00	22.55	22.55
MIL	XMIXX020	E Small Tools	0.46 HR	1.39			0.46	0.64	0.64
MIL	T50GM008	E TRK,HWY,4X2 3500 PICKUP, 8600GV	0.25 HR	9.12			0.25	2.28	2.28
MIL	A20XX007	E AIR HOSE, 3.0", 50', HARDROCK	2.00 HR	2.01			2.00	4.02	4.02
	TOTAL				2.25	35.50	4.71	50.74	86.24
	SIWRC	3 B-rodman + Small Tools			PROD = 100%			CREW HOURS =	54
MIL	B-RODMAN	F Rodmen (reinforcing)	1.00 HR	18.45	1.00	18.45			18.45
MIL	B-RODMAN	L Rodmen (reinforcing)	3.00 HR	17.95	3.00	53.86			53.86
MIL	XMIXX020	E Small Tools	0.68 HR	1.39			0.68	0.95	0.95
	TOTAL				4.00	72.32	0.68	0.95	73.26
	ULABE	1 B-laborer + Misc. Power Tools			PROD = 100%			CREW HOURS =	2133
MIL	B-LABORER	L Laborer (Semi-Skilled)	1.00 HR	12.86	1.00	12.86			12.86
MIL	B-LABORER	F Laborer (Semi-Skilled)	0.25 HR	13.36	0.25	3.34			3.34
MIL	XMIXX010	E Misc. Power Tools	0.22 HR	5.85			0.22	1.29	1.29
MIL	XMIXX020	E Small Tools	0.09 HR	1.39			0.09	0.13	0.13
	TOTAL				1.25	16.20	0.31	1.41	17.61
	XIWSD	2 X-strsteel + Small Tools			PROD = 100%			CREW HOURS =	16800
MIL	XMIXX020	E Small Tools	1.00 HR	1.39			1.00	1.39	1.39
MIL	X-STRSTEELF	Outside Steel Worker	0.17 HR	25.15	0.17	4.28			4.28
MIL	X-STRSTEELA	Outside Steel Worker	1.00 HR	19.72	1.00	19.72			19.72
MIL	X-STRSTEELL	Outside Steel Worker	1.00 HR	24.65	1.00	24.65			24.65
MIL	X-LABORER	L Outside Laborer	1.00 HR	14.85	1.00	14.85			14.85
	TOTAL				3.17	63.50	1.00	1.39	64.89
	XKYWG	Place Precast Panels			PROD = 100%			CREW HOURS =	832
MIL *	C75PH010	E CRANE,HYD,SELF, 50 TON	1.00 HR	61.41			1.00	61.41	61.41
MIL *	W35XX007	E WELDER, 400 AMP W/2 AXLE TRLR	1.00 HR	4.95			1.00	4.95	4.95
MIL *	XMIXX010	E Misc. Power Tools	1.00 HR	5.85			1.00	5.85	5.85
MIL *	XMIXX020	E Small Tools	2.00 HR	1.39			2.00	2.78	2.78

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
MIL *	XX0XX005	E 100 To 300 Ton Barge	1.00	HR	12.37			1.00	12.37	12.37
MIL *	X-EQOPRHVYL	Outside Equip. Op. Heavy	1.00	HR	20.30	1.00	20.30			20.30
MIL *	X-EQOPROILL	Outside Oiler	1.00	HR	18.26	1.00	18.26			18.26
MIL *	X-LABORER L	Outside Laborer (Semi-Skilled)	8.00	HR	14.85	8.00	118.80			118.80
MIL *	X-STRSTEELL	Outside Steel Worker	1.00	HR	24.65	1.00	24.65			24.65
	TOTAL					11.00	182.01	6.00	87.36	269.37
	XKYWH	Drill 2nd Level of Wall			PROD =	100%			CREW HOURS =	2387
MIL *	A15XX013	E AIR COMPR, 750 CFM, 100 PSI	1.00	HR	21.26			1.00	21.26	21.26
MIL *	A20XX007	E AIR HOSE, 3", 50',HARDROCK	6.00	HR	2.01			6.00	12.07	12.07
MIL *	D10SU002	E DRILL,AIR TRACK,2.5- 4"DIA,12'F	1.00	HR	22.55			1.00	22.55	22.55
MIL *	XMIXX020	E Small Tools	1.00	HR	1.39			1.00	1.39	1.39
MIL	XX0XX005	E 100 To 300 Ton Barge	1.00	HR	12.37			1.00	12.37	12.37
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76
MIL *	X-LABORER L	Outside Laborer (Semi-Skilled)	2.00	HR	14.85	2.00	29.70			29.70
	TOTAL					4.00	65.46	10.00	69.63	135.09
	XKYWI	Drill and Set Anchors			PROD =	100%			CREW HOURS =	3200
MIL *	D10GD001	E DRILL,AIR TRACK,3.5"HOLE,12'FD	1.00	HR	19.39			1.00	19.39	19.39
MIL *	XX0XX005	E 100 To 300 Ton Barge	1.00	HR	12.37			1.00	12.37	12.37
MIL *	A15XX013	E AIR COMPR, 750 CFM, 100 PSI	1.00	HR	21.26			1.00	21.26	21.26
MIL *	XMIXX020	E Small Tools	1.00	HR	1.39			1.00	1.39	1.39
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	1.00	HR	17.88	1.00	17.88			17.88
MIL *	X-LABORER L	Outside Laborer (Semi-Skilled)	4.00	HR	14.85	4.00	59.40			59.40
	TOTAL					5.00	77.28	4.00	54.41	131.69
	XKYWJ	Move Rubble			PROD =	100%			CREW HOURS =	300
MIL *	L40FN001	E LDR,FE,WH, 16 CF	4.00	HR	6.51			4.00	26.06	26.06
MIL	X-EQOPRLT L	Outside Equip. Oper Light	4.00	HR	17.62	4.00	70.48			70.48
	TOTAL					4.00	70.48	4.00	26.06	96.54
	XXRAA	150 T Floating Crane & Tug Boat			PROD =	0.00%			CREW HOURS =	600
MIL	B25ES005	E BKT,CLAM,1-1/2CY,GEN PURP/SQNOS	1.00	HR	2.85			1.00	2.85	2.85
MIL	X-EQOPROILL	Outside Oiler	1.00	HR	18.26	1.00	18.26			18.26
MIL	XX0XX001	E 150ton Floating Crane 290hp W/2	1.00	HR	160.99			1.00	160.99	160.99
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76
MIL	XX0XX002	E 500 To 800hp Tug Boat	1.00	HR	53.07			1.00	53.07	53.07
MIL	XX0XX006	E 500 To 800 Ton Barge	1.00	HR	18.36			1.00	18.36	18.36
MIL *	X-LABORER L	Deckhands (semi-skilled)	4.00	HR	14.85	4.00	59.40			59.40
	TOTAL					7.00	113.42	4.00	235.27	348.69

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-CARPNTER	Carpenters	14.33	0.0%	21.4%	2.44	0.00	19.84	HR	05/01/92	19.84	11547
MIL	B-CEMTFINR	Cement Finishers	11.67	0.0%	19.8%	0.00	0.00	13.98	HR	05/01/92	13.98	3528
MIL	B-EQOPRCRN	Eq Oper, Crane/Shovl	15.08	0.0%	23.3%	2.61	0.00	21.20	HR	05/01/92	21.20	1787
MIL	B-EQOPRMED	Eq Oper, Medium	12.29	0.0%	22.0%	2.16	0.00	17.15	HR	05/01/92	17.15	2499
MIL	B-EQOPROIL	Eq Oper, Oilers	7.81	0.0%	22.0%	1.47	0.00	11.00	HR	05/01/92	11.00	1787
MIL	B-LABORER	Laborer (Semi-Skilled)	9.25	0.0%	21.5%	1.62	0.00	12.86	HR	05/01/92	12.86	21311
MIL	B-POWDERMN	Powdermen	9.50	0.0%	22.0%	1.27	0.00	12.86	HR	05/01/92	12.86	5420
MIL	B-RODMAN	Rodmen (reinforcing)	13.80	0.0%	30.1%	0.00	0.00	17.95	HR	05/01/92	17.95	218
MIL	X-ELECTRN	Outside Electrician	19.19	0.0%	0.0%	3.48	0.00	22.67	HR	10/29/93	22.78	47
MIL	X-EQOPRHVY	Outside Equip. Op. Heavy	15.85	0.0%	0.0%	4.45	0.00	20.30	HR	10/29/93	19.19	832
MIL	X-EQOPRLT	Outside Equip. Oper Light	13.17	0.0%	0.0%	4.45	0.00	17.62	HR	10/29/93	17.05	1200
MIL	X-EQOPRMED	Outside Equip. Op. Medium	13.43	0.0%	0.0%	4.45	0.00	17.88	HR	10/29/93	17.43	9173
MIL	X-EQOPROIL	Outside Oiler	13.81	0.0%	0.0%	4.45	0.00	18.26	HR	10/29/93	13.49	1432
MIL	X-LABORER	Outside Laborer (Semi-Skilled)	12.35	0.0%	0.0%	2.50	0.00	14.85	HR	10/29/93	11.84	43509
MIL	X-STRSTEEL	Outside Steel Worker	18.85	0.0%	0.0%	5.80	0.00	24.65	HR	10/29/93	18.82	37288

** EQUIPMENT BACKUP **

SRC	EQUIP ID	DESCRIPTION	DEPR	CAPT	FUEL	FOG	EQ REP	TR WR	TR REP	TOTAL	UOM	** TOTAL ** HOURS
MIL	A15XX009	AIR COMPR, 250 CFM, 100 PSI	2.05	0.72	2.80	0.7	2.24	0.04	0.01	8.65	HR	1787
MIL	A15XX013	AIR COMPR, 750 CFM, 100 PSI	4.88	1.73	7.08	1.9	5.35	0.19	0.03	21.26	HR	7253
MIL	A20XX002	AIR HOSE, 1", 50',HARDROCK	0.14	0.02			0.24			0.40	HR	1787
MIL	A20XX007	AIR HOSE, 3", 50',HARDROCK	0.71	0.08			1.22			2.01	HR	17652
MIL	B25ES005	BKT,CLAM,1-1/2CY,GEN PURP/SQNOSE	1.31	0.37			1.17			2.85	HR	600
MIL	C65MS005	CONCRETE VIBRATOR, 6.0"	0.43	0.06		0.1	1.46			2.10	HR	3573
MIL	C65WC002	CONC VIB.,HI-FREQ,INT,2-1/2"HD	0.27	0.04	0.10	0.1	0.91			1.50	HR	76
MIL	C75PH010	CRANE,HYD,SELF, 50 TON	19.74	8.03	6.96	2.0	20.64	3.43	0.52	61.41	HR	832
MIL	C80LI007	CRANE,HYD,TRKMTD, 60T W/110'BOOM	18.63	8.32	7.08	1.8	16.96	1.12	0.17	54.13	HR	1787
MIL	D10GD001	DRILL,AIR TRACK,3.5"HOLE,12'FD	7.05	2.19		0.7	9.36			19.39	HR	3200
MIL	D10SU002	DRILL,AIR TRACK,2.5- 4"DIA,12'FD	8.24	2.56		0.8	10.94			22.55	HR	4053
MIL	G10HO004	GEN SET, 5.5 KW, PORTABLE	0.22	0.05	0.88	0.2	0.16			1.52	HR	38
MIL	L40FN001	LDR,FE,WH, 16 CF	1.74	0.63	1.42	0.6	1.75	0.34	0.05	6.51	HR	1200
MIL	T40XX012	TRUCK OPT,FLATBED, 8' x 9.0'	0.23	0.06			0.18			0.47	HR	2224
MIL	T50GM008	TRK,HWY,4X2 3500 PICKUP, 8600GVW	1.30	0.34	4.66	1.3	1.27	0.21	0.03	9.12	HR	972
MIL	T50GM012	TRK, HWY, 2 AXLE, 24000 GVW, 4X2	2.57	0.76	4.32	1.1	2.36	0.51	0.08	11.72	HR	2224
MIL	W35XX007	WELDER, 400 AMP W/2 AXLE TRLR	0.77	0.26	2.36	0.5	0.92	0.06	0.01	4.95	HR	832
MIL	XMIXX010	Misc. Power Tools	1.95	0.70	0.55	0.2	2.41			5.85	HR	2086
MIL	XMIXX020	Small Tools	0.46	0.17	0.13	0.0	0.57			1.39	HR	28858
MIL	XX0XX001	150ton Floating Crane 290hp W/25	53.75	19.17	15.16	6.6	66.29			160.99	HR	600
MIL	XX0XX002	500 To 800hp Tug Boat	17.72	6.32	5.00	2.1	21.85			53.07	HR	600
MIL	XX0XX005	100 To 300 Ton Barge	4.13	1.47	1.17	0.5	5.09			12.37	HR	6419
MIL	XX0XX006	500 To 800 Ton Barge	6.13	2.19	1.73	0.7	7.56			18.36	HR	600

CORPS OF ENGINEERS, U.S. ARMY OHIO RIVER DIVISION CEORN-EP-D Noshville District	COMPUTATION SHEET SUBJECT: KENTUCKY LOCK GATE PAINTING	PAGE 1 OF 1 PAGES DATE 12/20/93
COMPUTED BY: JEP CHECKED BY:	COMPUTATION: PAINTING SCHEDULE	NUMBER

Operations on Interior of gate will take longer than the Exterior so only Interior Operations are shown

Assume one person is working in each gate at all times

~~Operation~~

Unwater Lock		48 HRS
Wash Interior	24,500 SF @ 100 SF./HR =	245 HRS
Air Chisel Interior	15,925 SF @ 40 SF./HR =	400 HRS
SANDBLAST INTERIOR	24,500 SF @ 140 SF/HR	175 HRS
REMOVE BLAST MATERIAL	24,500 SF @ 170 SF/HR	144 HRS
PAINT INTERIOR	98,000 SF @ 100 SF/HR	980 HRS
FLOOD LOCK		24 HRS
		2016 HRS
		84 DAYS

SAY 90 DAY CLOSURE.

ORD Form 427
1 APR 83

KY LOCK LRR (Paint Gates)

Designed By: Nashville District, COE
Estimated By: Nashville District, COE

Prepared By: Johnny E. Parham

Date: 10/28/93

M C A C E S G O L D E D I T I O N

Release 5.20J

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

BACKUP REPORTS — BACKUP PAGE

*** END TABLE OF CONTENTS ***

	QUANTY	UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
05 Locks							
05.01 Mob & Demob							
05.01. 1 Mob & Demob (Dewater Lock)							
Mob & Demob (Dewater Lock)			200,000	60,000	0	260,000	
Mob & Demob			200,000	60,000	0	260,000	
05.57 Lock Gates							
05.57.09 Finishes (Painting)							
05.57.09. 1 Power Wash Exterior	33000	SF	60,692	18,208	0	78,899	2.39
05.57.09. 2 Sandblast Exterior	33000	SF	130,093	39,028	0	169,121	5.12
05.57.09. 3 Paint Exterior	33000	SF	159,529	47,859	0	207,387	6.28
05.57.09. 4 Power Wash Interior	98000	SF	290,607	87,182	0	377,789	3.85
05.57.09. 5 Sandblast Interior	98000	SF	327,760	98,328	0	426,088	4.35
05.57.09. 6 Remove Sandblast Debris Interior	98000	SF	205,329	61,599	0	266,928	2.72
05.57.09. 7 Paint Interior	392000	SF	1,032,433	309,730	0	1,342,163	3.42
05.57.09. 8 Chisel Bitumastic From Interior	63700	SF	530,662	159,199	0	689,861	10.83
05.57.09. 9 Chisel Bitumastic From Exterior	24750	SF	120,808	36,242	0	157,050	6.35
Finishes (Painting)			2,857,913	857,374	0	3,715,286	
Lock Gates			2,857,913	857,374	0	3,715,286	
Locks			3,057,913	917,374	0	3,975,286	
30 Engineering & Design							
30. 1 Engineering & Design							
Engineering & Design			170,030	34,006	0	204,036	
Engineering & Design			170,030	34,006	0	204,036	
31 Supervision & Administration							
31. 1 Supervision & Administration							
Supervision & Administration			170,030	34,006	0	204,036	
Supervision & Administration			170,030	34,006	0	204,036	
KY LOCK LRR (Paint Gates)			3,397,973	985,386	0	4,383,358	

Johnny E. Parham
Cost Engineer

Phil Mitchell 1/5/94
Phil Mitchell
Chief, Cost Engineering Branch

** PROJECT INDIRECT SUMMARY - LEVEL 4 **

		QUANTY UOM	DIRECT	OVERHEAD	PROFIT	BOND	TOTAL COST	UNIT
05	Locks							
05.01	Mob & Demob							
05.01. 1	Mob & Demob (Dewater Lock)							
	Mob & Demob (Dewater Lock)		200,000	0	0	0	200,000	
	Mob & Demob		200,000	0	0	0	200,000	
05.57	Lock Gates							
05.57.09	Finishes (Painting)							
05.57.09. 1	Power Wash Exterior	33000 SF	47,738	7,161	5,490	303	60,692	1.84
05.57.09. 2	Sandblast Exterior	33000 SF	102,326	15,349	11,768	650	130,093	3.94
05.57.09. 3	Paint Exterior	33000 SF	125,479	18,822	14,430	798	159,529	4.83
05.57.09. 4	Power Wash Interior	98000 SF	228,580	34,287	26,287	1,453	290,607	2.97
05.57.09. 5	Sandblast Interior	98000 SF	257,804	38,671	29,647	1,639	327,760	3.34
05.57.09. 6	Remove Sandblast Debris Interior	98000 SF	161,504	24,226	18,573	1,027	205,329	2.10
05.57.09. 7	Paint Interior	392000 SF	812,072	121,811	93,388	5,162	1,032,433	2.63
05.57.09. 8	Chisel Bitumastic From Interior	63700 SF	417,399	62,610	48,001	2,653	530,662	8.33
05.57.09. 9	Chisel Bitumastic From Exterior	24750 SF	95,023	14,253	10,928	604	120,808	4.88
	Finishes (Painting)		2,247,924	337,189	258,511	14,288	2,857,913	
	Lock Gates		2,247,924	337,189	258,511	14,288	2,857,913	
	Locks		2,447,924	337,189	258,511	14,288	3,057,913	
30	Engineering & Design							
30. 1	Engineering & Design							
	Engineering & Design		170,030	0	0	0	170,030	
	Engineering & Design		170,030	0	0	0	170,030	
31	Supervision & Administration							
31. 1	Supervision & Administration							
	Supervision & Administration		170,030	0	0	0	170,030	
	Supervision & Administration		170,030	0	0	0	170,030	

	QUANTY UOM	DIRECT	OVERHEAD	PROFIT	BOND	TOTAL COST	UNIT
KY LOCK LRR (Paint Gates)		2,787,984	337,189	258,511	14,288	3,397,973	
Contingency						985,386	
TOTAL INCL OWNER COSTS						4,383,358	

		QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
05 Locks								
05.01 Mob & Demob								
05.01. 1 Mob & Demob (Dewater Lock)								
	Mob & Demob (Dewater Lock)		0	0	0	200,000	200,000	
	Mob & Demob		0	0	0	200,000	200,000	
05.57 Lock Gates								
05.57.09 Finishes (Painting)								
05.57.09. 1	Power Wash Exterior	33000 SF	30,390	17,348	0	0	47,738	1.45
05.57.09. 2	Sandblast Exterior	33000 SF	36,468	39,551	21,688	4,620	102,326	3.10
05.57.09. 3	Paint Exterior	33000 SF	67,663	30,941	8,395	18,480	125,479	3.80
05.57.09. 4	Power Wash Interior	98000 SF	166,512	61,828	0	240	228,580	2.33
05.57.09. 5	Sandblast Interior	98000 SF	118,933	60,505	64,406	13,960	257,804	2.63
05.57.09. 6	Remove Sandblast Debris Interior	98000 SF	97,951	49,833	0	13,720	161,504	1.65
05.57.09. 7	Paint Interior	392000 SF	502,348	229,673	24,931	55,120	812,072	2.07
05.57.09. 8	Chisel Bitumastic From Interior	63700 SF	270,585	137,656	0	9,158	417,399	6.55
05.57.09. 9	Chisel Bitumastic From Exterior	24750 SF	45,585	49,438	0	0	95,023	3.84
	Finishes (Painting)		1336434	676,772	119,420	115,298	2,247,924	
	Lock Gates		1336434	676,772	119,420	115,298	2,247,924	
	Locks		1336434	676,772	119,420	315,298	2,447,924	
30 Engineering & Design								
30. 1 Engineering & Design								
	Engineering & Design		30	0	0	170,000	170,030	
	Engineering & Design		30	0	0	170,000	170,030	
31 Supervision & Administration								
31. 1 Supervision & Administration								
	Supervision & Administration		30	0	0	170,000	170,030	
	Supervision & Administration		30	0	0	170,000	170,030	

	QUANTY UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
KY LOCK LRR (Paint Gates)		1336494	676,772	119,420	655,298	2,787,984	
Prime Contractor's Overhead						337,189	
SUBTOTAL						3,125,173	
Prime's Profit						258,511	
SUBTOTAL						3,383,684	
Prime Contractor's Bond						14,288	
TOTAL INCL INDIRECTS						3,397,973	
Contingency						985,386	
TOTAL INCL OWNER COSTS						4,383,358	

05.01. Mob & Demob	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
05. Locks									
05.01. Mob & Demob									
Mob & Demob (Dewater Lock)					0	0	0	200,000	200,000
Mob & Demob					0	0	0	200,000	200,000

05.57. Lock Gates	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
05.57. Lock Gates								
05.57.09. Finishes (Painting)								
05.57.09. 1. Power Wash Exterior								
USR AA Power Wash Exterior				0.92	0.53	0.00	0.00	1.45
	33000 SF	XKYWA	120.00	30,390	17,348	0	0	47,738
Power Wash Exterior				30,390	17,348	0	0	47,738
05.57.09. 2. Sandblast Exterior								
USR AA Sandblast Exterior				1.11	1.20	0.66	0.00	2.96
	33000 SF	XKYWC	100.00	36,468	39,551	21,688	0	97,706
USR AA Personal Protective Equipment				0.00	0.00	0.00	0.14	0.14
	33000 SF		0.00	0	0	0	4,620	4,620
Sandblast Exterior				36,468	39,551	21,688	4,620	102,326
05.57.09. 3. Paint Exterior								
USR AA Paint Exterior (4-coats)				0.51	0.23	0.06	0.00	0.81
	132000 SF	XKYWE	250.00	67,663	30,941	8,395	0	106,999
USR AA Personal Protective Equipment				0.00	0.00	0.00	0.14	0.14
	132000 SF		0.00	0	0	0	18,480	18,480
Paint Exterior				67,663	30,941	8,395	18,480	125,479
05.57.09. 4. Power Wash Interior								
USR AA Power Wash Interior				1.70	0.63	0.00	0.00	2.33
	98000 SF	XKYWB	100.00	166,512	61,828	0	0	228,340
USR AA Pick Boards				0.00	0.00	0.00	240.00	240.00
	1.00 LS		0.00	0	0	0	240	240
Power Wash Interior				166,512	61,828	0	240	228,580
05.57.09. 5. Sandblast Interior								
USR AA Sandblast Interior				1.21	0.62	0.66	0.00	2.49
	98000 SF	XKYWD	140.00	118,933	60,505	64,406	0	243,844

05.57. Lock Gates	QUANTY UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
USR AA Personal Protective Equipment				0.00	0.00	0.00	0.14	0.14
	98000 SF		0.00	0	0	0	13,720	13,720
USR AA Pick Boards				0.00	0.00	0.00	240.00	240.00
	1.00 LS		0.00	0	0	0	240	240
Sandblast Interior				118,933	60,505	64,406	13,960	257,804
05.57.09. 6. Remove Sandblast Debris Interior								
USR AA Remove Blast Material Interior				1.00	0.51	0.00	0.00	1.51
	98000 SF	XKYWD	170.00	97,951	49,833	0	0	147,784
USR AA Personal Protective Equipment				0.00	0.00	0.00	0.14	0.14
	98000 SF		0.00	0	0	0	13,720	13,720
Remove Sandblast Debris Interior				97,951	49,833	0	13,720	161,504
05.57.09. 7. Paint Interior								
USR AA Paint Interior(4-coats)				1.28	0.59	0.06	0.00	1.93
	392000 SF	XKYWE	100.00	502,348	229,673	24,931	0	756,952
USR AA Personel Protective Equipment				0.00	0.00	0.00	0.14	0.14
	392000 SF		0.00	0	0	0	54,880	54,880
USR AA Pick Boards				0.00	0.00	0.00	240.00	240.00
	1.00 LS		0.00	0	0	0	240	240
Paint Interior				502,348	229,673	24,931	55,120	812,072
05.57.09. 8. Chisel Bitumastic From Interior								
USR AA Chisel Paint From Interior				4.25	2.16	0.00	0.00	6.41
	63700 SF	XKYWD	40.00	270,585	137,656	0	0	408,241
USR AA Pick Boards				0.00	0.00	0.00	240.00	240.00
	1.00 LS		0.00	0	0	0	240	240
USR AA Personal Protective Equipment				0.00	0.00	0.00	0.14	0.14
	63700 SF		0.00	0	0	0	8,918	8,918
Chisel Bitumastic From Interior				270,585	137,656	0	9,158	417,399

05.57. Lock Gates	QUANTY UOM CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
05.57.09. 9. Chisel Bitumastic From Exterior							
USR AA Chisel Paint From Exterior			1.84	2.00	0.00	0.00	3.84
	24750 SF XKYWC	60.00	45,585	49,438	0	0	95,023
Chisel Bitumastic From Exterior			45,585	49,438	0	0	95,023
Finishes (Painting)			1336434	676,772	119,420	115,298	2,247,924
Lock Gates			1336434	676,772	119,420	115,298	2,247,924
Locks			1336434	676,772	119,420	315,298	2,447,924

30. 1. Engineering & Design	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
30. Engineering & Design									
Cost based on approximately 6% of contract cost.									
Engineering & Design					30	0	0	170,000	170,030
Engineering & Design					30	0	0	170,000	170,030

31. 1. Supervision & Administration	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
31. Supervision & Administration									
Approximately 6% of contract cost.									
Supervision & Administration					30	0	0	170,000	170,030
Supervision & Administration					30	0	0	170,000	170,030
KY LOCK LRR (Paint Gates)					1336494	676,772	119,420	655,298	2,787,984

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	**** LABOR **** COST	**** EQUIP **** HOURS	**** EQUIP **** COST	TOTAL COST
	XKYWA	Wash Gate Exterior			PROD =	100%			CREW HOURS =	550
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76KUP.
MIL *	X-LABORER L	Outside Laborer (Semi-Skilled)	4.00	HR	14.85	4.00	59.40			59.40KUP.
MIL *	X-LABORER F	Foreman	1.00	HR	15.35	1.00	15.35			15.35KUP.
MIL *	W25AC004 E	Power Washer 1600 CFM	2.00	HR	5.03			2.00	10.06	10.06KUP.
MIL *	A15XX014 E	AIR COMPR, 900 CFM, 100 PSI	2.00	HR	23.52			2.00	47.03	47.03KUP.
USR	XX0XX030 E	Spider Climber	4.00	HR	1.50			4.00	6.00	6.00KUP.
	TOTAL					7.00	110.51	8.00	63.09	173.60
	XKYWB	Wash Gate Interior			PROD =	100%			CREW HOURS =	1960
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76KUP.
MIL *	X-LABORER L	Outside Laborer (Semi-Skilled)	4.00	HR	14.85	4.00	59.40			59.40KUP.
MIL *	X-LABORER L	Confined Space Safety Observer	4.00	HR	14.85	4.00	59.40			59.40KUP.
MIL *	X-LABORER F	Foreman	1.00	HR	15.35	1.00	15.35			15.35KUP.
MIL *	A15XX014 E	AIR COMPR, 900 CFM, 100 PSI	2.00	HR	23.52			2.00	47.03	47.03KUP.
MIL *	W25AC004 E	Power Washer 1600 CFM	2.00	HR	5.03			2.00	10.06	10.06KUP.
USR	XX0XX030 E	Power Climber	4.00	HR	1.50			4.00	6.00	6.00KUP.
	TOTAL					11.00	169.91	8.00	63.09	233.00
	XKYWC	Sandblast Gate Exterior			PROD =	100%			CREW HOURS =	1485
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76KUP.
MIL *	X-LABORER L	Outside Laborer (Semi-Skilled)	4.00	HR	14.85	4.00	59.40			59.40KUP.
MIL *	X-LABORER F	Foreman	1.00	HR	15.35	1.00	15.35			15.35KUP.
MIL *	A15XX014 E	AIR COMPR, 900 CFM, 100 PSI	2.00	HR	23.52			2.00	47.03	47.03KUP.
USR	XX0XX030 E	Spider Climber	4.00	HR	1.50			4.00	6.00	6.00KUP.
MIL *	A20CM006 E	SANDBLSTR,1T CAP W/ACC-ADD COMP	4.00	HR	8.35			4.00	33.41	33.41KUP.
USR	A20CM006 E	SANDBLSTR,1T CAP W/ACC-ADD COMP	4.00	HR	8.35			4.00	33.41	33.41KUP.
	TOTAL					7.00	110.51	14.00	119.85	230.36
	XKYWD	Sandblast Gate Interior			PROD =	100%			CREW HOURS =	5738
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76KUP.
MIL *	X-LABORER L	Outside Laborer (Semi-Skilled)	4.00	HR	14.85	4.00	59.40			59.40KUP.
MIL *	X-LABORER L	Confined Space Safety Observer	4.00	HR	14.85	4.00	59.40			59.40KUP.
MIL *	X-LABORER F	Foreman	1.00	HR	15.35	1.00	15.35			15.35KUP.
MIL *	A15XX014 E	AIR COMPR, 900 CFM, 100 PSI	2.00	HR	23.52			2.00	47.03	47.03KUP.
MIL *	A20CM006 E	SANDBLSTR,1T CAP W/ACC-ADD COMP	4.00	HR	8.35			4.00	33.41	33.41KUP.
USR	XX0XX030 E	Power Climber	4.00	HR	1.50			4.00	6.00	6.00KUP.
	TOTAL					11.00	169.91	10.00	86.44	256.35
	XKYWE	Paint Gate Exterior			PROD =	100%			CREW HOURS =	8896
MIL *	X-EQOPRMEDL	Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76KUP.
MIL *	X-LABORER F	Foreman	1.00	HR	15.35	1.00	15.35			15.35KUP.
MIL *	B-PAINTSS L	Painter, Struct Stl	4.00	HR	19.26	4.00	77.04			77.04KUP.
MIL *	A15XX014 E	AIR COMPR, 900 CFM, 100 PSI	2.00	HR	23.52			2.00	47.03	47.03KUP.
USR	XX0XX030 E	Spider Climber	4.00	HR	1.50			4.00	6.00	6.00KUP.
MIL	XMIXX020 E	Small Tools	4.00	HR	1.39			4.00	5.56	5.56KUP.
	TOTAL					7.00	128.15	10.00	58.59	186.74

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-PAINTSS	Painter, Struct Stl	11.12	0.0%	21.0%	5.80	0.00	19.26	HR	12/01/93	13.46	35584ACKUP
MIL	X-EQOPRMED	Outside Equip. Op. Medium	13.43	0.0%	0.0%	4.45	0.00	17.88	HR	10/29/93	17.43	37258 CKU
MIL	X-LABORER	Outside Laborer (Semi-Skilled)	12.35	0.0%	0.0%	2.50	0.00	14.85	HR	10/29/93	11.84	88352 CKU

** EQUIPMENT BACKUP **

SRC	EQUIP ID	DESCRIPTION	DEPR	CAPT	FUEL	FOG	EQ REP	TR WR	TR REP	TOTAL	UOM	** TOTAL ** HOURS	
MIL	A15XX014	AIR COMPR, 900 CFM, 100 PSI	5.49	1.95	7.68	2.1	6.03	0.19	0.03	23.52	HR	37258MENT	BA
MIL	A20CN006	SANDBLSTR,1T CAP W/ACC-ADD COMP	2.50	0.37		0.2	5.12	0.07	0.01	8.35	HR	34832 T	BA
MIL	W25AC004	WATER BLASTER, 5.5 GPM 3500 PSI	0.91	0.13	2.10	0.3	1.35	0.02		5.03	HR	5020 T	BA
MIL	XMIXX020	Small Tools	0.46	0.17	0.13	0.0	0.57			1.39	HR	35584 T	BA
USR	XX0XX030	Spider Climber	1.50							1.50	HR	74516 T	BA

CORPS OF ENGINEERS, U.S. ARMY OHIO RIVER DIVISION	COMPUTATION SHEET	PAGE 1 OF 1 PAGES
		DATE
CEORN-EP-D Nashville District	SUBJECT: KENTUCKY LOCK GATE REPLACEMENT	
COMPUTED BY: JEP	COMPUTATION: CONSTRUCTION TIME	NUMBER
CHECKED BY:		

DEWATER LOCK	2 DAYS
REMOVE UPPER GATES	10 DAYS
INSTALL NEW UPPER GATES	27 DAYS
REMOVE LOWER GATES	15 DAYS
INSTALL NEW LOWER GATES	35 DAYS
	89 DAYS

SAY 90 DAYS

ORD Form 427
1 APR 83

KY LOCK LRR (Replace Gates)

Designed By: Nashville District, COE
Estimated By: Nashville District, COE

Prepared By: Johnny E. Parham

Date: 12/28/93

M C A C E S G O L D E D I T I O N

Release 5.20J

SUMMARY REPORTS SUMMARY PAGE

DETAILED ESTIMATE DETAIL PAGE

BACKUP REPORTS BACKUP PAGE

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	QUANTY	UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT
05 Locks							
05.01 Mob & Demob							
05.01. 1 Mob & Demob (Dewater Locks)							
Mob & Demob (Dewater Locks)			200,000	60,000	0	260,000	
Mob & Demob			200,000	60,000	0	260,000	
05.57 Lock Gates							
05.57.05 Metals							
05.57.05. 1 Remove Old Gates	1850.00	TON	682,437	204,731	0	887,168	479.55
05.57.05. 2 Install New Gates	1872.00	TON	14,122,489	4,236,747	0	18,359,236	9807.28
Metals	1872.00	TON	14,804,926	4,441,478	0	19,246,404	10281
Lock Gates			14,804,926	4,441,478	0	19,246,404	
Locks			15,004,926	4,501,478	0	19,506,404	
30 Engineering and Design							
30. 1 Engineering and Design							
Engineering and Design			1,500,000	450,000	0	1,950,000	
Engineering and Design			1,500,000	450,000	0	1,950,000	
31 Supervision and Administration							
31. 1 Supervision and Administration							
Supervision and Administration			900,030	225,008	0	1,125,038	
Supervision and Administration			900,030	225,008	0	1,125,038	
KY LOCK LRR (Replace Gates)			17,404,956	5,176,485	0	22,581,441	

Johnny E. Parham
Cost Engineer

Phil Mitchell 1/5/94
Phil Mitchell
Chief, Cost Engineering Branch

	QUANTY UOM	DIRECT	OVERHEAD	PROFIT	BOND	TOTAL COST	UNIT
05 Locks							
05.01 Mob & Demob							
05.01. 1 Mob & Demob (Dewater Locks)							
Mob & Demob (Dewater Locks)		200,000	0	0	0	200,000	
Mob & Demob		200,000	0	0	0	200,000	
05.57 Lock Gates							
05.57.05 Metals							
05.57.05. 1 Remove Old Gates	1850.00 TON	537,568	80,635	61,820	2,413	682,437	368.88
05.57.05. 2 Install New Gates	1872.00 TON	11,124,547	1,668,682	1,279,323	49,937	14,122,489	7544.06
Metals	1872.00 TON	11,662,116	1,749,317	1,341,143	52,350	14,804,926	7908.61
Lock Gates		11,662,116	1,749,317	1,341,143	52,350	14,804,926	
Locks		11,862,116	1,749,317	1,341,143	52,350	15,004,926	
30 Engineering and Design							
30. 1 Engineering and Design							
Engineering and Design		1,500,000	0	0	0	1,500,000	
Engineering and Design		1,500,000	0	0	0	1,500,000	
31 Supervision and Administration							
31. 1 Supervision and Administration							
Supervision and Administration		900,030	0	0	0	900,030	
Supervision and Administration		900,030	0	0	0	900,030	
KY LOCK LRR (Replace Gates)		14,262,146	1,749,317	1,341,143	52,350	17,404,956	
Contingency						5,176,485	
TOTAL INCL OWNER COSTS						22,581,441	

		QUANTY	UOM	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT
05 Locks									
05.01 Mob & Demob									
05.01. 1 Mob & Demob (Dewater Locks)									
	Mob & Demob (Dewater Locks)			0	0	0	200,000	200,000	
	Mob & Demob			0	0	0	200,000	200,000	
05.57 Lock Gates									
05.57.05 Metals									
05.57.05. 1	Remove Old Gates	1850.00	TON	174,856	362,712	0	0	537,568	290.58
05.57.05. 2	Install New Gates	1872.00	TON	826,301	1,368,806	8,929,440	0	11,124,547	5942.60
	Metals	1872.00	TON	1001157	1,731,519	8,929,440	0	11,662,116	6229.76
	Lock Gates			1001157	1,731,519	8,929,440	0	11,662,116	
	Locks			1001157	1,731,519	8,929,440	200,000	11,862,116	
30 Engineering and Design									
30. 1 Engineering and Design									
	Engineering and Design			0	0	0	1,500,000	1,500,000	
	Engineering and Design			0	0	0	1,500,000	1,500,000	
31 Supervision and Administration									
31. 1 Supervision and Administration									
	Supervision and Administration			30	0	0	900,000	900,030	
	Supervision and Administration			30	0	0	900,000	900,030	
	KY LOCK LRR (Replace Gates)			1001187	1,731,519	8,929,440	2,600,000	14,262,146	
	Prime Contractor's Overhead							1,749,317	
	SUBTOTAL							16,011,463	
	Prime's Profit							1,341,143	
	SUBTOTAL							17,352,606	
	Prime Contractor's Bond							52,350	
	TOTAL INCL INDIRECTS							17,404,956	
	Contingency							5,176,485	
	TOTAL INCL OWNER COSTS							22,581,441	

05.01. Mob & Demob	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
05. Locks									
05.01. Mob & Demob									
Mob & Demob (Dewater Locks)					0	0	0	200,000	200,000
Mob & Demob					0	0	0	200,000	200,000

05.57. Lock Gates	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
05.57. Lock Gates									
05.57.05. Metals									
05.57.05. 1. Remove Old Gates Includes cost to load on to barges for disposal. Actual disposal costs is assumed to be offset by salvage value so no disposal is included.									
USR AA Remove Old Gates					94.52	196.06	0.00	0.00	290.58
	1850.00	TON	XXRAA	1.20	174,856	362,712	0	0	537,568
Remove Old Gates					174,856	362,712	0	0	537,568
05.57.05. 2. Install New Gates Material Price is fabricated cost delivered to job site by barge.									
USR AA Install New Gates (Upper)					0.13	0.26	2.39	0.00	2.77
	1174000	LBS	XXRAA	900.00	147,924	306,884	2,799,990	0	3,254,798
USR AA Install New Gates (Lower)					0.13	0.26	2.39	0.00	2.77
	2570000	LBS	XXRAA	900.00	323,820	671,798	6,129,450	0	7,125,068
USR AA Lock Wall Crane					0.03	0.10	0.00	0.00	0.13
	3744000	LBS	XXQHC	900.00	122,429	359,798	0	0	482,227
USR AA On-Site Welding					0.06	0.01	0.00	0.00	0.07
	3744000	LBS	XIWRE	900.00	232,128	30,326	0	0	262,454
Install New Gates					826,301	1,368,806	8,929,440	0	11,124,547
Metals					1001157	1,731,519	8,929,440	0	11,662,116
Lock Gates					1001157	1,731,519	8,929,440	0	11,662,116
Locks					1001157	1,731,519	8,929,440	200,000	11,862,116

30. 1. Engineering and Design	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
30. Engineering and Design									
Approximately 10% of Contract cost									
Engineering and Design					0	0	0	1,500,000	1,500,000
Engineering and Design					0	0	0	1,500,000	1,500,000

31. 1. Supervision and Administration	QUANTY	UOM	CREW ID	OUTPUT	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST
31. Supervision and Administration									
Approximately 6% of contract cost									
Supervision and Administration					30	0	0	900,000	900,030
Supervision and Administration					30	0	0	900,000	900,030
KY LOCK LRR (Replace Gates)					1001187	1,731,519	8,929,440	2,600,000	14,262,146

Wed 05 Jan 1994 U.S. Army Corps of Engineers TIME 14:30:06

PROJECT GATNEW: KY LOCK LRR (Replace Gates)

KY Lock LRR New Gates BACKUP PAGE 1

** CREW BACKUP **

SRC	ITEM ID	DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	XIWRE	2 X-rodman + 1 Gasoline Welding Machine			PROD =	100%			CREW HOURS =	8320
MIL	XMIXX020	E Small Tools	1.00	HR	1.39		8	1.00	1.39	1.39KUP.
MIL	W35XX002	E WELDER, 200 AMP W/1 AXLE TRLR	1.00	HR	5.92			1.00	5.92	5.92KUP.
MIL	X-RODMAN	F Outside Rodman	0.17	HR	19.32	0.17	3.28			3.28KUP.
MIL	X-RODMAN	L Outside Rodman	2.00	HR	18.82	2.00	37.64			37.64KUP.
MIL	X-LABORER	L Outside Laborer	1.00	HR	14.85	1.00	14.85			14.85KUP.
	TOTAL					3.17	55.77	2.00	7.31	63.08
	XXQHC	1 X-eqoprhvy + 1-100 Ton Crane, Cwlr			PROD =	100%			CREW HOURS =	8320
MIL	C85LB007	E CR,ME,CWLR,LIFTING,100T,230'BOO	1.00	HR	86.50			1.00	86.50	86.50KUP.
MIL	X-EQOPRHVY	L Outside Equip. Op. Heavy	1.00	HR	20.30	1.00	20.30			20.30KUP.
MIL	X-EQOPROIL	L Outside Oiler	0.50	HR	18.26	0.50	9.13			9.13KUP.
	TOTAL					1.50	29.43	1.00	86.50	115.93
	XXRAA	150 T Floating Crane & Tug Boat			PROD =	0.00%			CREW HOURS =	11403
MIL	B25ES005	E BKT,CLAM,1-1/2CY,GEN PURP/SQNOS	1.00	HR	2.85			1.00	2.85	2.85KUP.
MIL	X-EQOPROIL	L Outside Oiler	1.00	HR	18.26	1.00	18.26			18.26KUP.
MIL	XX0XX001	E 150ton Floating Crane 290hp W/2	1.00	HR	160.99			1.00	160.99	160.99KUP.
MIL *	X-EQOPRMED	L Outside Equip. Op. Medium	2.00	HR	17.88	2.00	35.76			35.76KUP.
MIL	XX0XX002	E 500 To 800hp Tug Boat	1.00	HR	53.07			1.00	53.07	53.07KUP.
MIL	XX0XX006	E 500 To 800 Ton Barge	1.00	HR	18.36			1.00	18.36	18.36KUP.
MIL *	X-LABORER	L Deckhands (semi-skilled)	4.00	HR	14.85	4.00	59.40			59.40KUP.
	TOTAL					7.00	113.42	4.00	235.27	348.69

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	X-EQOPRHVY	Outside Equip. Op. Heavy	15.85	0.0%	0.0%	4.45	0.00	20.30	HR	10/29/93	19.19	8320ACKUP
MIL	X-EQOPRMED	Outside Equip. Op. Medium	13.43	0.0%	0.0%	4.45	0.00	17.88	HR	10/29/93	17.43	22807 CKUF
MIL	X-EQOPROIL	Outside Oiler	13.81	0.0%	0.0%	4.45	0.00	18.26	HR	10/29/93	13.49	15563 CKU.
MIL	X-LABORER	Outside Laborer (Semi-Skilled)	12.35	0.0%	0.0%	2.50	0.00	14.85	HR	10/29/93	11.84	53933 CKUP
MIL	X-RODMAN	Outside Rodman	12.95	0.0%	30.1%	1.97	0.00	18.82	HR	05/01/92	18.82	18054 CKUP

** EQUIPMENT BACKUP **

SRC	EQUIP ID	DESCRIPTION	DEPR	CAPT	FUEL	FOG	EQ REP	TR WR	TR REP	TOTAL	UOM	** TOTAL ** HOURS	
MIL	B25ES005	BKT,CLAM,1-1/2CY,GEN PURP/SGNOSE	1.31	0.37			1.17	8		2.85	HR	11403MENT	BA
MIL	C85L8007	CR,ME,CWLR,LIFTING,100T,230'BOOM	31.28	15.32	4.46	0.9	34.46			86.50	HR	8320	T BA
MIL	W35XX002	WELDER, 200 AMP W/1 AXLE TRLR	0.44	0.15	3.85	0.9	0.52	0.03	0.00	5.92	HR	8320	T BA
MIL	XMIXX020	Small Tools	0.46	0.17	0.13	0.0	0.57			1.39	HR	8320	T BA
MIL	XXOXX001	150ton Floating Crane 290hp W/25	53.75	19.17	15.16	6.6	66.29			160.99	HR	11403	T BA
MIL	XXOXX002	500 To 800hp Tug Boat	17.72	6.32	5.00	2.1	21.85			53.07	HR	11403	T BA
MIL	XXOXX006	500 To 800 Ton Barge	6.13	2.19	1.73	0.7	7.56			18.36	HR	11403	T BA

SYLLABUS

This report was prepared pursuant to authorities provided by the October 2, 1972 resolution of the U.S. Senate Committee on Public Works, and by the September 9, 1982 resolution of the U.S. Senate Committee on the Environment and Public Works. The report is an interim response, concentrating on the portions of the lower Cumberland and Tennessee Rivers downstream of Barkley Canal that form the Kentucky-Barkley navigation system.

The Tennessee River, with 650 miles of navigable waterway, and the Cumberland River, with over 380 miles of navigable waterway, are the largest tributaries of the Ohio River. The 1967 construction of Barkley Canal connected the Tennessee and Cumberland Rivers creating the Kentucky-Barkley navigation system. The system is comprised of Barkley Canal, Kentucky Lock and the lower Tennessee River, Barkley Lock and the lower Cumberland River, and a short section of the Ohio River. The system is bounded on the Ohio River by Smithland's twin 1200-foot locks and the authorized twin 1200-foot locks at Olmstead. To traverse the Kentucky-Barkley system tows must squeeze through the 600-foot lock at Kentucky or 800-foot lock at Barkley.

The Kentucky-Barkley system gives shippers direct access to the Ohio River and the Tennessee-Tombigbee Waterway. These waterways link the system with markets in Mid-America, the Gulf Coast, and the Lower Mississippi River Valley. As one of the major intersections on the inland waterway, the system serves commerce from 20 states. The primary commodities include coal (representing almost half the traffic), aggregates, grain, chemicals, iron and steel, ores and minerals, and petroleum products.

In recent years, an average of 33.5 million tons of cargo transited the Kentucky-Barkley system with almost 90 percent of the traffic using Kentucky Lock. This high use of Kentucky causes significant congestion and delay. Over 80 percent of all tows using Kentucky Lock experience delays that averaged 3-1/2 hours. This delay adds to the already excessive time it takes to process a tow (most tows require double lockages) and results in an average transit time of about 5-1/4 hours - one of the highest in the Ohio River system.

Traffic on the Kentucky-Barkley system is projected to grow at about the same rate as the rest of the Ohio River system. By the year 2000, traffic demand is projected to reach 44.0 million tons at Kentucky driving lock delays even higher. These delays will divert millions of tons of cargo to the higher-cost routing of Barkley Lock and the lower Cumberland River and to overland modes of transportation. The problem is exacerbated in years when one of the existing locks is closed for maintenance.

Several factors make Barkley Lock and the lower Cumberland River a more costly route. The lower Cumberland is narrow and sinuous, similar to a country road, while the lower Tennessee is broad and straight, similar to an interstate highway. On the lower Cumberland, smaller tows must travel slower and use more fuel to safely navigate the swift current and narrow bends. In addition, the lower Cumberland is a longer route. It costs an average of $0.50 per ton more to travel the lower Cumberland than the lower Tennessee.

The major objectives of this study were threefold: (1) to reduce transportation costs to the nation; (2) to provide safe and dependable commercial navigation throughout the study period (2005-2054); and (3) to conserve fish and wildlife and other natural resources in the Tennessee and Cumberland Rivers. The concerns and interests of the navigation industry, environmental and conservation interests, and the general public were sought and considered throughout the study.

The "without-project condition" is defined as the most likely condition expected to exist in the future in absence of any federal improvements. Benefits and costs relative to the without-project condition serve as the baseline against which incremental costs and benefits of alternatives are measured. The without-project condition for this study includes the following key features: (1) modified hydropower operations at the Barkley Powerplant to allow safe passage of high volumes of traffic on the lower Cumberland River, (2) the most efficient lockage policy along with helper boats at Kentucky Lock by the year 2000 to maximize system capacity, (3) routine, periodic, and major maintenance performed at both locks as needed to insure continued safe and dependable operation of the system, and (4) the congressionally authorized replacement of locks and/or dams at Gallipolis L&D, Olmstead L&D, McAlpine L&D, Winfield L&D, Point Marion L&D, and Gray's Landing L&D assumed to be in-place. The average annual Ohio River System transportation rate savings of the without-project condition over the period of analysis total $3,656.6 million. The average annual cost of the without-project condition is $23.8 million (October 1991 dollars). This includes $6.3 million to operate and maintain both locks, $2.6 million for helper boats, and $14.9 million in lost hydropower revenues.

Alternatives included six locations for a new lock at the Kentucky Project, a plan to modify bendways on the lower Cumberland River, three canal schemes to connect the lower Cumberland and Tennessee Rivers, and traffic management. Adding a new lock at Kentucky proved to be most economically viable while meeting the objectives of the study.

The final plans include three 110-foot wide locks at Kentucky in differing lengths - 600, 800, and 1,200 feet. All of the plans have essentially the same impacts to environmental, social, recreational, and cultural resources in the project area and throughout the Cumberland and Tennessee River systems. However, a new 1200-foot lock will employ the more sizable construction force and make the maximum contribution to regional economic development. The incremental average annual benefits and costs associated with the 1200-foot lock, compared against the without-project condition, are $53.8 million and $31.9 million, respectively, resulting in net benefits of $21.9 million. This is $1.5 million more than the net benefits associated with a new 800-foot lock and $3.2 more than the 600-foot lock. The 1200-foot lock is large enough to operate efficiently well beyond the 50-year planning horizon and offers the greatest insurance against performance risks. In addition, industry leaders voiced their strong preference for a 1200-foot lock at the Feasibility Review Conference in August 1990, at the Public Meeting in June 1991, and in written response to the draft report.

The recommendation of this report is to add a 110-foot wide, 1200-foot long lock at the Kentucky Project. The plan includes constructing a new railroad bridge immediately downstream of the project and elevating a short section of highway. The initial project cost is estimated at $448 million at October 1991 prices.

On May 10, 1991, a Memorandum of Agreement between the Tennessee Valley Authority (TVA) and the U.S. Army Corps of Engineers (USACE) was signed that gives USACE the responsibility to implement the Kentucky Lock Project, including all design and construction activities. See Exhibit 1.

KENTUCKY LOCK STUDY
ANNUAL BENEFITS AND COSTS FOR THE RECOMMENDED PLAN
IMPACT OF CHANGE IN THE FEDERAL DISCOUNT RATE
(Millions of October 1991 Dollars)

	Without Project Condition		Plan A - 1200 ft Lock	
Item	8-3/4%	8-1/2%	8-3/4%	8-1/2%
Capital Costs	—	—	51.1	49.3
O & M Costs	6.4	6.3	4.7	4.7
Helper Boat Costs	2.6	2.6	—	—
Hydropower Costs	14.9	14.9	0.1	0.1
Highway Traffic Detour Costs	—	—	1.6	1.6
Total Annual Costs	23.9	23.8	57.5	55.7
Total Incremental Annual Costs			33.6	31.9
Incremental Rate Savings			49.5	49.6
Advanced RR Bridge Replacement			0.1	0.1
Unemployment Benefits			4.2	4.1
Total Incremental Annual Benefits			53.8	53.8
Net Incremental Benefits			20.2	21.9
Benefit-Cost Ratio			1.6	1.7

FINAL
LOWER CUMBERLAND AND TENNESSEE RIVERS
NAVIGATION FEASIBILITY REPORT
KENTUCKY LOCK ADDITION

VOLUME 1

MAIN REPORT

SECTION 1 - THE STUDY AND REPORT

SCOPE OF STUDY

1.01 This study is an evaluation of the Kentucky-Barkley navigation system, shown on Figure 1, which is a weakening link in the Nation's inland waterway network. Navigation shipments using the Cumberland, Tennessee, and Ohio Rivers and Tennessee-Tombigbee Waterway are threatened with ever-increasing shipping costs as congestion and delay mount at Kentucky Lock. This feasibility study will describe the problem and answer how and when it can be remedied.

AUTHORITY OF STUDY

1.02 An October 2, 1972 resolution, adopted by the U.S. Senate Committee on Public Works, requested the Corps of Engineers to investigate the advisability of navigation improvements on the Cumberland and Tennessee Rivers, generally below the connecting Barkley Canal. This study responds to the 1972 resolution and is an interim or partial response to another resolution adopted on September 9, 1982 by the U.S. Senate Committee on the Environment and Public Works. This resolution requested the Corps of Engineers to evaluate the entire Tennessee River with a view to determining whether any modifications to improve navigation are advisable.

DESCRIPTION OF STUDY AREA

1.03 The Cumberland and Tennessee Rivers are the Ohio River's largest tributaries. The 13 multipurpose projects on the Cumberland and Tennessee Rivers provide more than 1,037 miles of nine-foot deep navigable waterway. This feasibility study focuses on the Kentucky-Barkley portion of this navigation network. The 1967 construction of Barkley Canal connected the Cumberland and Tennessee Rivers and created the Kentucky-Barkley navigation system. The system shown, on Figure 2, is comprised of the 30.6-mile segment of the Cumberland River below Barkley Dam, Barkley Lock, the sections of Lake Barkley and Kentucky Lake immediately above the dams (including the

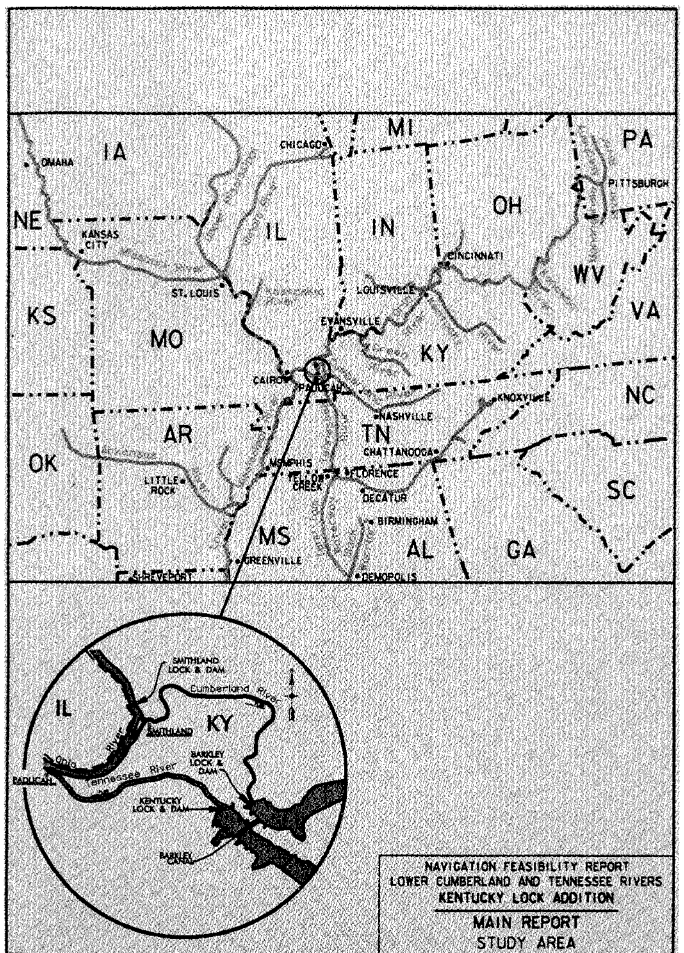

IA
MI
PA
OMAHA
CHICAGO
PITTSBURGH
NE
IL
IN
OH
KANSAS CITY
CINCINNATI
WV
KS
ST. LOUIS
LOUISVILLE
VA
MO
EVANSVILLE
KY
CAIRO
PADUCAH
NC
NASHVILLE
KNOXVILLE
AR
TN
OK
CHATTANOOGA
MEMPHIS
LITTLE ROCK
FLORENCE
SC
DECATUR
BIRMINGHAM
MS
AL
GA
GREENVILLE
SHREVEPORT
DEMOPOLIS
SMITHLAND LOCK & DAM
Cumberland River
IL
KY
SMITHLAND
Ohio River
PADUCAH
Tennessee River
BARKLEY LOCK & DAM
KENTUCKY LOCK & DAM
BARKLEY CANAL
NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
MAIN REPORT
STUDY AREA

Figure 1

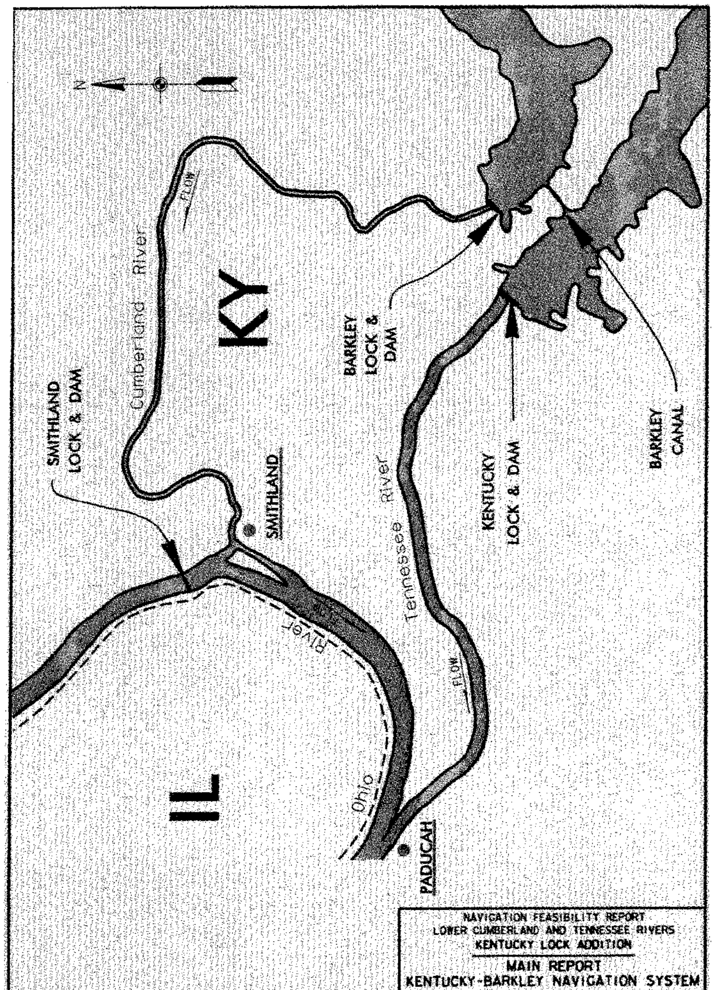

SMITHLAND
LOCK & DAM
N
Cumberland River
FLOW
IL
KY
SMITHLAND
Ohio
River
PADUCAH
Tennessee River
FLOW
BARKLEY
LOCK &
DAM
KENTUCKY
LOCK & DAM
BARKLEY
CANAL
NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
MAIN REPORT
KENTUCKY-BARKLEY NAVIGATION SYSTEM

Figure 2

interconnecting canal), the 22.4 miles of the Tennessee River below the Kentucky Project, Kentucky Lock, and the intervening section of the lower Ohio River - Smithland to Paducah, Kentucky.

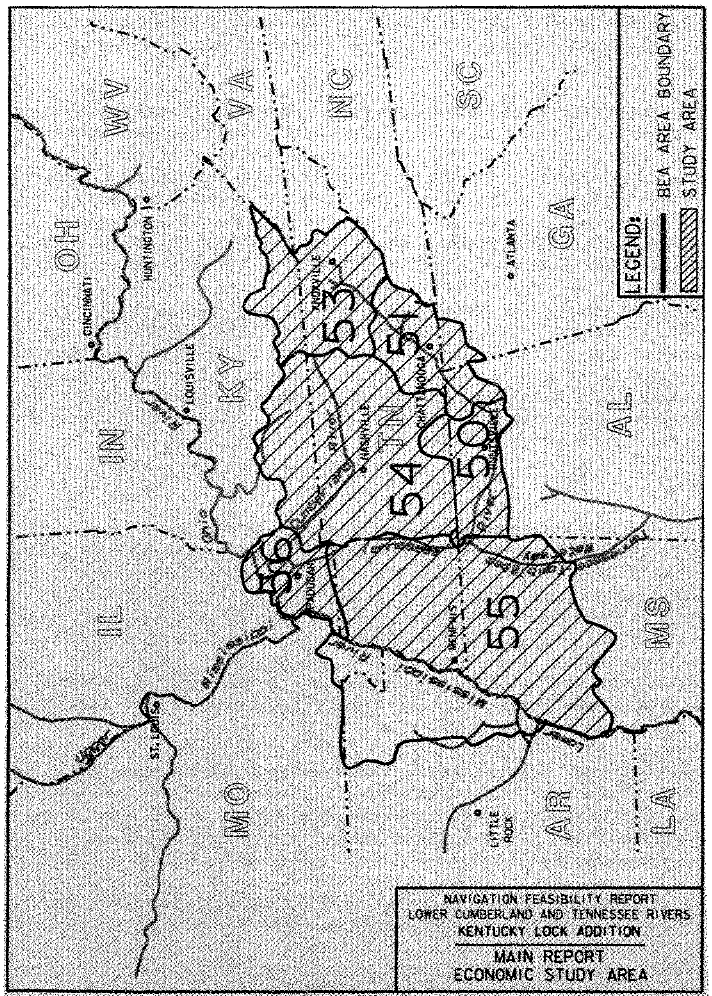
1.04 The economic impacts of the navigation problems and potential solutions encompass a wide geographical area. The Kentucky-Barkley system represents one of the busiest intersections on the inland waterway. In 1988, twenty states shipped or received waterborne commerce which passed through either Kentucky or Barkely Lock. The economic study area selected for this feasibility study is shown on Figure 3 and is comprised of six Bureau of Economic Analysis (BEA) economic areas. These encompass the entire navigable reaches of the Cumberland and Tennessee Rivers and represent the origin or destination points for nearly all barge shipments through the Kentucky-Barkley navigation system. The economic study area includes 170 counties in five states and covers an area of 76,488 square miles. Each BEA area includes a center of economic activity and the surrounding counties that are economically connected to the center. The six centers of economic activity are Paducah, Kentucky (056); Nashville, Tennessee (054); Knoxville, Tennessee (053); Chattanooga, Tennessee (051); Huntsville, Alabama (050); and the portion of the Memphis, Tennessee (055) BEA area east of the Mississippi River.

CONTENTS OF REPORT

1.05 This main report is a nontechnical summary of the feasibility study investigating the need to improve the efficiency of the Kentucky-Barkley navigation system. It presents a broad view of the overall study for both the general and technical reader. The following topics are presented in the report in the order they are listed: a description of the study area, including existing and future conditions; a definition of area problems and the need for measures to alleviate those problems; the formulation and evaluation of alternatives; the selection of a recommended plan; a summary of the selected plan's economics, including costs and benefits; and a description of how the plan could be implemented.

1.06 This report also includes an Environmental Impact Statement (EIS). The EIS contains an evaluation of environmental and social impacts associated with the alternatives considered in the study with emphasis on the selected plan. These impacts were coordinated with the appropriate state and Federal environmental agencies. Their views are included and discussed in the EIS.

1.07 In addition to this main report and EIS (Volume I), there are other volumes which contain technical appendices. Volume II contains Appendices A and B. Appendix A, Plan Formulation and Public Involvement, includes a technical presentation of the process used to formulate and evaluate


NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
MAIN REPORT
ECONOMIC STUDY AREA
LEGEND:
BEA AREA BOUNDARY
STUDY AREA
OH
WV
VA
NC
SC
GA
AL
MS
LA
AR
MO
IL
IN
KY
TN
53
51
54
50
55
56
CINCINNATI
HUNTINGTON
LOUISVILLE
KNOXVILLE
NASHVILLE
CHATTANOOGA
ATLANTA
MEMPHIS
LITTLE ROCK
ST. LOUIS
PADUCAH
Figure 3

alternative plans and a description of the involvement of the shipping and towing industry and the general public in the planning process. It will include all responses to the formal public review of this report. Appendix B, Economics, includes the details of the economic impacts of the various alternatives. Volume III contains Appendix C, Project Design, which includes the engineering details and analyses associated with the selected plan and the detailed cost estimate. Volume IV contains Appendix D - Systems Analysis, which includes the details of the forecasting and navigation systems modeling processes.

PARTICIPANTS IN STUDY

1.08 Participants in the Lower Cumberland and Tennessee Rivers Navigation Study, in addition to the Nashville District Corps of Engineers, include the Ohio River Division (ORD) Navigation Planning Center, the North Pacific Division, the Louisville District, the U.S. Coast Guard, the Tennessee Valley Authority (TVA), the U.S. Fish and Wildlife Service (USFWS), and the Kentucky Department of Fish and Wildlife Resources. The ORD Navigation Planning Center identified and estimated commodity movements, developed transportation rates and traffic demand forecasts, forecasted future waterway traffic, finalized fleet selection, computed the capacity of the Kentucky-Barkley navigation system, and computed system rate savings for the without-project condition and the final alternatives. The Louisville District participated in initial aspects of the system's economic model. They began the fleet selection process and computed preliminary estimates of the capacities of Kentucky and Barkley Locks. The U.S. Coast Guard provided accident statistics for the lower Cumberland River and participated in all coordination meetings with the towing industry and in preparing the Environmental Impact Statement (EIS).

1.09 Both the North Pacific Division and TVA participated in the evaluation of Barkley hydropower releases on navigation conditions in the lower Cumberland River. The North Pacific Division estimated the costs of adding additional generating capacity at the Kentucky Project. TVA estimated the value of Barkley's hydropower generation under several operating scenarios.

1.10 Under the direction of the Nashville District, TVA assisted in design and cost studies that evaluated several plans for a new lock at Kentucky. TVA also assisted in preparing the design and cost estimate for the selected plan and are a participating agency in the EIS.

1.11 The U.S. Fish and Wildlife Service (USFWS) reviewed the study and provided comments and recommendations under authority of the Fish and Wildlife Coordination Act. As the study progressed through different stages of refinement the USFWS provided a Preliminary Coordination Act Report (April

1989), which was followed by a Draft Supplemental Coordination Act Report (April 1991). This document contains the recommendations of USFWS as set forth in the Final Coordination Act Report (October 1991) and is based upon the latest project information. The USFWS coordinated all three reports with the Kentucky Department of Fish and Wildlife Resources (KDFWR). For coverage under Section 7 of the Endangered Species Act, USFWS reviewed the Corps' Biological Assessment (BA) and provided a Biological Opinion.

COORDINATION AND INDUSTRY INVOLVEMENT

1.12 The District held its initial meeting with the public on January 9, 1975 at Kentucky Dam Village near Gilbertsville, Kentucky. Both waterway users and local landowners attended. The waterway users favored improving the waterway, while riparian landowners along the lower Cumberland looked for amelioration of erosion and high water.

1.13 On November 22, 1976, the District held another meeting to further discuss landowners' concerns about erosion and high water. Thirty citizens of the lower Cumberland area attended along with the Livingston County Attorney and Magistrates.

1.14 In April 1983, the District met with 24 representatives of the shipping and towing industries, representatives of the Tennessee-Cumberland Waterways Council, the U.S. Coast Guard, and the Tennessee Valley Authority. The group identified the major navigation problems on the Tennessee River. In November 1983, the district met again with the Tennessee-Cumberland Waterways Council and posed questions to further define the problems. The Council sent a formal response in May 1984.

1.15 On May 24, 1984, the District sent a scoping letter to all agencies, groups, and individuals identified as having an interest in the project. On August 30, 1984, the District published a Notice of Intent in the Federal Register that announced the District's intent to prepare an EIS. Many responses were received. Navigation interests supported the Corps' effort to improve existing navigation facilities. Agency responses varied according to mission functions and perspectives. Private individuals concerned about past and present erosion along the Cumberland River below Barkley Dam expressed concern about the effects of more navigation traffic on that stream, generally expressing strong sentiments against bend modifications on the lower Cumberland River.

1.16 On September 6, 1984 the District sponsored an inspection trip of the lower Cumberland River for members of the Tennessee-Cumberland Waterways

Council. Council members further identified navigational problems on the lower river.

1.17 In January 1985, the District began a series of interviews with six of the main users of the system. The companies provided information on their decision making process regarding the routing choice between Kentucky Lock and the lower Tennessee and Barkley Lock and the lower Cumberland.

1.18 The scheduled maintenance of Kentucky Lock between June 2 and September 15, 1986 forced all system traffic to use Barkley and the lower Cumberland River for a period of 104 days. The lock staff at Barkley surveyed lock users to obtain specific information on the use of the lock and the lower Cumberland River during this high-traffic period.

1.19 The District conducted additional interviews with eight companies in February and March 1987 and with 17 companies from October 1988 to March 1989. Both sets of interviews provided information valuable to portraying the existing and future operation of the system.

1.20 On October 5, 1989, the district held a meeting with a Task Force selected by the Tennessee-Cumberland Waterways Council (TCWC). Eleven representatives of the towing industry and representatives from the U.S. Coast Guard and TVA attended. The District and the Ohio River Division Navigation Planning Center presented details on how the economic model portrays the existing navigation system, the without project condition, and the measures under evaluation to improve the efficiency of the existing system. Feedback from this meeting gave further refinement to the without project condition assumptions.

1.21 A Feasibility Review Conference (FRC) was held in the City of Paducah, Kentucky during the period of 7-8 August, 1990. The conference was attended by representatives from ASA(CW), HQUSACE, CEBRH, CEWRC-WLR, CEORD, CEORN, CEORH, the Tennessee Valley Authority, U.S. Fish and Wildlife Service, U.S. Coast Guard, the Kentucky Department of Fish and Wildlife Resources, the navigation industry and a number of other organizations. The FRC was held to provide an agency review of the feasibility study and to discuss feasibility activities that needed to be accomplished to receive agency support. Representatives of the navigation industry expressed strong support for modernization of Kentucky Lock by providing an additional 110-foot by 1,200-foot lock chamber.

1.22 On May 31, 1991 the district announced the availability of the draft feasibility report, the comment period (June 7 - July 22, 1991), and the date of the public meeting. The public meeting was held at Kentucky Dam Village

State Park on June 19, 1991, about 100 people attended. The District Engineer presented a brief summary of the report and his tentative recommendations. A TVA representative discussed TVA's role in the study and the importance of Kentucky Lock in the nation's inland waterway system. Comments from the floor were taken. Further discussion of the meeting can be found in Appendix A - Public Involvement. All written comments are included in the FEIS.

1.23 On October 31, 1991 the district meet with members of the TCWC Task Force to discuss three topics - major maintenance at Kentucky Lock, reduced operation of Barkley Lock, and traffic management. Feedback from this meeting aided in refinement of the report's recommendations.

EARLIER STUDIES AND REPORTS

1.24 The Nashville District prepared four reports on the Cumberland River since completion of the Barkley Project in 1967. Each discusses navigation conditions on the lower Cumberland River below Barkley Canal. The first report is dated December 1967 and entitled "Effect of Turbine Operations on Navigability, Cumberland River Below Barkley Dam". It concluded that limiting the rate of increase in hydropower generation could improve the navigability of the river.

1.25 The second report, entitled "Report on Effects of Reservoir Operations on the Cumberland River Below Barkley Dam" is dated November 1968. It concluded that durations and crests of flood stages since the completion of Barkley Dam are not generally greater than they would have been under natural conditions. Also, the flood crests are usually lowered by reservoir operations.

1.26 The third report, entitled "Improvement of Navigation Conditions on the Lower Cumberland-Tennessee Rivers Below Barkley Canal" and dated February 1972, is a reconnaissance investigation. It identified impediments to navigation on the lower rivers and recommended several minor improvements. The report also recommended detailed studies of the problems.

1.27 The fourth report is entitled "Lower Cumberland and Tennessee Rivers Below Barkley Canal-12047 - Stage II Report". Completed in 1981, it documented investigations into the advisability of navigation modifications on the Cumberland and Tennessee Rivers downstream of Barkley Canal. Investigations focused on the collection of data, identification of problems, and formulation and evaluation of preliminary alternatives. The report recommended more detailed studies to determine the most feasible solution to the problems on the lower Cumberland and Tennessee Rivers.

SECTION 2 - RESOURCES AND ECONOMY

2.01 An assessment of the study area's natural and human resources, development, and economy provides a profile of existing and future conditions. This is the baseline used for formulating and comparing alternative plans to improve the efficiency of the Kentucky-Barkley navigation system.

STREAM DESCRIPTION

2.02 The Cumberland River is formed at the junction of Poor and Clover Forks in Harlan County, Kentucky. As shown on Figure 4, it flows 693 miles through southeastern Kentucky, northern middle Tennessee, and southwestern Kentucky until it enters the Ohio River near Smithland, Kentucky at Ohio River Mile 923. The river is navigable from its mouth to Celina, Tennessee, a distance of some 381 miles. Navigation is maintained by four multipurpose lock and dam projects, see Table 1. The Cumberland River has a drainage area of 17,598 square miles. The total fall of the river is 842 feet, with an average slope of 1.2 feet per mile. The average slope of the navigable portion of the river, which begins at Mile 381, is 0.52 feet per mile.

TABLE 1. PERTINENT DATA
CUMBERLAND RIVER LOCKS

Project	River Mile	Year in Operation	Main Chamber Length	Main Chamber Width	Auxiliary Chamber Length	Auxiliary Chamber Width	Normal Lift
Barkley	30.6	1964	800' X	110'	-	-	57'
Cheatham	148.7	1952	800' X	110'	-	-	26'
Old Hickory	216.2	1954	400' X	84'	-	-	60'
Cordell Hull	313.5	1973	400' X	84'	-	-	59'

2.03 The Tennessee River is formed by the junction of the Holston and French Broad Rivers near Knoxville in eastern Tennessee. From there, it flows 652 miles through Tennessee, northern Alabama, the northeast corner of Mississippi, and western Kentucky until it enters the Ohio River near Paducah, Kentucky at Ohio River Mile 934.4, see Figure 5. A commercially navigable channel is provided along the entire 652 miles by means of 9 multipurpose projects containing 13 locks, see Table 2. Navigation also extends about 60 miles up the Clinch River, 20 miles up the Hiwassee River, and 20 miles up the

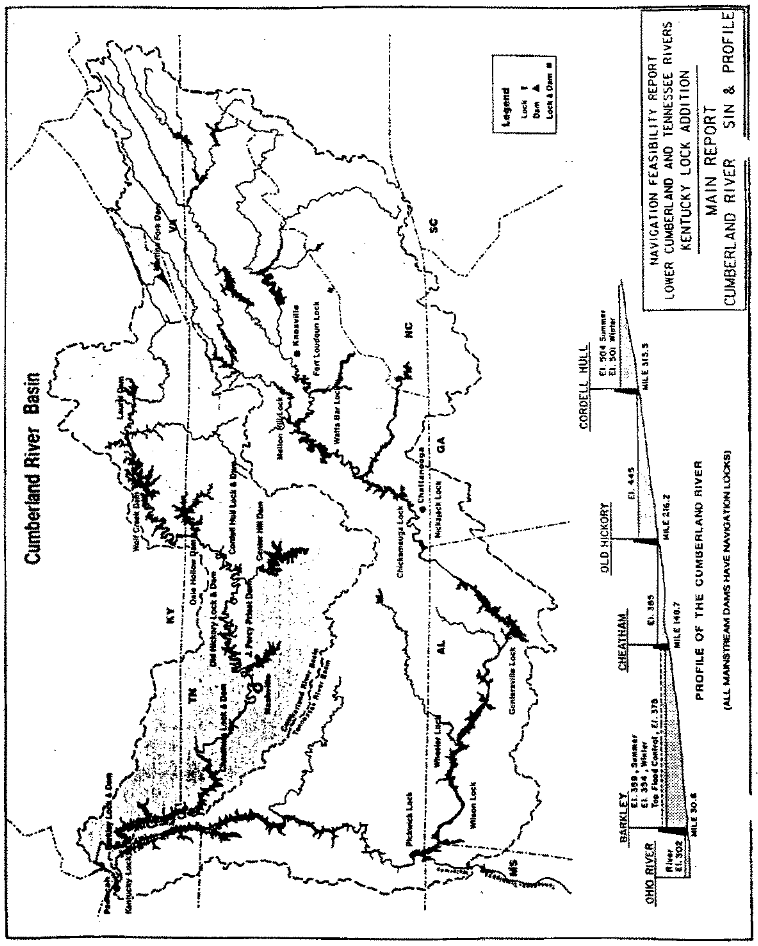

Cumberland River Basin
Legend
PROFILE OF THE CUMBERLAND RIVER
(ALL MAINSTREAM DAMS HAVE NAVIGATION LOCKS)
OHIO RIVER
BARKLEY
CHEATHAM
OLD HICKORY
CORDELL HULL
NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
MAIN REPORT
CUMBERLAND RIVER SIN & PROFILE

Figure 4

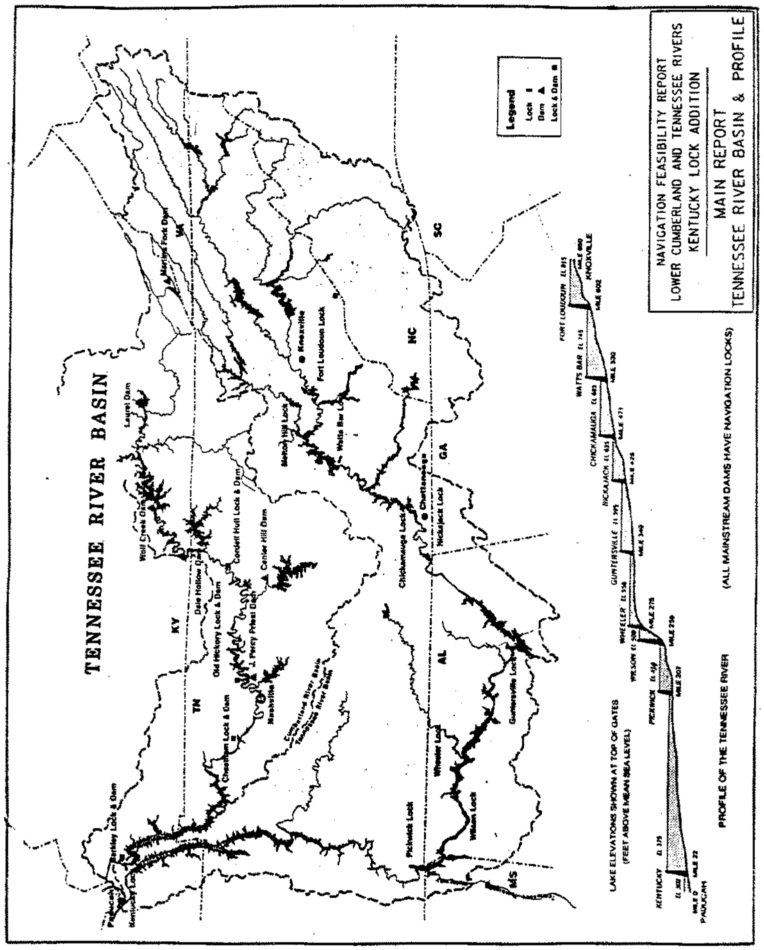

TENNESSEE RIVER BASIN
NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
MAIN REPORT
TENNESSEE RIVER BASIN & PROFILE
LAKE ELEVATIONS SHOWN AT TOP OF GATES
(FEET ABOVE MEAN SEA LEVEL)
PROFILE OF THE TENNESSEE RIVER
(ALL MAINSTREAM DAMS HAVE NAVIGATION LOCKS)

Figure 5

Little Tennessee River. The Tennessee River has a drainage area of 40,910 square miles. The total fall of the river is about 500 feet, with an average slope of 0.77 feet per mile.

TABLE 2. PERTINENT DATA
TENNESSEE RIVER LOCKS

Project	River Mile	Year in Operation	Main Chamber Length		Main Chamber Width	Auxiliary Chamber Length		Auxiliary Chamber Width	Normal Lift
Kentucky	22.4	1942	600′	X	110′		*		56′
Pickwick	206.7	1937	1000′	X	110′	600′	X	110′	55′
Wilson	259.4	1927	600′	X	110′	300′	X	60′**	94′
Wheeler	274.9	1934	600′	X	110′	400′	X	60′	48′
Guntersville	349.0	1937	600′	X	110′	360′	X	60′	39′
Nickajack	424.7	1967	800′	X	110′***	600′	X	110′	39′
Chickamauga	471.0	1937	360′	X	60′	-		-	49′
Watts Bar	529.9	1941	360′	X	60′	-		-	58′
Fort Loudoun	602.3	1943	360′	X	60′	-		-	72′

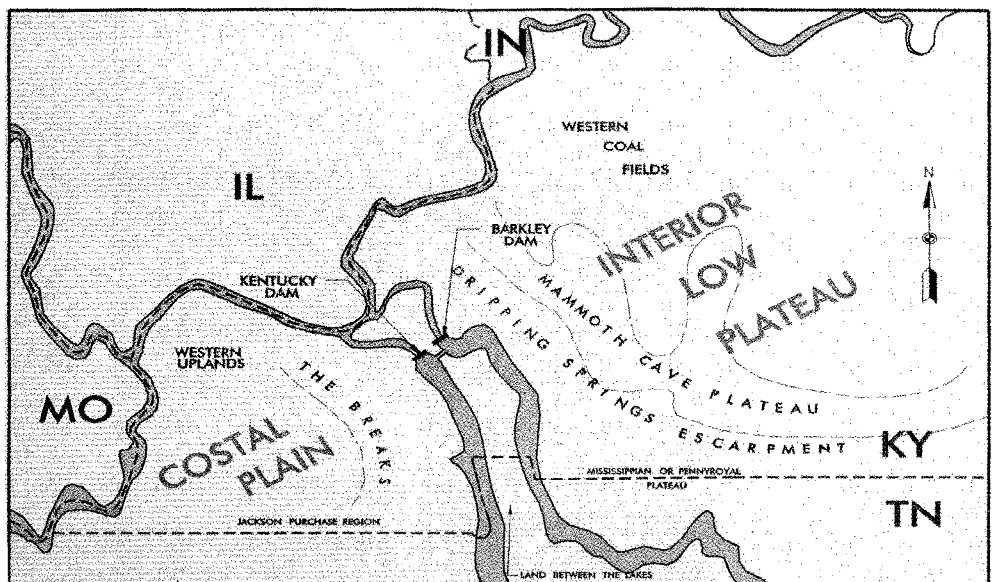
* Barkley Lock serves as auxiliary chamber.
** Two-stage lift lock.
*** Only underwater portion of main chamber completed.

CLIMATE

2.04 The climates of both the Cumberland and Tennessee River Basins are similar and generally moderate with warm summers and mild winters. Rainfall averages about 51 inches per year and is fairly well distributed throughout the year. Snowfall is relatively light averaging between 6 and 12 inches per year. Individual snowfalls are also light, with an average of 13 snowfalls per year. The frost-free period ranges from 180 days in the Cumberland Plateau to 220 days near Paducah, Kentucky.

PHYSIOGRAPHY

2.05 As shown on Figure 6, the study area lies within two regional physiographic provinces: the Interior Low Plateaus in the northeast or Cumberland River area and the Coastal Plain Province in the southeast or Tennessee River area. The Interior Low Plateaus Province is characterized by an erosion resistant bedrock that slopes gently to the northeast. The two Plateaus in this Province are the Mammoth Cave Plateau, on sandstones, and the



NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION

MAIN REPORT
PHYSIOGRAPHIC MAP

Figure 6

Pennyroyal or Mississippian Plateau, a karst plain of low relief and abundant sinkhole development. The Jackson Purchase Region of the Coastal Plain Province is in the southwestern portion of the study area. This region contains three distinct sub-regions ranging from moderate relief and well developed dentritic drainage patterns, to a highly dissected strip of deeply washed, steeply sloping lands, to hilly uplands where larger streams have cut broad, deep alluvial valleys.

GEOLOGY

2.06 The bedrock in the general area of the project are Mississippian and Pennsylvanian in age. The Mississippian rocks consist of limestones with minor amounts of shale, while sandstones having shale and coal interbeds comprise the younger Pennsylvanian rocks. The Pennsylvanian rocks constitute the Western Kentucky Coal Field. A concentration of northeasterly trending faults has splintered the Mississippian rocks into a complex strata of intricate faults. Kentucky Dam is located just south of a faulted area. The limestones have been fractured into a series of blocks separated by innumerable joints which are perpendicular to the bedding planes. Both the lower Cumberland and Tennessee Rivers have completely cut down through the younger sediments that once filled the Mississippi Embayment and have incised themselves into the underlying trough of Paleozoic rocks. Alluvium is present in the valley bottoms of all major streams and rivers and generally consists of silt, clay, sand, and gravel. Silts and clays are overbank deposits in the floodplain. Underlying these are sandy channel deposits which in turn are underlain by gravelly channel deposits over rock.

2.07 The most common rocks and sediments in the project area consist of limestones, sands, clays, and gravels. These were laid down by advances and retreats of ancient seas. Ages of rocks range from Cretaceous Age (most recent) to Mississippian (oldest). Foundation rock at Kentucky Dam consists of evenly bedded, cherty limestone of the Mississippian age Fort Payne formation. These rocks contain significant solution cavities and jointing features affecting the suitability of this area for lock foundations.

2.08 The area is subject to seismic activity. Approximately 60 miles to the southwest runs the famous New Madrid fault, along which in 1811-1812 occurred a series of violent earthquakes and tremors which resulted in formation of Reelfoot Lake.

LAND USE

2.09 For the land adjacent to the lower Cumberland and lower Tennessee Rivers, agriculture as a whole accounts for roughly 75% of the land use, while row crops and pasture lands make up roughly 50% of this category. Of the total lands in the vicinity, 20%-40% of the acreage meets criteria for classification as prime farmland. The region also has large areas of extensive forest, such as the Land Between the Lakes National Recreation Area. The only nearby urban center is Paducah, Kentucky, and its suburban areas. There are several small residential communities having little more than basic supportive commercial services for the townspeople and residents of the surrounding agricultural areas. Industrial land use is significant on the Tennessee River below Kentucky Dam, with various oil terminals, tug, and fleeting services located at Paducah, Kentucky, and a large chemical complex located at Calvert City, Kentucky. Finally, quarrying of limestone and associated activities are important to the area.

2.10 Primary land uses in the upper Cumberland and Tennessee River basins are related to resource extraction, such as coal mining and logging. Some farming occurs but is somewhat limited by the ruggedness of the terrain and lack of fertile bottomlands. The relative isolation of the upper basins and general poor access to transportation corridors has, among other things, limited industrial and commercial development. The middle portion of the two basins supports agricultural and industrial development, with some mining for limestone, zinc, and other minerals. Major population centers with extensive development are at Nashville, on the Cumberland River, and at Knoxville, Chattanooga, and Muscle Shoals-Florence-Sheffield, on the Tennessee River.

VEGETATION

2.11 The lower Cumberland and Tennessee Rivers lie within the Western Mesophytic Forest Region. This Region represents a transition in forest types between the Mixed Mesophytic Forest, located to the east in the Appalachian and Cumberland Mountains, and the Oak-Hickory Forest which extends westward from the project area. The vegetation of the study area now exists as a patchwork of communities in various stages of plant succession. Agriculture predominates the flatter landss, consisting of row crops and pasture. Major crops farmed in the area are corn, soybeans, and sorghum. Most of the pasture land is devoted to cattle grazing. Occasional fence rows separate fields and add to the otherwise low floral diversity of this community.

2.12 Except for occasional isolated woodlots in alluvial areas and riparian bands of trees, most of the forests still in the area occur on the more remote and inaccessible hills, bluffs, and ridges. Of the surviving forest-type communities in the area, the Oak-Hickory Forest is the most common. Dominent canopy trees include white, southern red, northern red, post, and black oaks, pignut, shellbark, shagbark, and mockernut hickories, sugar maple, slippery elm, and, occasionally, red cedar. Components of the Alluvial Forest, found primarily as riparian bands of trees, include sycamore, silver maple, river birch, sweetgum, hackberry, and cottonwood.

WILDLIFE

2.13 The terrestrial wildlife resources of the lower Cumberland and Tennessee Rivers are inseparably tied to the quality and quantity of available habitat. Within the study area, the habitat is tied to continuing rowcrop and pastoral agriculture practices. Other sources of habitat change are extraction of timber, mining, construction of transportation corridors, and establishment of urban and residential areas.

2.14 Agricultural practices tend to preclude the presence of many wildlife species but create large quantities of edge type habitat. Perching birds use cleared areas as sources of food, while raptores hunt from wooded fence rows and bordering forested areas. Agricultural lands support a high number of small mammal species, such as rodents. In addition, the white-tailed deer has benefited from the creation of edge-type habitat caused by clearing for farming.

2.15 The generally dry upland habitat of the Oak-Hickory Forest community supports a diverse assemblage of wildlife including the gray squirrel, chipmunk, woodchuck, opossums, shrew, gray fox, bobcat, and striped skunk. Commonly seen birds include towhee, cardinal, blue jay, several species of woodpecker, warblers, thrushes, vireos, owls, wild turkey, and black and turkey vultures.

2.16 The moist environment of Alluvial Forest provides habitat for white-tailed deer, gray fox, opossum, raccoon, muskrat, beaver, mink, weasel, several species of mice, bats, and many species of amphibians and reptiles. Numerous birds are found due to the presence of abundant water; they include great blue herons, green herons, and kingfishers. Aquatic insects emerging from the water provide food for insectivorous birds such as barn and cliff swallows. Large riparian trees offer abundant opportunities for cavity nesting birds such as woodpeckers and wood ducks.

AQUATIC RESOURCES

2.17 Aquatic habitat in the Cumberland River downstream of Barkley Dam typically consists of steeply sloping banks and shoreline areas composed mainly of clay, silt, and sand. Along limited reaches of the bank, rocky bluffs and outcroppings of limestone and sandstone occur. The navigation channel is underlain by substrates ranging from cobble and gravel to mud and silt. Physical habitat variability in the Cumberland River has been reduced over the years by stream modifications to improve navigability. Snag removal and dredging operations occur at various locations and have lowered the diversity of habitat, particularly shallow water habitat. Gravel accumulations in shallow water occur primarily at the mouths of tributary streams. The entire tailwater reach can be considered as pool-type habitat. No islands exist in this reach, with the exception of Cumberland Island at the mouth of the river.

2.18 Algal populations present in the lower Cumberland River are representative of those present in Lake Barkley. Cyanophycean algae and diatoms dominate the standing crop, but macrophytes are nonexistent. The microinvertebrate community inhabiting the Cumberland River downstream of Barkley Dam includes shellfish, insects, and a variety of other organisms. The molluscan component of the invertebrate community has been investigated in greatest detail. A survey in 1981 revealed 21 species of mussels representing 16 genera continuing to survive in the Barkley tailwater, with six species making up almost 75% of the mussel population. More recent investigation of mussel populations in the tailwater has revealed a gradual increase in mussel population numbers at some sites. This could indicate that the tailwater environment is becoming more habitable for these organisms.

2.19 An important sport and commercial fishery exists in the lower Cumberland River, despite a low diversity of fish habitat and fish species. The immediate tailwater of Barkley Dam (CRM 27.7 - 30.5) represents the major fish harvest area on the river. Creel surveys indicate that at least twenty species of sport, pan, and commercial fish are harvested. Dominant species taken include catfish (blue, channel, and flathead), white bass, white crappie, blue gill, sauger, freshwater drum, carp, paddlefish, and buffalofish. Blue catfish is the single most important commercial species harvested. Barkley Dam serves as a concentration point for migrating fish offering good angler success.

2.20 Physical habitat of the Tennessee River downstream of Kentucky Dam is similar to the lower Cumberland River in many respects. Shorelines are steep and composed predominantly of unconsolidated materials which easily erode. The entire tailwater area is a pool-type habitat, with sufficient flow, however, to prevent accumulation of sediment in most areas near the dam. Bank sloughing is common. The substrate within the tailwater ranges from swept bedrock to sand and silt. Extensive areas of clean gravel and sand occur, which support valuable mollusc populations.

2.21 Mussel resources in the lower Tennessee River represent a remnant of the large and diverse populations that once occurred throughout much of the river prior to its impoundment and modification. Recognizing the value of this resource, the Kentucky Department of Fish and Wildlife Resources (KDFWR) designated the Tennessee River between TRM 22.4 (Kentucky Lock and Dam) and 17.8 as a mussel sanctuary. Mussels may not be harvested within the sanctuary. The sanctuary effectively protects the existing molluscan fauna of this river reach. The purpose of the sanctuary is to provide a source of replenishment for mussel populations depleted elsewhere by overharvest, pollution, and other causes.

2.22 Mollusc populations of the lower Tennessee River have been extensively studied. A 1985 survey of the 22.4 mile tailwater reach revealed a total of 34 live species of mussels in the tailwater. Five species accounted for 75% of the total population. The most diverse and extensive mussel beds occur within the state mussel sanctuary. Below TRM 12.0, mussel density and diversity decreases noticeably.

2.23 Surveys in the lower Tennessee River generally indicate mussels occur wherever suitable flow and substrate are found. A major mussel bed is located between TRM 21.6 and TRM 20.5, adjacent the right bank. This bed exhibits recruitment of young mussels. Two recent surveys have been conducted which provide an assessment of the status of mussels in proximity of the dam. A 1987 survey revealed 27 species of mussels occupying the bed upstream of Interstate 24. This study focused only upon the right bank mussel bed. The second and most recent survey was conducted during 1990. Areas likely to be impacted by construction and operation of the new lock and associated structures were sampled. In summary, this survey revealed 23 live species of mussels, with 80% of the population consisting of two species. Detailed results are contained within the project Biological Assessment (See FEIS).

2.24 The lower Tennessee River supports a valuable and popular recreational and commercial fishery. The immediate tailwater area between TRM 21.1 (Interstate 24 bridge) and TRM 22.4 (Kentucky Dam) is especially heavily fished. At least 19 species of sport and commercial fish are harvested by anglers. Dominant species taken include blue catfish, channel catfish, flathead catfish, sauger, white bass, white crappie, striped bass, and paddlefish. Kentucky Dam serves as a concentration point for migrating fish, offering good angler success.

FEDERAL THREATENED OR ENDANGERED SPECIES

2.25 Until recently, only relic shells of federally threatened or endangered species of mussels had been recovered from the lower Cumberland River. In December 1987, an investigator discovered live specimens of the fat pocketbook mussel (Potamilis capax), at CRM 0.2, in a backchute of Cumberland Island

Towhead. Further surveys have not revealed any more individuals of this species in the lower Cumberland River. Two species of aquatic gastropods under review for possible listing as threatened or endangered exist in the lower Cumberland River. These are the armored rock snail (Lithasia armigera), and ornate rock snail (Lithasia geniculata).

2.26 The lower Tennessee River, with its extensive mussel populations, supports several federally endangered species. These include documented individuals (found in the last 15 years) of the following mussels: pink mucket pearly mussel (Lampsilis orbiculata), orange-footed pearly mussel (Plethobasus cooperianus), fanshell mussel (Cyprogenia stegaria), and ring pink mussel (Obovaria retusa). Several other species of mussels and four species of gastropods occurring in the lower Tennessee River are candidates for Federal listing.

2.27 The lower Tennessee River could support two candidate fish species--blue sucker (Cycleptus elongatus) and lake sturgeon (Acipenser fulvescens).

2.28 Terrestrial threatened or endangered species could occur in the area. The bald eagle, (Haliaeetus leucocephalus), may occur on a transitory basis. The Arctic peregrine falcon, (Falco peregrinus tundrius) is an unlikely visitor to the area as a winter migrant. Two bat species, Indiana bat (Myotis sodalis) and Rafinesque's big-eared bat (Plecotus rafinesquii), could occur within the project area, principally as individuals of summer colonies. The gray bat, (Myotis griscens) may forage through the area. Among candidate species, the southeastern bat, (Myotis austroriparius), Bachman's sparrow (Aimophila aestivalis) and copperbelly water snake (Nerodia erythrogaster neglecta) may occur within the project area.

2.29 No federally endangered, threatened, or candidate species of vascular plants occur in the project area.

NATURAL RESOURCES

2.30 Major natural resources in the economic study area (Figure 3) include coal, limestone, sand and gravel, commercially significant timber resources and nationally important zinc deposits. In addition to zinc ore, a variety of metal bearing ores and metallic minerals are found. These include sulfide ore, feldspar and olivine. About 3.1 billion tons of demonstrated coal reserves are located in the study area's rugged terrain of southeastern Kentucky and East Tennessee and are part of the Appalachian coal-producing region. This high-quality bituminous coal is characterized as high BTU, low sulfur and low ash. Limestone is produced throughout the area, with two of the largest quarries, Reed's Crushed Stone and Three Rivers Rock, in close proximity to the Kentucky and Barkley Projects. Both production and consumption of sand and gravel occur within the study area. Most of the sand and gravel output is earmarked for construction. Sand and gravel are produced by dredging operations along the Tennessee River and on the Ohio River at the mouth of the Cumberland River. About 70 percent of the land area in east Tennessee and southeast Kentucky is covered by forest. Timber production, such as lumber and pulpwood, is the major contribution from these forests. The predominate trees are hardwood generally used for furniture, shipping pallets, flooring, and railroad ties. The softwoods are used for construction lumber and pulpwood for paper and fibers.

HUMAN RESOURCES

2.31 The population of the economic study area in 1986 was almost 7 million, representing an overall population density of about 91 persons per square mile. About 75% of the population resided in the Memphis, Nashville, and Knoxville BEA areas. The population grew faster than the nation as a whole between 1976 and 1986, 21.4% versus 19.7%. The Nashville BEA area grew the most at 30%, while the Paducah area grew the least at about 6%. About 34% of the area's population resided in urban areas compared to 61% nationally. Most of the area's population was characterized as rural (46%) and nonrural (20%), and resided in numerous incorporated and unincorporated communities throughout the region.

CULTURAL RESOURCES

2.32 History. The earliest American Indian presence in the project area may well have been as much as 12,000 years ago. The earliest Euro-American presence within the lower Cumberland and lower Tennessee Rivers area likely occurred during the seventeenth century when explorers, fur traders, and missionaries traversed the area. Diversified settlement occurred after the year 1800 with the rivers playing an increasingly important role in local trade and commerce. This later type of historic settlement is exemplified by the remnants of "old" Gilbertsville (1870), formerly located near the site of Kentucky Dam on the Tennessee River. The predominant use of the lands adjacent to the Cumberland and Tennessee Rivers was initially, and continues to be, agricultural.

2.33 No historic sites within the immediate project area are currently listed on the National Register of Historic Places. However, Kentucky Lock and Dam and original associated structures has been determined to be eligible for listing as an individual resource and as an integral part of the TVA system.

2.34 __Archeology__. Direct evidence of prehistoric Indian occupation in the lower Cumberland River area begins about 8,500 years ago; however, indirect evidence places the initial occupation of the area about 12,000 years ago. Prehistoric occupation continued through the late Mississippian period ending about A.D. 1540. Professional archeological investigations within the project area were initiated in the 1920's and 1930's. Additional work was conducted as part of the River Basin Program under the administration of the Smithsonian Institution during the 1940's and 1950's. More recent investigations resulted from the construction of several large reservoir projects in the region (Lake Barkley). A large number of archeological sites have been located along the lower Cumberland and Tennessee Rivers, ranging from deeply stratified basecamp-type sites, to ephemeral hunting camps and prehistoric homesteads.

2.35 A single archeological site, the Whalen site (15Ly48) on the Cumberland River, is listed on the National Register of Historic Places, although many more sites may be considered eligible for listing. Adjacent to Kentucky Lock and Dam, there are two significant, and therefore eligible, sites (15Lv204 and 15Lv24). Survey and testing within areas likely to be impacted below Kentucky Lock located a buried Woodland period site (15Lv204, ca. 1,000 years before the present). A relatively small cemetery containing late prehistoric burials; a small associated prehistoric farmstead is also in the immediate vicinity of Kentucky Lock.

RECREATIONAL RESOURCES

2.36 The area of influence for purposes of potential recreation use extends in roughly a 25-mile range and includes primarily the Kentucky counties of McCracken, Marshall, Trigg, Caldwell, Crittenden, Lyon, and Livingston. This market area is generally typified by small rural communities of less than 10,000 population. Paducah, Kentucky (1980 population 61,310) is the largest city in the area of influence.

2.37 The immediate area of influence offers a wide variety of opportunities for most types of general outdoor recreation. Major developments, such as the Land Between the Lakes operated by the TVA, three highly developed state parks, several Corps of Engineers recreation areas, and numerous private campgrounds and resorts, all combine to attract a variety of recreationalists. Nearly all of these developments are for activities on one of the lakes or the adjoining shoreline. Recreation, primarily from out-of-state, has a major impact on the surrounding economy. The major attractions are lake-related activities like boating, warm-water fishing, water skiing, picnicking, swimming, and family camping.

2.38 Currently, developed access to the Cumberland River downstream of Barkley Dam is rather limited. Although several access sites exist (see Figure 7), most of them are in poor condition or lack adequate parking facilities. Figures are not available on recreation use of these sections of river, but indications are that it is very limited, primarily because access sites are generally unmarked and unknown to potential users. Recreation use in these areas is almost totally due to fishing activity, and is probably less than 20,000 to 30,000 visitors annually.

2.39 Downstream of Kentucky Dam there is a commercial dock near the mouth of Clarks River thus giving somewhat better access to the lower Tennessee than the lower Cumberland (see Figure 7). Recreation use of this section of the Tennessee River is more varied than below Barkley, and more transient. Usage is estimated to be between 40,000 to 60,000 visitors annually, with most of this activity associated with the boat docks.

2.40 Access to the Cumberland and Tennessee Rivers immediately below the dams is provided at sites operated by the Corps of Engineers and the TVA, respectively. Yearly attendance at the river developments below Lake Barkley is over 300,000, forty percent of which is due to fishing activity, with the remainder consisting mostly of sightseeing. Developments on the Tennessee River below the Kentucky Lock and Dam include access for bank and boat fishing, sightseeing, and camping (Kentucky Dam Village State Park). Actual use information below the Kentucky project is not readily available, but estimates are that it would equal or exceed the use experienced below the Barkley project.

DEVELOPMENT AND ECONOMY

2.41 The region's economy and resources define the limits of the commodities that could potentially move on the waterway. The economic study area's manufacturing-based economy developed around its natural resources -- water, coal, wood, limestone, and nonferrous metal ores -- and the demands of larger regional economies which are driven by textile and furniture industries. Abundant coal resources and hydroelectric generation on many of the area's streams offered relatively inexpensive energy for many years. This low-cost energy attracted energy-intensive aluminum smelting to the Tennessee Valley. Wood resources were used for paper and furniture making and for the manufacture of synthetic fibers.

2.42 Much of the region's activity, in terms of bulk commodity flows, is intertwined. Aluminum smelting depends on relatively cheap energy, and paper production is contingent upon water and wood resources. Chemical plants in the area use the abundant local wood resources to manufacture synthetic fibers

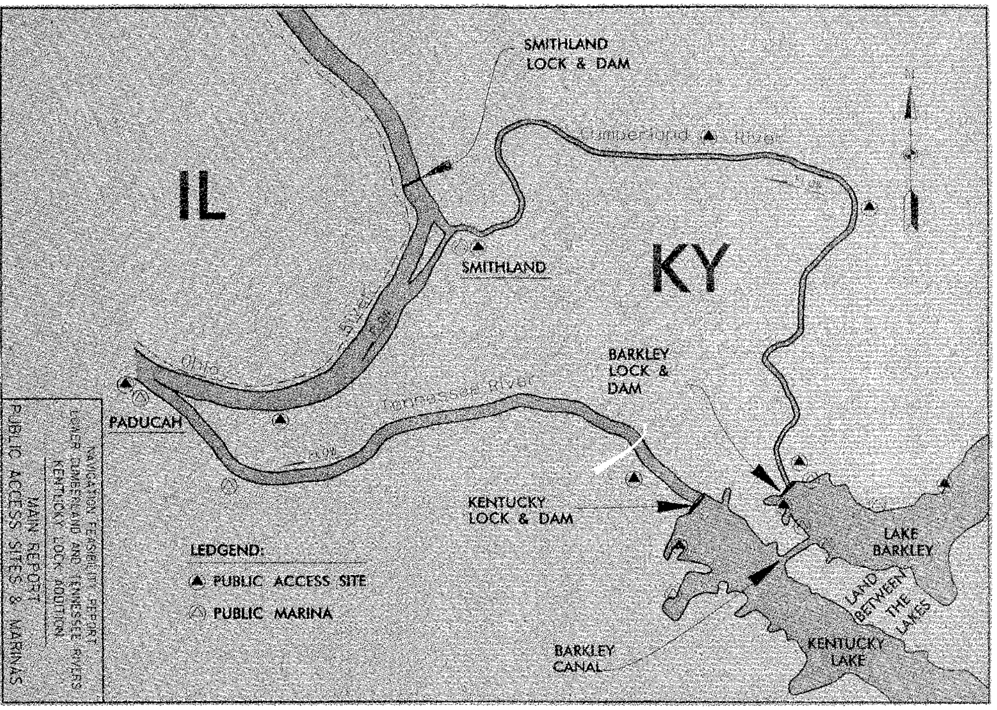

SMITHLAND
LOCK & DAM
Cumberland River
IL
KY
SMITHLAND
Ohio River
BARKLEY
LOCK &
DAM
Tennessee River
PADUCAH
KENTUCKY
LOCK & DAM
LAKE
BARKLEY
LEDGEND:
PUBLIC ACCESS SITE
PUBLIC MARINA
LAND
BETWEEN
THE
LAKES
KENTUCKY
LAKE
BARKLEY
CANAL
NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
MAIN REPORT
PUBLIC ACCESS SITES & MARINAS

Figure 7

for nearby paper mills. All of the major industrial facilities in the study area use coal directly or indirectly.

2.43 Grain processors, some of which are relative newcomers to the region, serve three major markets: the huge poultry feed markets of north Georgia, Alabama, and South Carolina; the southeastern market for corn sweeteners and vegetable oils; and, the volatile but growing export feed market. Their waterside locations allow them to source Midwestern grain at competitive prices and reach the export market in New Orleans.

TRANSPORTATION

2.44 Waterways. A navigable channel with a minimum depth of 9 feet is maintained on the lower 381 miles of the Cumberland River by four lock and dam projects. Table 1 under Stream Description lists the Cumberland River projects. A canal between Lakes Barkley and Kentucky at Cumberland River Mile 32.8 and Tennessee River Mile 25.3 provides a navigation link between the Cumberland and Tennessee Rivers.

2.45 Nine lock and dam projects containing 13 locks maintain a 9-foot deep navigable channel for the entire 642 miles of the Tennessee River. Table 2 under Stream Description lists the Tennessee River projects. Navigation also extends about 60 miles up the Clinch River, 20 miles up the Hiwassee River, and 20 miles up the Little Tennessee River.

2.46 Study area waterways provide significant links in the national inland waterway system, see Figure 1, Section 1. Contiguous to the study area is the Ohio River, one of the nation's most important navigable waterways and the lifeline for bulk commodity movements in the Ohio and Tennessee Valleys. The Ohio River links the industrial heartland of America with overseas markets and provides a low-cost mode of transport for coal and other bulk commodities.

2.47 The Ohio, together with the Monogahela and Allegheny Rivers, link the Cumberland and Tennessee Valleys to the upper Ohio Basin. The study area is also linked to the upper Midwest and the Great Lakes by way of the upper Mississippi, Illinois, and Missouri Rivers, to the lower Ohio Basin by the Ohio River, and to the Gulf Coast by the lower Mississippi River and the Tennessee-Tombigbee Waterway.

2.48 Railroads. The Cumberland River Basin is well served by two major railroads: CSX Transportation and the Norfolk Southern Railway. Except for the upper Cumberland area from Gainesboro to Celina, Tennessee, facilities on the navigable portion of the Cumberland River have access to a main line railroad within a radius of 20 miles. Lack of service in the upper Cumberland area is due to the rugged, steep terrain. Nashville, with main line trackage in all directions connecting to major cities, has the greatest access to rail facilities.

2.49 The Tennessee River Basin is served by three major railroads which focus on the major cities of Chattanooga and Knoxville. These railroads are CSX Transportation, the Illinois Central Gulf, and the Norfolk Southern Railway. In addition, the northeast portion of Mississippi has a small railroad connecting the cities of Corinth, Mississippi and Counce, Tennessee. In general, the mainstem Tennessee River has access to a main line railroad within a radius of 20 miles. The major exception to this pattern is from just south of Johnsonville Steam Plant to Savannah, Tennessee. Most of the Alabama portions of the river are well served by railroads, particularly the cities and surrounding areas of Florence and Decatur.

2.50 The project area is well served by the Paducah and Louisville Railroad which transverses both dams and connects Paducah with Louisville and the main Chicago to New Orleans line. In addition, the Seaboard System provides service from Paducah to southwestern Tennessee and the Mississippi River.

2.51 Highways. Highways of various categories (interstates, primaries, secondaries, and state highways) are extensive in the Cumberland River Basin. Nashville, the regional focal point is served by three interstates and three major U.S. primary roads. The interstate facilities are Interstate 40 connecting Nashville with Memphis and Knoxville, Interstate 65 connecting Louisville and Birmingham via Nashville, and Interstate 24 connecting Nashville with Chattanooga and St. Louis. The most notable lack of adequate highway facilities is the upper Cumberland area where only minor arterials serve the area.

2.52 Highways of various categories are also extensive in the Tennessee River Basin. Knoxville and Chattanooga are connected by Interstate 75 and are connected to Nashville via Interstates 40 and 24, respectively. Interstate 75 continues south from Chattanooga to Atlanta. Interstate 65 passes through Nashville from Louisville, continues south through the middle Tennessee section of the basin, and passes between Decatur and Huntsville, Alabama, giving access to both urban areas. The Tennessee River Basin has many more Federal primary, secondary, and state highways than does the Cumberland Basin. Knoxville and Chattanooga are connected with three major U.S. highways, Florence and Huntsville by two, and Decatur by one. The most notable lack of major highways is in the same areas as was indicated in rail facilities: the western portion of the Tennessee River from Perryville, Tennessee to the northwestern portion of Alabama, just west of the City of Florence.

2.53 The major highway in the project area is Interstate 24 which connects Paducah, Kentucky with Nashville and St. Louis. In addition, there are several Kentucky state routes, namely Route 60 from Paducah to Smithville, Route 62 from Paducah to Eddyville, and Route 64 from Murray to Marion.

2.54 **Pipelines**. The amount of petroleum fuels consumed in the Cumberland and Tennessee River Basins exceeds the amount produced in the region. A series of pipelines brings petroleum fuels into the region from refineries on the Gulf and East Coasts. Most of the more than seven million tons of petroleum fuels used in the areas surrounding Chattanooga, Nashville, and Knoxville are transported through the Colonial Pipeline system.

2.55 In addition, the Texas Eastern Transmission pipeline, which runs from the Texas Gulf to Central Ohio, serves Evansville, Indiana, Cincinnati, Ohio, Paducah, Kentucky, and the surrounding areas including the project area. An 8-inch Amoco line from Chicago, Illinois to Decatur, Alabama supplies petro chemicals to consumers in Nashville and Evansville.

SECTION 3 - NAVIGATION CONDITIONS ON THE LOWER CUMBERLAND AND TENNESSEE RIVERS

HISTORICAL DEVELOPMENT

3.01 Before modern locks and dams, flatboats used the Cumberland and Tennessee Rivers for commercial transport as early as the 1800's. Navigating these unimproved rivers, however, often proved difficult and was sometimes impossible. Navigation was hindered by physical obstructions such as gravel bars, sand bars, shoals, and snags. Swift currents, caused by channel constrictions and steeply sloped streambeds, and uncertain depths, caused by seasonal differences in rainfall, also hindered navigation. Early commercial shipments were almost always downbound and mainly consisted of timber, coal, and agricultural products.

3.02 The advent of the steamboat, which was in general use on the Cumberland and Tennessee Rivers in 1835, brought about a new era in river transportation and served as an impetus for river improvements. The improvements, however, were scattered and largely ineffectual due to inadequate funding and poor designs. This pattern of river improvement continued on both rivers until after the Civil War.

3.03 In 1888, the Corps began construction of the first lock and dam on the Cumberland River. The project, Lock and Dam No. 1, was located just downstream of the Nashville Harbor. The lock measured 52 feet by 280 feet. Between 1888 and 1924, 13 additional projects were constructed to create a six-foot deep navigable channel from the mouth of the Cumberland River to Carthage, Tennessee (about 330 river miles).

3.04 In 1946, Congress authorized the construction of a nine-foot channel from the mouth of the Cumberland to Nashville. The original plan to replace the existing facilities with three moderately high-lift locks and dams was later modified, substituting one large multi-purpose structure, the Barkley Project, for the two lowermost locks and dams. The modified plan included a short navigation canal to connect the Cumberland and Tennessee Rivers. Later three other lock and dam projects were constructed thereby providing a 9 foot deep navigation channel for a total of 381 miles up the Cumberland River.

3.05 Canals were the earliest improvements on the Tennessee River. In 1831, a canal was constructed between the river and Huntsville, Alabama, and in 1836, a canal was constructed around Muscle Shoals, also in Alabama. Both canals were soon abandoned because of poor design. In 1890, a second Muscle Shoals canal, providing a 5-foot minimum depth, was opened. The Colbert Shoals Canal near Florence, Alabama was completed in 1911 and provided a

7-foot channel. The first lock and dam project, Hales Bar, was completed in 1913 by a private power company and provided a 6-foot deep channel 33 miles upstream to Chattanooga, Tennessee. Widow's Bar Locks and Dam, constructed 23 miles below Hales Bar, was completed in 1925 and provided a 5-foot deep channel. Wilson Locks and Dam, completed by the Corps of Engineers (COE) in 1925, was constructed to improve navigation through the Muscle Shoals area. It provided a 9-foot deep channel. However, an auxiliary lock and dam 2.5 miles downstream was needed to improve the approach to Wilson. Florence Canal, the canal created by the auxiliary structures, had a navigable depth of 7 feet.

3.06 In 1933, Congress created the Tennessee Valley Authority (TVA). At that time, TVA took over the construction of Wheeler Lock and Dam from the COE and began implementing the plan to fully develop the Tennessee River. In addition to Wilson and Wheeler Locks and Dams, seven other high-lift, multipurpose projects were built on the Tennessee River between 1933 and 1945. These nine projects provide a 9-foot deep navigation channel from Kentucky Dam to the river's head near Knoxville. The full project depth of 9 feet was provided in 1954 with the completion of dredging below Kentucky Dam.

DESCRIPTION OF PRESENT NAVIGATION SYSTEM

3.07 Table 1, see Section 1 - Stream Description, lists pertinent data for the four navigation projects on the Cumberland River. The location of each is shown on Figure 4. Table 2, see Section 1 - Stream Description, lists the pertinent data for the 9 mainstem navigation projects on the Tennessee River. Tellico Dam provides navigation about 20 miles up the Little Tennessee River with locking facilities available via a canal connecting the Tellico and Fort Loudoun Lakes. The locations of the Tennessee River projects are shown on Figure 5. The following paragraphs provide a detailed description of the components of the Kentucky-Barkley navigation subsystem.

3.08 <u>**BARKLEY LOCK AND DAM**</u>. Construction of this multipurpose project, located at Cumberland River Mile 30.6 near Grand Rivers, Kentucky, began in 1957, see Figure 8. The dam is 157 feet high and 10,180 feet long. It has an 800-foot long concrete spillway with 12 tainter gates capable of discharging flood waters at a rate of 570,000 cubic feet per second (cfs). Lake Barkley has 1,417 miles of shoreline and a surface area of 93,400 acres. It is capable of storing 1,213,000 acre-feet of flood waters. Barkley Lock, opened to traffic in July 1964, measures 110 feet by 800 feet with a normal lift of 57 feet. It is capable of passing a modern 11-barge tow in one lockage. The Barkley Project has four hydroelectric generating units, with a total plant capacity of 130,000 kilowatts.

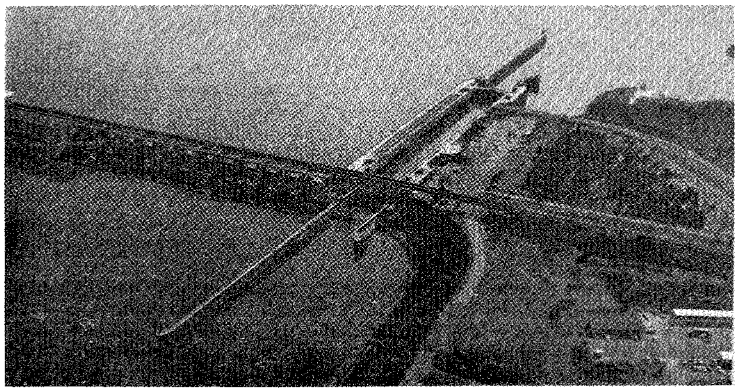


Figure 8 - Barkley Lock and Dam

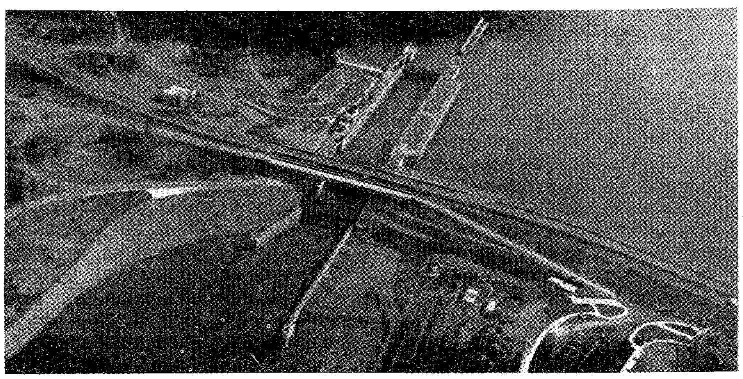


Figure 9 - Kentucky Lock and Dam

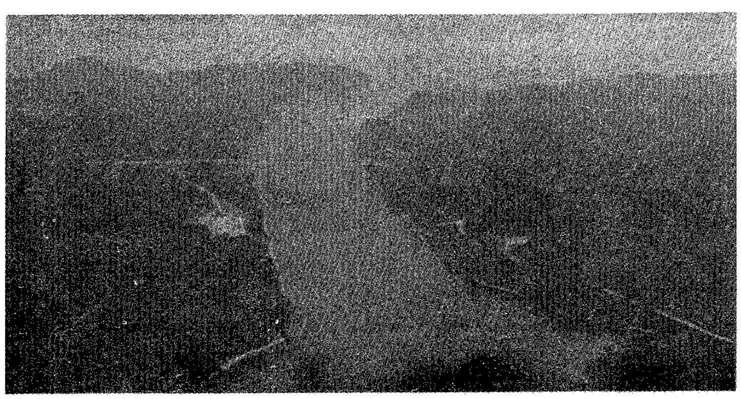


Figure 10 - Barkley Canal

3.09 **KENTUCKY LOCK AND DAM**. Completed in 1944, this multipurpose project is the first major structure above the mouth of the Tennessee River, see Figure 9. It is located near Paducah, Kentucky at Tennessee River Mile 22.4. Kentucky Dam is 206 feet high and 8,422 feet long. The 160,000 acre lake can store over 4 million acre-feet of flood waters. Kentucky Lock opened to commercial traffic in 1942. It measures 110 feet by 600 feet and is capable of passing an 8-barge tow in one lockage. The normal lift at the lock is 56 feet. The Kentucky Project has five hydroelectric generating units, with a total plant capacity of 175,000 kilowatts.

3.10 **BARKLEY CANAL**. Two miles upstream of Barkley Dam and three miles above Kentucky Dam, Barkley Canal connects the two lakes and provides an exceptional degree of coordination and flexibility with respect to navigation, flood control, hydropower generation, and recreation, see Figure 10. This 400-foot wide, 1.75-mile long canal makes alternate routings available to navigation traffic. This choice can save a waterway user up to 65 miles, depending on the point of origin and destination. The canal allows vessels to bypass the lower portion of the Cumberland River, which is narrow and winding, in favor of the lower Tennessee River, which is broad and straight. In addition, the canal enhances the flood control functions of both lakes and has improved navigability in the Cheatham and Old Hickory pools by lessening flood-related pool fluctuations. The flexibility provided by Barkley Canal also improves the efficiency of both projects with respect to hydropower generation by decreasing flood releases.

HISTORIC AND PROJECTED WATERBORNE COMMERCE

3.11 **HISTORIC TRAFFIC AND GROWTH**. Most of the tonnage shipped on the Cumberland and Tennessee Rivers moves inbound from or outbound to the Ohio River. This largely external orientation is a function of the types of industries along the rivers, the resources of both basins, and the location of the industries' product supply and market areas.

3.12 The Kentucky-Barkley navigation system reached an all time high level of traffic in 1988 of 37.3 million tons. This high level of traffic was directly related to drought conditions present throughout most of the nation that year. The drought increased traffic levels in two ways. First, many Ohio River Basin industries rerouted shipments (destined to or from the Gulf Coast) via Kentucky-Barkley and the Tennessee-Tombigbee Waterway (TTW) to avoid the severe restrictions and shut-downs on the Mississippi River. Secondly, the drought resulted in much lower than normal hydropower production in the Cumberland and Tennessee River Valleys. This in turn caused an increase in waterborne coal shipments to TVA's coal-fired electric generating plants. A return to a more normal hydrological condition in 1989 resulted in lower

Kentucky-Barkley traffic, 33.3 million tons. Also, TVA's Sequoyah nuclear power plant units 1 and 2 were brought back on-line in late 1988 and early 1989 further lowering the demand for waterborne coal shipments. Traffic declined further in 1990 as the national economy began to slide into a recession and as a result of TVA's Colbert plant being shutdown for part of the year for repair. Traffic data since 1986 for Kentucky and Barkley Locks is summarized in Table 3.

TABLE 3. - RECENT TRAFFIC KENTUCKY AND BARKLEY LOCKS
1986 - 1990
(Millions of Tons)

Year	Kentucky L&D	Barkley L&D	Kentucky-Barkley Navigation System
1986*	21.1	13.1	34.3
1987	30.1	5.0	35.1
1988	32.4	4.9	37.3
1989	29.6	3.7	33.3
1990	28.9	3.0	31.9

*Adjusted based on comparison of 1986 Performance Monitoring System data and Waterborne Commerce Statistical Center data by the ORD Navigation Planning Center. Note that Kentucky Lock was closed for 3 1/2 months in 1986 resulting in higher than normal traffic at Barkley.

Source: COE Performance Monitoring System data

3.13 The economic study area's continued industrial expansion caused a steady growth of waterborne traffic since the Kentucky-Barkley system was completed in 1967. Between 1967 and 1986, Kentucky-Barkley tonnage almost tripled, increasing from about 13 to 34 million tons. This is equivalent to an annual growth rate of 5.2 percent, which far exceeds the growth rate of 2.2 percent for the Ohio River system as a whole. This higher growth rate in Kentucky-Barkley traffic reflects a faster regional economic growth in the Tennessee and Cumberland Basins relative to the Ohio Basin for the period. Historical tonnage on the Kentucky-Barkley navigation system and the Ohio River system is summarized in Table 4.

TABLE 4. - HISTORIC TRAFFIC
KENTUCKY-BARKLEY AND OHIO RIVER SYSTEMS
1967 - 1986 (Million Tons)

Year	Kentucky-Barkley Navigation System	Ohio River System
1967	13.1	147.4
1970	17.1	163.9
1975	26.4	171.4
1980	30.8	200.9
1986	34.3	223.9
Average Annual Rate, 1967-1986	5.2%	2.2%

Source: Corps of Engineers Waterborne Commerce Statistics.

3.14 **EXISTING TRAFFIC AND SHIPPING PATTERNS**. The most recent traffic forecasts use 1986 as the base year for projecting future traffic levels. The base year for developing traffic projections should not be a year of unusually low traffic such as that experienced during the recession of the early 1980's. It also should not reflect any unusual exogenous events such as a major coal strike or the drought of 1988. 1986 was determined to be a good representative year for Ohio River Basin traffic. In 1986, 34.3 million tons of commerce were shipped through the Kentucky-Barkley navigation system. Presented in Table 5 are 1986 traffic statistics by commodity group for the Kentucky-Barkley system.

3.15 Coal is the major commodity moved on the Kentucky-Barkley system, accounting for 47 percent of total tonnage. About 85 percent of the coal moves upbound, destined for steam plants along the Cumberland and Tennessee Rivers and the southeastern utility market. Lesser amounts are destined for export and industrial users. Downbound coal goes to powerplants on the Mississippi River.

3.16 Aggregate traffic is second only to coal traffic in terms of tonnage shipped on the Kentucky-Barkley navigation system accounting for 22 percent of total tonnage. About one-fourth of this traffic is upbound from dredging operations along the Ohio River and is largely used in construction activities around the Nashville area. The remaining aggregates traffic is downbound primarily destined for the lower Mississippi and Gulf Coast. This downbound traffic originates from study area quarries.

3.17 Coal and aggregates collectively represented 69 percent of the total tonnage on the Kentucky-Barkley system in 1986. Other important commodities included grains with 13 percent of total tonnage, chemicals with 4 percent, iron and steel with 3 percent, ores and minerals with 3 percent, and petroleum fuels with 2 percent. The remaining 6 percent of total tonnage is comprised of various miscellaneous commodities.

TABLE 5. - 1986 TRAFFIC BY COMMODITY GROUP
KENTUCKY-BARKLEY NAVIGATION SYSTEM
(Thousand Tons)

Commodity	Tonnage
Coal	16,250
Petroleum Fuels	608
Aggregates	7,667
Grains	4,297
Chemicals	1,520
Ores & Minerals	943
Iron & Steel	1,013
Others	2,026
Total	34,324

Source: Corps of Engineers Waterborne Commerce Statistics.

3.18 **PROJECTED TRAFFIC DEMANDS**. Because of the commonality of traffic among the projects comprising the Ohio River Navigation System, projections of traffic demand were developed for the entire system rather than separately for each navigation project. The projections were made by the ORD Navigation Planning Center located in the Huntington District, U.S. Army Corps of Engineers and documented in a report titled "Forecast of Future Ohio River Basin Waterway Traffic, 1986-2050", May 1990.

3.19 Future traffic demands on the Ohio River navigation system were projected as a function of future economic growth in the markets served by industries using the waterway. These include local, regional, national, and international markets. The traffic demand projections were developed with reference to industry-produced supply and demand forecasts; the 1985 OBERS Regional Projections, prepared by the Bureau of Economic Analysis, Department of Commerce, and other government forecasts.

3.20 The general procedures for projecting traffic included computing growth indices (using industry-produced forecasts, OBERS projections, and other government forecasts) and applying these indices to traffic flows on the Ohio River system for the base year (1986). These projections are movement specific and translate into traffic demand projections for the total Ohio River System, each of the navigable waterways in the system, and each lock and dam project in the system. A detailed description of the traffic forecasts can be found in Appendix D - Systems Analysis.

3.21 The predominant commodity shipped through the Kentucky-Barkley system is coal destined for TVA coal-fired electric generating plants. Consequently, in developing the traffic projections, TVA's load forecast and power supply summary prepared for fiscal year 1989 was used in developing traffic demand projections.

3.22 Projected traffic demands for the Kentucky-Barkley navigation system and the Ohio River System are shown in Table 6. Kentucky-Barkley traffic demand is projected to more than double, from 34 million tons in 1986 to 83 million tons by 2050, an equivalent annual growth rate of 1.4 percent. This is slower than the historic growth rate and reflects the maturing of the region's industrial base. Kentucky-Barkley traffic demand is projected to increase at about the same rate as the Ohio River navigation system.

TABLE 6. - PROJECTED TRAFFIC DEMANDS 1986-2050
(Million Tons)

Year	Kentucky-Barkley	Ohio River System
1986	34.3	223.9
2000	46.5	315.9
2010	51.2	350.9
2020	55.2	381.0
2030	63.7	437.9
2040	72.7	490.2
2050	82.9	548.7
Average Annual Growth Rate	1.4%	1.4%

Source: COE Waterborne Commerce Statistics and "Forecasts of Future Ohio River Basin Waterborne Traffic, 1986-2050", March 1990, ORD Navigation Planning Center

3.23 The relative distribution of the commodities shipped on the Kentucky-Barkley navigation system is projected to change slightly in the future, see Figure 11. Petroleum fuels are projected to decrease to only one percent by 2050 and is grouped with the "others" category. Coal and aggregate shares are also projected to decrease, while iron and steel, ores and minerals, and others will increase in relative importance.

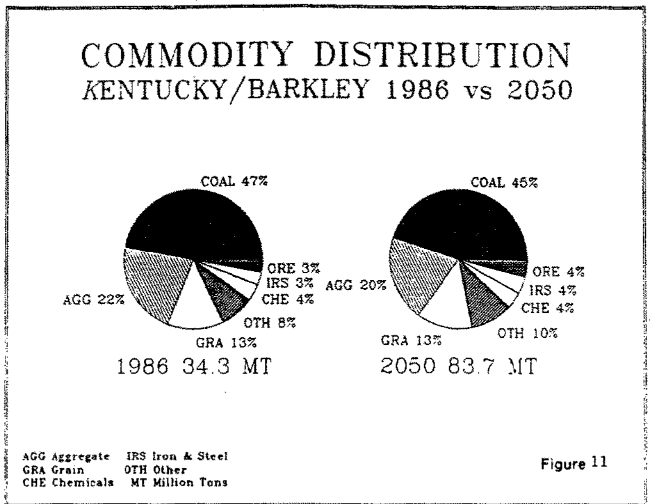


Figure 11

VESSEL TRAFFIC AND LOCK USE

3.24 In 1989 Kentucky and Barkley Locks processed a total of 40,417 commercial barges in 4,739 tows for an average tow-size of about 8.5 barges. The locks at Kentucky and Barkley present a unique situation to the inland waterway system because of the 1-3/4 mile canal that joins the Tennessee River and the Cumberland River just above these locks. This allows shippers to choose which lock and which river to use when transiting to and from the Ohio River and to and from the Cumberland and Tennessee River Basins. Historic data shows that shippers generally prefer to use the 600-foot lock at Kentucky rather than the 800-foot lock at Barkley. Table 7 shows the 1989 traffic split between the two locks.

3.25 In 1989, Kentucky Lock processed a total of 3,731 commercial tows and 33,686 commercial barges for an average of 10 tows a day. This translates into 79% of the tows and 83% of the barges transiting through the system. The main reason for the greater usage of Kentucky Lock is to avoid the hazards of the lower Cumberland, especially the numerous bendways, one-way traffic areas, hydropower discharges, and fog (dense fog occurs much more frequently on the lower Cumberland River than on the lower Tennessee). These hazards, along with the longer distance to the Ohio River, result in higher operating costs for the lower Cumberland compared to the lower Tennessee River. Appendix D - Systems Analysis presents more detailed information on vessel traffic and lock use.

TABLE 7. - 1989 COMMERCIAL LOCKAGE STATISTICS
KENTUCKY-BARKLEY NAVIGATION SYSTEM

Item	Kentucky Lock		Barkely Lock		System
	Number	% of System	Number	% of System	
No. of Tows	3,731	79%	1,008	21%	4,739
No. of Barges	33,686	83%	6,731	17%	40,417
Avg Barge/Tow	9.0		6.7		8.5

SOURCE: COE's Performance Monitoring System data.

SECTION 4 - PROBLEMS AND NEEDS

NAVIGATION PROBLEMS

4.01 **GENERAL**. The 1967 construction of Barkley Canal connected the Cumberland and Tennessee Rivers and created the Kentucky-Barkley subsystem of the inland waterway. This subsystem lies at the heart of the inland waterway and provides a vital link between major markets. The Kentucky-Barkley system is unique in that it gives waterway users a choice of how to reach their destinations.

4.02 Historically most users, even those with origins or destinations on the Cumberland River, choose to reach their destinations via Kentucky Lock and the lower Tennessee River. They make this choice for predominantly economic reasons; it generally costs less to use the lower Tennessee River than it does to use the lower Cumberland. This cost differential occurs because the physical characteristics of the two rivers are so distinct.

4.03 The lower Tennessee River can be compared to an interstate highway, see Figure 12. It is broad and straight with relatively stable currents. The distance between Barkley Canal and the confluence of the Ohio and Mississippi Rivers via the lower Tennessee is only 66 miles. Also, the mouth of the Tennessee River is 16 miles below Smithland Dam on the Ohio River. Consequently, releases from Smithland have little effect on the water-surface elevation of the Tennessee River and the difference in elevation between the two rivers is fairly constant.

4.04 The Cumberland River, on the other hand, can be characterized as a rural road. It is narrow and contains numerous curves and sharp bends, see Figure 13. The narrowness of the channel contributes to swift currents and intensifies the adverse effects of fog and hydropower releases. The distance between Barkley Canal and the confluence of the Ohio and Mississippi Rivers via the lower Cumberland is 94 miles, about 28 miles further than via the lower Tennessee. In addition, the mouth of the Cumberland is only 4 miles downstream of Smithland Dam and water-surface elevations on the lower Cumberland River can be significantly affected by Smithland releases. The most serious impacts occur when the Smithland tailwater is low, coinciding with hydropower releases from Barkley and creating a major difference in the water-surface elevations of the two rivers and a steep grade for tows upbound on the lower Cumberland. The resulting high velocities and channel slope cause tows to burn more fuel per hour on the lower Cumberland than on the lower Tennessee. This is compounded by slower tow speeds, smaller tows, and the longer distance via the lower Cumberland. The smaller tows result in companies making more trips to move the same amount of tonnage. Systems

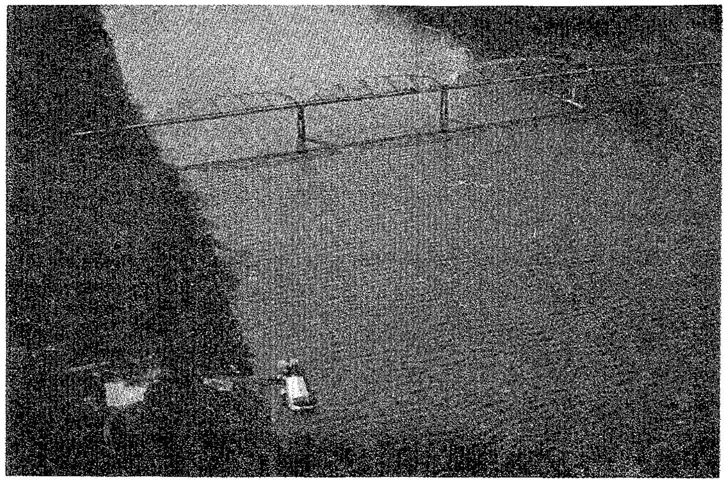


Figure 12 - Lower Tennessee River

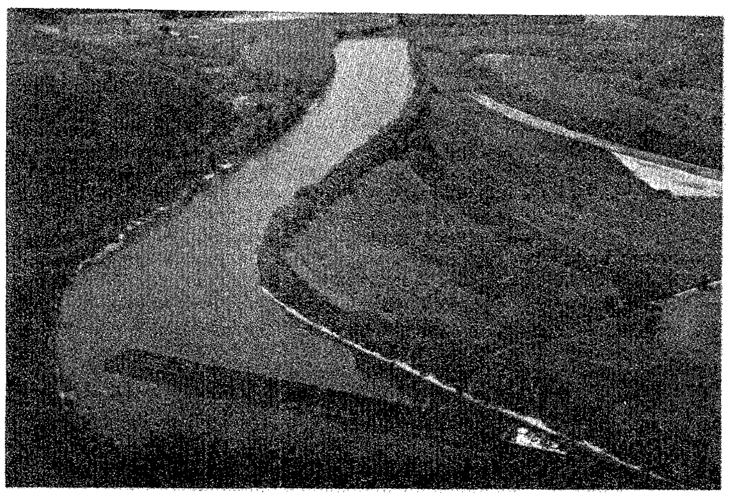


Figure 13 - Lower Cumberland River

analyses indicate that the above factors cause the costs of transiting the lower Cumberland to currently be about $0.50 per ton higher than the costs of transiting the lower Tennessee in the absence of lock delays. (See Appendix D - Systems Analysis for further discussion.)

4.05 This historic trend of system users preferring the lower Tennessee River causes significant congestion and delay problems at Kentucky Lock. The following paragraphs describe these problems and the physical characteristics of the lower Cumberland River in more detail.

DEFICIENCIES IN LOCK CAPACITY

4.06 Table 8 depicts the physical capacity of the existing Kentucky-Barkley navigation system and projected rates of utilization based on current forecasts of traffic demand. Although Barkley Lock is 200 feet longer than Kentucky Lock, its tonnage capacity is less because a high percentage (63% in 1989) of Barkley's traffic is empty barges and a high percentage (59% in 1989) of Kentucky's traffic is loaded. This unusual traffic split occurs because of the tortuous condition of the lower Cumberland channel; the hazards of the lower Cumberland are less for empty barges. The projected level of traffic demand for the Kentucky-Barkley system is essentially the traffic demand for Kentucky Lock. Practically all waterborne traffic would prefer to use Kentucky Lock and the lower Tennessee routing. In 1988, Kentucky Lock reached 86 percent of its physical capacity, while Barkley Lock reached only 20 percent. The rate of use for the Kentucky-Barkley system was 60 percent. Essentially, Barkley Lock serves as the auxiliary chamber to Kentucky. By the year 2000, however, traffic demands will exceed the capacity of Kentucky Lock. Demands in that year would amount to a 134 percent use rate at Kentucky Lock which translates into an 81 percent rate for the system. This excess demand can be accommodated at Barkley in the year 2000; however, by the year 2020, the entire Kentucky-Barkley system becomes saturated. Traffic demands amount to a 153 percent use rate at Kentucky and a 94 percent use rate for the system.

TABLE 8. - ESTIMATED PHYSICAL CAPACITY AND USE KENTUCKY-BARKLEY NAVIGATION SYSTEM 1986-2050

Existing Project	Physical Capacity (Million Tons)	Actual & Potential Lock Use (%)(1) 1986(2)	1988	2000	2020	2040	2050
Kentucky	37.7	56	86	134	156	197	222
Barkley(3)	24.7	53	20	57	87	100	100
Kentucky-Barkley System	62.4	55	60	81	94	119	134

(1) Use greater than 100% indicates project demand exceeds physical capacity.
(2) Kentucky was closed for 3 1/2 months in 1986.
(3) By 2000, Kentucky is saturated, diverting Kentucky demands to Barkley.

4.07 The deficiencies in lock capacity described above are magnified during lock maintenance closures. Table 9 displays the impacts of lock closures on the annual physical capacity for the existing Kentucky-Barkley navigation system. Under normal operating conditions, the system has a capacity of 62.4 million tons. When Kentucky Lock is closed, system capacity is reduced to 42.0 million tons, and when Barkley Lock is closed, system capacity is reduced to 37.9 million tons. Projected traffic demand for the Kentucky-Barkley system in the year 2000 amounts to about 50 million tons. This far exceeds the capacity of the system when either lock is closed.

TABLE 9. - IMPACTS OF LOCK CLOSURES ON PHYSICAL CAPACITY KENTUCKY-BARKLEY NAVIGATION SYSTEM

Kentucky-Barkley System Without-Project	Annual Physical Capcity (Million Tons)
Normal Operations	62.4
Kentucky Lock Closed (1)(2)	42.0
Barkley Lock Closed (1)	37.9

(1) Assumes helper boats would be employed at the open lock.
(2) Assumes modification of Barkley power releases to allow full use of Barkley. Without modification capacity is reduced to 26.4 million tons

4.08 **CONGESTION PROBLEMS**. The major lockage problems of the Kentucky-Barkley Navigation System occur at Kentucky Lock which suffers from chronic congestion as can be illustrated by several statistics. Delay time is the major component of the time it takes a tow to transit the lock. Delay at Kentucky varied from 122 minutes (2 hours) in 1982 to 253 minutes (4.2 hours) in 1987. The average delay time for the period is 188 minutes (3 hours). This delay time is one of the highest in the Ohio River System.

4.09 As the demand for Kentucky Lock increases, the average time a tow is delayed will increase. Figure 14 shows the relationship between the amount of traffic at Kentucky Lock (measured in tons) and the average time a tow is delayed. As can be seen, Kentucky Lock is poised on the brink of exponentially increasing delays, which translate into exponentially increasing costs to the towing industry. By the year 2000, delays at Kentucky Lock will become so high that traffic will be forced to use higher cost routings, either Barkley Lock and the lower Cumberland River or overland transportation. Again, this translates into ever increasing costs to the towing industry.

4.10 **LOWER CUMBERLAND CHANNEL CONDITIONS**. The navigation conditions on the narrow, serpentine lower Cumberland River are less than favorable at best and often quite hazardous. Two physical characteristics contribute most significantly to the river's hazardous nature - bendways and hydropower releases. These characteristics are discussed below.

4.11 Bendways. Less than half the 30 miles between Barkley Lock and the Ohio River is suitable for two-way traffic. Six sections on the lower Cumberland are designated as one-way traffic zones as shown on Figure 15. These zones are characterized by sharp bends and some include awkward approaches to narrow bridge openings. If two tows are traveling in opposite directions and approaching any one of these zones, the upbound tow must pull over and wait until the downbound tow clears the area.

4.12 The District conducted several surveys of industry to obtain information about navigation conditions on the lower Cumberland. The information from these surveys proved useful in both specifically defining the major navigation constraints and in the economic modeling of the existing and future "without-project" scenarios. A survey conducted during the 1986 closure of Kentucky Lock reflected a high traffic situation (13.1 million tons). Because hydropower releases were limited to 20,000 cfs, the survey did not reflect the multiple impacts of hydropower releases. It did, however, provide valuable information on how tows operate under high traffic conditions.

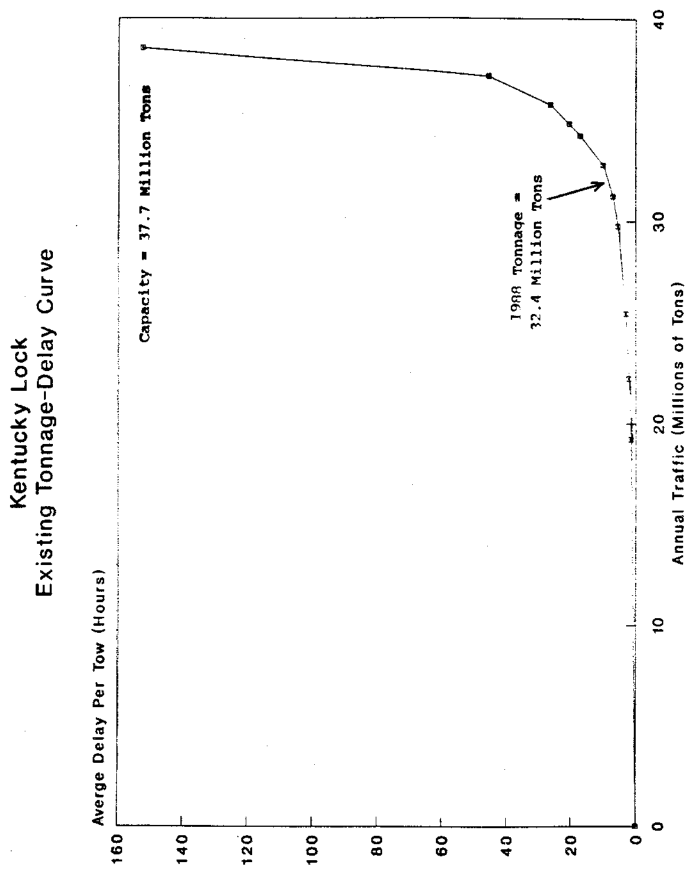
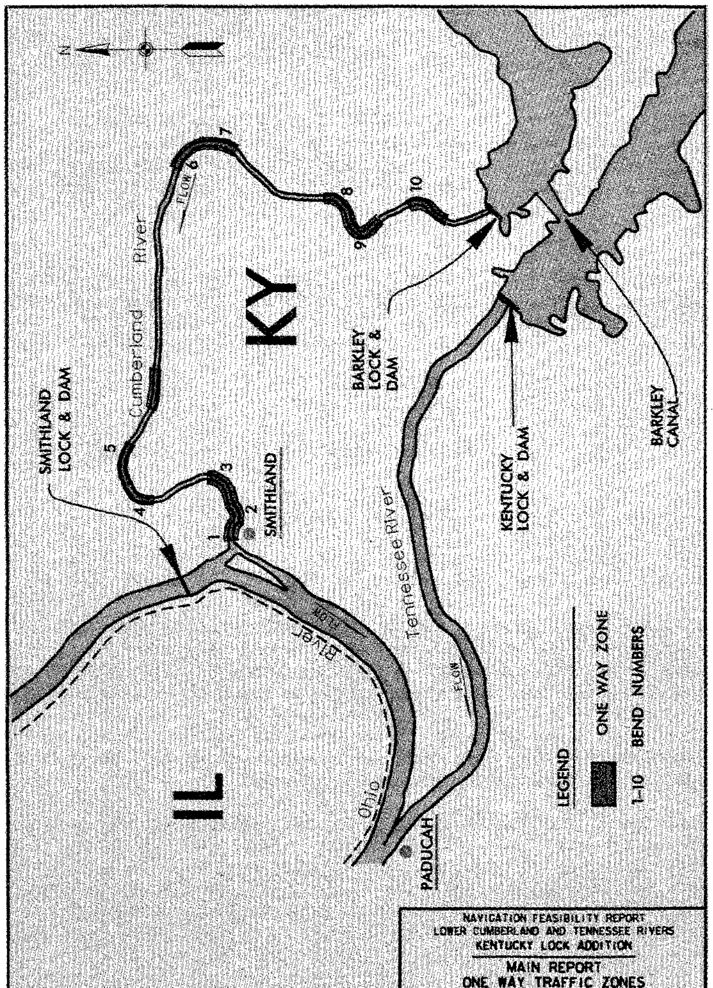

Kentucky Lock
Existing Tonnage-Delay Curve
Averge Delay Per Tow (Hours)
Capacity = 37.7 Million Tons
1988 Tonnage =
32.4 Million Tons
160
140
120
100
80
60
40
20
0
0
10
20
30
40
Annual Traffic (Millions of Tons)

Figure 14


N
SMITHLAND LOCK & DAM
Cumberland River
FLOW
KY
IL
SMITHLAND
Ohio River
FLOW
Tennessee River
FLOW
PADUCAH
BARKLEY LOCK & DAM
KENTUCKY LOCK & DAM
BARKLEY CANAL
1
2
3
4
5
6
7
8
9
10
LEGEND
ONE WAY ZONE
1-10 BEND NUMBERS
NAVIGATION FEASIBILITY REPORT
LOWER CUMBERLAND AND TENNESSEE RIVERS
KENTUCKY LOCK ADDITION
MAIN REPORT
ONE WAY TRAFFIC ZONES
Figure 15

4.13 Another survey conducted in late 1988 and early 1989 obtained information about towing operations on both the lower Cumberland and Tennessee Rivers. Eight of the companies ranked the bendways from most to least hazardous. See Table 10.

TABLE 10. - INDUSTRY RANKINGS OF LOWER CUMBERLAND BENDWAYS

Rank	Bend Name	River Mile
1 (worst)	Camp Rowdy (Bend No. 10)	27.5 - 28.6
2	Lucy Jefferson Lewis Memorial Hwy Bridge (Bend No. 2)	3.1 - 3.7
3	Ferguson Creek (Bend No. 3)	4.1 - 5.3
4	Smithland (Bend No. 1)	2.0 - 3.1
5	Three Rivers/Bissell Bluff (Bends No. 4 and 5)	7.2 - 9.4
6	Dooms Landing (Bend No. 8)	24.1 - 25.0
7	Lower/Upper Dycusburg (Bends No. 6 and 7)	19.2 - 20.5
8 (best)	Iuka (Bend No. 9)	25.0 - 26.4

4.14 <u>Hydropower</u>. Based on coordination with the towing industry, both the volume and the rate at which water is released from the Barkley Powerplant significantly impact navigation on the lower Cumberland. The narrowness of the channel magnifies these effects to such an extent that the river is "down" or unavailable to a vast majority of the towing industry about a third of the time. Letters from the navigation industry state that they will not use the lower Cumberland River when hydropower discharges are above 35,000 to 40,000 cubic feet per second and prefer smaller releases.

4.15 During interviews, some towboat operators reported that they met a "wall of water" several feet high when traveling upstream on the lower Cumberland. This "wall of water" is produced by a rapid acceleration of the water as it is released instantaneously from the turbines and is very hazardous resulting in an extreme loss of maneuverability. The majority of companies surveyed in 1988 and 1989 considered this rapid fluctuation in flow caused by hydropower releases as a major problem on the lower Cumberland River.

4.16 Based upon the above studies and discussions with companies that operate on the lower Cumberland, the Nashville District placed restrictions on hydropower operations at both Barkley and Kentucky to improve navigation conditions. The minimum instantaneous discharge at Kentucky is 20,000 cfs and the minimum daily release averages 25,000 cfs. The minimum instantaneous discharge at Barkley is 6,000 cfs and the rate of change in the discharge is limited to the equivalent of one generating unit operating at full capacity per hour or about 10,000 cfs per hour. Also, velocities in Barkley Canal are controlled by limiting the maximum difference in water-surface elevations between Kentucky and Barkley reservoirs to one foot.

SECTION 5. PLAN FORMULATION

STUDY OBJECTIVES

5.01 The Principles and Guidelines stipulate that "the Federal objective of water and related land-resources planning is to contribute to national economic development (NED) consistent with protecting the nation's environment...". Contributions to NED are direct benefits and costs that accrue to the study area and the rest of the nation. The Federal objective is further specified in terms of alleviating problems, satisfying needs, and realizing opportunities within the study area or region. The following specific objectives were developed for this study:

a. Reduce the lockage delays (costs) to navigation traffic currently using the Kentucky-Barkley navigation system.

b. Facilitate the safe and efficient movement of traffic on the Cumberland and Tennessee Rivers through Barkley and Kentucky Locks to the level of demand projected during the economic life of potential replacement projects.

c. Minimize the adverse effects to the navigation industry of maintenance closures at Kentucky and Barkley Locks.

d. Preserve and enhance fish and wildlife and other natural resources in the Cumberland and Tennessee Rivers including the valuable fishery resources and mussel sanctuary below Kentucky Dam. Integrate environmental protection into the planning, design, construction, and operation of the project.

e. Maintain navigation traffic to the maximum extent possible during project construction.

f. Minimize the adverse effects on Cumberland and Tennessee River recreational boating due to construction of the project.

RATIONALE AND CONSTRAINTS

5.02 The plan formulation rationale is to identify and evaluate a range of alternatives that will fully or partially satisfy the problems and needs discussed in Section 4 and the study objectives listed above. Plan formulation for this study has focused on alternatives to improve waterway transportation insofar as the U.S. Army Corps of Engineers or the Tennessee Valley Authority has development authority. Other resource problems, needs, and opportunities, such as hydropower and fish and wildlife conservation, have been addressed in the overall context of potential navigation improvements.

5.03 The planning and development of water resource improvements follow guidance given in current policies and regulations. Principles and Guidelines has two major guidelines: 1) the recommended plan must have incremental system benefits (transportation savings) in excess of incremental system costs, and 2) the recommended plan should provide the maximum net economic benefits to the nation (NED Plan). The NED Plan must be selected unless there are overriding reasons to select another plan. In addition, the Water Resources Development Act of 1986 (Public Law 99-662) requires that one-half of the construction cost of inland navigation projects be paid from the Inland Waterways Trust Fund. Therefore, a recommended plan must also be acceptable to the navigation industry as represented by the Inland Waterway User's Board.

WITHOUT-PROJECT CONDITION

5.04 GENERAL. The without-project condition is the most likely situation expected to exist in the future in the absence of the navigation improvement or any change in law or public policy. The without-project condition serves as the baseline against which alternatives are evaluated. The benefits, costs, and effects attributed to each alternative plan being evaluated represent the increment of change or difference between the with- and without-project conditions.

5.05 There are several potential components of the without-project condition for the Kentucky-Barkley navigation system. Some components are self evident and stipulated in Principles and Guidelines, other more project specific components require evaluation and screening to determine the most appropriate scenario. Both the specific components and the screening process are discussed below.

5.06 The without-project conditions stipulated in Principles and Guidelines are as follows:

a. Ordinary operation and maintenance will be performed at Barkley and Kentucky Locks and Dams for the period of analysis. In addition, rehabilitation of these projects will be undertaken as needed to ensure continued navigability. As discussed later in this section, the Barkley and Kentucky projects are generally sound; however, rehabilitation of the surface concrete, wall armor, lock gates, valves, and operating machinery will be needed during the study period (2005-2054).

b. Existing waterway projects and those under construction or authorized for construction are to be considered in operation over the period of analysis. Specifically, a new 1200-foot lock at the Gallipolis Project on the

Ohio River, a new 800-foot lock at the Winfield Project on the Kanawha River, new 720- X 84-foot locks at Grays Landing and Point Marion Projects on the Monongahela River, and the Olmsted Locks and Dam replacement of Locks and Dams 52 and 53 and the new 1200-foot lock at McAlpine Locks and Dam on the lower Ohio River are assumed to be in-place.

c. All feasible nonstructural measures for improving lock efficiency that are within the purview of the Corps of Engineers will be implemented at the appropriate time. Specifically, all locks on the Ohio River navigation system (including the Cumberland and Tennessee River projects) will use the most efficient lockage policy.

d. Taxes will be collected on all fuel consumed by commercial users of the inland waterways as prescribed by law (Title II of Public Law 95-502 — Inland Waterway Revenue Act of 1978 and Title III of Public Law 95-662 — Water Resources Development Act of 1986).

e. Alternative modes of transportation for waterway shipments will have sufficient capacity to move projected traffic at current rates.

5.07 **CONDITION AND MAINTENANCE OF EXISTING PROJECTS**. The without-project condition also assumes that Kentucky and Barkley Locks will be maintained throughout the planning period. The the condition of both locks and the types of maintenance activities expected to occur are described below.

5.08 General. The Corps of Engineers operates and maintains the locks on the Cumberland River. On the Tennessee River, the Corps operates the locks and shares maintenance responsibilities with TVA. Both Barkley and Kentucky Locks and Dams are in good condition for their age; but, by the end of the planning period (2054), Kentucky Lock will be 112 and Barkley Lock will be 90 years old. A significant amount of resources will be needed to maintain service at these locks for the period of analysis.

5.09 Routine. Routine maintenance, such as oiling, greasing, and painting, is accomplished in by the lock's staff. An estimate of routine maintenance is included as downtime in the Kentucky-Barkley system model.

5.10 Periodic. The maintenance program conducted by the Corps and TVA has two major components inspection/prediction and maintenance/repair. The Corps' primary concern is operation of the lock, while TVA's primary concern is dam safety. Current agreements call for a dewatering interval of 5 years. Maintenance closures are planned with particular emphasis on the next two events (5 and 10 years out). Kentucky lock is 50 years old so there is always a long list of items needing repair. These items are ranked considering three factors: 1) condition, 2) consequences of failure, and 3) how the repair fits into the overall closure schedule. The condition of all critical components of the lock is monitored and compared to previous inspections. Any item that can be deferred usually is. Items essential to maintaining navigation or dam safety are given higher priority. The most important aspect of any closure is its length. Lock outate is kept to a minimum. Critical paths are developed including only the most essential items. Other items are added only if they do not impact outage time.

5.11 Table 11 displays the periodic maintenance schedule for the period 1990 to 2055 for both Kentucky and Barkley Locks. The table lists the year a closure will take place, the time the lock will be closed, the first cost of dewatering, inspecting, and repairing the lock, and a description of the repairs. For the most part, specific items to be repaired are not listed. A typical dewatering is described in Appendix A - Plan Formulation.

5.12 The costs of the general or unspecified dewaterings range from $315,000 to $520,000 (October 1991 price levels) and are based on District experience with all 17 Tennessee and Cumberland Rivers locks. The dewatering and inspection cost about $200,000. The remaining funds are for repairs. The costs, as well as the length of closure, of the unspecified work generally increase over time with the effects of age and wear and tear.

5.13 The costs of the specified periodic closures are based on a detailed evaluation of the items to be repaired. These estimates were developed by experienced District personnel in both Operations and Readiness and Engineering Divisions based on experience at locks throughout the district.

5.14 Major. The major maintenance category includes all closures scheduled to last 8 weeks or more. Generally, the items to be repaired and the estimated time required to make the repairs were developed by a panel of experienced District personnel. However, detailed estimates were made for the concrete repairs. The panel developed a list of specific items to be repaired or replaced during the planning period (2005 to 2054) and assigned a decade in which each item is expected to need repair. This list was then combined with the list of periodic closures. Major maintenance events were scheduled so as not to occur when the other lock in the system would be closed for periodic maintenance. Four 13-week events and an eight-week event are scheduled for Kentucky Lock during the planning period. At Barkley, four 14-week events and an eight-week event are scheduled.

5.15 By the year 2006, Kentucky Lock will have been in operation 64 years. One of the most heavily used locks on the inland waterway system, Kentucky Lock experiences daily wear on the concrete and wall armor. The continuously

TABLE 11. PERIODIC AND MAJOR MAINTENANCE CLOSURES - KENTUCKY AND BARKLEY LOCKS
WITHOUT-PROJECT CONDITION - 1990-2055
(OCTOBER 1991 DOLLARS)

YEAR	PROJECT	LENGTH OF CLOSURE (WEEKS)	COST OF REPAIR ($1,000)	MAJOR ITEMS TO BE REPAIRED
1990	BARKLEY	6	625	REINFORCE VALVE MONOLITHS, REPLACE QUOINS AND MITER BLOCKS, INSTALL NEW HYDRAULIC SYSTEM ADD PROGRAMMABLE CONTROLLER SYSTEM
1992	KENTUCKY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
1995	BARKLEY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
1997	KENTUCKY	2	365	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2000	BARKLEY	2	365	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2002	KENTUCKY	5	1,250	REHABILITATE TOW HAULAGE UNIT; ADD PROGRAMMABLE CONTROLLER SYSTEM; REPLACE GUARDBOOM CONNECTION & MOORING BITTS; UPGRADE MAIN POWER CIRCUITS
2005	BARKLEY	3	675	REHABILITATE TOW HAULAGE UNIT; REPLACE ALL WATER AND AIR PIPING
2006	KENTUCKY	13	7,000	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK; REPLACE AIR/WATER PIPING; PAINT GATES
2007	KENTUCKY	13	4,865	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK;
2008	KENTUCKY	13	4,865	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK;
2009	KENTUCKY	13	4,865	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK;
2010	BARKLEY	4	520	UPGRADE MAIN POWER CIRCUITS; REPLACE INTAKE SCREEN
2012	KENTUCKY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2015	BARKLEY	2	415	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2017	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2020	BARKLEY	4	1,145	REPLACE MOORING BITTS; REHABILITATE UPPER EMERGENCY DAM
2022	KENTUCKY	8	14,145	REPLACE MITER GATES, VALVES, OPERATING MACHINERY AND MOORING BITTS
2025	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2027	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2030	BARKLEY	4	730	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2032	KENTUCKY	4	1,145	REPLACE FLOATING GUARD BOOM TIMBER & INTAKE SCREEN
2035	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2037	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2038	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2039	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2040	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2041	BARKLEY	14	5,200	CONCRETE AND WALL ARMOR REPAIRS TO 1/4 LOCK
2042	KENTUCKY	4	780	REPLACE INTAKE SCREENS
2045	BARKLEY	2	315	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2047	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2050	BARKLEY	8	1,145	REHABILITATE/REPLACE GATES, VALVES & MACHINERY
2052	KENTUCKY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED
2055	BARKLEY	3	520	UNWATER FOR INSPECTION AND REPAIR AS NEEDED

increasing levels of traffic projected for Kentucky Lock will exacerbate the situation such that the concrete and wall armor must be rehabilitated before 2010.

5.16 Deterioration of concrete and structural steel components is caused by time, weather, and friction. The constant frictional wear is caused by horizontal and vertical rubbing of towboats and barges passing through the lock. In the mid-60's deterioration of the concrete and wall armor became a major problem at the lock. Repairs have been made at every dewatering since that time. Several areas currently showing wear to a depth of two inches have been repaired five times. The last repair was in 1986. During the 1992 closure, repairs to the concrete and wall armor will be the critical path and actually set the length of the closure. As the patching continues, the areas to be patched grow. By the year 2010 the entire lock will need resurfacing.

5.17 The consequences of allowing the wall armor to become exposed can be significant and are discussed in more detail in Appendix A - Plan Formulaion. Barges can and will snag the wall armor and tear it away from the wall exposing other barges to dangers ranging from scrapping or ripping the outer skin to breaching the cargo hold. The consequences of a maritime accident in the lock depend greatly on the type of cargo involved and can range from a few days lock closure to clean up sand or gravel to wide-spread water pollution halting all navigation through the area until the contamination is removed or dissipated.

5.18 During this major closure would be the most logical time to replace the water and air piping which is also deteriorating rapidly. In addition, the miter gates at the lock will be painted during this major maintenance event. (The underwater portion of the gates were last painted in 1986.) The rehabilitation is estimated to cost $21,595,000 (October 1991 price levels), and would be accomplished over four years beginning in 2006 and ending in 2009. The lock is expected to be out of service for 13 consecutive weeks each of those years. The cost of the rehabilitation and the length of closure are based on conceptual designs and estimates of quantities. Work crew production is based on similar work done in the Pittsburgh and Rock Island Districts and in-house construction expertise. As much work as possible will be completed before the lock is taken completely out of service. (Further details of this and other major maintenance events are given in Appendix C-Project Design.)

5.19 By the year 2022, Kentucky Lock will be 80 years old. The District estimates that by then the gates, valves, operating machinery, and mooring bitts will have deteriorated and/or worn to the point where a wholesale changeout will be necessary. The work is expected to cost $14,145,000 (October 1991 price levels) and the lock will be closed for 8 weeks. The cost and length of closure are based on similar work in the District.

5.20 By the year 2038, Barkley Lock will have been in operation 74 years. The District estimates that by 2038 a major rehabilitation of these concrete and wall armor components will be required. The job is expected to close the lock for four 14-week periods per year, beginning in the year 2038 and ending in 2041. The construction cost is estimated at $20,800,000 (October 1991 price levels). Both the cost and the estimated length of closure are based on detailed studies at Kentucky Lock discussed above.

5.21 By the year 2050, Barkley Lock will have been in service 86 years. By that time the district estimates that the miter gates and operating valves and machinery will need rehabilitation. The work is expected to cause an 8-week closure and is estimated to cost $11,145,000 (October 1991 price levels). The cost and length of closure are based on similar work accomplished at other locks in the District.

5.22 **WITHOUT-PROJECT ALTERNATIVES**. The initial screening of without-project alternatives is summarized in Table 12. This screening is based on deductive or inferential economic, engineering, and environmental evaluations. The alternatives include a plan to modify Barkley hydropower releases, various lockage policies, several helper boat plans, and the addition of a terminal downstream of Kentucky Lock. The initial screening will eliminate some alternatives from further analysis, while others will be carried forward. The combination of alternatives that represents the most cost-effective scenario in absence of a Congressionally authorized project will become the without-project condition.

5.23 Hydropower Modification. As discussed in Section 4, pool fluctuations caused by hydropower discharges are a major impediment to navigating the lower Cumberland River. Barkley's current hydropower operations interfere with industry's ability to use the lower Cumberland River and Barkley Lock during periods of peak power generation (when the amount of water being discharged is changed rapidly) and when discharges are greater than 40,000 cubic feet per second (cfs). This equates to Barkley Lock being "down" or unavailable to a vast majority of the towing industry about a 40 percent of the time.

5.24 Under the without-project alternative the minimum continuous hydropower release would be increased to 9,000 cfs, while the maximum release would be limited to 40,000 cfs. Some of the flow that would go through Barkley's turbines under current conditions would be diverted to Kentucky under the without-project condition. The major change in hydropower operations involves

TABLE 12. WITHOUT-PROJECT ALTERNATIVES
LOWER CUMBERLAND AND TENNESSEE RIVERS FEASIBILITY STUDY

DESCRIPTION	ADVANTAGES	DISADVANTAGES	OTHER CONSIDERATIONS	CONCLUSIONS
HYDROPOWER MODIFICATION - modify Barkley's hydropower releases: increase min. flow to 9,000 cfs; limit max. to 40,000 cfs; limit rate of change	Increases Barkley capacity by 40%; lower Cumberland safer; allows larger tows	Reduces the amount of water available for peak power production; reduces hydro-power revenues	Necessary to accomodate high volumes of traffic on lower Cumberland River	Becomes part of the without-project condition
LOCKAGE POLICIES				
FIFO - first tow to arrive will be served first, and so forth	Efficient when traffic levels are low	Does not work well with helper boats	Existing condition; use to compare other policies	Not best plan; drop from analysis
1UP-1DN - during queues, tows lock from alternate directions	Reduces capacity alone, works well w/helper boats	None	Capacity gains very similar to 3UP-3DN	Not best plan; drop from analysis
3UP-3DN-during queue, every 4th tow locks from opp. direction	Reduces capacity alone, works well w/helper boats	None	Benefits similar to 1UP-1DN preferred by lock master	Best plan; add to without project condition
SETOVER BAN-separating towboat to set along side tow for service is banned during queues	Negligible increase in capacity	Unsafe for tows to operate as setover from mooring cell	Capacity and delay gains less than best helper boat	Neglible capacity gain; drop from analysis
HELPER BOAT PLANS (W/3UP-3DN)				
SCHEME A - 1st cut pulled out of chamber & held on wall for reconfiguration	Reduces locking time, increases capacity over existing condition	Reduced, but acceptable level of safety	Provides less benefits than Scheme B	Not best plan; drop from analysis
SCHEME B - same as Scheme A, except 1st cut held at end of wall so chamber can be turned back during reconfiguration	Reduces locking time, increases capacity over existing condition	Least safe scheme compared to Schemes A and C, however safety level adequate	provides less benefits than Scheme C	Not best plan; drop from analysis
SCHEME C - same as Scheme B, except 1st cut held at fleeting area for reconfiguration; turn-back after cut clears chamber	Reduces locking time, increases capacity over existing condition	Less safe than Scheme A, safer than Scheme B; needs additional mooring cells	Provides more benefits than Scheme B or A	Best plan; becomes part of without-project condition
DOWNSTREAM TERMINAL - add terminal below lock to move some traffic now moving from existing terminal above lock	Slightly reduces lock demand & delay, does not accomodate traffic growth	Private sector study shows it is not cost-effective	Destroys major portion of downstream mussel santuary; impacts cultural resources	Not viable alternative; drop from analysis

limiting the rate of change in discharge. The rate of change would be limited to 6,000 cfs in a 6-hour period. These modifications would reduce the average annual generation at Barkley by about 7 percent and would be implemented in 2005. The cost of this without-project assumption is estimated to be $14,900,000 on an average annual basis at October 1991 price levels. This cost represents the value of power revenues foregone and is based on an analysis done by TVA and the Nashville District. Additional information is included in Appendix B - Economics.

5.25 The benefits accruing to navigation will make this plan cost-effective. Hydropower modifications at Barkely are, therefore, included in the without-project condition.

5.26 Lockage Policies. This phase of study evaluates five lockage policies at Kentucky Lock where major delays occur. The first-in-first-out (FIFO) policy represents existing conditions and serves as the basis for comparing the other policies. Two policies, one-up-one-down (1UP-1DN) and three-up-three-down (3UP-3DN), are almost identical in terms of capacity. Both provide slightly less capacity than FIFO when analyzed alone, but when analyzed in combination with helper boat plans, they both produce capacity gains. However, 3UP-3DN is preferred by lock personnel. The FIFO and 1UP-1DN lockage policies are therefore dropped from further analysis, while 3UP-3DN is carried forward. Banning set-over lockages is dropped because it provides fewer capacity and delay gains than helper boats and severely limits industry's flexibility regarding the size and make-up of tows.

5.27 Helper Boat Schemes. Three helper boat schemes are evaluated using the best of the lockage policies - 3UP-3DN. Under normal operations the first cut of a double lockage is removed from the lock chamber by a tow haulage unit. The unit holds the first cut on the wall until the second cut is processed; the tow is remade on the wall.

5.28 In Scheme A, a helper boat pulls the first cut out of the chamber and holds the cut on the approach wall until the second cut has processed through the lock. The tow is remade on the wall. The chamber is not turned-back (filled or emptied) until the remade tow clears the lock chamber. Under Scheme B, a helper boat pulls the first cut out of the chamber as in Scheme A. The boat then holds the first cut at the end of the approach wall allowing the chamber to be turned-back more quickly than in Scheme A. Scheme C requires constructing two mooring cells above and two cells below Kentucky Lock. In Scheme C the helper boat pulls the first cut out of the chamber and takes it to the new mooring cells. The lock is turned-back immediately after the first cut clears the chamber. The second cut is then locked through and the chamber turned back immediately for the next tow. Tows are reconfigured on the mooring cells. This scheme minimizes the amount of time each cut spends in the chamber and approaches.

5.29 Downstream Terminal. The last measure evaluated for the without-project condition is the addition of a terminal below Kentucky Lock to accomodate some of the traffic now moving to and from an existing upstream terminal. Facilities at the terminal include three docks, a quarry, a rail-to-barge transfer operation, and a coal blending operation. In recent years, crushed stone, riprap, and coal from the terminal made up about 10 percent of the traffic through Kentucky Lock. A downstream terminal could remove some of the crushed stone traffic from the lock.

5.30 The owners of the terminal have considered this measure in some detail. Their evaluation, determined that the only suitable downstream site is between the Russell Creek and the Interstate 24 Bridge (due to the added expense of hauling around or tunneling through the interstate and the lack of suitable land downstream). Initial plans were to excavate a 200-foot wide, 3,200-foot long strip of bank between Interstate 24 and Russel Creek (within the area designated by the state as a mussel sanctuary). After consultation with state and federal environmental agencies, and internalizing the cost of environmental impacts, the terminal became cost prohibitive.

5.31 There are several other negative impacts associated with a terminal immediately below Kentucky Lock. A terminal would interfere considerably with lock traffic, especially when helper boats are in use. Terminal traffic added to this congestion would create an unmanageable situation and create a long-term congestion problem below the lock. The real estate necessary for a barge loading facility in this area is owned by TVA. They raised the additional concern that the terminal could interfere with the long-term operation of the Kentucky Project. The accumulation of these extremely negative impacts eliminate this measure from further consideration.

5.32 Summary. In summary the without-project condition includes maintaining Kentucky and Barkley Locks in accordance with current policies and procedures, modifying hydropower operations at Barkley to allow safe navigation of the lower Cumberland River under high traffic conditions, and implementing helper boat Scheme C concurrently with a 3UP-3DN lockage policy. In spite of nonstructural improvements, the without-project condition implies a substantial escalation in tow processing times at Kentucky Lock as traffic demands increase. This will result in ever-increasing amounts of traffic being diverted to the more costly Barkley/lower Cumberland River routing. Even with the navigation improvements provided by the without-project condition, the Barkley/lower Cumberland routing adds an additional $0.50 per ton in operating costs compared to the lower Tennessee in the absence of lock delays. Furthermore, the without-project condition has no effect on the severe hardships to navigation during lock maintenance closures.

ALTERNATIVES

5.33 The formulation of alternative plans includes considering an array of preliminary measures, refining the array into intermediate alternatives, and further refining them into final plans for possible selection and recommendation. The alternatives and the process used to screen them are discussed below.

5.34 **PRELIMINARY ALTERNATIVES**. Preliminary alternatives are broad measures with several variations and possible combinations. They are often described in general rather than specific terms and screened based on deductive or inferential economic, engineering, and environmental evaluations. Some of the preliminary alternatives will be dropped, while others will be carried forward and further defined for intermediate evaluation.

5.35 At this stage of the navigation planning process, very little economic data is available. Thus, the economic evaluation is often inferred from related data such as reductions in delay time and increases in capacity. Benefit-cost ratios are seldom explicitly calculated. A significant amount of judgement based on previous experience and literary research is also called into play.

5.36 Engineering evaluations at this level are often limited to cost comparisons between plans. However, rough estimates of quantities and costs may be obtained. The main purpose of the preliminary engineering evaluation is to eliminate from further consideration technically infeasible or inherently cost-prohibitive alternatives.

5.37 Environmental evaluations are limited by the degree of alternative definition. Usually only possible impacts can be iterated at this time. Many alternatives have significant intrinsic impacts. For example, channel modification and dredging cause turbidity. Other measures such as nonstructural alternatives tend to have very few environmental impacts. Alternatives such as lock additions have impacts that are very dependent on the location. The main purpose of the environmental evaluation at this stage is to point out sensitive or critical habitats and concerns. All structural alternatives will, in some fashion, affect the national register qualities of the lock and dam.

5.38 The advantages and disadvantages of the preliminary alternatives are displayed on Table 13. Included are six schemes to add capacity at Kentucky

TABLE 13. PRELIMINARY ALTERNATIVES
LOWER CUMBERLAND AND TENNESSEE RIVERS FEASIBILITY STUDY

DESCRIPTION	ADVANTAGES	DISADVANTAGES	CARRY FORWARD
ADDITIONAL CAPACITY AT KENTUCKY			
SCHEME A - landward of existing lock; upstream sill 1100' above existing upstream sill	Lessens relocation; avoids mussel bed; provides auxiliary chamber	High cost due to low rock, high walls & cofferdams; interferes w/upstream terminal	No
SCHEME B - landward of existing lock; upstream sill about 500' below existing upper gate	Best foundation conditions; provides auxiliary chamber	Extensive relocations; disturbs mussel bed & boat ramp	Yes
SCHEME C - extend existing lock	No major foundation problems; impact on mussel bed	No auxiliary chamber; no available during construction; filling time double that of existing lock	No
SCHEME D - riverward of existing lock through the island between the lock & powerhouse; upstream sill 200' downstream of existing	Best alignment w/downstream channel; no mussel bed impact; auxiliary chamber	Extensive relocations incl. swithyard foundation suspect; traffic during construction	No
SCHEME E - left bank; skewed about 30 degrees; upper sill downstream of embankment	Avoids mussel bed; provides auxiliary chamber	Foundation deep; high walls; extensive dredging; approach difficult when generating; reduced tailwater fishing	No
SCHEME F - through powerhouse	Avoids mussel bed; auxiliary chamber; no interference during construction	Spillway & powerhouse breached; deep foundation; approach difficult when generating; reduced tailwater fishing	No
BENDWAY MODIFICATIONS			
Modify 1-10 of the major bends on the lower Cumberland	Reduces costs/improves safety on lower Cumberland	No capacity gain; no auxiliary chamber significant aquatic & cultural impacts	Yes
CANAL SCHEMES			
CRM 27.6/TRM 19.4 - canal to connect lower rivers & by-pass lower Cumberland bends	Circumvents 9 of 10 bends on lower Cumberland; improves safety; reduces transit time	No capacity gain; no auxiliary chamber significant aquatic & cultural impacts requires massive excavation & a lock	No
PARALLEL TO I-24 - canal to connect lower rivers downstream of Barkley Lock to just above I-24 bridge on the Tennessee	Circumvents bends on lower Cumberland; improves safety; decreases transit time	No capacity gain; no auxiliary chamber significant aquatic & cultural impacts requires massive excavation & a lock or modifying channel below Barkley	No
TO SMITHLAND - connect lower Cumberland to Ohio to by-pass bends & problems at the mouth of the Cumberland	Circumvents 1/2 bends on lower Cumberland; improves safety reduces transit time	No capacity gain; no auxiliary chamber significant aquatic & cultural impacts requires massive excavation & a lock	No
TRAFFIC MANAGEMENT priority to downbound tows at Barkley/upbound tows at Kentucky	Evenly splits system traffic; eliminates bend delays; reduces delays at Kentucky	Does not address closures; positive effects diminish rapidly as traffic grows	Yes

Lock either by constructing a new lock or by enlarging the existing lock. A plan to improve channel conditions on the lower Cumberland River by modifying bendways and three canal schemes, two that would connect the Cumberland and Tennessee Rivers below Barkley and Kentucky Locks and one that would connect the Cumberland and the Ohio Rivers, are also evaluated. Each of these canal schemes would enable tows to bypass some or all of the lower Cumberland River with its tortuous bends and high flows. The remaining alternative is a traffic management scheme to more evenly split traffic between Kentucky and Barkley Locks.

5.39 Additional Capacity. The existing Kentucky Project is constructed on a hill with the top-of-rock dropping off sharply immediately upstream and downstream of the dam. The existing lock was sited to make the most cost-effective use of this topography and geology. Of the locations considered for a new lock, Scheme B, adjacent to the existing lock, has the best foundation conditions. Also the elevation of the rock is higher, making the height of the lock walls less than with the other schemes. The condition and elevation of rock have the greatest potential to impact construction cost. Other schemes are discussed in Appendix A - Plan Formulation.

5.40 Bendway Modification. Modifying some or all ten bendways on the lower Cumberland would reduce delays in the bends, slightly increase the average tow speed, and improve navigational safety. Although the cost of traveling the lower Cumberland River would be reduced, the cost would remain higher than the lower Tennessee. The measure does nothing to address the lack of capacity during closures and only partially addresses the general lack of system capacity. In addition, the modifications would cause significant impacts to both aquatic and cultural resources. This measure is carried forward for further analysis.

5.41 Canal Schemes. A canal connecting the lower Cumberland and Tennessee Rivers would enable tows to circumvent some or all of the treacherous bends of the lower Cumberland thus reducing transit time and improving safety. Three such schemes were evaluated. All three, however, are dropped from further analysis because of high construction costs.

5.42 Traffic Management. This plan consists of giving priority to downbound tows at Barkley and upbound tows at Kentucky to more evenly split system traffic. The plan would reduce existing and near-term delays at Kentucky by reducing the amount of traffic using the lock. Traffic management could significantly reduce delays at Kentucky in the near-term when traffic levels are well below system capacity and is is carried forward for further analysis.

5.43 **INTERMEDIATE ALTERNATIVES**. The purpose of this phase of the study is to further screen alternatives so that detailed evaluations are done on the minimum number of plans. The costs and benefits presented in this section of the report have been updated to October 1991 price levels. As the range of alternatives narrows, the more detailed and accurate the evaluation of the alternatives becomes.

5.44 Without-project Condition. As discussed earlier, the without-project condition is the most likely condition expected in the absence of navigation improvements or any change in law or public policy. After preliminary screening, the without-project condition includes maintaining the existing projects in accordance with current policies and procedures, modifying or limiting releases from the Barkley Powerplant, and instituting helper boat Scheme C at Kentucky Lock together with a 3UP-3DN lockage policy for both locks. These measures combined with the assumptions listed earlier in this section will serve as the basis for comparing the intermediate and final alternatives.

5.45 Under the without-project condition the capacity of the Kentucky-Barkley System will increase as displayed in Table 14. During periods of normal operations in which no closures occur the capacity of Barkley Lock and the entire Kentucky-Barkley System is increased about 25 percent.

TABLE 14. - EXISTING AND WITHOUT-PROJECT CAPACITY
KENTUCKY-BARKLEY NAVIGATION SYSTEM

Project/Conditions	Existing Capacity (Million Tons)	Without-Project (Million Tons)
Kentucky		
No closures	37.7	43.6
Barkley closed	37.9*	37.9*
Barkley		
No closures	24.7	34.8
Kentucky closed	42.0*	42.0*
Kentucky-Barkley System		
No closures	62.4	78.4
Kentucky closed	42.0*	42.0*
Barkley closed	37.9*	37.9*

*There is no difference in how the projects are operated during closures of either lock.

5.46 Alternatives. Table 15 displays the intermediate alternatives and without-project condition in terms of costs and benefits. The intermediate alternatives include a new lock at Kentucky with three chamber lengths (600, 800, and 1200 feet), modifying bendways on the lower Cumberland River, and traffic management. All three chambers would be located just landward of the existing lock (Scheme B under preliminary alternatives).

5.47 The bendway modification plan consists of widening ten bends to safely accommodate a towboat pushing a 15-barge tow, configured three wide and measuring 105 X 1200 feet and assumes helper boats at Kentucky Lock. Riprap would be placed in each bend to prevent bank erosion. Significant cultural resources would be impacted by the modifications. Preservation costs are included in the capital costs. This measure would have several adverse environmental impacts - increased sediment loads and destruction of terrestrial habitat and prime agricultural lands at each disposal site.

5.48 The plan has an estimated capital cost of $49.5 million. In addition to the capital costs, the costs of modifying hydropower releases from Barkley are also included. The annual incremental costs are estimated at $4.4 million, while the annual incremental benefits are $1.8 million. The annual incremental net benefits are negative $2.6 million. The annual incremental net benefits are negative because bendways are not as effective as the without-project condition.

5.49 Traffic management is a means of more evenly dividing traffic between Kentucky and Barkley Locks. The benefit is derived from reduced delay at Kentucky which is offset somewhat by higher operating costs on the lower Cumberland. Several nonstructural measures must be in-place before this scheme could be implemented, including modification of the hydropower releases from Barkley and helper boats at Kentucky. The cost of these measures is the cost to implement traffic management. However, these measures are included in the without-project condition, leaving traffic management with no incremental costs.

5.50 The annual incremental net benefits of traffic management are $3.3 million. Traffic management reduces the overall capacity of the Kentucky-Barkley system such that future traffic demands cannot be met. As traffic increases the benefits of traffic management decrease to the extent that the without-project becomes more beneficial. In this evaluation traffic management is discontinued when it no longer provides incremental net benefits, assuring the maximum net benefits. While these benefits are

TABLE 15. INTERMEDIATE ALTERNATIVES
KENTUCKY-BARKLEY NAVIGATION SYSTEM
(MILLIONS OF OCTOBER 1991 DOLLARS)

DESCRIPTION	COSTS			ANNUAL BENEFITS			CONCLUSIONS
	INITIAL (1)	ANNUAL	INCREMENTAL ANNUAL (2)	SYSTEM TRANS. RATE SAVINGS	INCREMENTAL ANNUAL (2)	INCREMENTAL NET (3)	
WITHOUT-PROJECT CONDITION							
O & M		6.3					
HELPER BOAT SCHEME C (3UP-3DN LOCKAGE POLICY)		2.6					
HYDROPOWER MODIFICATION		14.9					
TOTAL		23.8		3,656.6			
ALTERNATIVES							
NEW LOCK AT KENTUCKY							
110' X 1200' CHAMBER	448.3	55.7	31.9	3,706.2	49.6	17.7	CARRY FORWARD
110' X 800' CHAMBER	399.7	52.6	28.8	3,702.7	46.0	17.2	CARRY FORWARD
110' X 600' CHAMBER	377.4	53.7	29.9	3,702.1	45.5	15.6	CARRY FORWARD
BENDWAY MODIFICATIONS							
MAXIMUM CASE - 10 BENDS(4)	49.5	28.2	4.4	3,658.4	1.8	-2.6	UNECONOMICAL, DROP FROM FURTHER ANALYSIS
TRAFFIC MANAGEMENT	0	22.6	(1.2)	3,658.7	2.1	3.3	CONSIDER WITH NEW LOCK

(1) SCREENING LEVEL COSTS SUITABLE FOR COMPARISON ONLY; INCLUDES INTEREST DURING CONSTRUCTION
(2) DIFFERENCE BETWEEN WITHOUT PROJECT & ALTERNATIVE
(3) DIFFERENCE BETWEEN INCREMENTAL COSTS AND BENEFITS
(4) INCLUDES HYDROPOWER MODIFICATIONS & HELPER BOAT SCHEME C AT KENTUCKY

significant, they are considerably below the annual incremental net benefits of any of the lock plans. Thus, traffic management is dropped from further analysis.

5.51 **DEVELOPMENT OF FINAL PLANS**. In the third phase of plan formulation, the best intermediate alternatives are refined, evaluated, and compared in detail. The environmental, cultural, social, and national and regional economic, aspects of each plan are given full consideration. The final plans include the without-project condition and three lock alternatives - adding a 110- X 1200-foot chamber (Plan A), adding a 110- X 800-foot chamber (Plan B), and adding a 110- X 600-foot chamber (Plan C) at Kentucky.

5.52 In developing the final plans, other measures were considered in combination with the best intermediate plans to increase net benefits. All the final plans include reduced operation and maintenance of Barkley Lock. Plan A, the 1200-foot lock, eliminates double lockages and provides suffcient capacity throughout the planning period without other measures. However, traffic management would be implemented during closures of the 1200-foot lock. Neither Plan B or C eliminates double lockages; thus, both require nonstructural measures (similar to the without-project condition) to meet traffic demand. With Plan B, an 800-foot lock, helper boats are needed about 20 years after completion of the new lock to accomodate traffic. Traffic management would also be needed when the new lock is down for maintenance. With Plan C, a 600-foot lock, helper boats are needed at Kentucky immediately after the new lock opens. Traffic management will be needed when either the new or existing lock is closed.

5.53 Two helper boats, one above and one below, would be required at Kentucky Lock. The boats would assit the first cut of a multicut lockage out of the chamber and to the fleeting area. The tow boat would power the second cut to the mooring cells where the tow would be reconfigured. Because of the complications in assigning priority to tows under helper boat situations an additional lock operator is needed to keep track of locking order and schedule new arrivals.

5.54 Traffic management more evenly splits system traffic between Kentucky and Barkley Locks. It could be accomplished by giving priority to downbound tows at Barkley and upbound tows at Kentucky. Helper boats are needed at Kentucky to balance the capacities of the locks. Barkley's hydropower releases must also be modified to the without-project condition.

5.55 With all three locks very little commercial traffic is expected to use Barkley Lock and the lower Cumberland River. Thus the operation and maintenance of the project can be reduced. Barkley Lock would be staffed 5 days a week. Anyone wishing to lock through Barkley at other times could make arrangements by calling Kentucky Lock. Less usage reduces wear and tear, one of the major factors contributing to the need for maintenance (age is the other factor). After the new lock opens Barkley's periodic maintenance closures will occur on a 10-year cycle. Repairs to Barkley's concrete and wall armor are shifted out beyond the period of analysis with all three lock sizes.

5.56 Figure 16 displays a comparison of the final alternatives in terms of capacity. The 600-foot lock would function similarly to the existing lock. It would accommodate an 8-barge tow and towboat in one lockage. Having two 600-foot locks at the Kentucky Project would provide 50 percent additional system capacity during normal operations. The 800-foot lock would accomodate 11 barges and a towboat and provide 64 percent more capacity during normal operations. The 1200-foot lock would accommodate an entire 15-barge tow in one lockage and would make Kentucky compatible with locks on the mainstem of the Ohio River with which it shares a significant portion of its traffic. The 1200-foot lock would also be compatible with the 1000-foot chamber at Pickwick (which can pass a 14-barge tow and towboat in one lockage). It would provide about 130 percent more capacity during normal operations. (The above capacities are compared to the without-project condition.)

ANNUAL PHYSICAL CAPACITY
Kentucky/Barkley Navigation System

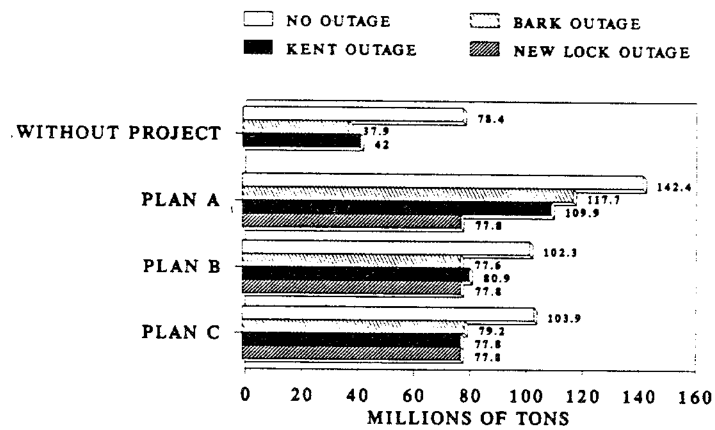


Figure 16

SECTION 6 - EFFECTS OF FINAL PLANS

SYSTEM ECONOMIC EFFECTS

6.01 **GENERAL**. The system economic impacts and navigation benefits for each of the final plans are based on a thorough systems study. The systems-based approach is needed to capture the complex interaction and interdependence of traffic flows among the many individual components of the inland waterway. It is possible that other projects within the system could restrict traffic flows through Kentucky and Barkley Locks and prevent the expected benefits from materializing. At the same time, the additional traffic permitted to move because of improvements at Kentucky could increase delays at other projects and thereby reduce system benefits.

6.02 Systems analyses account for these effects by measuring the performance of the total Ohio River navigation system both with and without each of the final plans. These results are then used to define the incremental impact of the final plans on system operational characteristics including lockage delays, towing costs, traffic levels, and transportation rate savings.

6.03 The complexity of the navigation system and the voluminous data requirements for a complete system study dictate the use of computer modeling. The Tow Cost Model (TCM) was used to analyze all the traffic interactions and estimate the National Economic Development (NED) benefits and navigation system impacts for the final plans. A detailed description of this model is found in Appendix D - Systems Analysis.

6.04 One of the major data requirements of the TCM is an estimate of the tonnage capacities for each lock being analyzed. Estimates of lock capacity were made for all of the projects in the Ohio River system where significant congestion currently exists or is expected over the planning period. Table 16 shows the physical capacity of the Kentucky-Barkley system for the final plans. The annual physical capacity of Kentucky Lock ranges from 43.6 million tons under the without-project condition to 117.7 million tons under Plan A - an additional 110- X 1200-foot lock. Likewise, the annual physical capacity for the Kentucky-Barkley system (normal operation) ranges from 78.4 million tons under the without-project condition to 142.4 million tons under Plan A. Capacities were also estimated for Kentucky when Barkley Lock is closed (37.9 million tons) and for Barkley when Kentucky Lock is closed (42.0 million tons).

6.05 The capacity (measured in tons) of Kentucky Lock is less when Barkley is closed, and the capacity (measured in tons) of Barkley Lock is greater when Kentucky is closed than under normal operating conditions. During a closure, the fleets of both locks combine to transit the open lock, thereby increasing the percentage of empty barges at Kentucky when Barkley is closed and decreasing the percentage of empty barges at Barkley when Kentucky is closed. The capacities for the Kentucky-Barkley system during lock closures are also shown for the final plans. Plan A - adding a 110- X 1200-foot lock - provides the most auxiliary capacity to handle traffic demands during lock closures.

TABLE 16. - ANNUAL PHYSICAL CAPACITIES UNDER FINAL PLANS
KENTUCKY-BARKLEY NAVIGATION SYSTEM
(Million Tons)

			Kentucky-Barkley Navigation System			
Condition/Plan	Kentucky L&D	Barkley L&D	Normal Ops	Barkley Closed	Kentucky Closed	New Chamber Closed(3)
W/O Project Condition(1)	43.6	34.8	78.4	37.9	42.0	----
PLAN A - 1200' X 110'	117.7	24.7	142.4	117.7	109.9	77.8
PLAN B - 800' X 110'(2)	77.6	24.7	102.3	77.6	80.9	77.8
PLAN C - 600' X 110'(2)	79.2	24.7	103.9	79.2	77.8	77.8

(1) Switchboat at Kentucky, modified hydropower releases at Barkley.
(2) Includes switchboats in 2025 with the 800' and 2005 with the 600' chamber.
(3) Traffic management is in effect during closures of the new chamber.

6.06 **IMPLICATIONS OF THE WITHOUT-PROJECT CONDITION**. The normal performance of the Kentucky-Barkley navigation system under the without-project condition is summarized in Table 17. Beginning at the dawn of the twenty-first century and continuing over the period of analysis, significant volumes of traffic will be blocked from transiting Kentucky Lock. Most of this traffic will divert to Barkley and the lower Cumberland River. However, significant tonnages will also divert to either an alternate waterway routing (the Mississippi or TTW) or to more costly overland modes of transportation to avoid delays at Kentucky Lock. The without-project condition is woefully inadequate during maintenance closures of either Kentucky or Barkley Locks. Traffic demands throughout the projection period far exceed the physical capacity of either lock when the other is closed. Thus, large volumes of traffic will divert to alternate waterway routes or to expensive, overland modes of transportation during lock closures.

TABLE 17. - PERFORMANCE OF KENTUCKY-BARKLEY NAVIGATION SYSTEM UNDER WITHOUT-PROJECT CONDITION, NORMAL OPERATING CONDITIONS (Million Tons, Hours Per Tow)

Year	Projected Traffic Demands	Kentucky Traffic Moved	Barkley Traffic Moved	Traffic Diverted to Alt Waterway(1) or Overland Mode	Average Delay Per Tow: Kentucky	Average Delay Per Tow: Barkley
2000	46.5	37.7	5.9	2.9	7.8	0.4
2010	51.2	38.9	9.0	3.3	11.4	0.7
2020	55.2	39.2	12.2	3.8	12.0	1.1
2030	63.7	39.9	19.7	4.1	13.5	2.1
2040	72.7	40.5	26.3	5.9	15.3	4.3
2050	82.9	42.2	33.4	7.3	42.5	32.7

(1) Some Kentucky-Barkley traffic has the option of diverting to an alternate waterway route (i.e. the Mississippi River or the TTW) to avoid long delays at Kentucky Lock.

6.07 The total average annual cost of the without-project condition is estimated to be $23.9 million (October 1991 dollars). This cost includes $6.4 million for ordinary operation and maintenance of the locks, $2.6 million for helper boats, and $14.9 million in lost revenues associated with modifying hydropower operations at Barkley. The ordinary operation and maintenance cost includes adding one lock operator per shift at Kentucky. Modifying the hydropower operation for the entire study period would cost an average of $15.2 million annually. However, when Barkley Lock is closed for maintenance, the powerplant can operate unrestricted. This saves about $0.3 million annually for a total annual cost of $14.9 million in lost hydropower revenues. A detailed description of these calculations can be found in Appendix B - Economics.

ECONOMIC PERFORMANCE UNDER FINAL PLANS

6.09 **GENERAL**. The navigation impacts of the final plans are categorized as two major types -- localized which include effects within the Kentucky-Barkley system and systemic which include effects throughout the remainder of the Ohio River system. This section presents and describes these effects for the final plans, with particular focus on traffic levels, delay time, and waterway rate savings. The earliest probable date by which any of the alternative plans could be operational is 2005. Thus, the 50-year economic life of the alternative plans extends from the year 2005 to 2054. The effects of each alternative are measured as the increment of change over the without-project condition during this period.

6.10 The incremental system benefits for the final plans are less than the benefits measured solely at the Kentucky and Barkley projects. The traffic added to the Ohio River system as a result of reducing the processing time at Kentucky causes delays to increase at several other locks along the shipping route. This reduces the waterway rate savings for the affected traffic and for some non-Kentucky-Barkley movements it becomes uneconomical to ship by barge. The magnitude of these effects is a direct function of the additional amount of Kentucky-Barkley traffic accommodated by an alternative plan and the level of system congestion a plan creates.

6.11 <u>TRAFFIC ACCOMMODATED</u>. The results of system studies in terms of the volume of traffic that could move through Kentucky and Barkley Locks and the Ohio River navigation system from the year 2000 to 2050 are presented in Tables 18 and 19 for the final plans under normal operating conditions. Traffic levels estimated for the without-project condition are presented for comparison.

6.12 The studies show that under normal operating conditions the amount of Kentucky-Barkley traffic that could move on the waterway at a rate savings increases only slightly with Plans A and B, and not at all with Plan C. Under normal operating conditions, none of the final alternatives would increase system traffic levels.

6.13 All final plans would decrease the amount of Kentucky traffic diverted to Barkleyand the lower Cumberland River. Building an additional lock at Kentucky allows future traffic to use the less expensive, preferred lower Tennessee River. Barkley's primary function has been to provide auxiliary capacity during closures of Kentucky Lock. Both plans would return Barkley to its traditional role of being an auxiliary chamber for Kentucky. Plan A, however, allows the most traffic to return to the Kentucky routing.

6.14 <u>LOCK DELAYS</u>. The average delay time under normal operating conditions for each of the lock-replacement alternatives over the period of analysis is presented in Table 20 and displayed graphically in Figures 17 and 18. All of the final plans would be effective in reducing lock delays associated with the without-project condition. The average lock delay per tow would be lowest for Plan A, ranging from 0.2 to 0.8 hours at Kentucky with no traffic at Barkley. Delays are lowest under Plan A because only Plan A totally eliminates double and knockout lockages at Kentucky. Plan B reduces lock delays but is not as effective as Plan A. Delays under Plan B would range from 0.5 to 3.5 hours per tow at Kentucky with no traffic using Barkley. Plan C reduces lock delays and is the least effective plan. Delays for Plan C range from 0.7 to 15.5 hours per tow at Kentucky. Plan A also provides sufficient auxiliary capacity

TABLE 18. - ADDITIONAL WATERWAY TRAFFIC ACCOMMODATED UNDER WITH AND WITHOUT-PROJECT CONDITIONS
NORMAL OPERATING CONDITIONS
(Million Tons)

	Without Proj. Condition			Change in Traffic with Alternative Plans								
				Plan A			Plan B			Plan C		
Year	Kent. Traffic Moved	Bark. Traffic Moved	Total Traffic Moved	Kent. Traffic Moved	Bark. Traffic Moved	Total Traffic Moved	Kent. Traffic Moved	Bark. Traffic Moved	Total Traffic Moved	Kent. Traffic Moved	Bark. Traffic Moved	Total Traffic Moved
2000	37.7	5.9	43.6	5.9	-5.9	0.0	5.9	-5.9	0.0	5.9	-5.9	0.0
2010	38.9	9.0	47.9	9.0	-9.0	0.0	9.0	-9.0	0.0	9.0	-9.0	0.0
2020	39.2	12.2	51.4	12.2	-12.2	0.0	12.2	-12.2	0.0	12.2	-12.2	0.0
2030	39.9	19.7	59.6	19.7	-19.7	0.0	19.7	-19.7	0.0	19.7	-19.7	0.0
2040	40.5	26.3	66.8	26.4	-26.3	0.1	26.4	-26.3	0.1	26.3	-26.3	0.0
2050	42.2	33.4	75.6	33.5	-33.4	0.1	33.5	-33.4	0.1	33.2	-33.2	0.0

TABLE 19. - ADDITIONAL WATERWAY TRAFFIC ACCOMMODATED UNDER WITH AND WITHOUT-PROJECT CONDITIONS
OHIO RIVER NAVIGATION SYSTEM, NORMAL OPERATING CONDITIONS
(Million Tons)

	Without Proj Condition		Change in Traffic with Alternative Plans					
			Plan A		Plan B		Plan C	
Year	Kent-Bark Traffic	ORS Traffic	Kent-Bark Traffic	ORS Traffic	Kent-Bark Traffic	ORS Traffic	Kent-Bark Traffic	ORS Traffic
2000	43.6	276.1	0.0	0.0	0.0	0.0	0.0	0.0
2010	47.9	304.4	0.0	0.0	0.0	0.0	0.0	0.0
2020	51.4	325.3	0.0	0.0	0.0	0.0	0.0	0.0
2030	59.6	370.0	0.0	0.0	0.0	0.0	0.0	0.0
2040	66.8	406.0	0.1	0.0	0.1	0.0	0.0	0.0
2050	75.6	445.3	0.1	0.0	0.1	0.0	0.0	0.0

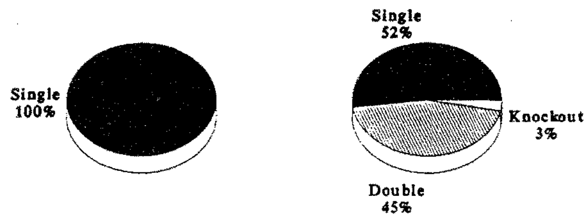
TABLE 20. - AVERAGE LOCK DELAYS UNDER WITH- AND WITHOUT PROJECT CONDITIONS
KENTUCKY-BARKLEY NAVIGATION SYSTEM, NORMAL OPERATING CONDITIONS
(Hours per Tow)

	Without Proj Condition		Plan A		Plan B(1)		Plan C	
Year	Kentucky	Barkley	Kentucky	Barkley	Kentucky	Barkley	Kentucky	Barkley
2000	7.6	0.4	0.2	---	0.5	---	0.7	---
2010	11.4	0.7	0.2	---	0.5	---	0.8	---
2020	12.0	1.1	0.3	---	0.7	---	0.9	---
2030	13.5	2.1	0.4	---	1.0	---	1.6	---
2040	15.3	4.3	0.5	---	1.6	---	3.2	---
2050	42.5	32.7	0.8	---	3.5	---	15.5	---

(1) Switchboats at Kentucky are added to Plan B in 2025.

TYPES OF LOCKAGES-PLAN A vs PLAN B

Kentucky/Barkley Navigation System



PLAN A
1200' Lock

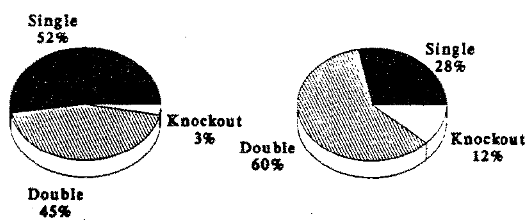
PLAN B
800' Lock

PLAN A ELIMINATES DOUBLES AND KNOCKOUTS

Figure 17

TYPES OF LOCKAGES-PLAN B vs PLAN C

Kentucky/Barkley Navigation System



PLAN B
800' Lock

PLAN C
600' Lock

PLAN B REDUCES DOUBLES AND KNOCKOUTS

Figure 18

to handle future traffic demands during lock maintenance closures without significant delays occurring.

6.15 All the final plans would result in a significant net reduction in lock delays on the Ohio River Navigation System. The plans would greatly reduce tow delays at Kentucky-Barkley and slightly increase tow delays at other locks within the Ohio River system. Plan A would be the most effective for reducing delays at Kentucky-Barkley but would also have the greatest effect on increasing lock delays elsewhere. However, Plan A provides the greatest net reduction in system lock delays. Delays for the Ohio River system are shown in Appendix D - Systems Analysis.

6.16 **SYSTEM RATE SAVINGS**. System rate savings are typically defined as the cumulative difference in transportation costs between a water-routing and the least costly overland routing. In this study, the final plans also generate significant rate savings by allowing millions of tons of traffic to switch from the Barkley Lock/lower Cumberland River routing back to Kentucky Lock/lower Tennessee River routing. Estimated total system rate savings for the without-project condition and the incremental impact of Plans A and C are presented in Table 21. All alternatives would result in a significant net increase in system rate savings over the without-project condition. The net increase would be highest for Plan A.

TABLE 21. - OHIO RIVER NAVIGATION SYSTEM RATE SAVINGS UNDER WITH- AND WITHOUT-PROJECT CONDITIONS (Millions of October 1991 Dollars)

Condition/Plan	ORS Rate Savings	Increm. Rate Savings
W/O Project Condition	$3,656.6	—
PLAN A - 1200' X 110'	$3,706.2	$49.6
PLAN B - 800' X 110'	$3,702.6	$46.0
PLAN C - 600' X 110'	$3,702.1	$45.5

ENVIRONMENTAL, CULTURAL, AND SOCIAL IMPACTS

6.17 **GENERAL**. Certain unavoidable environmental, cultural, and social impacts are associated with construction of a new lock at the Kentucky Project. Most adverse impacts, however, can be limited to relatively small geographic areas. Since the final plans are at the same location and have the same major features, the environmental, cultural and social impacts are essentially the same for all the final plans.

6.18 **ENVIRONMENTAL IMPACTS**. Excavation for the lock chamber, right bank downstream guidewall, and lower approach will generate material to be placed in a disposal site. Some of the rock will be used to armor the bank between the lock and Interstate 24. The remainder will be placed in a single 45-acre site that will also provide borrow. The site is about one mile north of Kentucky Lock and Dam, adjacent Kentucky Highway 453 in Livingston County. It site is highly disturbed by past activities of the Reed Crushed Stone Company. Some of the site was cut to its present grade, while the remainder was filled with overburden from quarrying operations. Virtually all original trees from the site have been removed, leaving a cover of herbaceous growth and sapling trees. Borrow material for the railroad approaches will be taken before excess materials from lock construction are desposited.

6.19 A 22-acre tract adjoining the borrow/disposal site will be used for mitigation. This tract consists of upland hardwood forest and low-lying land next to Russell Creek that was once part of a sediment retention pond. The levee that impounded the pond is now breached and Russell Creek now flows through unimpeded. Repairing the levee and reflooding the area would create a pond to capture and treat runoff from the borrow/disposal site.

6.20 The construction plant and equipment laydown area would be between Russell Creek and the relocated Paducah & Louisville Railroad on the right bank. This area consists of mixed hardwoods that have regrown since construction of Kentucky Lock and Dam in the early 1940's. Runoff from the construction laydown area would be retained and treated before being allowed to enter the Tennessee River or any of its tributaries to prevent degradation of the aquatic environment.

6.21 Relocating the Paducah & Louisville Railroad will cause permanent modification of some terrestrial areas on both sides of the river. On the right bank, the railroad will impact an area of mature upland oak-hickory forest, powerline rights-of-way, and maintained open areas. On the left bank, the relocation will impact open areas and a planted pine forest. The proposed alignment avoids bottomland hardwoods and forested wetland areas on the left bank. Mussels inhabiting the bridge pier placement points would be removed and relocated to suitable habitat before the bridge is constructed.

6.22 Lock construction impacts to the aquatic environment upstream of Kentucky Dam would be negligible. Downstream of the dam much of the work will be performed in the dry, behind a cofferdam. Mussels inhabiting the area to be dewatered would be removed and relocated to suitable habitat. After the lower approach is reflooded, colonization by similar assemblage of shellfish will occur. Some sediment will be released into the tailwater from shoreline excavation immediately downstream of the lower guidewall. Measures will be taken to minimize release of sediment, and river flows will aid in dispersion.

6.23 For aquatic resources, molluscs in particular, the most significant impact will arise from dredging a small portion of the right bank mussel bed between the mouth of Russell Creek and the Interstate 24 bridge. The area tapers gradually from upstream to downstream, merging with the existing navigation channel at the bridge. Part of the area supports dense populations of mussels (see the Biological Assessment) with populations declining dramatically in the direction of the bridge. To reduce impacts, mussels will be removed before excavation begins and relocated to suitable habitat further downstream. Dredged material will be deposited adjacent the right bank of the Tennessee River at mile 19.7 to create new gravel shoal habitat. The river bank at mile 19.7 is severely eroding and the bottom is generally soft and sandy. Placing dredged materials there will improve aquatic habitat and reduce bank sloughing. Immediately upstream of the placement site good mussel habitat exists affording an opportunity to link the new habitat to existing mussel habitat. Habitat for mussels has been improved at other locations in the Tennessee River by depositing gravel over finer substrates.

6.24 The stone training dike, if needed, would severely impact resident benthic fauna, principally molluscs. Besides direct burial, the dike would alter long established flow patterns, resulting in loss or alteration of existing mussel populations. Resident mussels, by the nature of their sedentary habits, do not generally relocate to more suitable areas when existing habitat conditions such as flow, food quality, and sedimentation rates change. Determining the effect of a dike upon tailwater hydraulic characterisitcs will require extensive modeling. Results of the modeling will provide information concerning impact to resident mussels. Once in place, a dike itself would provide habitat for aquatic macroinvertebrates, with the notable exception of mussels, and improve fish habitat by providing additional underwater structure.

6.25 The recent 1990 mussel survey indicates that in the right bank mussel bed the densest populations occur close to the right shoreline, well away from the proposed dredging site. The survey did not reveal any individuals of Federally endangered mussels above Interstate 24. An earlier 1987 survey covering part of the same mussel bed did reveal one pink mucket mussel (Lampsilis orbiculata), near the right bank. This was the only federally listed individual collected out of a total of about 16,000 animals sampled during both surveys, pointing out that, if they persist at all, federally threatened or endangered mussels occur only as widely scattered individuals between Interstate 24 and Kentucky Dam.

6.26 Impacts to the very valuable tailwater fishery will be negligible. Some sediment will be released and dispersed by river flows. Channel dredging will be scheduled to avoid the February through June spawning season. The stone training dike could improve fish habitat by providing more structure in the tailwater and supporting populations of benthic macroinvertebrates. Stone generated from construction of the project will be available to armor banks and improve fish habitat and angler access.

6.27 The boat ramp on the right bank just below the lock will be lost to the project. The ramp is currently in poor condition and receives little use. By contrast the left bank boat ramp receives heavy use and provides direct access to the immediate tailwater area infringing on the navigation channel. No suitable site exists for relocating the right bank boat ramp. Loss of the right bank boat ramp will be mitigated by expenditure of resources to improve and upgrade the left bank facility that is managed by Kentucky Dam Village State Resort Park.

6.28 Bank fishing is a popular activity in the tailwater. Lock construction will preclude fishing from much of the right bank. Construction of the railroad bridge will temporarily close a small portion of the left shore to bank fishing, remove the existing restroom facility, and impact existing parking lots. Most bank fishing opportunities will be restored, and facilities improved with completion of the project. The restroom and parking will be replaced in-kind. Railroad bridge construction, however, will be completed in 3 years.

6.29 <u>**CULTURAL RESOURCES IMPACTS**</u>. Cultural resource assessment and survey level investigations were conducted within the proposed project area on the Tennessee River and at alternative locations along the Cumberland River. Assessement and pedestrian survey level investigation conducted within the area of the former community of Gilbertsville revealed that no significant elements of the community remain extant; the community appears to have been completely destroyed during the construction of Kentucky Lock and Dam. Although extensive prehistoric remains, including both surface and subsurface buried deposits, are located along the Cumberland and Tennessee Rivers, survey and subsurface testing indicates that they are not as extensive within the areas affected by the proposed lock additions. A single buried prehistoric site, 15Lv204, is within the river bank immediately downstream of Russell Creek and a small, late prehistoric cemetery and village, 15Lv24, is adjacent to the construction laydown area. Both of these sites are eligible for listing on the National Register of Historic Places by concensus determination with the Kentucky State Historic Preservation Officer. With the exception of riprap along the right bank below the lock, impacts to these archeological sites is expected to be minimal. Additionally, the Kentucky Lock and Dam is eligible for listing on the National Register. All the alternatives propose modification of the existing facility and will have an effect on the National Register qualities of the lock and dam. Several other archeological sites, including sites 15Lv12, 15Lv20, 15Lv21, and 15Lv23, were either destroyed by past construction activities, were not relocated (or were mislocated), or are well outside areas of proposed impact. Sites 15Lv22 and 15Lv204 are the same site.

6.30 **SOCIAL IMPACTS**. Each of the alternatives lowers transportation costs. This increases income to shippers and ultimately consumers. The effects multiply throughout the region. For instance, lower costs to transport coal allow utilities to hold down electric rates benefiting every resident and business in the service area. Using unemployed labor to construct the project increases regional income for the entire construction period. Seven counties in the study area are designated as areas of "substantial and persistent" unemployment. The only adverse social impact is the closure of U.S. Highways 62 and 641 which cross the lock. While the highway is elevated, traffic will be detoured between 2 and 7.5 miles to Interstate 24. Under Plan A the highway will be closed 55 months, 50 months under Plan B, and 44 months under Plan C.

6.31 **RIVER SYSTEM AND SITE-SPECIFIC ENVIRONMENTAL IMPACTS**. The presence of improved lock capacity at the Kentucky Project will reduce future traffic levels on the lower Cumberland River. The reduction of traffic using the Cumberland River will be a positive factor in maintaining environmental quality for aquatic and other resources dependent.

6.32 Traffic levels will grow significantly on the lower Tennessee River both with and without a new lock. The lower Tennessee River is more suited for use by commercial river traffic, since it is wider and lacks the sharp bends of the lower Cumberland. Higher navigation traffic will not adversely impact significant aquatic biological resources of the lower Tennessee River such as the molluscs and fishery on a system-wide basis. These biological resources are more dependent upon river substrate characteristics and the quality and quantity of food items moving through the aquatic system, which will not be affected by increased traffic. Available evidence concerning system-wide impacts of navigation traffic in large rivers (i.e. Ohio and Kanawha) indicates that, at most, there would be minimal disturbance or degradation of the aquatic environment outside of the navigation channel (Miller and Payne, Misc. Paper EL-89-4, June 1989).

6.33 The only location where significant, site-specific impacts from navigation traffic and the operation of the new lock are possible is the right bank mussel bed between TRM 21.6 to 20.5 and adjacent to the existing navigation channel. Widening the lower approach will bring traffic closer to the densest mussel populations in the upper half of the bed, just off the right shore. Placing two mooring cells on the right channel margin will prevent tows from mooring along or pushing into critical areas. Degradation or adverse consequences to the mussel bed arising from navigation traffic or alteration of flows is unlikely. Changes in hydraulic flows over the bed and/or tow induced scour would have to result in removal or erosion of substrate in order to degrade the resource. The best method to quantify this possibility would be with a model study to document project induced changes in tailwater hydraulic forces relative to ecological parameters required to maintain the mussel bed.

MITIGATION MEASURES

6.34 **FISH AND WILDLIFE RESOURCES**. Adding a new lock at the Kentucky Project will affect fish and wildlife resources. A variety of environmental protection and mitigation actions are recommended including the following:

A. Removal of mussels from areas to be dredged, dewatered, or buried by a project feature and relocating them to areas of suitable substrate. Any representatives of federally endangered species would be relocated according to guidance provided by the U.S. Fish and Wildlife Service.

B. Replacement gravel bar or shoal type habitat will be constructed from materials dredged in the lower approach. The gravel bar habitat will be environmentally engineered and designed to mimic existing habitat. A monitoring program will be initiated to document colonization of this area by invertebrate populations, with emphasis on recruitment of molluscs. The program will be long-term and designed to evaluate the success of habitat creation using dredged materials.

C. Rock from lock excavation will be placed to armor the right bank of the Tennessee River between Russell Creek and Interstate 24 preventing further bank erosion. Rock will be used to create other enhancement features in the tailwater, principally to improve fish habitat and angler access.

D. Wetland and bottomland hardwood areas have been identified and will be avoided wherever possible by construction activities.

E. The borrow/disposal area is to be regraded, seeded, and vegetated with plants favorable to wildlife. A tract of land adjacent to the borrow/disposal site will be converted into wetland type habitat.

F. The existing riparian forest zone between the mouth of Russell Creek and Interstate 24 will be augmented with new plantings.

G. Loss of the right bank tailwater boat ramp will be mitigated through upgrading of the existing left bank ramp.

H. Loss of TVA's Taylor Park Campground will be mitigated by relocation to another site near Kentucky Dam.

6.35 **FARMLANDS**. Construction of the new lock at the Kentucky Project will affect less than 5 acres of prime farmland (FEIS Figure 11).

6.36 **CULTURAL RESOURCES**. Mitigation measures for cultural resources affected by the proposed Kentucky Lock addition are subject to stipulations contained within a Memorandum of Agreement (MOA) among the Corps of Engineers, Tennessee Valley Authority, Kentucky Heritage Council, and the Advisory Council on Historic Preservation. Those stipulations require the following:

A. Archeological surveys of all previously undisturbed areas impacted by the proposed project.

B. Test and evaluate National Register eligibility of sites identified during additional survey.

C. Test site 15Lv204, and any newly identified sites of sufficient scope, allowing for preparation of a data recovery plan, should data recovery become necessary.

D. Document affected portions of the Kentucky Lock and Dam to archival standards acceptable to the Historic American Engineering Record (HAER) and Historic American Building Survey (HABS) offices of the National Park Service.

E. Data recovery plans should be implemented shoudl avoidance and preservation of any significant archeological resources prove impratical.

All mitigation measures will be conducted in accordance with standards, guidelines, and coordination requirements defined within the MOA.

7.01 Summarized in this section are the benefits and costs for the final alternatives - Plans A, B, and C. The benefits and costs credited to each plan represent the incremental differences between the with and without-project conditions. Both annual benefits and costs were estimated using a 50-year period of analysis and a base year of 2005. End of year discounting factors for an annual interest rate of 8-1/2 percent were used for economic analysis and plan formulation. All benefits and costs are expressed in October 1991 prices.

BENEFITS

7.02 GENERAL. The total annual incremental benefits for each of the final plans include benefits for the reduction of transportation costs, benefits for shifting movements from more costly modes of transportation, benefits for extending the useful life of the railroad bridge by early replacement, and benefits for the direct use of otherwise unemployed or underemployed labor resources during project construction. A summary of the average annual incremental benefits for each of the final plans is shown in Table 22 below.

TABLE 22 - SUMMARY OF AVERAGE ANNUAL BENEFITS OF FINAL PLANS
(Millions of October 1991 Dollars)

Item	Without Project	Plan A	Plan B	Plan C
Transportation Rate Savings*	$3,656.6	$3,706.2	$3,702.6	$3,702.1
Incremental Rate Savings*				
Normal Operations	—	25.1	22.2	22.0
Periodic Maintenance Closures	—	5.9	5.8	5.8
Major Maintenance Closures	—	18.6	18.0	17.7
Total Incremental Rate Savings*	—	49.6	46.0	45.5
Advanced RR Bridge Replacement	—	0.1	0.1	0.1
Unemployment Benefits	—	4.1	3.1	3.0
Total Avg An Incremental Benefits		$53.8	$49.2	$48.6

* Transportation rate savings for the Ohio River Navigation System

7.03 **ANNUAL TRANSPORTATION RATE SAVINGS**. The annual transportation rate savings within the Ohio River System include two types - cost-reduction and shift-of-mode. The cost-reduction benefits for each plan are derived by reducing the delays at Kentucky Lock associated with the without-project traffic and by shifting traffic (forced to divert to the more costly Barkley Lock/lower Cumberland routing under the without-project condition) to the less costly Kentucky Lock/lower Tennessee routing. Shift-of-mode benefits are generated by returning traffic to the waterway that would be diverted to an overland mode in the without-project condition. Shift-of-mode benefits are significant in later years when traffic demand is highest and during periods of lock closures. A final breakdown of transportation rate savings into cost-reduction and shift-of-mode categories is provided in Appendix D - Systems Analysis.

7.04 Table 22 above displays the transportation rate savings for periods of normal operations (all chambers open) and closures. As indicated, adding auxiliary capacity at Kentucky provides significant savings. Plan A saves $25.1 million annually during normal operations, $5.9 million during periodic closures, and $18.6 million during major closures. Plan B and Plan C provide fewer benefits. During normal lock operations Plan A out performs Plans B and C by a wide margin. Plan A eliminates double lockages and almost all lock delays. Thus, it provides the greatest transportation rate savings over the period of analysis. Plan A also provides the greatest total annual incremental rate savings at $49.6 million. A more detailed discussion of transportation rate savings is contained in Appendix D - Systems Analysis.

7.05 **ADVANCED RAILROAD BRIDGE REPLACEMENT**. Under all final plans the railroad built atop Kentucky Dam must be relocated downstream. The service life of the new bridge will extend beyond that of the old bridge. Accordingly, advanced bridge replacement benefits were calculated for the 58-year period that the useful life of the bridge is extended. Discussion and calculations of these benefits are included in Appendix B - Economics.

7.06 **UNEMPLOYMENT**. Benefits for the direct use of otherwise unemployed or underemployed labor resources during project construction occur with each of the plans. Principles and Guidelines allows unemployment benefits to be claimed in areas that qualify with "substantial and persistent" unemployment. Unemployment benefits cannot be used to determine the feasibility of a project or the NED plan. They can, however be included in the presentation of final analysis of benefits and costs. The calculation of benefits for the direct use of otherwise unemployed or underemployed labor resources is presented in Appendix B - Economics.

COSTS

7.07 **CONSTRUCTION COSTS**. The detailed estimates of construction or first cost for the final plans and the associated engineering and design studies are discussed in Appendix C - Project Design. A summary of the construction costs is included in Table 23. The costs include contingencies which range from 20 to 25 percent. All estimated first costs are considerede economic costs for the benefit-cost analysis.

TABLE 23 - CONSTRUCTION COSTS OF FINAL PLANS
(Millions of October 1991 Dollars)

Item	Plan A 1200' x 110' Lock	Plan B 800' X 110' Lock	Plan C 600' x 110' Lock
Real Estate	1.1	1.1	1.1
Relocations			
Roads	15.1	15.1	15.1
Railroads	39.7	39.7	39.7
Utilities	6.3	6.3	6.3
Esplanade	0.9	0.9	0.9
Campground	1.5	1.5	1.5
Lock	319.0	275.5	253.9
Buildings, Project Operations	1.1	1.1	1.1
Recreation Facilities	0.4	0.4	0.4
Cultural Resources	0.5	0.5	0.5
Buildings, Grounds & Utilities	0.8	0.8	0.8
Subtotal	$386.4	$342.9	$321.3
Engineering & Design	43.4	42.7	42.3
Supervision & Administration	18.5	15.3	15.0
Total	$448.3	$400.9	$378.6

7.08 **INVESTMENT COSTS**. Investment costs, shown in Table 24, are the sum of the construction expenditures for each alternative and the accrued interest on those expenditures up to the time that plan benefits become available. Interest During Construction (IDC) was computed using an estimated sequence of construction expenditures for each plan and end-of-year discounting factors. (See Appendix B for further details.)

TABLE 24 - INVESTMENT COSTS OF FINAL PLANS
(Millions of October 1991 Dollars)

Item	Without Project	Plan A 1200'	Plan B 800'	Plan C 600'
Construction Cost	—	$448.3	$400.9	$378.6
Interest During Construction	—	122.3	118.6	117.9
Total Investment Cost	—	$570.7	$518.3	$495.3

7.09 TOTAL ANNUAL COSTS. The total annual costs include investment costs, operation and maintenance (O & M) costs, helper boat and mooring cell costs (as needed), hydropower modification costs, and costs for detouring US 62 and 641 traffic to Interstate 24 for several years during project construction. Average annual costs are summarized in Table 25 below.

TABLE 25 - AVERAGE ANNUAL COSTS OF FINAL PLANS
(Millions of October 1991 Dollars)

Item	Without Project	Plan A 1200'	Plan B 800'	Plan C 600'
Capital Costs	—	$49.3	$44.8	$42.5
O & M Costs	6.3	4.7	4.8	6.0
Helper Boat Costs	2.6	0.0	0.5	2.6
Hydropower Costs	14.9	0.1	1.1	1.1
Highway Traffic Detour Costs	0.0	1.6	1.4	1.2
Total Annual Costs	$23.8	$55.7	$52.6	$53.7
Incremental Annual Costs		$31.9	$28.8	$29.9

7.10 Capital Costs. Annual capital costs include the average annual interest and amortization charges on the investment costs for each plan.

7.11 O & M Costs. The annual operation and maintenance costs for the plans are based on actual experience at Kentucky and Barkley Locks, as well as other navigation projects in the Nashville District, as discussed in Section 5. Each of the plans have lower O & M costs compared to the without-project condition reflecting the savings associated with operating Barkley Lock on a reduced scheduled. Plan C has somewhat higher O & M costs than Plans A and B.

7.12 Helper Boat Costs. During the six-week closure of Barkley Lock in the summer of 1990, a self-help program was used to expedite tows transitting Kentucky Lock and minimize delays. The average horsepower of these towboats was 2213. However, the high winds encountered often upstream of the lock inhibited the willingness of the tow operators to implement the most effective helper boat scheme. This indicates that a larger boat, in the range of 2800-horsepower is needed upstream of the lock. Thus, an average of the costs for 2200- and 2800-horsepower boats was used to determine the cost to implement the without-project condition. Under Plan A, no helper boat is needed. Under Plan B, helper boats are needed by 2025. Helpér boats are needed immediatiely upon opening the lock under Plan C. The helper boat schemes for Plans B and C are similar to the without-project condition except that two helper boats are needed instead of one.

7.13 Hydropower Costs. Under the without-project condition, modifying hydropower operations at Barkley result in an annual loss of $14.9 million in power revenues. Under Plan A, it is necessary to modify hydropower only during closures of the new lock resulting in an annual loss of only $100,000. Both Plans B and C, however, would require modifications during closure of the new lock as well as closures of the existing Kentucky Lock. Hydropower losses for Plans B and C amount to $1.1 million annually. These hydropower losses are treated as costs of the plans. The losses were calculated using procedures outlined in Principles and Guidelines. Appendix B presents a detailed description of the calculations.

7.14 Highway Detour Costs. To fully capture the economic costs of the final plans, the costs associated with the detour of traffic during lock construction are included. Traffic will be detoured for 4 years and 7 months under Plan A, 4 years and 2 months under Plan B, and 3 years and 8 months under Plan C. The detour distance averages 3.5 miles with a 7.5 maximum and 2.0 minimum. Based on average daily traffic counts obtained from the Kentucky Department of Highways, 12 percent of the traffic is commercial trucks with the remainder being automobile traffic. The cost to motorists annualized over the 50-year study period would be $1.6 million for Plan A, $1.4 million for Plan B, and $1.2 million for Plan C.

SUMMARY OF ANNUAL BENEFITS AND COSTS

7.15 A summary of the total average annual benefits and average annual costs of the plans and the corresponding net annual benefits and benefit-cost ratios are presented in Table 26. Plan A provides the highest net benefits at $21.9 million and has a BCR of 1.7.

TABLE 26. - SUMMARY OF AVERAGE ANNUAL BENEFITS AND COSTS OF FINAL PLANS (Millions of October 1991 Dollars)

Item	Plan A	Plan B	Plan C
Average Annual Incremental Benefits	$53.8	$49.2	$48.6
Average Annual Incremental Costs	$31.9	28.8	$29.9
Net Annual Incremental Benefits	$21.9	$20.4	$18.7
Benefit-Cost Ratio	1.7	1.7	1.6

7.16 As discussed earlier in this section, unemployment benefits cannot be used to determine project feasibility. Without the unemployment benefits, Plan A yields net annual benefits of $17.8 million, while Plan B yields $17.3 million, and Plan C amounts to $15.7 million. Thus, all plans are feasible without unemployment benefits.

SECTION 8 - EVALUATION AND COMPARISON OF FINAL ALTERNATIVE PLANS

8.01 The final alternative plans for an additional lock at Kentucky Lock and Dam were evaluated based on the following standards: satisfaction of study objectives, contributions to Principles and Guidelines accounts, and responsiveness to specific evaluation criteria.

SATISFACTION OF STUDY OBJECTIVES

8.02 The study objectives are based on the problems identified and the opportunities associated with the water and related land resources within the study area. These objectives are discussed in Section 5.

8.03 All the final alternatives significantly reduce delays for present and projected traffic demand; all handle the projected traffic demand during normal operations. The difference is in how the projected traffic is served and what happens during maintenance closures. Plan A accommodates all system traffic without the addition of any nonstructural measures. Delays remain low throughout the planning period and during closures of either existing lock. Virtually no traffic is expected at Barkley; thus, its operation and maintenance would be reduced. Under Plan B, however, helper boats are needed at Kentucky Lock about 20 years after the new lock opens when delays begin increasing. Little commercial traffic is expected on the lower Cumberland and the operation and maintenance of Barkley Lock can be reduced. Traffic management is needed during closure of the new lock. With Plan C, helper boats are needed at Kentucky immediately upon lock opening. Delays are about 1 hour in 2005 and increase steadily throughout the planning period, reaching a high of 10.5 during normal operations. Traffic management is needed when either lock at Kentucky is closed. The operation and maintenance of Barkley Lock could also be reduced.

8.04 Each of the final alternatives allow traffic to pass through the Kentucky-Barkley System during project construction. Each could be implemented in a manner that would minimize adverse impacts on existing traffic through the system. The existing locks at both Kentucky and Barkley would remain open during the construction period.

8.05 All final plans preserve the existing recreational opportunities within the study area. Visitors access to the lock, powerhouse, and fisherman's platform downstream of the existing dam would be curtailed during construction to protect the public. The campground just above the lock would be relocated before significant construction begins. The railroad relocation (required in all final plans) would temporarily impact a portion of Kentucky Dam Village State Park on the left bank downstream of the dam. However, no additional park facilities, including the public boat ramp, would be closed during the construction period.

8.06 All of the final plans would inevitably impact some aquatic and terrestrial resources within the project area. Future navigation traffic levels would not significantly impact the biology of the lower Tennessee River or Kentucky Reservoir. Project planning and design takes into consideration the valuable aquatic and terrestrial resources with in the project area (mussel sanctuary, federally endangered and threatened species, fisheries, wetlands, bottomland hardwoods, etc.). These resources are identified, and where possible, project impacts avoided or reduced. Archeological sites identified in the project area will be scientifically explored and, where warranted, preserved.

8.07 Specific project features that avoid or reduce adverse consequences for important resources include the following:

a. Leaving buffer zones to protect wetlands and bottomland hardwoods.

b. Completely avoiding stands of palustrine forested wetlands that contain large baldcypress trees with the alignment of the railroad on the left bank.

c. Minimizing dredging in the lower approach, adjacent the right bank mussel bed to reduce impacts to mussels.

d. Creating gravel bar habitat below the state mussel sanctuary with material from the lower approach.

e. Placing stone on the right bank between Russell Creek and I-24 to prevent further loss of riparian habitat.

f. Augmenting the existing riparian strip along the right bank of the Tennessee River through plantings.

CONTRIBUTION TO PRINCIPLES AND GUIDELINES (P&G) ACCOUNTS

8.08 **NATIONAL ECONOMIC DEVELOPMENT ACCOUNT**. The plans for constructing a new lock at the Kentucky Project make contributions to the National Economic Development (NED) account in varying amounts. NED navigation benefits consist of reductions in transportation costs for traffic moving under the without-project condition and for traffic added as a result of shifts in modes of transport. Other NED benefits include early replacement of the railroad bridge and unemployment. Plan A provides $53.8 million in incremental benefits, Plan B provides $49.2, and Plan C provides only $48.6 million. Plan A has the greatest net annual benefits ($21.9 million), with $1.5 million more than those of Plan B ($20.4 million) and $3.2 more than those of Plan C ($18.7). Plans B and C provide smaller locks, involve longer delays, employ less labor, and therefore have fewer NED benefits.

8.09 **ENVIRONMENTAL QUALITY ACCOUNT**. Constructing any of the new locks will cause some unavoidable adverse impacts at the project site. Most, however, can be limited to relatively small geographic areas. The final plans are at the same location, have the same major features and environmental impacts. Perhaps the most significant impact will arise from dredging to improve the lower approach channel between the new lock and Interstate 24. The impact to the state mussel santuary is relatively minor considering the total amount of habitat for mussels available there. Some of the material generated from the excavation of the new chamber will be placed in a highly disturbed, upland disposal site with a low terrestrial habitat value. Stone generated from lock excavation will be used to armor the right bank between the mouth of Russell Creek and Interstate 24, and create other enhancement features in the tailwater. Additionally, impacts to the National Register eligible lock and dam and other cultural resources can be acceptably mitigated.

8.10 **REGIONAL ECONOMIC DEVELOPMENT ACCOUNT.** All three plans make positive contributions to the Regional Economic Development (RED) account in the form of increased regional employment and income. Lower transportation costs on the Cumberland and Tennessee Rivers will result in increased income to shippers and ultimate savings to consumers. The use of unemployed labor during project construction will also result in increased regional income. Lower transportation costs to industries in the Cumberland and Tennessee River Valleys could stimulate further economic development and further increasing regional employment and income. Some adjustments to the operations of Reed's Crushed Stone, the Paducah and Louisville Railroad, and the BRT Terminal may be required during construction of any of the plans. Every effort will be made to minimize these impacts. Plan A has the largest construction costs and would make the greatest net contribution to the RED account. Plans B and C require smaller construction forces, produce fewer navigation benefits, and contribute less to the RED account.

8.11 **OTHER SOCIAL EFFECTS ACCOUNT**. All the lock plans contribute positively to the Other Social Effects (OSE) account by improving lockage operations - not only reducing the risk of potential accidents, but also potential conflicts between commercial and recreational users. Plan A reduces the risk of accidents more effectively because it completely eliminates double lockages at Kentucky. No displacement of families is required with any plan. During project constrution increased noise and construction traffic could detract from the quality of the recreational experience at the Kentucky Dam Village State Park just downstream of the project site. Other impacts include the detour of US 62 and 641 traffic to Interstate 24 which averages about 3.5 miles. Traffic would be detoured for about 55 months with Plan A, 50 months with Plan B, and 44 months with Plan C.

RESPONSIVENESS TO EVALUATION CRITERIA

8.12 Principles and Guidelines stipulates that alternative plans should be formulated and evaluated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability. The following is a summary of these evaluations.

8.13 **COMPLETENESS**. The term "completeness" refers to the extent to which an alternative plan provides and accounts for all investments or other actions necessary to ensure the realization of the planned effects. Each of the final plans is equally complete in that all investments and actions for a new lock at the Kentucky Project are accomplished during an initial construction phase.

8.14 **EFFECTIVENESS**. "Effectiveness" refers to the extent to which an alternative alleviates specified problems and achieves desired outputs. The final plans are all effective because each includes a new main lock that, together with the existing locks at Kentucky and Barkley, could physically pass the projected level of traffic throughout the economic life of the project. Plan A is judged to be more effective than either Plan B or Plan C because the physical capacity is greater and the projected lockage delays are fewer. Under Plans B and C, congestion and delay become problems during lock closures and during normal operations toward the end of the planning period.

8.15 **EFFICIENCY**. "Efficiency" refers to the extent to which an alternative is the most cost-effective means of alleviating the specified problems and achieving the desired output. Maximum net benefits and benefit-cost analysis are the two common means of measuring efficiency. Plan A has the highest benefit-cost ratio (1.7) and greatest net annual benefits ($21.9 million), or $1.5 million more than those of Plan B ($20.4 million) and $3.2 million more than Plan C ($18.7). Plan A is, therefore, the most efficient.

8.16 **ACCEPTABILITY**. "Acceptability" refers to the viability of an alternative plan as viewed by state and local entities and the general public, and its compatibility with existing laws, regulations and public policy. Most opinions regarding acceptability have come from special-interest groups. At the Feasibility Review Conference held August 7 and 8, 1990 members of the towing industry stated that they prefer Plan A which provides for a new 1200-foot lock because its physical lock capacity is greater than a new

600-foot long lock and because only single lockages will be necessary. Both written and oral comments taken on the public draft of this report are almost without exception supportive of the project. The Commonwealth of Kentucky is highly supportive of the project. All final alternative plans are compatible with existing laws, regulations, and policies.

THE NATIONAL ECONOMIC DEVELOPMENT PLAN

8.17 The plan that reasonably maximizes net contributions to the national economic development account (excluding unemployment benefits) is designated the National Economic Development (NED) plan. Plan efficiency was discussed above under responsiveness to evaluation criteria. Plan A has net annual benefits of $17.8 million whereas Plans B and C have net annual benefits of $17.3 million and $15.7 million, respectively. Plan A has the greatest net benefits and it is therefore designated the NED plan.

SENSITIVITY ANALYSIS

8.18 The final plans for improvement were evaluated using what was judged to be the most probable future navigation conditions both with and without the project. Several analyses were performed to measure the sensitivity of the plans to changes in key variables. These variables include projections for future traffic demand and alternative interest rates for discounting project benefits and costs. Detailed discussions of the sensitivity analsyis are included in Appendix B - Economics.

8.19 To demonstrate the sensitivity of the final plans to traffic demand forecasts, the benefits for the final plans were estimated using traffic demands 15 percent higher and 15 percent lower than the most probable forecast. The net benefits for all the final plans are considerabley lower under the low projections and higher under the high projections. All the alternatives, however, are still justified. Plan A remains the NED plan under the high projections, while Plan B yields slightly higher net benefits with the low projections.

8.20 Plan benefits were also evaluated assuming no growth in traffic levels after the first 20-year period. Since 2005 was the base year for project evaluation, projected traffic was held constant at the 2025 level. Although the results of this analysis show a reduction in net benefits, all plans would still produce positive net benefits and Plan A would be the NED plan.

8.21 To demonstrate the sensitivity to alternative federal discount rates, the benefits for the NED plan were evaluated using an 8 percent rate and a 10 percent rate. The current federal discount rate is 8-1/2 percent. The net benefits for Plan A increase markedly using an 8 percent discount rate. Conversely, net benefits decrease substantially if benefits and costs are discounted at a 10 percent interest rate. However, Plan A remains feasible at the higher discount rate.

CONGESTION FEE

8.22 A congestion fee is a non-structural measure that serves as a rationing devise to restrict demand for lock use and induce shippers to choose alternative routings or other modes of transportation. Congestion fees were evaluated in the feasibility studies to determine their impact in reducing congestion at Kentucky Lock and their impact on Ohio River System rate savings. The average annual benefits for a congestion fee are estimated at $12.0 million, and the costs for implementing and administering the fee are about $0.8 million annually. The resulting in net benefits of $11.2 million are substantially less than any of the lock plans. For example, the net benefits the 1200-foot lock are $21.9 million, or nearly twice the congestion fee. Detailed discussion of these evaluations is presented in Appendix D - Systems Analysis (Section 7).

8.23 In addition to being less efficient economically, there are other problems with the congestion fee that make it undesirable. First, it does nothing to increase the capacity of the Kentucky-Barkely System. It merely shifts traffic from the otherwise more efficient Kentucky routing to the circuitous lower Cumberland River. As a result, shippers would face higher delays and shipping costs with this measure than with any of the lock plans. Second, the large volumes of traffic that would be forced to use the lower Cumberland would create safety concerns that must be thoroughly addressed. Third, the economic benefits are considered to be very speculative. Since this alternative has never been implemented on a navigation project anywhere in the world, there is no basis for judging its actual performance. However, there is a high risk that it would not perform as well a as the theoretical model. Finally, congestion fees are strongly opposed by the towing industry and other regional waterway interests. They perceive the added costs as a constraint to the future economic viability of the entire Tennessee Valley. The added government regulation would increase production costs, erode their competitive advantage relative to other competing modes and waterways, and hinder thier ability to compete in national and international markets. Consequently, the congestion fee was eliminated from further consideration.

SECTION 9 - THE RECOMMENDED PLAN

SUMMARY OF FINAL PLANS

9.01 This study investigated in detail three alternative plans to add a new lock at the Kentucky Project:

Plan A - a 110- X 1200-foot lock

Plan B - a 110- X 800-foot lock

Plan C - a 110- X 600-foot lock

Except for the length of the new lock, the major features of the locks are the same. Each new chamber would be adjacent to and landward of the existing lock. Each plan includes reduced operation and maintenance of Barkley Lock. The rationale for plan selection and details of the selected plan are discussed in the following paragraphs.

RATIONALE FOR PLAN SELECTION

9.02 The three primary study objectives are (1) to reduce existing lockage delays at Kentucky Lock, (2) to efficiently serve future traffic using the Kentucky-Barkley Navigation System throughout the planning period (2005-2054), and (3) to efficiently serve future traffic using the Kentucky-Barkley Navigation System during periods of lock closures. A more complete listing of the study objectives is found in Section 5. Each of the final plans would significantly reduce the lockage delays for the projected traffic demand; efficiently handle 99 to 100% of the projected traffic demand during normal operations, and adequately handle projected traffic demand for the system during lock closures. All the final plans are economically feasible and have significant net benefits.

9.03 Principles and Guidelines states that the recommended plan must provide the maximum net NED benefits, that the NED Plan must be the selected plan unless there is some overriding reason for selecting another plan, and that the recommended plan must have incremental system benefits in excess of incremental costs (a benefit-to-cost ratio above unity).

9.04 Figure 19 graphically displays the net benefits of the final plans. Plan A has the highest net benefits, with $21.9 million. It increases system capacity during normal operations by about 130 percent. Also, a 1200-foot chamber can single-lock the fleet anticipated to use Kentucky Lock throughout the planning period, thereby minimizing delays. For only about 15 percent

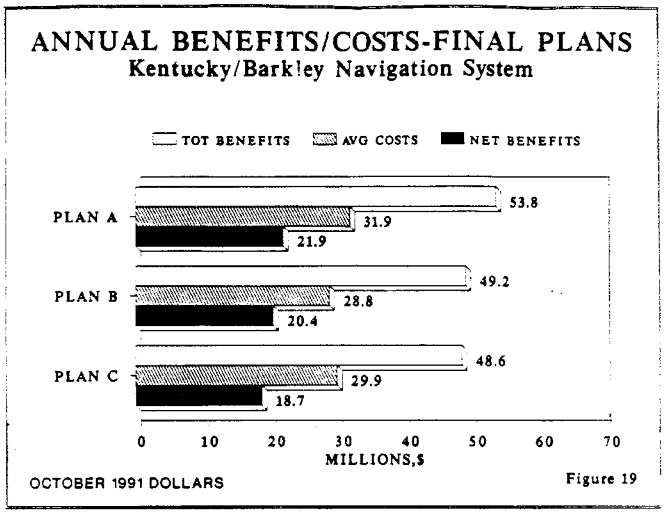


Figure 19

more investment, Plan A provides about 70 percent more capacity than Plan C. For about 10 percent more investment, Plan A provides about 50 percent more capacity than Plan B. No nonstructural measures are needed to meet traffic demand during the period of analysis. In addition, the larger lock of Plan A will serve the industry more efficiently than either Plan B or C when one of the existing locks is closed. The benefit-to-cost ratio (BCR) of Plan A is 1.7.

9.05 Plan B has a BCR of 1.7 and net benefits of $20.4 million. It does not eliminate double lockages. With Plan B, helper boats are needed at Kentucky about 20 years after the new lock is completed. In addition, the 800-foot lock is much less efficient than the 1200-foot lock during maintenance closures. Traffic management will be needed when the 800-foot lock is down.

9.06 Plan C has a BCR of 1.6 and net benefits of $18.7 million. The total capacity of the Kentucky Project would be less under Plan C and a greater portion of the projected traffic demands would be use Barkley Lock and the more costly lower Cumberland routing. Under Plan C, half of the tows transiting Kentucky Lock would require double lockages resulting in high delays. The smaller lock would not serve the industry as efficiently as the other plans when either of the existing locks is closed. Helper boats are needed at Kentucky immediately after the new lock opens and hydropower generation at Barkley must be reduced later in the planning period. Traffic management will be needed when either the new or existing Kentucky Lock is closed.

9.07 The construction of any of the lock plans would essentially result in the same impacts to the environmental, social, recreational, and cultural resources in the project area and throughout the Cumberland and Tennessee River systems as was discussed in Section 8. However, Plan A, which provides the greatest transportation savings and employs a more sizable construction force, would make the maximum contribution to regional economic development.

9.08 Plan A, adding a 110-foot wide and 1200-foot long lock at the Kentucky Project yields the highest net annual benefits ($21.9 million) and a benefit-to-cost ratio of 1.7. In addition, at the August 1990 Feasibility Review Conference, representatives of the towing industry strongly voiced their preference for the 1200-foot lock. For all these reasons, Plan A is the best plan to meet the navigation demands on the Kentucky-Barkley System throughout the planning period and is, therefore, the recommended plan.

PLAN DESCRIPTION

9.09 The recommended plan, provides an additional lock, 110 feet wide and 1200 feet long, at the Kentucky Project. The lock is sited immediately landward of the existing Kentucky Lock with its upper miter sill about 300 feet downstream of the existing upper miter sill. The plan calls for using the existing chamber at Kentucky as an auxiliary and reducing the operation and maintenance of Barkley Lock after construction of the new lock. Figure 20 shows the layout of the selected plan. Several measures will be required to efficiently handle traffic on the system until the new lock is opened including maintaining both locks and the lower Cumberland River.

9.10 The proposed lock will be a concrete, gravity structure with walls similar to the existing lock. The upstream and downstream miter sills will be set to provide 18 feet of navigational clearance at minimum headwater and tailwater. Both gates are steel miter type. An emergency gate is proposed upstream of the upper miter gates. Stoplogs will be provided downstream of the lower miter gate and stored on-site. Slots and seals will be provided to dewater the lock for maintenance.

9.11 The downstream guidewall will extend a distance equal to the length of the chamber (1200 feet). The top will be at elevation 348.0, five feet above the 40-year flood level. The upstream guidewall will be constructed on steel bearing piles. Precast concrete beams will be constructed on top of the

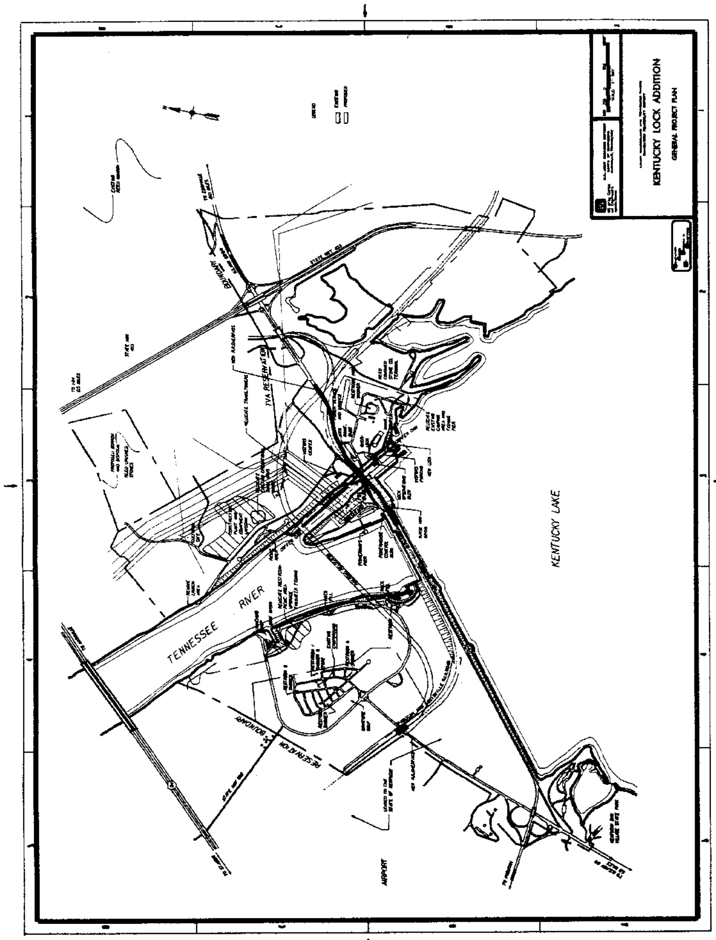

KENTUCKY LOCK ADDITION
GENERAL PROJECT PLAN
TENNESSEE RIVER
KENTUCKY LAKE
TVA RESERVATION

Figure 20

cells, and a poured-in-place mass concrete wall will be constructed on top of the beams to the same elevation as the lock walls. This guidewall will extend 350 feet above the upper end of the existing approach wall floating boom (for a total length 1500 feet). The five mooring cells just upstream of the existing lock will be removed and replaced by two new cells aligned with the upstream guidewall of the new lock. Two new mooring cells will be constructed below the dam between the new lock and the interstate. Neither the upstream nor downstream cofferdams will encroach upon approaches to the existing lock.

9.12 Nearly 1.7 million cubic yards of material will be excavated for the new lock and about 145,000 cubic yards of material will be removed from the approaches to the lock. The selected borrow\disposal site is about one mile north of Kentucky Dam on lands previously disturbed by quarring operations. The majority of work in the approaches will be in the 1.3-mile reach between the new lock and the interstate. The navigable span of the bridge is 500 feet wide and located near the middle of the river, while both the new and the existing locks are along the right bank. The existing navigation channel must be shifted toward the right bank to provide a safe entrance and exit to the lock.

9.13 The proposed lock requires extensive relocations and will affect large areas on both sides of the river. However, the construction (except the borrow/disposal area) and all proposed relocations are within the existing Tennessee Valley Authority Reservation boundary, on the railroad right-of-way, or along the US 62 and 641 roadway. A construction easement will be needed from the trustees of Walker Cemetery for the railroad relocation, and an easement will be provided across the proposed railroad right-of-way for permanent access to the cemetery. TVA's current lease with the Commonwealth of Kentucky for the recreation area along the left bank must be modified. New contracts or agreements with the railroad, Commonwealth of Kentucky, and Marshall and Livingston Counties will be needed for the rail and highway adjustments.

9.14 The Paducah and Louisville Railroad will be the major relocation. Currently, the track crosses the existing lock downstream of the chamber and has adequate vertical clearance. The existing track would cross the chamber of the proposed lock, however, and vertical clearance would not be sufficient. The need for slight ascending and descending grades dictates relocating the railroad to a crossing about 0.3 miles downstream of the dam. This requires constructing 1.4 miles of approaches and a 1/2-mile, high-level bridge over the Tennessee River. Other requirements associated with the railroad relocation include constructing two No. 8 turnouts, one on the south approach and another on the north; constructing a grade separation at the intersection with US Highways 62 and 641; and relocating or protecting a 6-inch waterline, a 14-inch sanitary sewer, a telephone line, and railroad signal lights.

9.15 Elevating a portion of US 62 and 641 is the next largest relocation item. The horizontal alignment of the roadway will be similar to the existing roadway with major changes in vertical grades. Traffic will be detoured an average of 3.5 miles to Interstate 24 during construction. Relocating the highway eliminates existing access to the powerhouse and switchyard. A new access road and a high-level bridge will be provided just upstream of the relocated railroad bridge. The 1300-foot bridge will tie into an existing road in the switchyard. Other road modifications include relocating a 500-foot section of Ferry Landing Road (now located along the right bank of the river) to the east of the new lock and under the relocated railroad and constructing a new access road and two parking areas near the dam.

9.16 Thirteen transmission lines cross the project just downstream of the existing lock, from the switch yard to seven transmission towers on the right bank. These lines must be raised to provide the minimum vertical clearance of 140 feet above the new lock. Two new pull-off structures must be constructed near the switchyard on the left bank and three new towers must be constructed on the right bank. In addition, seven smaller towers will be needed on the right bank to provide a transition down to existing elevations.

9.17 Four buildings will replace existing facilities removed by the new lock. The new lock operations building will be constructed near the proposed upstream miter gate. Lock maintenance and flammable liquid storage buildings are also required.

ENVIRONMENTAL CONSIDERATIONS

9.18 The recommended plan will impact some lands now in TVA's Kentucky Dam Reservation and 67 acres about 1 mile north of Kentucky Dam on lands previously disturbed by quarrying operations. Lands will be affected by construction of the lock itself, realignment of railroad right-of-way, construction of haul roads, storage of equipment, excavation of river bank, and disposal of excavated materials. In some areas, changes will be permanent, while other areas can be restored through planting vegetation and other land management practices to control erosion. No toxic or hazardous materials will be disposed of as a result of construction.

9.19 The proposed lock will be designed to minimize downstream excavation along the right bank of the Tennessee River. Some excavation, however, will be needed to create a suitable approach for tows. Most bank excavation will be in the dry, behind a cofferdam, thus greatly reducing inputs of suspended sediment into the tailwater. An additional length of river bank equal to the guidewall length (1200 feet) will be excavated under both dry and wet conditions. The downstream terminus of this excavation will be near the mouth of Russell Creek. The modified right river bank will be protected with stone riprap downstream of the landward approach wall.

9.20 In-river dredging of the lower lock approach between TRM 21.1 and 21.6 (Interstate 24 bridge) will directly impact a small portion of the right bank tailwater mussel bed. Portions of the area to be dredged support dense populations of mussels, while other areas are scoured and sparsely populated. Dredging will release some sediment that will be diluted and dispersed downstream with normal releases from the dam. Relocating mussels from the area to other sites is planned. Few, if any, individuals of federally endangered mussels are in the area to be dredged. The dredged material will be placed in an open-water site in the lower Tennessee River to create replacement habitat. Dredging will be coordinated to avoid the spring fish migration and spawning season.

U.S. FISH AND WILDLIFE RECOMMENDATIONS

9.21 The U.S. Fish and Wildlife Service reviewed the final alternatives and provided analysis in a Final Fish and Wildlife Coordination Act Report (FFWCAR) dated October 1991. They offered several recommendations intended to protect downstream aquatic resources in the Tennessee River. All recommendations relate to construction rather than operational or system impacts. The report is included as Appendix A in the Final Environmental Impact Statement (FEIS). Based upon environmental design features incorporated into the proposed project and relatively minor terrestrial impacts, the USFWS deemed a HEP or Habitat Based Methodology not warranted (Exhibit 4, FEIS).

CULTURAL RESOURCES CONSIDERATIONS

9.22 Construction of the proposed lock will result in an adverse effect on the Kentucky Lock and Dam, a National Register eligible property. Use of areas on the right bank downstream of Kentucky Lock and Dam and below Russell Creek may similarly have an effect on a National Register archeological site, 15Lv204. Additionally, a small historic cemetery and a previously identified prehistoric cemetery are adjacent to the equipment laydown area; as currently proposed, the project will not affect these latter resources. Several other archeological sites identified in past surveys were destroyed by the construction of Kentucky Lock and Dam, were unable to be relocated, or are mis-located (15Lv12, 15Lv20), are no longer considered archeological sites (15Lv21), or are located well outside areas of potential project impact (15Lv23). Sites 15Lv22 and 15Lv204 are identified in the same locality and are, for purposes of this report, considered as the same site.

COORDINATION

9.23 **ENVIRONMENTAL**. Fish and wildlife resource concerns were and continue to be coordinated with appropriate federal and state agencies. The primary agencies involved in natural resource issues are the U.S. Fish and Wildlife Service (USFWS) and the Kentucky Department of Fish and Wildlife Resources (KDFWR). Project review is being conducted primarily under the auspices of the Fish and Wildlife Coordination Act. Endangered species issues were addressed according to provisions of the 1973 Endangered Species Act, as amended. In addition, TVA and the U.S. Coast Guard (USCG) assumed cooperating agency status for the Environmental Impact Statement. All significant environmental review events are being closely coordinated by official points of contact established by the Nashville District, TVA, and USCG.

9.24 **CULTURAL RESOURCES**. Coordination and consultation with the Kentucky State Historic Preservation Officer and the Kentucky Heritage Council were initiated on September 10, 1990, and the Council was provided with the preliminary draft report for the Kentucky Lock addition. The initial coordination letter requested archeological information specific to the project area, noted the general lack of archeological survey data for the project area, added that further survey would be conducted, and requested a consensus determination of eligibility for the Kentucky Lock and Dam. The Kentucky Heritage Council response of October 5, 1990 provided the requested consensus determination of eligibility statement and further noted that the project appeared to have the potential to impact archeological sites eligible for listing on the National Register. By letter of November 5, 1990, the Kentucky Heritage Council was requested to provide guidance concerning the appropriate procedures for the disposition of human skeletal remains which may be encountered in archeological contexts or historic cemeteries. Guidance and consultation requirements were provided to the District by letter of December 5, 1990. A Memorandum of Agreement has been initiated among the Corps of Engineers, TVA, Kentucky Heritage Council, and the Advisory Council on Historic Preservation.

OPTIMUM PROJECT TIMING

9.25 The purpose of the optimum timing analysis is to determine the completion date that produces the maximum net annual benefits. The benefit analysis in this report is based on an additional lock being completed and available for use by the year 2005. This was the most likely date by which a new lock could be completed. Optimum replacement timing for the selected plan was evaluated by estimating the average annual benefits and costs of completion dates ranging from 2005 to 2010. The net benefits would be maximized with project completion in 2006.

PROJECT FINANCING

9.26 In accordance with Section 102 of the Water Resources Development Act of 1986 (Public Law 99-662), as amended, one-half the costs of constructing the recommended plan will be paid from amounts appropriated from the general fund of the Treasury and one-half from the Inland Waterways Trust Fund. The term construction in this specific case is defined to include post-feasibility level planning; engineering and design; surveying; acquiring all lands, easements, and rights-of-way; and accomplishing all relocations, disposal of materials, and fish and wildlife mitigation. Proposals to modify or rehabilitate elements of the inland and coastal waterways system of the United States, defined by Section 206 of the Inland Waterways Revenue Act of 1978, as amended, will recommend financing on this basis. Operation and maintenance costs on all inland and coastal waterways are 100 percent Federal, pursuant to Section 102(b) of the Water Resources Development Act of 1986.

ECONOMIC CONSIDERATIONS

9.27 The construction cost of the selected plan is $467.6 million. The total investment cost, including $129.8 million in interest during construction, is $597.4 million. Annual economic costs are $60.5 million and include $4.7 million for operation and maintenance of the existing and proposed projects, $0.1 million for hydropower modifications at Barkley during maintenance closures at Kentucky, and $2.6 million for the traffic detour during the relocation of the highway. All costs were prepared at October 1989 price levels and indexed to October 1991 levels. Annual costs were computed using an interest rate of 8-3/4 percent and an economic life of 50 years. The annual cost over and above the without-project condition is $36.6 million.

9.28 The general approach for assignment of contingencies used an average or base of 20 percent, except where risks associated with each sub-feature dictated a variance from the base level. Risks considered in assigning contingencies included the following: the accuracy of quantity calculations, the relative certainty that design parameters could change due to the dynamic nature of design guidance, and the accuracy of known site conditions.

9.29 The incremental annual benefits for the selected plan total $52.1 million. This includes $47.8 million in transportation rate savings, $0.1

million for advanced railroad bridge replacement, and $4.2 million for unemployment benefits. The benefit-to-cost ratio is 1.4.

PED AND CONSTRUCTION SCHEDULE

9.30 **GENERAL**. In accordance with the concepts of Life Cycle Project Management, a project manager is assigned to this study. Schedules and cost estimates are based on network analyses with input from all elements involved in the project. All aspects of the project from the feasibility report, through preconstruction, engineering, and design (PED) activities and project construction are covered.

9.31 The PED estimate includes all costs necessary to ready the project for construction including plans and specifications for the first construction contract. As discussed in Appendix C - Project Design, a very conservative approach was used in the design of the project and development of the baseline cost estimate. This, combined with the high degree of certainty associated with the recommended plan, allows PED to proceed directly from the feasibility report to design memoranda (DMs). It is very unlikely that any additional information would affect plan evaluation or site selection. As shown on Figure 21, the PED schedule runs two years and assumes funds are available in FY 93. The construction schedule runs ten years and assumes funds are available in FY 95. A more detailed schedule can be found in Appendix D - Project Design.

9.32 **DESIGN MEMORANDA AND FIRST P&S**. The first Design Memroanda (DMs) will focus heavily on geotechnical design and hydraulic modeling. Additional borings and channel mapping will be completed. Borings will cover the proposed railroad relocation, lock features, and the upstream cofferdam. The hydraulic modeling, conducted by the COE's Waterways Experiment Station (WES), will include studies to evaluate and refine the the design of the lock and a river model to correctly align the lower approach with the navigation span of the Interstate 24 Bridge. Separate DMs will be prepared for the recreation area, railroad, highway and utility relocations, foundations, structural properties and special design considerations, mechanical/electrical features, environmental engineering features, cofferdams, and lock structure. Plans and specifications will be completed for the relocation of the TVA campground as the first construction contract.

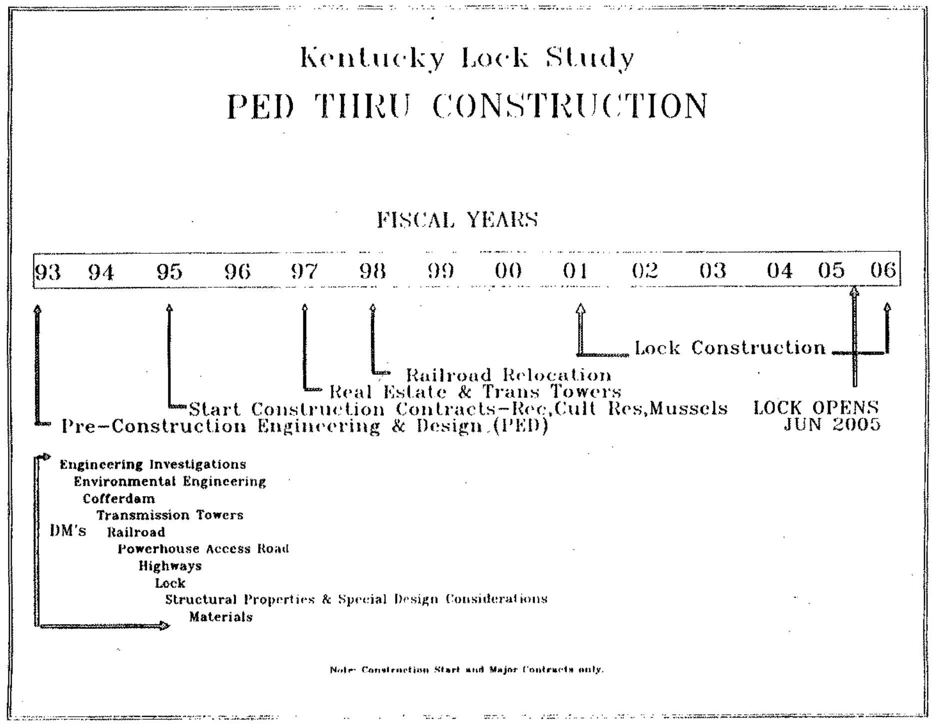

Kentucky Lock Study
PED THRU CONSTRUCTION
FISCAL YEARS
93 94 95 96 97 98 99 00 01 02 03 04 05 06
Lock Construction
Railroad Relocation
Real Estate & Trans Towers
Start Construction Contracts-Rec,Cult Res,Mussels
Pre-Construction Engineering & Design (PED)
LOCK OPENS
JUN 2005
Engineering Investigations
Environmental Engineering
Cofferdam
Transmission Towers
DM's
Railroad
Powerhouse Access Road
Highways
Lock
Structural Properties & Special Design Considerations
Materials
Note: Construction Start and Major Contracts only.

Figure 21

SECTION 10 - CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

10.01 In recent years, an average of 33.5 million tons of cargo transited the Kentucky-Barkley navigation system with almost 90 percent using Kentucky Lock. This high use of Kentucky causes significant congestion and delay. Currently, an average of 82 percent of all tows using Kentucky Lock experience delays, averaging 3-1/2 hours per tow. This delay time adds to an already excessive processing time (the vast majority of tows transiting Kentucky Lock require double lockages) and results in one of the highest transit times in the Ohio River system, 5-1/4 hours.

10.02 Traffic on the Kentucky-Barkley system is projected to grow at the same rate as the Ohio River system. By the year 2000, the traffic accomodated by the Kentucky-Barkley navigation system is projected to reach 43.6 million. In that year the average delay at Kentucky Lock will be almost 8 hours. This high delay will divert millions of tons of cargo to the higher-cost routing of Barkley Lock and the lower Cumberland River or to overland modes of transportation.

10.03 The problem is exacerbated in years when one of the existing locks is closed for maintenance. In 2006 through 2009 when Kentucky Lock is scheduled to be closed 13 weeks each year for maintenance, delays at Barkley are projected to range from 85 hours per tow to 93 hours per tow. In the years 2038 through 2041, when Barkley is scheduled to be closed 14 weeks each year, delays at Kentucky are projected to range from 86 hours per tow to 89 hours per tow. High delays are a substantial cost to the shipping industry and ultimately the consumer.

10.04 In addition to high delays at Kentucky and Barkley, the without-project condition carries other costs including those associated with helper boats which will be needed at Kentucky Lock before the year 2000. Helper boats and the additional mooring cells required to implement the measure have an average annual cost of $2.6 million (October 1991 prices). To accommodate the high level of traffic projected to use the lower Cumberland River under the without-project condition, safety improvements would be made and hydropower discharges at Barkley would be modified. The modification would affect the current operation of the powerplant and result in an average annual loss of $14.9 million (October 1991 prices) in hydropower revenues. This loss is also a cost of the without-project condition.

10.05 A new 110- X 1200-foot lock at the Kentucky Project will eliminate delay and congestion problems in the Kentucky-Barkley Navigation System. If the new lock is in-place by the year 2005 when Barkley is scheduled for a three week closure, delays at Kentucky will average only 0.2 hours (versus 19.5 without a new lock). In 2006, when the existing Kentucky Lock is scheduled to be closed for 13 weeks, delays at the new lock will average only 0.2 hours per tow and since all traffic will be accomodated at Kentucky, there will be no delay at Barkley (versus 85 hours without a new lock). The 1200-foot lock will also eliminate the need for a helper boat and the need to modify hydropower operations at Barkley Powerplant.

10.06 A new 1200-foot lock at Kentucky will efficiently accommodate all traffic projected to move on the Kentucky-Barkley navigation system for the period of analysis (2005 to 2054) even during years in which closures are scheduled. Although a new 1200-foot lock at the Kentucky project will cause increased congestion at other locks in the Ohio River navigation system, the benefits of the new lock substantially outweigh the cost of the increased congestion. The incremental benefits to the Ohio River system will average $53.8 million annually, while the net incremental benefits will average $21.9 million annually.

10.07 Environmental impacts of the project on significant resources can be summarized as being relatively minor and highly localized. Certain unavoidable losses will occur to resident mollusc populations; however, these populations are not unique and will exhibit some recovery following completion of the project. Aquatic habitat creation downstream using dredged materials will further offset direct project impacts on the mussel sanctuary, and the integrity of the state mussel sanctuary will be maintained. The valuable tailwater fishery will be unaffected by the project. Potential adverse effects on cultural resources have been identified and can be acceptably mitigated.

10.08 The impact on terrestrial resources will be minimized through identification of significant resources and avoidance of these areas wherever possible. Some opportunity exists for arresting ongoing environmental degradation through armoring of eroding banks. Borrow/disposal sites will be restored and revegetated, and the augmentation of the right bank riparian strip through plantings will restore that feature.

10.09 Loss of the right bank tailwater boat ramp will be mitigated with a significant upgrading of the existing left bank tailwater boat ramp that will provide the recreating public with an excellent facility.

RECOMMENDATIONS

10.10 Having carefully considered the environmental, social, economic, engineering, and public safety aspects of maintaining and modernizing commercial navigation facilities on the Kentucky-Barkley navigation system, I recommend that an additional 110- X 1200-foot lock be authorized for construction as a Federal project, with such modifications as, at the discretion of the Chief of Engineers, may be advisable. The recommendations also include traffic management as appropriate and such measures as necessary to maintain safe navigation on the lower Cumberland River. The total estimated first cost of this project, based on October 1991 prices and conditions, is $448 million. Annual operation and maintenance for the Kentucky and Barkley Locks and Dam, as modified by this recommendation, is estimated to be $4.7 million. Project financing is to be in accordance with Section 102 of the Water Resources Development Act of 1986 (Public Law 99-662), as amended.

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

Stephen M. Sheppard
Lieutenant Colonel, Corps of Engineers
District Engineer

FINAL

LOWER CUMBERLAND AND TENNESSEE RIVERS

NAVIGATION FEASIBILITY REPORT

KENTUCKY LOCK ADDITION

VOLUME I

MAIN REPORT AND ENVIRONMENTAL IMPACT STATEMENT

EXHIBITS

MEMORANDUM OF AGREEMENT

BETWEEN

THE TENNESSEE VALLEY AUTHORITY

AND

THE U.S. DEPARTMENT OF THE ARMY

SUBJECT: Kentucky Lock Addition, Tennessee River Mile 22.4

1. PURPOSE: The purpose of this Memorandum of Agreement (MOA) is to define the responsibilities of the U.S. Department of the Army (DA), acting through the U.S. Army Corps of Engineers (USACE), and the Tennessee Valley Authority (TVA) in connection with a new lock at Kentucky Dam. The scope of the project to be undertaken is to be fully described in the "Lower Cumberland and Tennessee Rivers - Kentucky Lock Addition" feasibility report. This MOA does not supersede or modify previous Memoranda of Agreement between TVA and DA, but is entered into for the sole purpose of implementing the Kentucky Lock Addition Project. Nothing in this document is intended to diminish, modify, or otherwise affect the statutory or regulatory authorities of the agencies involved.

2. AUTHORITIES:

a. The TVA Act of 1933 (16 U.S.C. 831 *et seq.*)

b. The Economy Act (31 U.S.C. 1535)

c. 10 U.S.C. 3036(d)

EXHIBIT # 1

3. RESPONSIBILITIES:

a. USACE will be responsible for:

(1) PROJECT FEASIBILITY REPORT. USACE will submit the "Lower Cumberland and Tennessee Rivers - Kentucky Lock Addition" feasibility report for Washington-level review and approval by the Assistant Secretary of the Army (Civil Works). TVA will work in close coordination with USACE in development and completion of the report.

(2) AUTHORIZATION AND FUNDING. In accordance with DA policies and procedures, USACE will request Congressional authorization and funding for all activities undertaken in accordance with this MOA, except as otherwise specifically provided.

(3) PROJECT DESIGN AND CONSTRUCTION. Acting through its Nashville District Office, USACE will fund and execute preconstruction engineering and design activities in accordance with USACE procedures and, following Congressional authorization and funding, construct the new Kentucky Lock. Unless otherwise required by law, all contract work undertaken by USACE shall be performed in accordance with DA procurement policies and procedures.

#1/2

b. TVA will be responsible for:

(1) REVIEW AND APPROVAL. Responsibility for Kentucky Dam, including the integrity of the dam and its appurtenant lock structures, is retained by law by TVA. In order to ensure such integrity and in accordance with Section 26a of the TVA Act, TVA will review and approve the final design plans and planned construction sequencing for the new lock project. TVA may retain the services of independent experts and consultants to assist it in performing such internal review.

(2) TECHNICAL ASSISTANCE. TVA will provide technical and other assistance to USACE during design and construction on a reimbursable basis as requested by USACE. Such assistance requests and coordination procedures will be individually formalized by Interagency Agreements between TVA's Senior Executive Officer and USACE's Nashville District Engineer.

4. ENVIRONMENTAL REVIEW: USACE shall be the lead agency on environmental reviews conducted for activities undertaken pursuant to this MOA. TVA shall be a cooperating agency on such reviews.

5. COORDINATION: TVA and USACE will coordinate all activities undertaken pursuant to this MOA with each other and will provide such cooperation as is necessary to fully effectuate the purposes of this MOA. This coordination will also include appropriately scheduled joint inspections of the construction work in progress and upon completion of the new lock.

*1/3

6. PUBLIC INFORMATION: USACE will be responsible for Congressional liaison in development of the project and for public announcements normal to the the solicitation and contract award process. All other public announcements are to be coordinated with TVA's Office of Communications.

7. AMENDMENT AND TERMINATION: This MOA may be modified or amended by written agreement between TVA and USACE headquarters, and may be terminated by mutual agreement of TVA and DA, or by either party upon 90-day written notice to the other. USACE will retain contract administration responsibilities for contracts awarded by USACE until such contracts are financially closed.

8. EFFECTIVE DATE: The MOA is effective the date of the latest signature shown below.

U.S. Department of the Army

G. Edward Dickey
Acting Principal Deputy Assistant
Secretary of the Army (Civil Works)

Date: Jan 10, 1991

Tennessee Valley Authority

W. F. Willis
Senior Executive Officer

Date: JAN 15 1991

OGC

*1/4

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310-0103

10 MAY 1991

Mr. Marvin Runyon
Chairman
Board of Directors
Tennessee Valley Authority
400 West Summit Hill Drive
Knoxville, Tennessee 37902

Dear Mr. Runyon:

This is in response to your letter of January 18, 1991, requesting execution of a Memorandum of Agreement (MOA) with the Tennessee Valley Authority for the Department of the Army to be responsible for actions necessary to implement a tentatively proposed lock addition at Kentucky Dam.

I have given this matter careful consideration and agree that it is appropriate for the Department of the Army, acting through the Army Corps of Engineers, to assume these responsibilities. Since the Congress authorized the Secretary of the Army to investigate the need for additional navigation improvements on the Tennessee River, the MOA provides the basis for the Corps to continue with the normal procedures to obtain project authorization and funding for design and construction.

While the MOA states that the Corps will pursue the project in accordance with the policies and procedures of the Department, I believe some clarification is warranted. It must be understood that the Corps will only request Congressional authorization and funding if the feasibility report reaches a favorable conclusion and is in accordance with the Administration's budgeting priorities and policies. This means that the project must compete against other projects in the budgeting process. With this understanding, I have signed both copies of the MOA and have enclosed a copy.

We appreciate the confidence that you have shown in the Department and see this as a strengthening of the cooperative partnership that our agencies have cultivated.

Sincerely,

G. Edward Dickey
Acting Principal Deputy
Assistant Secretary (Civil Works)

Enclosure

FINAL
ENVIRONMENTAL IMPACT STATEMENT

Lower Cumberland and Tennessee Rivers
Navigation Feasibility Report

Kentucky Lock Addition
Livingston and Marshall Counties, Kentucky

The responsible lead agency for preparation of this Environmental Impact Statement (EIS) is the U.S. Army Engineer District, Nashville. The Tennessee Valley Authority (TVA) and United States Coast Guard (USCG) are cooperating agencies in development of the EIS.

ABSTRACT: The Nashville District has investigated the lower Cumberland and lower Tennessee Rivers with respect to improving navigation conditions in this portion of the inland waterway system. Three construction alternatives to improve future navigation conditions have received detailed analysis. All construction alternatives would add a new lock at Kentucky Lock and Dam on the Tennessee River. The existing 110' x 600' lock at Kentucky would operate as an auxiliary. A "no action" alternative has also been evaluated.

The three construction alternatives would place an additional lock landward of the existing lock. Lock chamber sizes considered are 110' x 1200' (Plan A), 110' x 800' (Plan B), and 110' x 600' (Plan C). A "no action" alternative involving modification of hydropower discharges at Barkley Lock and Dam, addition of helper boats, use of a 3UP-3DOWN lockage policy at Kentucky Lock and Dam, and continued maintenance and replacement in-kind of existing navigation facilities has been evaluated.

The selected plan is construction of a 110' x 1200' lock (Plan A).

Send your comments to the District by:

For further information please contact:

Mr. Richard Tippit
Engineering-Planning Division
U.S. Army Engineer District,
Nashville
P.O. Box 1070
Nashville, Tennessee 37202-1070

Telephone: (615) 736-2020

FINAL
ENVIRONMENTAL IMPACT STATEMENT

KENTUCKY LOCK ADDITION

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SUMMARY

Major Conclusions

Three alternative construction plans and a "no action" alternative have been evaluated for satisfying future navigation needs of the Kentucky-Barkley Navigation System. All construction alternatives would add a new lock at Kentucky Lock and Dam landward of the existing lock. The construction alternatives are: (1) Plan A, 110' x 1200' lock, (2) Plan B, 110' x 800' lock, and (3) Plan C, 110' x 600' lock (Main Report, Section 9).

Plan A, construction of a 110' x 1200' lock has been selected as the preferred alternative (Main Report, Section 9). The existing lock at the Barkley project would continue operations, and the existing Kentucky Lock would serve in an auxiliary capacity. The "no action" alternative would institute certain nonstructural measures to increase system traffic capacity.

All three final plans would reduce lockage delays for projected traffic demand. Delay reduction provided by Plan A is significantly greater than that provided by Plan B or C. All plans would reasonably handle projected traffic demand during lock closures in the Kentucky-Barkley Navigation System. Each lock plan is economically feasible and has significant net benefits. Plan A has been selected as the National Economic Development (NED) Plan because it provides the maximum net benefits (Main Report, Section 8). Plan A is preferred by waterway shippers as it would accommodate the present and future expected fleet in single lockages.

Environmental consequences of all final construction alternatives are similar. Plans B and C would impact as much aquatic habitat as Plan A because they would require the same amount of excavation on the right bank and have equal requirements for lower approach channel dredging. All construction plans require relocation of the Paducah & Louisville Railroad.

Sensitive and significant environmental resources have been identified and, where possible, as the first step of mitigation, avoided by construction features. Most adverse environmental impacts of construction alternatives will be mitigated through sound environmental planning and the application of environmental engineering and design concepts. Avoidance of major impacts and sound planning to mitigate unavoidable impacts negates the need to perform a habitat evaluation procedure (See Exhibit 5).

All lock construction alternatives would result in localized impacts on environmental resources. Temporary degradation of water quality in the immediate vicinity of Kentucky Lock and Dam would occur, due primarily to limited increases in suspended solids resulting from construction activities, such as bank reshaping or dredging. Existing terrestrial flora would be eliminated from certain areas, with accompanying loss of wildlife dependent upon this habitat. Wildlife habitat lost during construction would be partially restored through seeding, planting, and natural succession of disturbed areas. Areas converted to lock operations, support functions, and railroad right-of-way would be permanently altered and lost to wildlife. Some materials, principally rock, generated from lock pit excavation will be used in a beneficial manner to armor eroding river banks in the tailwater, improve aquatic habitat diversity, and improve angler access. Restoration of a portion of the riparian strip along the Tennessee River's right bank is planned.

Some aquatic biota, principally molluscs and other macroinvertebrates, will be destroyed due to lock construction, modification of the navigation channel and lower approach, and by possible placement of a stone training dike in the tailwater. Project environmental design includes provision for creation of replacement aquatic habitat using dredged materials.

The potential for project features to impact federally endangered, threatened, proposed, and candidate species has been assessed and consultation completed (See Biological Assessment, Appendix B and Biological Opinion, Appendix C). Four species of federally endangered freshwater mussels could be adversely affected by the project. Individuals of two of these endangered mussel species have recently been documented in proximity to the project impact area. Impacts on listed species would originate primarily from widening of the existing navigation channel to improve the downstream lock approach. Release of sediment downstream from construction activities would have a minimal likelihood of impacting endangered species. Overall, adverse impacts would be limited to taking of scattered individuals of federally listed mussels.

A measure to protect and ensure continued survival of federally listed freshwater mussels will be the thorough reconnaissance of all aquatic areas directly affected by the project and relocation of these animals into secure habitat. At present, individuals of endangered mussel species are widely scattered throughout the tailwater, a factor likely limiting successful reproduction of these species. Individuals of two candidate freshwater gastropods occur in areas to be dredged and otherwise affected. These gastropods exist in large numbers elsewhere in the lower Tennessee River.

It is important to note that the Corps of Engineers will meet the exemption requirements of Section 404(r) of the Clean Water Act. The Corps will have met exemption requirements by providing an EIS containing a 404(b)(1) evaluation (Exhibit 3) to Congress. The Corps will also meet state water quality requirements with issuance of a public notice concurrent with release of the draft report to the public in May 1991, detailing project activities and impacts applicable under Section 404(b)(1) of the CWA. The 404(b)(1) evaluation concerns only the discharge of fill material below ordinary high water. Discharge material would consist of limestone riprap used for bank armoring. Concrete and steel would be placed for structures such as the lock walls, guidewalls, and bridge piers. Sheet piling and gravel would be placed to form temporary cofferdams.

For federally listed, terrestrial species, determinations of impact likelihood were based upon habitat requirements, known occurrence of species, and corresponding construction impacts for these habitats. Suitable habitat exists in proximity to Kentucky Lock and Dam which could support summer maternity colonies of federally endangered Indiana bats. Recognizing this, construction features have been planned to, wherever possible, avoid potential bat habitat.

Several National Register of Historic Places eligible properties are located within or immediately adjacent to proposed construction impact areas. These include archeological sites 15Lv204, 15Lv24, and the Kentucky Lock and Dam. The impact of construction on these properties has been evaluated and a Memorandum of Agreement among the Corps of Engineers, Tennessee Valley Authority, the Kentucky Heritage Council, and the Advisory Council on Historic Preservation has been initiated which stipulates measures that will serve to mitigate any adverse effects (Exhibit 5).

Recreational resources will be impacted adversely during project construction. The right bank boat launching ramp at the mouth of Russell Creek will be removed during bank excavation. The permanent loss of the right bank boat ramp will be mitigated by upgrading of the existing left bank tailwater boat ramp. TVA's Taylor Park Campground will be adversely impacted by the new lock and will require relocation. A suitable relocation site that meets the public need for lakeside camping will be determined.

Construction activity on the right bank will close that area below the dam to bank fishing. The heavily used left bank boat ramp will not be directly impacted by any construction activity, and is proposed for significant upgrading as mitigation for loss of the right bank boat ramp. Construction of the railroad bridge will at times disrupt fishing activities in the river immediately downstream of the spillway and hydropower plant, as well as interfere with some fishing opportunities on the left bank. With completion of the railroad relocation which will take three years, all recreational opportunities will be restored on the left bank. Plans also include improving bank fishing access, with provision of handicap angler facilities. Except for the permanent loss of the right bank boat ramp, all other recreational impacts are temporary. The project offers opportunities to significantly improve recreational resources, particularly for anglers, a significant user of the area. Recreational boaters locking through at Kentucky will benefit from the end to long lockage delays.

Construction of the new lock will close US 62-641 over Kentucky Dam for a period of 55 months. The detour route mileage using nearby I-24 would vary from a minimum of 2 miles to a maximum of 7.5 miles depending upon individual motorist routing needs.

An evaluation of the potential for encountering hazardous, toxic, or radiological waste (HTRW) has been completed by the Tennessee Valley Authority and the Corps of Engineers. In performing the HTRW assessment, TVA reviewed available real estate records and construction drawings, consulted with knowledgeable individuals, and evaluated other pertinent data. The Corps of Engineers queried the Paducah & Louisville Railroad and Reed Crushed Stone Company concerning potential sources of HTRW. Those findings are contained in Appendix E. Some materials (asbestos) in the existing lock operations building to be demolished are considered hazardous and will be handled appropriately. At this time little likelihood exists of encountering other sources of HTRW on project lands.

Areas of Concern or Controversy

One area of concern is the project's potential impact on the state designated tailwater mussel sanctuary and federally listed threatened or endangered species residing there. The selected plan will permanently modify a small portion of a large, productive mussel bed within the sanctuary. This bed is known to contain individuals of at least two federally endangered mussel species. The sanctuary harbors and protects a remnant of the diverse and abundant mussel fauna that once occurred throughout much of the Tennessee River. Information gained during the September 1990 mussel survey of this area indicates that dredging to improve the lower approach will not directly affect the most densely populated portion of this bed lying upstream of the I-24 bridge. This same survey and earlier studies indicate endangered species occur as widely scattered individuals in the tailwater reach. The U.S. Fish and Wildlife Service, in the project biological opinion, calculated an incidental take for four species of federally endangered mussels in the dredge area. The Kentucky Division of Water has witheld issuance of State Water Quality Certification for the proposed project pending their review of the final EIS.

Mitigation for the permanent removal of the right bank tailwater boat ramp will consist of significantly upgrading the left bank tailwater boat launching facility. This option has been coordinated with TVA and the Commonwealth of Kentucky. There was some early local interest in retaining a right bank ramp in the Kentucky Dam tailwater. Prior to release of the DEIS limited local interest was voiced to the Nashville District concerning closure of the ramp. Since release of the DEIS and the June 1991 public meeting, no local interests have come forward to voice any opinion or feelings to the Corps of Engineers concerning the fate of the right bank boat ramp.

Unknown cultural resources sites could be revealed upon more detailed study of the project site. These sites could require mitigation. Kentucky Lock and Dam may qualify for inclusion on the National Register as a historic site. Since project plans call for removal or modification of certain portions of existing structural features of Kentucky Lock and Dam, agreement will have to be reached with appropriate historic preservation authorities regarding project impact on the site and appropriate mitigation.

Unresolved Issues

The need to replace TVA's Taylor Park Campground is recognized. Nearby Kentucky Dam Village State Park has a favorable location on Kentucky Lake which would accommodate a campground and would serve as a relocation site. The Park at present has a tailwater camping area but no lakeside camping. Contact with the Commonwealth of Kentucky in this regard has elicited much interest in this possibility. At this time however, a final decision has not been reached between the Corps of Engineers and TVA concerning relocation of the campground to the state park. Future coordination, including an on-site meeting between the Corps and TVA is planned to resolve this issue.

1. PURPOSE OF AND NEED FOR ACTION

Study Authority

1.01 The Lower Cumberland and Tennessee Rivers Navigation Study was authorized by a resolution sponsored by United States Senator John Sherman Cooper. The resolution was adopted by the Committee on Public Works, United States Senate, on October 2, 1972. The resolution requested the Corps of Engineers to review the need to provide navigation improvements on the Cumberland River and Tennessee River, generally below the Barkley Canal connection.

Need for Action

1.02 The driving force for analysis of navigation conditions on the lower Cumberland and Tennessee Rivers is the need to determine the most effective plan that will satisfy future navigation facility demands and relieve traffic congestion conditions in the study area.

1.03 Most navigation traffic prefers to move through the existing waterway system on the Tennessee River. As Table 3 (Section 3, Main Report) illustrates, relatively little traffic uses the Cumberland River below Barkley Dam. Generally poor navigation conditions caused by the narrow, twisting channel, compounded by hydropower releases from Barkley Dam, have led to this trend. Without improvement of navigation facilities, congestion at Kentucky Lock will worsen in the future due to increasing traffic levels, Table 6 (Section 3, Main Report). By the year 2000 delays at Kentucky Lock are predicted to increase to the point where some traffic will divert to the more costly lower Cumberland route or resort to other modes of transportation. The need to periodically close aging Barkley and Kentucky navigation facilities for repair and maintenance will aggravate the situation. Increased tow processing times result in higher costs to industry and the nation as a whole.

Study Objectives

1.04 Study objectives are based upon finding the plan which contributes to national economic development (NED), satisfies needs identified by the study, and conserves environmental resources (fish, wildlife, cultural, etc.).

1.05 Major objectives of the present study are:

a. Reduce the lockage delays (costs) to navigation traffic currently using the Kentucky-Barkley

Navigation System.

b. Facilitate the safe and efficient movement of traffic on the Cumberland and Tennessee Rivers through Barkley and Kentucky Locks to the level of demand projected during the economic life of potential replacement projects.

c. Minimize the adverse effects to the navigation industry of maintenance closures at Kentucky and Barkley Locks.

d. Maintain navigation traffic to the maximum extent possible during the implementation of improvements.

e. Minimize the adverse effects on Cumberland and Tennessee River recreational boating due to implementation of improvements.

f. Preserve and enhance fish and wildlife and other natural resources in the Cumberland and Tennessee Rivers, including the valuable fishery resources and mussel sanctuary below Kentucky Dam. Integrate environmental protection during the planning, design, construction, and operation of the project.

2. ALTERNATIVES

Plans Eliminated from Further Study

2.01 An array of structural and nonstructural measures with potential to improve the capacity and/or efficiency of the Kentucky-Barkley Navigation System have been identified and analyzed. Alternatives reviewed below were dropped from further study because they did not adequately meet planning objectives or were unacceptable for other reasons (Main Report, Section 5).

2.02 Among six structural alternative plans considered to add lock capacity at Kentucky Lock and Dam, five were eliminated from further study and are summarized below. Further information concerning these plans is presented in Table 17 (Main Report, Section 5).

2.03 One potential placement of a lock would be landward of the existing lock with the upstream sill 1000' upstream of the existing lock's upper sill. A lock in this location was dropped due to problems with low founding levels that would result in very high construction costs. The lock could have interfered with an existing terminal above the dam.

2.04 Placement of a lock riverward of the existing lock through the island between the existing lock and powerhouse was considered. This plan was dropped due to poor foundation conditions, interference of the cofferdam with navigation traffic, and extensive relocation requirements for the switchyard, railroad, and highway.

2.05 Lock placement near the powerhouse and skewed at about 30 degrees with the upper sill downstream of the dam embankment received consideration. This plan was eliminated due to extensive dredging requirements and very poor foundation conditions that would result in high construction costs.

2.06 Consideration was given to extending the existing lock at Kentucky by an additional 600 feet. This would make the chamber 110' x 1200'. No major foundation problems were associated with this plan and direct construction impacts to downstream mussel beds would have been avoided. The plan was unacceptable because during construction the lock would be closed to use, resulting in unacceptable economic losses to industry. Filling times for the lock would have been very long and no auxiliary lock chamber would be provided.

2.07 Placement of a new lock through the powerhouse was eliminated because it required breaching the spillway and powerhouse. Other factors militating against this plan were low founding levels, impacts to tailwater fishing, and extensive downstream dredging.

2.08 Several canal schemes were considered. Two plans would have connected the tailwater reaches of the lower Cumberland and lower Tennessee rivers. A third canal scheme would have created a new route from the lower Cumberland River to the Ohio River above Smithland Dam, bypassing some of the tortuous bendways on the Cumberland.

2.09 The two potential canal alignments connecting the Cumberland and Tennessee Rivers were dropped from consideration due to high construction costs, environmental impacts to aquatic resources (primarily mussel beds), and miniscule benefits. In addition, the two-foot difference in tailwater elevations would create unacceptable velocities unless a lock was built in the canal or the Barkley tailwater modified.

2.10 A canal connecting the Cumberland River and Ohio River at miles 8.0 and 916.5 respectively was dropped. This plan would have required large amounts of excavation to create the canal and necessitated construction of a navigation lock. Plan costs were extremely high in relation to benefits.

2.11 Modification of up to ten bendways on the lower Cumberland River was considered. Under this plan narrow, serpentine bends on the river would be widened to provide an improved navigation channel. Though this plan would have improved safety margins in bends and reduced transit times, it did not provide a satisfactory long-term solution for future navigation needs. The required excavation and upland disposal of large quantities of material would have resulted in much more serious environmental impacts in the lower Cumberland than the new lock alternatives. Due to these negative features this plan was dropped.

2.12 A traffic management plan would give priority to upbound tows at Kentucky and downbound tows at Barkley. This plan decreases overall system capacity, limits flexibility of tow operators, and does not provide a long term solution to the basic system need.

2.13 Congestion fees are designed to discourage shippers deriving marginal benefits from waterborne transportation from using this mode of transport. Congestion fee implementation would reduce delays however, it has historically been unacceptable to the navigation industry. In addition they offer little benefit during periods of lock closure.

2.14 Measures for the without-project condition included modification of hydropower releases, institution of lockage policies, provision of helper boats, and provision of a downstream terminal. A description of each of these measures is provided below and in Table 16 (Section 5, Main Report).

2.15 Lockage operating policies prescribe the sequence by which tows are processed through the navigation facility. The existing policy is first-come-first-served. Several lock operating policies were examined and eventually eliminated due to their inability to provide a long-term solution to projected traffic demands in the system. Of the lockage policies, the 3UP-3DOWN was most efficient and was carried forward as part of the "no action" alternative.

2.16 Helper boats assist moving tows in and out of locks when they are broken apart for multiple lockages. Helper boats were examined in concert with the best lockage policies. Helper boats increase lockage capacities only slightly. Certain safety risks are considerations with their use. They are not a long-term solution to satisfy traffic demands.

No Action (Without-project Condition)

2.17 The no action alternative describes the way the existing project is operated today, and how it will be operated in the future. Normal operation and maintenance of the Kentucky-Barkley Navigation System will continue through the planning period (2005-2054). Measures to rehabilitate or replace in-kind, existing structures will be undertaken as needed to ensure navigability (Main Report, Section 5), as well as those actions the Corps could undertake through its normal operations; actions not requiring Congressional approval.

2.18 All existing waterway projects or those under construction are considered to be in place and will be operated and maintained throughout the period of analysis. It is anticipated that replacement of locks and/or dams at Gallipolis L & D, Olmsted L & D, McAlpine L & D, Winfield L & D, Point Marion L & D, and Gray's Landing L & D, will occur during the planning period.

2.19 Nonstructural measures that would take place within the planning period include instigation of a 3UP-3DOWN lockage policy, use of helper boats, and modification of hydropower discharges at Barkley Dam. It is Corps standard policy to review its lock operations to achieve the most efficient methods in moving riverborne traffic. If the new lock were not constructed, various operational changes would be evaluated under NEPA. This evaluation would be accomplished, if necessary, by preparing an Environmental Assessment or supplementing the Operations and Maintenance EIS for the Tennessee River or Cumberland River. For example, future evaluations of the three 3UP-3DOWN lockage policy and modification of hydropower discharges at Barkley could be required. More information on the project capacity under the without-project condition can be found in Section 5, Main Report.

Plans Considered in Detail

2.20 The three construction plans would add a new lock chamber immediately landward of the existing chamber at Kentucky Lock and Dam. Chamber sizes for the new lock are, 110' x 1200' (Plan A), 110' x 800' (Plan B), and 110' x 600' (Plan C). The upstream end of the lock would be in the same location for all three plans. Figures 1, 2, and 3 illustrate existing features and the relation of various construction features associated with a new lock, which is assumed to be Plan A (Main Report, Section 9).

2.21 Construction of an additional lock at the proposed location requires permanent relocation of the Paducah & Louisville Railroad. The railroad would be relocated onto a new bridge with left and right bank approaches. The left bank approach would mainly be built on fill material. The railroad would span the lower lock approach at the downstream end of the switchyard area and cross the main channel of the Tennessee River approximately 0.3 miles downstream of Kentucky Dam. No disruption of railroad line service would be incurred. The new downstream railroad alignment would be completed during a three year time span, and would be one of the early actions associated with new lock construction. Once complete, the railroad would be permanently rerouted onto its new alignment and the existing railroad crossing on Kentucky Lock and Dam and most trackage on the old alignment would be removed.

2.22 A new vehicular access road and bridge would link the right bank and switchyard. This bridge would span the lower lock approach, immediately upstream of the railroad bridge. In order to gain sufficient clearance for tows in the new lock chamber to clear the highway bridge, the US 62/641 highway crossing would be elevated on its present alignment. Vehicular traffic would be detoured to I-24 for the 55 month period of time the US 62/641 crossing is closed to traffic by construction activities. The detour length varies from 2 to 7.5 miles depending upon motorist routing.

2.23 The existing lock operations building is a component of the National Register eligible Kentucky Lock and Dam; appropriate mitigation treatment will be conducted prior to its removal. Removal of the existing lock operations building would be accomplished along with numerous other features, such as parking lots and landscaped areas. A new lock operations building would be constructed adjacent the new lock, downstream of US 62/641. Taylor Park Campground would be replaced.

2.24 Much of the existing right bank area in proximity to Kentucky Dam would be modified during construction. A construction plant and equipment lay-down area would be provided along with appropriate access roads. A 45 acre borrow/disposal site and 23 acre wooded buffer zone have been identified about one mile north of Kentucky Dam adjacent Kentucky Highway 453 on lands owned by Reed Crushed Stone Company. Borrow material would be taken from this site primarily to construct the railroad fill. Excess overburden and rock from lock construction would be hauled to the area and placed in the site. All materials placed in the site would be nonhazardous, nontoxic, and inert. At the conclusion of the work the area would be regraded and revegetated.

2.25 A cofferdam would be constructed downstream of the dam, adjacent the right bank. The area enclosed by the cofferdam would be dewatered and the existing right bank excavated in the dry to create the new lock approach. A concrete guidewall would replace the present riprapped bank. The guidewall would be the same length as the lock chamber.

2.26 Downstream of the guidewall an additional length of the right bank would be excavated, reshaped, and riprapped with stone to provide a suitable lower approach. This work would not be performed behind a cofferdam. The length of bank to be excavated may vary depending upon lock chamber length, but could extend as far downstream as the mouth of Russell Creek at TRM 21.6.

2.27 Some widening along the right margin of the existing navigation channel would be required between the existing lock approach (TRM 22.3) and I-24 bridge crossing (TRM 21.1). The amount of channel widening would be the same for all alternative lock plans. Channel widening would negatively impact a small portion of a productive mussel bed known to support many species of freshwater mussels. This bed extends from approximately TRM 20.5-21.6, from the right bank outward on a broad, gently sloping shelf to the edge of the existing navigation channel.

2.28 A stone training dike with top elevation 304' msl., intended to reduce turbulence in the lower approach for commercial tows, may be needed. If constructed it would extend from the downstream end of the switchyard island along the left channel margin for a distance of up to 3200'. This feature, which is not part of the recommended plan, will be studied further to determine its efficacy and potential environmental impacts on the tailwater. If such a dike is needed, project NEPA documents will be supplemented to provide full environmental review for this feature.

2.29 Two additional mooring cells would be added between I-24 and the dam along the right channel margin. The five existing mooring cells upstream of the lock would be removed and replaced with two new cells.

2.30 Mitigation and environmental planning measures for aquatic resources include removal and relocation of mussels from areas to be dredged, dewatered by the tailwater cofferdam, or impacted by piers of the new Paducah & Louisville Railroad bridge, to areas not impacted by construction. Excavated material from the river will be placed at an open water location adjacent the right bank of the Tennessee River at mile 19.7 to create replacement habitat. The replacement habitat will be an environmentally designed feature, specifically created to encourage colonization by molluscan and other benthic fauna. A long-term study will be initiated to follow mussel colonization on this replacement habitat, and assess the success of the effort (Biological Opinion, Appendix C). The above measures are further developed in Appendix D, Environmental Component Plan.

2.31 Mitigation of terrestrial impacts would include capping, grading, and revegetating the borrow/disposal site. Wetland creation is possible on a portion of this site. A planting or landscape plan would include vegetation of high value for wildlife. A buffer zone adjacent Russell Creek would protect most of the stream and its associated bottomland forest from construction related disturbance. The borrow/disposal site would be connected to existing TVA lands by a forested 23 acre buffer area. The existing narrow, riparian forest strip along the right bank of the Tennessee River between Russell Creek and I-24 would be augmented with plantings. The river bank in that same reach would be protected with stone obtained from lock pit excavation. Other areas disturbed during construction would be graded and seeded or landscaped as appropriate. The above measures are further developed in Appendix D, Environmental

Component Plan.

National Economic Development (NED) Plan

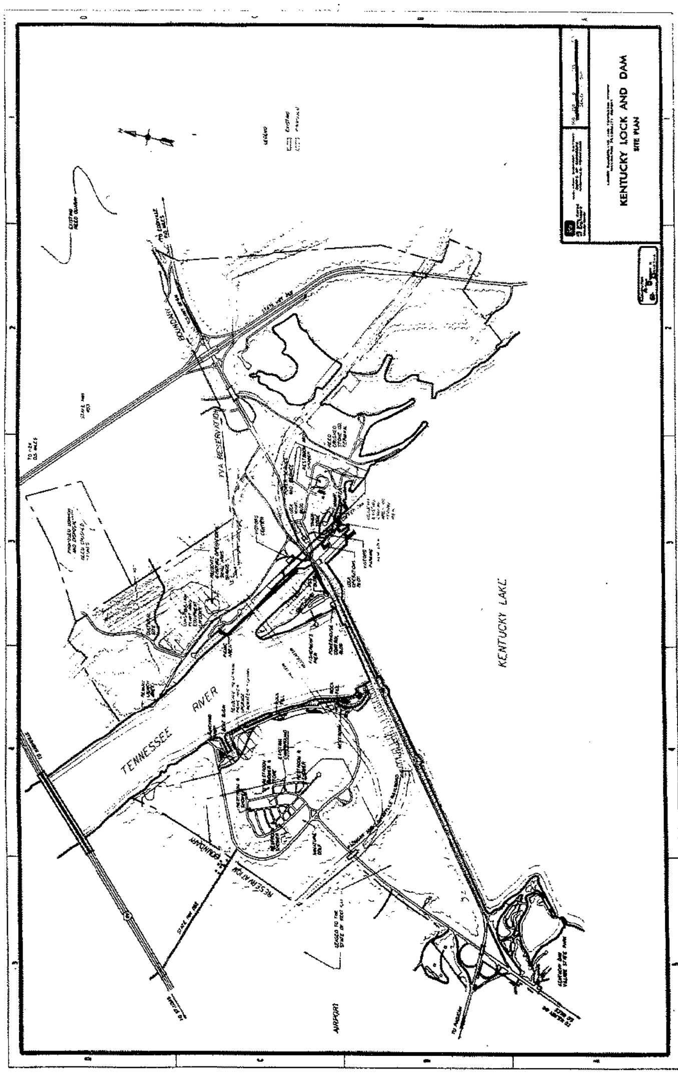
2.32 Plan A has greater net benefits than Plan B or C and is therefore the NED Plan.

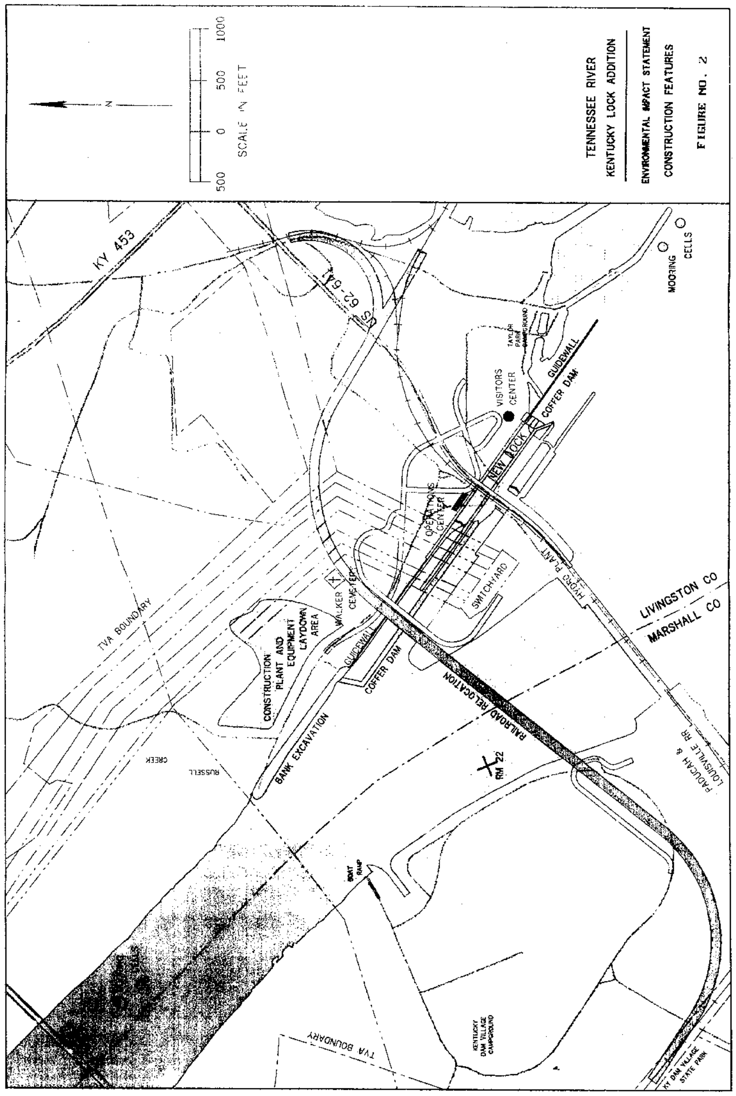
Environmentally Preferred Plan

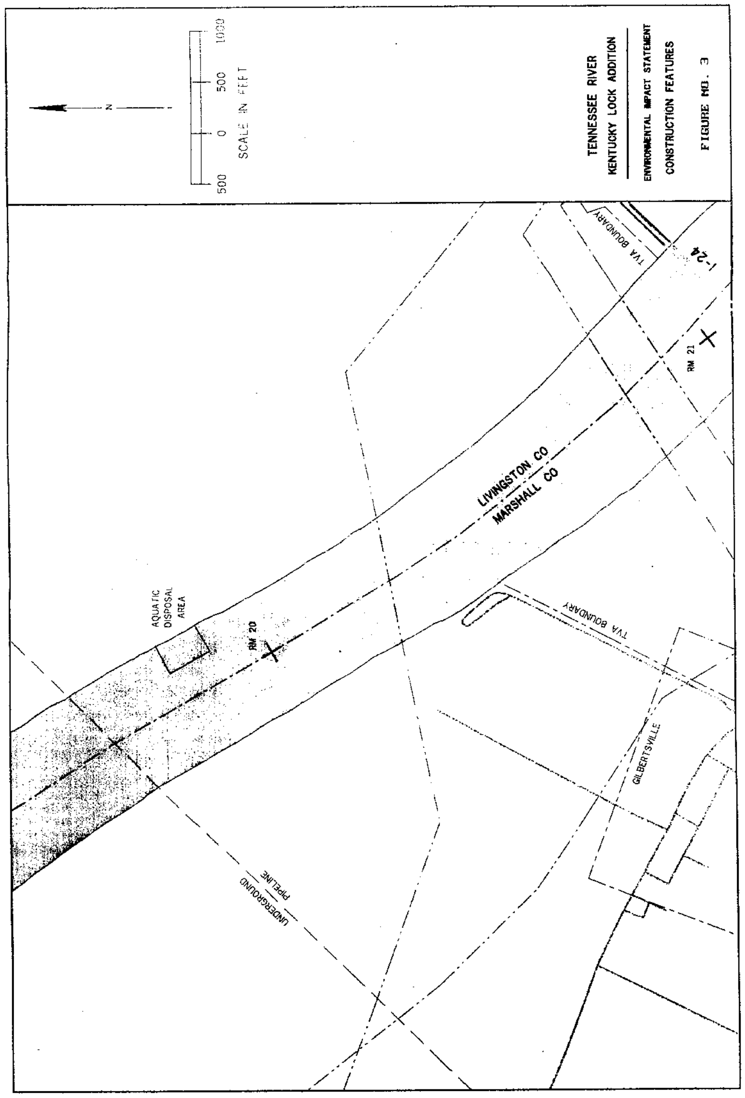
2.33 The environmentally preferred plan is the one fully meeting study objectives and needs while having least adverse impacts upon ecological, cultural, and aesthetic resources. The three plans are essentially equal in impacts therefore no clear choice emerges as the environmentally preferred plan. The selected plan will include environmental design to protect and improve significant aquatic and terrestrial resources.

Selected Plan

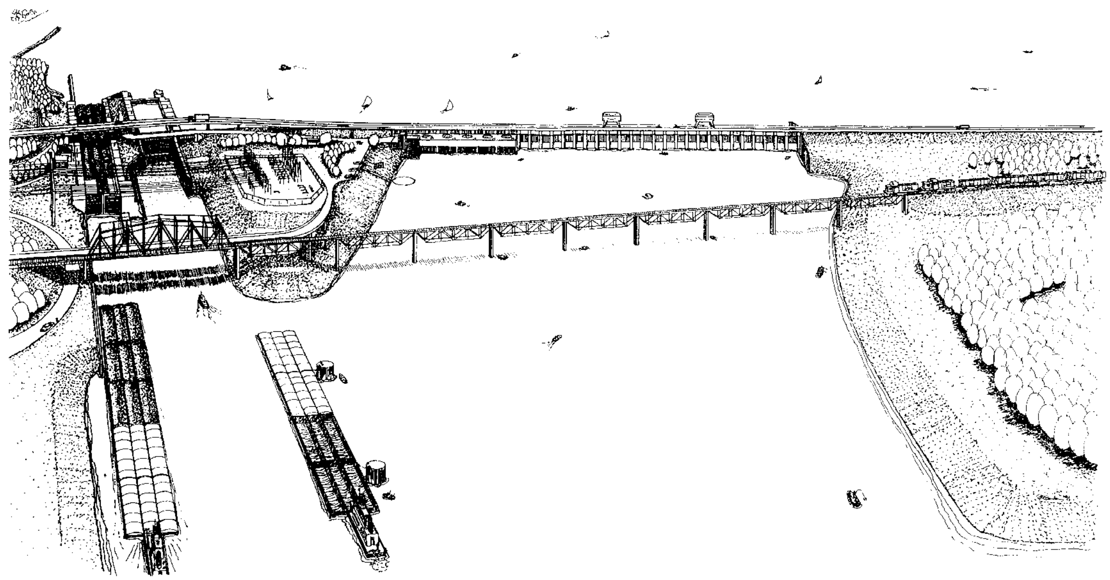
2.34 Plan A (110' x 1200' lock addition) has been selected as the preferred alternative. This plan has net benefits greater than those of Plans B or C and is preferred by industry. See Main Report, Section 9 for more details on the selected plan. Environmental consequences of the selected plan are essentially equal to those of Plans B or C. Figure 4 presents an artist's rendering of the completed Kentucky Lock Addition.


KENTUCKY LOCK AND DAM
SITE PLAN
KENTUCKY LAKE
TENNESSEE
RIVER
AIRPORT


TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
CONSTRUCTION FEATURES
FIGURE NO. 2
500 0 500 1000
SCALE IN FEET
N
KY 453
US 62-641
TVA BOUNDARY
CONSTRUCTION PLANT AND EQUIPMENT LAYDOWN AREA
WALKER CEMETERY
GUIDEWALL
COFFER DAM
RAILROAD RELOCATION
NEW LOCK
VISITORS CENTER
OPERATIONS CENTER
SWITCHYARD
HYDRO PLANT
GUIDEWALL
COFFER DAM
MOORING CELLS
LIVINGSTON CO
MARSHALL CO
PADUCAH & LOUISVILLE RR
BANK EXCAVATION
RUSSELL CREEK
RM 22
TVA BOUNDARY
KENTUCKY DAM VILLAGE CAMPGROUND
KY DAM VILLAGE STATE PARK



TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
CONSTRUCTION FEATURES
FIGURE NO. 3



ROPOSED LOCK ADDITION • KENTUCKY RESERVATION

TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ARTIST RENDERING

FIGURE NO. 4

FINAL

ENVIRONMENTAL IMPACT STATEMENT

LOWER CUMBERLAND AND TENNESSEE RIVERS NAVIGATION FEASIBILITY REPORT

KENTUCKY LOCK ADDITION LIVINGSTON AND MARSHALL COUNTIES, KENTUCKY

U.S. Army Engineer District, Nashville
Corps of Engineers
Nashville, Tennessee

November 1991

3. AFFECTED ENVIRONMENT

Environmental Conditions

3.01 The Cumberland and Tennessee Rivers are the largest tributaries of the Ohio River. Thirteen multipurpose dam projects on the Cumberland and Tennessee Rivers provide more than 1,037 miles of navigable waterway. Barkley Canal, constructed in 1967, connects the two river systems to form the Kentucky-Barkley Navigation System. The system is composed of Barkley Canal, Kentucky Lock and Dam on the Tennessee River (TRM 22.4), Barkley Lock and Dam on the Cumberland River (CRM 30.6), the two tailwater reaches, a short section of the Ohio River between the mouths of the Cumberland and Tennessee, and the portions of Kentucky Lake and Lake Barkley below Barkley Canal (Section 1, Figure 2, Main Report).

3.02 The Kentucky-Barkley Navigation System lies within the western Kentucky counties of Crittenden, Livingston, Lyon, Marshall, and McCracken. The project area has a predominantly rural character, consisting of land devoted to agriculture and forestry with some mineral extraction. Industrial development occurs mainly on the lower Tennessee, most notably at Calvert City and Paducah, Kentucky. Paducah is the only significant urban area in the immediate vicinity. Smaller urban areas consist of scattered villages and towns. TVA's Land Between the Lakes National Recreation Area occupies a significant portion of the dividing ridge between the Cumberland and Tennessee Rivers upstream of Barkley Canal.

3.03 The area supports a diverse array of ecological communities, both terrestrial and aquatic. Since settlement times the formerly pristine environment has been drastically altered by modern civilization. Land clearing has removed most of the formerly almost unbroken forest. Agricultural practices have altered plant successional patterns. Certain large forms of wildlife have been extirpated from the area by human pressures, however other forms of smaller wildlife flourish in the variety of terrestrial habitats available.

3.04 The area's rivers have also been drastically altered. Construction of modern dams and resulting regulation of the Cumberland and Tennessee Rivers has created an aquatic environment markedly different from presettlement times. The formerly freely flowing Cumberland and Tennessee Rivers now are a series of impoundments or modified riverine waterbodies, exhibiting characteristics of both lotic and lentic environments. Tailwater reaches below Barkley and Kentucky Dams are conditioned by upstream modification and regulation of rivers.

3.05 Physically the lower Cumberland and Tennessee Rivers can be characterized as being predominantly pool type habitat. Riverbanks are generally composed of unconsolidated materials which easily erode, often dumping portions of the generally narrow band of riparian forest into the stream. Several rocky bluffs and outcroppings do occur on the lower Cumberland. River substrates range from mud and silt to coarse gravel, boulders, and bedrock. Despite regulation by upstream dams, water levels still follow a general seasonal pattern of high flows in the winter and spring and lower flows in the summer and fall.

3.06 The Cumberland and Tennessee Rivers support a wide spectrum of aquatic biota including valuable fish and mollusc populations. Sport and commercial fishermen utilize the fishery heavily. Mussel populations outside of the state designated sanctuary on the lower Tennessee are harvested by musselers. Both tailwaters support valuable remnants of the original diverse molluscan populations which once flourished throughout the entire river systems.

Significant Resources

3.07 Water Quality. Chemical water quality of the lower Cumberland River is generally considered to be high quality. The lower Cumberland River is classified as effluent limited, meaning it supports and is expected to continue supporting designated stream uses.

3.08 Selected chemical water quality parameters have been monitored at a number of locations along the 30.5 mile reach of the Cumberland below Barkley Lock and Dam. Data indicate thermal stratification does not occur due to the lotic environment of the stream. Temperatures collected during an intensive sampling effort in the summer of 1986 indicated a less than three degree C change from top to bottom. Dissolved oxygen concentrations also are generally homogeneous throughout the water column. Dissolved oxygen values have been observed to occasionally drop below 5.0 mg/l, but recovery to acceptable levels usually occurs quickly. Conditions in Lake Barkley are a major modifier of downstream dissolved oxygen conditions. Values for ph generally range just above neutral (7.0-8.0). Conductivity values vary from 200-300 umhos/cm. These parameters represent values acceptable for maintaining biological production. Turbidity measurements in 1986, a drought year, ranged from 1.0-14.0 NTU's. Except for some trace metal violations, data for alkalinity, nutrients, solids, iron, and manganese reflect good water quality.

3.09 Water quality conditions in the lower Tennessee River are similar to the lower Cumberland. The river is well mixed at all times with no thermal stratification. Dissolved oxygen levels occasionally fall below 5.0 mg/l but recover quickly. A minimum release of 10,000 cfs from Kentucky Dam is maintained to dilute effluents from downstream industries. Chemical water quality is somewhat mixed in the lower Tennessee. Industrial wastewaters discharged into the Tennessee River at Calvert City are known to contain more than 30 organic priority pollutants. Various organics have been detected in the tailwater. Manganese concentrations in the tailwater consistently exceed the 50 microgram/liter criterion for domestic raw water supply (Cox and Wade, 1987). Elevated manganese levels detected in the tailwater are the result of reducing conditions found in the hypolimnion of upstream Kentucky Reservoir. These conditions occur during periods of low dissolved oxygen with manganese being released into the tailwater. Manganese typically precipitates under aerobic conditions such as those found in the lower Tennessee, however at a fairly slow rate. Despite concern over water quality in the lower Tennessee, perhaps the best indicator is the healthy population of invertebrates and fish the river supports.

3.10 Aquatic Biota-Lower Cumberland River. The lower Cumberland River is devoid of aquatic macrophytes. Physical habitat conditions, such as highly variable daily flows and a lack of shallow or protected areas, deter the establishment of aquatic macrophytes in the lower Cumberland.

3.11 Algal populations present in the river are similar to those occurring in upstream Lake Barkley. Dominant algal populations are members of the phyla Cyanophyta (blue-greens) and Chrysophyta (diatoms). Little algal productivity occurs in the lower Cumberland due to the rapid flow of water.

3.12 The macroinvertebrate community inhabiting the lower Cumberland River includes freshwater shellfish, insects, and other organisms. Shellfish populations (mussels and gastropods) have been extensively studied. Most recent investigations for other benthic macroinvertebrates have indicated the presence of a fairly limited benthic fauna consisting primarily of various worms and insects. Scour and daily variations in flows are factors contributing to the relatively depauperate benthic macroinvertebrate populations found in the tailwater reach.

3.13 The molluscan community of the lower Cumberland River consists of a variety of native freshwater mussels, various gastropods, and the Asiatic clam, *Corbicula fluminea*. Mussels occur throughout the tailwater but are generally sparse. Greatest densities of mussels occur in concentrations known as "beds". In the lower Cumberland, these beds occur primarily in straight reaches of the river with stable, suitable substrates of "gravel in compact sandy-clay" (Sickel, 1982).

3.14 In 1981 Dr. Jim Sickel of Murray State University conducted a systematic survey for mussels inhabiting the lower Cumberland River. A total of 21 species of mussels in 16 genera were found to be living in the lower Cumberland between Barkley Dam and CRM 4.0. Six species made up almost 75% of the existing population. These were in order of abundance: Megalonaias gigantea, Fusconaia ebena, Elliptio crassidens, Amblema plicata, Pleurobema cordatum, and Quadrula quadrula. Ten additional species in relic form were encountered. This investigation revealed poor mussel recruitment, with most individuals found being old, adult specimens. More recent surveys for mussels have added a few more species to the list of those known to inhabit the Barkley tailwater. These studies have also revealed a possible increase in recruitment of young individuals. A recent investigation of proposed navigation dredging areas in the lower Cumberland indicated mussel recruitment and populations are gradually increasing (USAED, Nashville, 1988). A limited amount of brailing for mussels is carried out in the Barkley tailwater.

3.15 A variety of gastropods occur in the Barkley tailwater. These animals graze primarily on periphyton. Certain species seem to tolerate the daily flow fluctuations in the river quite well. Releases from Barkley Dam, principally for peaking hydropower, typically vary from the minimum continuous release of 6,000 cfs to approximately 40,000 cfs. Fluctuation of river surface elevations in the tailwater typically vary on a daily basis by ten feet or more. Probably the most common gastropod is Lithasia armigera, the armored rocksnail, which occurs throughout the tailwater in great abundance.

3.16 The lower Cumberland supports an abundant and economically important fishery. Barkley Dam serves as a concentration point for fish and is where most sport and commercial fishing related activity occurs. All classes of freshwater fishes are present in the Barkley tailwater with the most common species being characteristic of large rivers.

3.17 In an April 1978 through March 1980 sport fishing creel survey at least twenty species of sport, commercial, and pan fish were harvested in the immediate Barkley tailwater (McLemore, 1980). Dominant species taken were catfish (blue, channel, and flathead), white bass, white crappie, bluegill, and sauger. Species of commerical value caught were freshwater drum, carp, paddlefish, and buffalofish. Blue catfish was the species havested most during the creel census.

3.18 Timmons surveyed lower Cumberland fishes and found a relatively low habitat and fish species diversity. A total of 37 species were collected. Timmons collected almost twice as many fish at one location on the Duck River in Tennessee as were collected in the entire lower Cumberland River (Timmons, 1985). Despite Timmons' finding of a relative lack of spawning and nursery habitat available in the lower Cumberland, large concentrations of fish do occur, especially in the spring, the apparent result of migrations upriver from the Ohio River (USAED, 1987).

3.19 Aquatic Biota-Lower Tennessee River. Within the lower Tennessee River aquatic macrophytes are almost totally nonexistent due to lack of suitable habitat and growing conditions. Shallow littoral areas favorable for aquatic macrophytes are uncommon in the lower Tennessee. This combined with frequent variations of flow and water surface elevations is not conducive to supporting aquatic macrophytes.

3.20 Algal populations of the lower Tennessee River probably resemble those found in the lower Cumberland River. The primary determiner of populations present is upstream Kentucky Lake which is similar biologically in many respects to Lake Barkley.

3.21 The macroinvertebrate community inhabiting the lower Tennessee River, with the notable exception of molluscs, has not been extensively studied. Based upon knowledge of the overall good physical-chemical water quality of the tailwater, a fairly abundant and diverse macrobenthic community of insects and other organisms can be expected.

3.22 The Tennessee River and its tributaries once supported the richest mussel populations of any river on earth (Sickel, 1985). Molluscan populations of the lower Tennessee River consist of a diverse and abundant assemblage of freshwater mussels and gastropods. The Asiatic clam, *Corbicula fluminea*, also occurs in much of the Tennessee River drainage. Due to the value of this reach of river, the state of Kentucky has designated the Tennessee River between Kentucky Dam at TRM 22.4 downstream to Cooper Creek at TRM 17.8 a mussel sanctuary. Within the sanctuary no harvesting of mussels is permitted. Outside the sanctuary brailing is the only legal method for collecting mussels. Commercial mussel harvesting has declined in the lower Tennessee River below the mussel sanctuary. Most mussel harveting in the area now takes place in Kentucky Reservoir.

3.23 Sickel's 1985 survey of mussels in the lower Tennessee River covered the entire tailwater and employed divers and brailing. A total of 34 species of mussels were recovered alive. Five species, Fusconaia ebena, Amblema plicata, Quadrula pustulosa, Pleurobema cordatum, and Cyclonais tuberculata accounted for almost 75% of the total population. The most diverse and densely populated beds occurred within the mussel sanctuary and exhibited recruitment. Sickel reported that between TRM 13-15, below Calvert City, few old mussels were found, but a number of young Fusconaia ebena were observed. This finding indicates a past decline of the mussel population probably due to input of pollutants from the Calvert City chemical complex area in the past, but that at least part of the river downstream of Calvert City has recovered somewhat. Williams (1969) reported substrate between TRM 0-3 to be composed of mud, silt, and debris supporting few mussels (Cox and Wade, 1987).

3.24 Sickel, in 1987, conducted a survey of mussel populations occupying the right bank mussel bed between TRM 21.6-21.1 in connection with the proposed construction of a barge terminal. A total of 27 live species of mussels were found in this survey. This mussel bed is one of the most densely populated, (reaching greater then 50 mussels per square meter in some areas), in the lower Tennessee. Species most commonly collected were Fusconaia ebena, Amblema plicata, Quadrula quadrula, and Megalonaias gigantea. One specimen of a federally endangered species was found, a gravid female Lampsilis orbiculata (pink mucket).

3.25 During the 1990 mussel survey of the tailwater a total of 23 mussel species were found by investigators. Two species, Fusconaia ebena and Amblema plicata comprised almost 80% of the total number of animals collected. Results of the investigation of the right bank mussel bed indicated a moderately diverse, moderately dense mussel fauna, when compared to other large rivers, in the immediate tailwater area (upstream of I-24, TRM 21.1). The densest mussel populations in that mussel bed were in a band just off the right bank shoreline. Reconnaissance of other areas outside this recognized mussel bed, but not in the navigation channel, indicated healthy mussel populations exist in the tailwater wherever suitable substrate (stable, gravel and sand bottom) exists.

3.26 Other molluscs besides unionids occur in the lower Tennessee River. The Asiatic clam, Corbicula, is found throughout the tailwater, however populations of this animal are generally low. Gastropods have been investigated as a side light to other surveys for mussels. A variety of native snail species occur in the tailwater reach, particularly in the ten miles of river immediately downstream of Kentucky Dam.

3.27 The zebra mussel, Dreissena polymorpha, has been confirmed in Kentucky Lake, with the finding of one 2.5 centimeter adult by a commercial musseler at TRM 30.5 during the summer of 1991. This species, a central Asian native, apparently was introduced into North America during the mid-1980's from Europe via ballast water of transAtlantic ships. It has spread rapidly throughout Lake Erie and Lake Ontario, and occurs at other locations in the Great Lakes, and in a number of other inland waters including the Mississippi River and lower Ohio River (ORM 964.5). These mussels form encrusting growths of incredible population density, (>100,000/sq. meter) and attach to virtually any solid surface. Zebra mussels are a major pest at power plants and water intakes. Structures such as locks are highly susceptible to zebra mussel infestation, and control strategies are being developed to deal with them in such facilities. Introduction of the zebra mussel into the Tennessee River may decimate remaining mussel stocks in much of the river. Zebra mussels attach in large numbers to substrates favored by native mussels, and form encrustations on native mussels themselves. Infestations are often so severe as to prevent shell closure or interfere with normal feeding of the native mussel, resulting in its death. In many areas of the Great Lakes, native mussels have been virtually eradicated by zebra mussels. There are to date no practicable means to control these animals in the environment. Zebra mussels have been taken into account in the design of the new lock. The U.S. Congress has recognized the magnitude of the zebra mussel threat and is providing significant funding for research programs to investigate the biology and control methods for these animals.

3.28 The lower Tennessee River supports a popular and productive sport and commercial fishery. Commercial fishing is allowed from the mouth of the river upstream to TRM 17.8. The immediate tailwater area between I-24 and the dam is fished very heavily by sport fishermen. Kentucky Dam, like Barkley Dam serves as a concentration point for fish. Absence of cove, embayment, and overbank habitats in the lower Tennessee limits spawning and nursery activities by most sedentary fish species (e.g., cyprinids and centrarchids). The riverine environment is suitable for species that spawn in open water or in flowing portions of large rivers.

3.29 A creel survey conducted in the immediate tailwater, TRM 22.4-21.1, between April 1978 to March 1980 indicated at least 19 species of sport and commercial fish are harvested by anglers. During this period more than four million pounds of fish were taken. Blue catfish was the most abundant species caught. Other commonly taken fish were channel catfish, flathead catfish, sauger, white bass, paddlefish, and striped bass.

3.30 Terrestrial Flora. The existing flora of the area differs markedly from presettlement conditions. Along the lower Cumberland River most land, especially the floodplain, is devoted to rowcrop agriculture. Interspersed with agricultural fields are small wooded areas and fence rows. Steeper slopes and ridges are generally wooded with second growth forest, principally oak-hickory. The immediate riparian corridor generally supports a band of woody vegetation, the alluvial forest, though in some places only bare, eroding banks remain. The major trees of the alluvial forest are sycamore, silver maple, river birch, sweetgum, hackberry, and cottonwood.

3.31 Flora of the lower Tennessee River area is similar to that of the lower Cumberland. Within the immediate project area and associated lands several forest associations occur. Mixed upland woodlands consist primarily of various oaks such as black, post, and white oaks and assorted hickories. Lower lying alluvial areas support red maple, sweetgum, river birch, hackberry, ashes, cherrybark oak, pin oak, and overcup oak. One slough containing large baldcypress is found on the left bank area near Kentucky Dam on TVA lands. Also on the left bank is a plantation of loblolly pines. Figure 5 presents existing forest resources in the immediate project area. The remainder of the project area consists of land maintained by mowing, agricultural leased lands, landscaped areas, and built up areas.

3.32 Wetlands. Wetlands occur in proximity to the lower Cumberland and lower Tennessee rivers (National Wetlands Inventory, 1988). Wetlands in the area have been much reduced in extent by man's activities during historical times, principally through draining, filling, and innundation due to reservoir creation. Remaining wetlands consist principally of palustrine forested types. Figure 6 provides locations of wetlands remaining in proximity to Kentucky Lock and Dam, as identified by recent aerial photography and National Wetlands Inventory mapping.

3.33 Terrestrial Fauna. The terrestrial wildlife resource of the lower Cumberland and Tennessee Rivers is tied to the quality and quantity of available habitat. The terrestrial ecosystems present are very different from those in existence during presettlement times. Agriculture has been the greatest influence on the quality and quantity of habitat available to wildlife. Other sources of disturbance include extraction of timber, mining, transportation, development of urban and industrial areas. Certain wildlife species have been favored by these changes, while others have been greatly reduced or eliminated from the area.

3.34 Though agricultural practices often preclude the presence of many wildlife species, much edge and fence row habitat has been created. Numerous species of songbirds, small mammals, and reptiles frequent these areas.

3.35 The generally dry oak-hickory upland forests support a diverse assemblage of wildlife. Common mammals include gray squirrel, chipmunk, woodchuck, opossum, shrews, and gray fox. Rocky outcrops and dry slopes provide habitat for bobcat and striped skunk as well as numerous reptiles. Many species of birds frequent the upland forest, including wild turkey, various raptors, and songbirds.

3.36 Within the alluvial forest a wide spectrum of animals are supported. Mammals of the alluvial forest include white-tailed deer, gray fox, opossum, raccoon, muskrat, beaver, mink, weasel, numerous species of rodents, and bats. With the presence of abundant water numerous amphibians and reptiles occur. Birds found in association with alluvial forest areas include great blue herons, green herons, and kingfishers. Aquatic insects emerging from the water provide food for insectivorous birds such as cliff and bank swallows. Large riparian trees and snags provide nesting cavities for woodpeckers and wood ducks.

3.37 Urban, residential, and other developed areas, (such as the immediate Kentucky Dam area) support a number of common wildlife species. The most visible component is songbirds, which are often attracted to landscaped areas. Common birds found in populated areas include cardinals, sparrows, mockingbirds, and wrens. During migration other species are present for periods of time. Developed areas also tend to support large numbers of small mammals, including mice, rats, squirrels, cottontail rabbits, among others.

3.38 In summary, terrestrial wildlife populations of the lower Cumberland and Tennessee Rivers are typical of the southeastern United States. The high diversity of vegetation and abundance of water within the area supports a high diversity of wildlife.

3.39 Threatened and Endangered Species. Aquatic species in some federal endangerment category identified by the U.S. Fish and Wildlife Service which could occur in the lower Cumberland or Tennessee Rivers are listed in Table 1. This list does not

TABLE 1

ENDANGERED, THREATENED, AND PROPOSED
AQUATIC AND TERRESTRIAL SPECIES
ON THE FEDERAL LIST WHICH COULD OCCUR
IN OR NEAR THE LOWER CUMBERLAND OR LOWER TENNESSEE RIVERS

Major Group and Species	Federal Protection Status	Live Record Since 1976	
		Cumb. R	Tenn. R
<u>Bivalves</u>			
Cumberlandia monodonta	R2		X
Cyprogenia stegaria	E		X
Epioblasma arcaeformis	R3A		
Epoiblasma cincinnatiensis	[3A]		
Epioblasma flexuosa	R3A		
Epioblasma florentina florentina	E		
Epioblasma obliquata obliquata	E		
Epioblasma personata	R3A		
Epioblasma propinqua	R3A		
Epioblasma stewardsoni	[3A]		
Epioblasma torulosa torulosa	E		
Hemistena lata	E		
Lampsilis orbiculata	E		X
Leptodea leptodon	R2		
Obovaria retusa	E		X
Plethobasus cicatricosus	E		
Plethobasus cooperianus	E		X
Pleurobema clava	R2		
Pleurobema plenum	E		
Pleurobema rubrum	R2		X
Potamilus capax	E	X	
Quadrula fragosa	PE		
Simpsonaiais ambigua	R2		
Villosa fabalis	R2		
Villosa lienosa	R2		
<u>Gastropods</u>			
Leptoxis praerosa	R2		
Lithasia armigera	R2	X	X
Lithasia geniculata	R2	X	X
Lithasia salebrosa	R2		X
Lithasia verrucosa	R2		X

TABLE 1
continued

Major Group and Species	Federal Protection Status	Live Record Since 1976 Cumb. R	Live Record Since 1976 Tenn. R.
Fish			
Acipenser fulvescens	R2		
Cycleptus elongatus	R2		X
Polyodon spathula	R3C	X	X
Reptiles			
Nerodia erythrogaster neglecta	R2		
Mammals			
Myotis sodalis	E		
Myotis griscens	E		
Myotis austroriparius	R2		
Plecotus rafinesquii	T		
Birds			
Haliaeetus leucocephalus	E		
Falco peregrinus tundrius	E		
Aimophila aestivalis	R2		
Plants			
Apios priceana	T		
Cimicifuga rubifolia	R2		
Armoracia aquatica	R2		

Federal Protection Status Codes

E -- Endangered; in danger of extinction.
T -- Threatened; likely to become endangered.
PE-- Proposed Endangered; review complete, proposed for listing
R -- Status Review; being considered for possible listing.
2 -- Evidence being gathered, listing may be appropriate.
3 -- Evaluated, found not to warrant listing because:
A -- Presumed extinct.
C -- Abundance does not warrant listing at this time.

imply that all of these species occur in the project area, but instead forms a basis for the examination of recent endangered species records from the project area. Live records of these species since 1976 are also indicated in Table 1. Molluscs dominate the table due to the decline of many species from pollution, damming and regulation of rivers, other modifications to available habitat, and overharvest of the mussel resource.

3.40 Sickel in 1982 did not locate any living representatives of federally endangered or threatened species during a comprehensive survey of the lower Cumberland River. Only old, dead shells of Plethobasus cooperianus (white-wartyback mussel), Plethobasus cicatricosus (orange-footed mussel), and Lampsilis orbiculata (pink mucket) were recovered. It is highly unlikely these species still live in the lower Cumberland. In 1987 however, Sickel collected the first two live specimens of the federally endangered mussel, Potamilus capax (fat pocketbook pearly mussel) ever collected in Kentucky. These were found at CRM 0.2, in the backchute of Cumberland Island Towhead, away from the primary navigation channel. Subsequent surveys of the Barkley tailwater have not revealed any more individuals of Potamilus capax.

3.41 Two species of aquatic gastropods currently under review for possible listing do occur in the lower Cumberland River. One species, Lithasia armigera (armored rocksnail) is abundant throughout the tailwater reach. The second species, Lithasia geniculata (ornate rocksnail) is considered rare in the tailwater.

3.42 Of the three fish species listed in Table 1, only the paddlefish, Polyodon spathula, is known to inhabit the lower Cumberland River.

3.43 In summary the lower Cumberland River is currently documented to support one species of federally endangered mussel, Potamilus capax. Recent extensive surveys have not revealed any other living representatives of federally listed species in the tailwater. Habitat for the status review armored rocksnail, Lithasia armigera, is abundant. These snails are found throughout the tailwater in high numbers. Lithasia geniculata, ornate rocksnail, occurs in the lower Cumberland River but seems to be quite scarce.

3.44 Of the 25 species of mussels listed in Table 1 which could occur in the lower Tennessee River, up to six of them probably persist in the Kentucky Dam tailwater. Four of the six, Lampsilis orbiculata, Plethobasus cooperianus, Obovaria retusa (ring pink), and Cyprogenia stegaria (fanshell) are federally endangered species. Lampsilis orbiculata has been found at TRM 14.7 and 17.8 (Sickel 1985), TRM 22.0 (Gooch, et. al. 1979), and TRM 21.4 (Sickel 1987). Plethobasus cooperianus was found only during 1985 by Sickel at TRM 13.5, 20.6, and 20.7. Obovaria retusa has been found at TRM 12.5 and 13.8 (Sickel 1985) and at TRM 18.6 (Miller 1987). Cyprogenia stegaria has been found at TRM 17.8 (Gooch, et. al. 1979).

3.45 The remaining two mussel species, Pleurobema rubrum and Cumberlandia monodonta, still found in the Kentucky Dam tailwater remain under review for possible addition to the federal list.

3.46 Five species of aquatic gastropods, all river snails, are included in Table 1. None of these species are listed as either endangered or threatened by the USFWS, but all of them are being considered for possible listing. Lithasia verrucosa is abundant throughout the full length of the lower Tennessee. Lithasia armigera and Lithasia verrucosa were found during the 1990 tailwater mussel survey.

3.47 Of the three fish species in Table 1, Cycleptus elongatus was collected in 1978 between TRM 8.0-11.0. Polyodon spathula is common in the lower Tennessee River and is frequently harvested.

3.48 To summarize, the lower Tennessee River supports individuals of four federally listed endangered mussels and nine other aquatic species (two mussels, five snails, and two fish) being considered for possible federal listing. The endangered mussel species persist as scattered individuals between about TRM 13.0 and Kentucky Dam. Two endangered mussel species occur in the large mussel bed near the right bank between TRM 21.6-20.5. Candidate mussel species documented in the tailwater occur as scattered individuals in the upper half of the 22.4 mile tailwater reach.

3.49 Among terrestrial species in Table 1 the bald eagle, Haliaeetus leucocephalus, may occur in the area on a transitory basis, primarily on winter migration routes. No documented successful nesting by the bald eagle has occurred recently in proximity to the lower Cumberland and Tennessee Rivers. The Arctic peregrine falcon, Falco peregrinus tundrius, could be an unlikely winter visitor to the area. Bachman's sparrow, Aimophila aestivalis, has not been recorded in the project area. Some habitat for this bird is present in the form of pine woodlands on the left bank near Kentucky Dam. Summer colonies of the Indiana bat, Myotis sodalis, Rafinesque's big-eared bat Plecotus rafinesquii, and Southeastern bat, Myotis austroriparius, could occur in the project area. The gray bat, Myotis griscens, may forage in the area. The copperbelly water snake, Nerodia erythrogaster neglecta, has not been recorded from the area. Palustrine forested wetlands are a favorite habitat for this snake.

3.50 No federally listed species of terrestrial plants occur in the project area.

3.51 Prime Farmland. Prime farmlands occur in the area. These soils are found in level lands along the Cumberland and Tennessee Rivers and in valleys formed by their tributaries. Most soils with slopes of less than 6% are considered prime farmlands in the area. Soils exceeding the 6% threshold but with slopes of less than 12% are categorized as soils of statewide importance. Farmlands of statewide importance are mainly found on ridgetops and at the foot of hills.

3.52 Some soils in the immediate project area were extensively modified during construction of Kentucky Lock and Dam. Soil surveys classify these locations as urban lands, meaning they have been graded or filled with earth, gravel, or both and then smoothed. The original soil type has been so modified as to be no longer recognizable. Figure 7 presents information on existing prime farmlands in proximity to Kentucky Lock and Dam.

3.53 Cultural Resources. The earliest American Indian presence in the project area may well have been as much as 12,000 years ago. Direct evidence, resulting from professional archeological examination of prehistoric Indian occupation, begins about 8,500 years ago; however, indirect evidence, consisting of artifacts in the hands of local collectors, places the initial occupations several thousand years earlier. Prehistoric occupation of the area continued through the late prehistoric Mississippian period ending about A.D. 1540. During this time span cultures in the area ranged from early hunter-gatherer groups to later, highly organized societies. The earliest Euro-American presence within the lower Cumberland/Tennessee Rivers area likely occurred during the seventeenth century when explorers, fur traders, and missionaries traversed the area. The first permanent, historic settlements were the communities of Centerville (1785) on Livingston Creek, and Smith's Town (1791) at the confluence of the Cumberland and Ohio Rivers. More extensive and diversified settlement occurred after the year 1800 with the rivers playing an important role in local trade and commerce. This later type of historic settlement is exemplified by the remnants of "old" Gilbertsville (1870), formerly located near the site of Kentucky Lock and Dam.

3.54 Archeological investigations conducted adjacent to the

Cumberland and Tennessee Rivers have revealed numerous archeological sites on and buried within the levee and terraces formed along the rivers. One such site, the Whalen Site (15Ly48) located near mile 25 on the Cumberland River, is listed on the National Register of Historic Places. This deeply stratified deposit contains cultural deposits dating from the early Archaic period (ca. 8,500 years before the present) to the late Woodland period (ca. 1,000 years B.P.). Similar sites have been found along the Tennessee River. Other typical sites range from small hunting camps and prehistoric homesteads, to small villages and prehistoric cemeteries.

3.55 Cultural resource assessment and survey level investigations have been conducted within the proposed project area on the Tennessee River and at alternative locations along the Cumberland River. Assessment and pedestrian survey level investigation conducted within the area of the former community of Gilbertsville revealed that no significant elements of the community remain extant; the community appears to have been completely destroyed during the construction of Kentucky Lock and Dam. Although extensive prehistoric remains, including both surface and subsurface buried deposits have been located along the Cumberland and Tennessee Rivers, survey and subsurface testing indicated that they are not as extensive within the areas affected by the proposed lock addition alternatives (Figure 8). A single buried prehistoric site, 15Lv204, is located within the river bank immediately downstream of Russell Creek and a small, late prehistoric cemetery and associated village component, 15Lv24, is located adjacent to proposed construction laydown areas. Both of these sites have been determined eligible for listing on the National Register of Historic Places by consensus determination with the Kentucky State Historic Preservation Officer. Several other sites identified in the files of the Kentucky Office of State Archeology are mislocated in the files, have been destroyed by past construction activities, were not relocatable, or are not in areas affected by the proposed lock addition. These sites include 15Lv12 and sites 15Lv20-23. For purposes of this report sites 15Lv204 and 15Lv22 are in the same locality and are considered as the same site.

3.56 Additionally, the Kentucky Lock and Dam and associated structural features are eligible for listing on the National Register as a single, significant, historic property and as a part of the Tennessee Valley Authority's system of locks and dams.

3.57 Socio-Economic Conditions. Kentucky and Barkley Locks are located in the vicinity of where Livingston County, Lyon County, and Marshall County adjoin. These three Kentucky counties and those counties directly adjacent to these counties were selected as the project area for measuring potential impacts during project construction.

3.58 The eleven counties comprising the project area are listed in Table 2 below. Also displayed are each county's population, per capita income, and unemployment rate for 1990. Per capita income in the project area is lower than the national average which is reflective of the rural nature of these counties. McCracken County, where Paducah is located, has the highest per capita income at $18,081.00, which is nearly twice as high as Pope County which has the lowest per capita income at $9,411. Seven of the eleven counties can be characterized as areas suffering from substantial and persistent unemployment (Principles and Guidelines), Section 2.11), including Livingston and Marshall.

TABLE 2

PROJECT AREA POPULATION, PER CAPITA INCOME, AND UNEMPLOYMENT
1990
(1990) DOLLARS

	Population	Per Capita Income	Unemployment Rate
Caldwell County, KY	13,187	$15,444	9.9%
Calloway County, KY	29,725	$14,679	4.9%
Crittenden County, KY	9,208	$14,530	8.4%
Graves County, KY	32,486	$15,538	10.8%
Livingston County, KY	9,725	$15,294	13.0%
Lyon County, KY	6,570	$12,951	6.6%
McCracken County, KY	60,977	$18,081	5.9%
Marshall County, KY	27,403	$15,029	8.1%
Trigg County, KY	9,807	$15,185	7.8%
Massac County, IL	15,517	$13,465	10.8%
Pope County, IL	4,064	$ 9,411	11.9%
PROJECT AREA	218,669	$15,652	8.0%
NATION (1,000'S)	245,800	$17,974	5.4%

SOURCE: Bureau of Economic Analysis via CERL.

3.59 Demographic forecasts for the project area are presented in Table 3, below. The 1990 population of the project area is projected to increase 9.7 percent by 2035 to about 240,000. Per capita income is projected to increase from $15,652 in 1990 to $25,845 by 2035. Total project area employment is projected to increase from 94,340 in 1990 to about 100,000 in 2000 and then remain relatively stable from 2000 to 2035. In 1990, the service sector was the largest employer with about 19 percent of total employment, followed by retail trade at 18 percent, manufacturing at 16 percent, government at 14 percent, and agriculture at 13 percent. These relative shares of total employment are projected to remain about the same.

TABLE 3

PROJECT AREA PROJECTED ECONOMIC TRENDS

	1990	2000	2035
Population	218,669	221,624	239,937
Per Capita Income (1990	$15,652	$18,277	$25,845
Total Employment	94,340	100,068	99,778
Agriculture	12,340	12,210	11,194
Mining	551	572	542
Construction	5,496	5,786	5,737
Total Manufacturing	15,305	15,315	14,124
Transp. & Pub. Util.	5,290	5,897	6,425
Wholesale Trade	4,147	4,410	4,658
Retail Trade	16,612	18,398	19,162
Finance, Insur., & Real Estate	3,278	3,738	3,947
Services	17,728	19,938	20,519

SOURCE: Bureau of Econonic Analysis via CERL.

3.60 The project area is well served by various modes of transportation. The Paducah and Louisville Railroad traverses both Barkley and Kentucky dams and connects Paducah with Louisville and the main line from Chicago to New Orleans. The Seaboard System provides service from Paducah to southwestern Tennessee and the Mississippi River. The major highway in the area is Interstate 24 which connects Paducah with Nashville. Another major highway, US 62-641 crosses Kentucky Dam and connects Paducah to Eddyville, Kentucky.

3.61 Air Quality. The control of air quality is set forth in the Rules and Regulations of the Division of Air Quality, Kentucky Department of Natural Resources and Environmental Protection (KDNREP). Primary (health-protecting) and secondary (welfare protecting) national ambient air quality standards (NAAQS) set forth by the U.S. Environmental Protection Agency

(EPA) must be met. These standards are prescribed for six pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. Secondary ambient air quality standards represent air quality parameters which protect public welfare from any known or anticipated adverse effects associated with the presence of air pollutants.

3.62 Air quality data is collected at locations known as State and Local Air Monitoring Stations (SLAMS). SLAMS are selected to meet EPA regulations for providing a State Implementation Plan air quality monitoring network (KDNREP, 1988). A SLAMS site exists in Livingston County, a few miles north of Kentucky Lock and Dam, across the Tennessee River from the Calvert City industrial area. Air quality parameters collected at the Livingston County SLAMS are particulate matter (10 microns or smaller), sulfur dioxide, and ozone. During 1990 for the parameter of particulate matter the highest recorded value for a 24 hour period was 96 micrograms/cubic meter, well below the secondary standard of 150 micrograms/ cubic meter. No exceedance of sulfur dioxide or ozone occurred during 1990. Both Livingston and Marshall counties are currently rated as areas of air quality attainment.

3.63 Recreation. The region encompassing the lower Cumberland and Tennessee Rivers is sometimes referred to as Kentucky's "Western Waterland". Lake Barkley, Kentucky Lake, lower Cumberland River, and lower Tennessee River provide abundant opportunities for flat water recreation. While fishing is pursued on a year-round basis, other recreational activities such as houseboating, general recreational boating, water skiing, and swimming are most closely tied to the warmer months of the year. A considerable local industry has grown up to support these recreational pursuits.

3.64 Land based recreation is provided, in part by Land Between the Lakes National Recreation Area and various TVA and Corps of Engineers recreation areas. Hunting as a recreational activity is popular on private and public lands where allowed. The locks and hydropower facilities at Kentucky and Barkley are popular visitor attractions. Nearby Kentucky Dam Village State Resort Park operated by the Commonwealth of Kentucky is a popular recreation area offering a wide range of recreational activities. TVA's Taylor Park Campground is located on the right bank immediately upstream of the existing lock.

3.65 Commercial and industrial development of the lower Cumberland and lower Tennessee Rivers may limit use of these streams for recreation. Some pleasure boating occurs on these rivers. Since the opening of the Tennessee-Tombigbee Waterway, many privately owned pleasure craft travel to the Gulf of

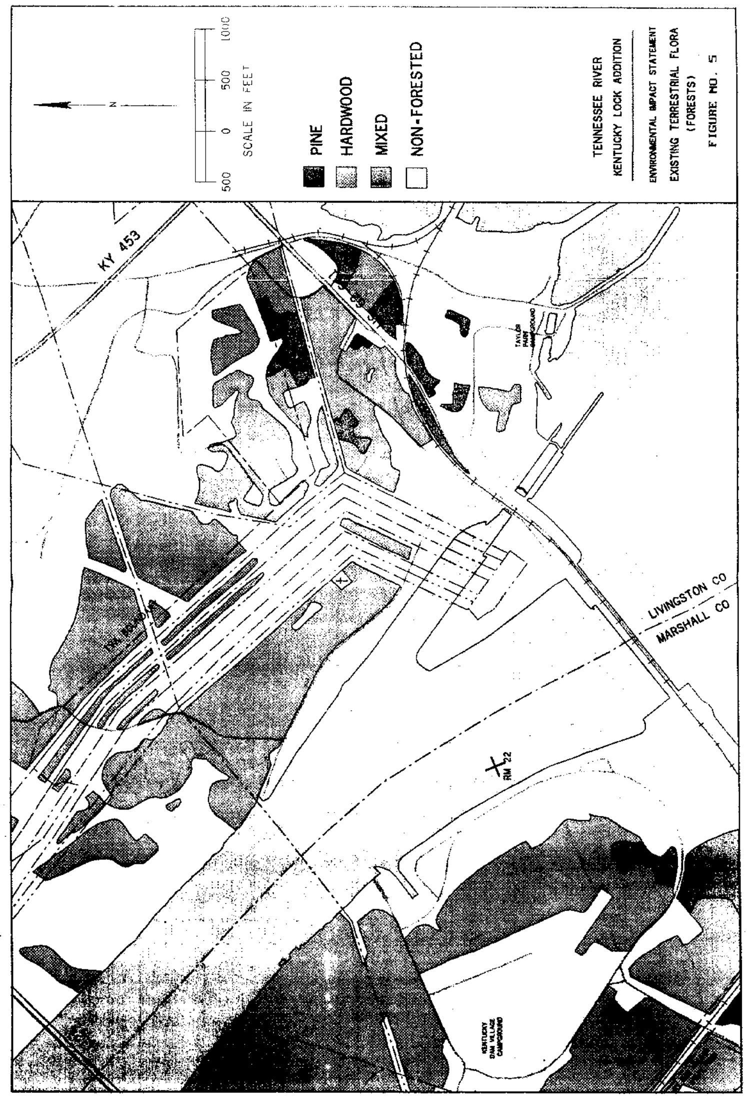
Mexico via the lower Cumberland and lower Tennessee as an alternative to traveling the longer Mississippi River route.

3.66 Both commercial and sport fishing are popular activities below Barkley Dam and Kentucky Dam. Several boat ramps provide access to the tailwaters. Parking areas on the left and right bank are provided for bank fishermen at Kentucky Dam, and a restroom is located on the left bank adjacent the parking lot. Bank fishing occurs primarily in the immediate vicinity of both dams and at other roads and ramps providing access. The vast majority of fishing activity occurs in the immediate tailwater areas of the dams, where fish are often concentrated due to blockage of migratory routes, and a ready food source is supplied by organic material passing through the dams. Both rivers are principally fished by local fishermen, who are familiar with area conditions. Creel surveys performed by the Kentucky Department of Fish and Wildlife Resources (KDFWR) between 15 April 1978 and 31 March 1980 revealed a total of 263,397 angler trips to the immediate tailwater of Barkley Dam. At Kentucky Dam for the same time frame, a total of 581,229 angler trips occurred (McLemore, 1980).

3.67 Canoeing and other human powered boating occurs on both rivers but are not popular activities. The presence of motorboats, navigation traffic, and contrary winds militate against this form of boating. The Cumberland River does offer a relatively pleasant recreational experience on a large, navigable river, in a rural setting for boaters.

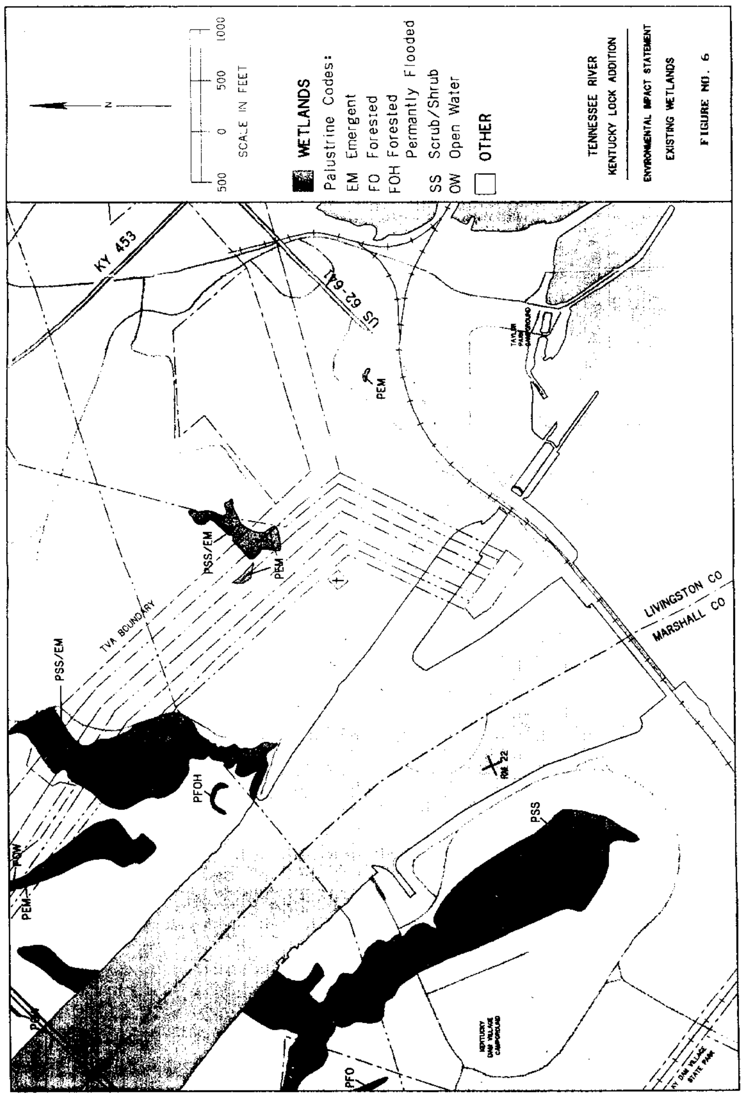
3.68 Aesthetics. The lower Cumberland and Tennessee rivers and their local environment possess many pleasing visual qualities. The area in general is of a rural character, consisting of a visually diverse assemblage of land forms and land uses.

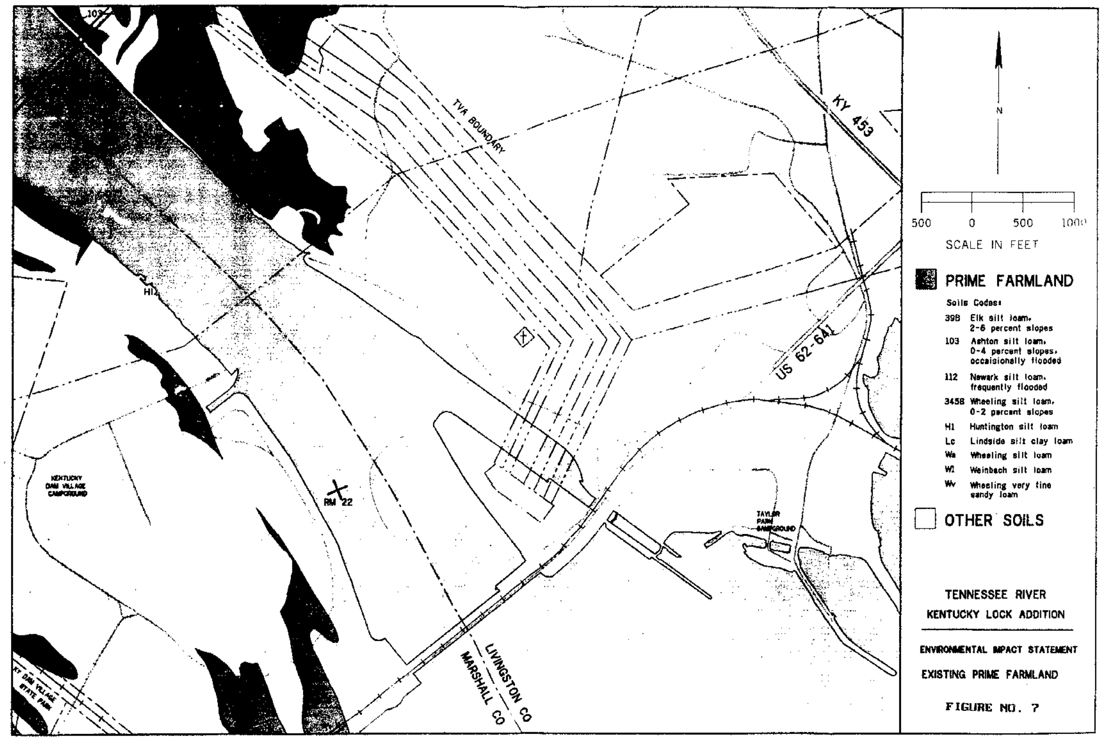
3.69 Within the vicinity of Kentucky Lock and Dam a mix of landscapes and land uses occur. These include woodlands, agricultural land, maintained areas, and lands disturbed by quarrying. Kentucky Lock and Dam itself stands as a permanent, impressive monument to modern development and utilization of water resources. Visitors can view activities at the lock and hydropower plant, gaze across the impressive expanse of Kentucky Reservoir and the lower Tennessee River, or enjoy natural areas to observe flora and fauna or sites of cultural resources.

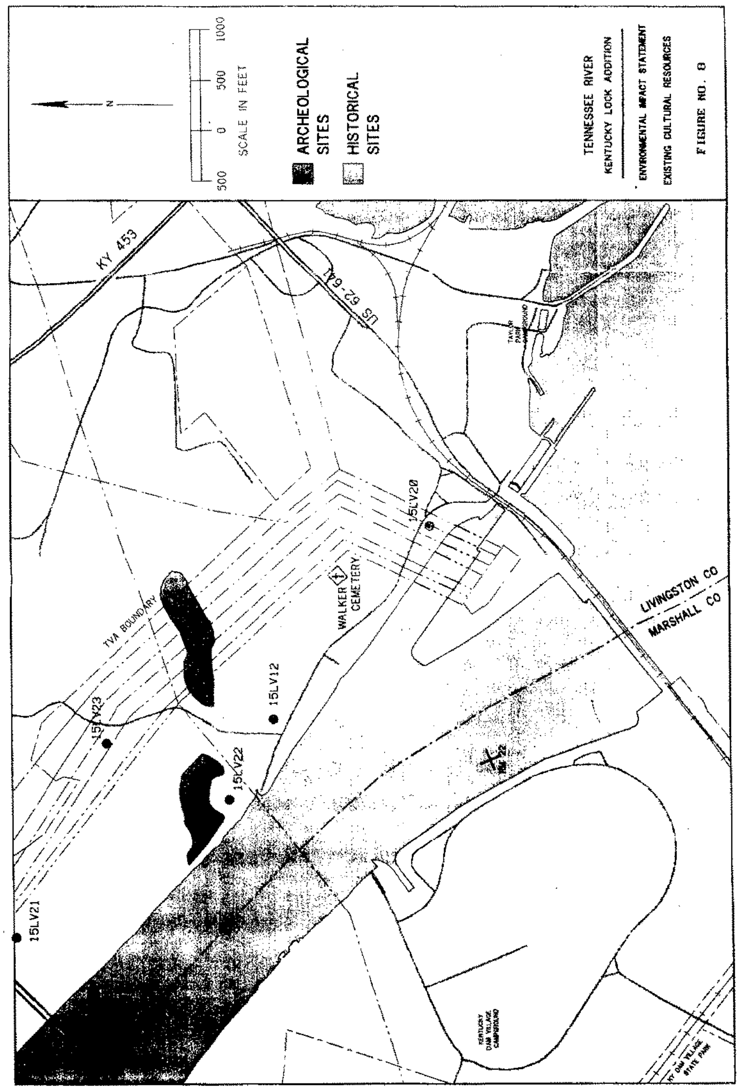


TENNESSEE RIVER
KENTUCKY LOCK ADDITION

ENVIRONMENTAL IMPACT STATEMENT
EXISTING TERRESTRIAL FLORA
(FORESTS)
FIGURE NO. 5


N
500 0 500 1000
SCALE IN FEET
WETLANDS
Palustrine Codes:
EM Emergent
FO Forested
FOH Forested Permantly Flooded
SS Scrub/Shrub
OW Open Water
OTHER
TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
EXISTING WETLANDS
FIGURE NO. 6
KY 453
US 62-641
PEM
PSS/EM
PEM
TVA BOUNDARY
PSS/EM
LIVINGSTON CO
MARSHALL CO
PFOH
RM 22
PSS
POW
PEM
PFO


N
500 0 500 1000
SCALE IN FEET
PRIME FARMLAND
Soils Codes:
39B Elk silt loam, 2-6 percent slopes
103 Ashton silt loam, 0-4 percent slopes, occaisionally flooded
112 Newark silt loam, frequently flooded
345B Wheeling silt loam, 0-2 percent slopes
H1 Huntington silt loam
Lc Lindside silt clay loam
Wa Wheeling silt loam
Wl Weinbach silt loam
Wv Wheeling very fine sandy loam
OTHER SOILS
TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
EXISTING PRIME FARMLAND
FIGURE NO. 7
KY 453
US 62-641
TVA BOUNDARY
LIVINGSTON CO
MARSHALL CO
RM 22



N
500 0 500 1000
SCALE IN FEET
ARCHEOLOGICAL SITES
HISTORICAL SITES
TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
EXISTING CULTURAL RESOURCES
FIGURE NO. 8
KY 453
US 62-641
TVA BOUNDARY
WALKER CEMETERY
15LV21
15LV22
15LV23
15LV12
15LV20
LIVINGSTON CO
MARSHALL CO

4. ENVIRONMENTAL CONSEQUENCES

Introduction

4.01 The consequences of construction and operation of the final array of alternatives, including a no action condition, on significant environmental resources are discussed in the following sections. Table 4, at the end of this section, presents a comparison of environmental impacts for the alternatives. All final structural plans involve construction of a new lock landward of the existing lock. For all significant resources, the structural plans have an essentially equal likelihood of effect. The lock plans have thus been grouped for analysis of environmental consequences.

Water Quality

4.02 No Action Condition. Any water quality impacts resulting from the no action condition would be minor. Helper boats would be implemented on the lower Tennessee between 1995 and 2000. Initially, they would slightly reduce the tendency of tows to moor close to erodible bank areas and idle excessively, by reducing waiting times for lockage.

4.03 Traffic levels on the lower Cumberland River would remain low until intolerable increases in delays at Kentucky Lock and Dam force significant amounts of traffic to use the Cumberland River, about the year 2000. Traffic levels would gradually increase on the Cumberland River, negatively impacting water quality due to resuspension of sediment and wave action on erodible banks. The tailwater environment created by Barkley Dam, ie. retention of sediment in Lake Barkley that would normally contribute to maintaining the integrity of banks on the lower Cumberland River, will not be changed with modification of hydropower discharges. Modification of hydropower releases should improve water quality.

4.04 Plans A, B, and C. The new lock and downstream guidewall will be constructed entirely in the dry, protected by a cofferdam, eliminating the possibility of sediment runoff entering the Tennessee River from this activity. The bulk of the approxiately 2,240,000 cubic yards of excavation for the lock, guidewall, and downstream right bank reshaping, will be accomplished behind the lower cofferdam. For that portion of the downstream right bank to be excavated that is not contained by the cofferdam, material would initially be removed in the dry by conventional earthmoving equipment. At a certain point the remainder of the material would be dredged by dragline or clamshell equipment under wet conditions. The wet portion of excavation would result in temporary increases in suspended solids in the Tennessee River. Flows from Kentucky Dam would be coordinated to maximize dispersion of these sediments. Input of sediment from this source would cease when the newly excavated bank is protected with riprap.

4.05 Dredging of approximately 59,400 cubic yards of clean material to widen the right margin of the existing navigation channel down to the I-24 bridge would temporarily increase suspended sediment loads in the Tennessee River. Effects of dredging on water quality would cease with completion of the dredging. Minor and short term impacts to water quality would result from placement of dredged materials adjacent the right bank at TRM 19.7.

4.06 Runoff from the construction plant and equipment laydown areas would be contained and properly treated before being returned to the river. Fuels, greases, oils, and any hazardous wastes or materials brought in or generated on the site, will be prevented from contaminating the lower Tennessee through proper management, containment, and treatment practices. All applicable Best Management Practices (BMP's) will be employed to contain and treat these potential contamination sources.

4.07 Impacts on water quality from the borrow/disposal site would be minimal. Runoff from the site would be contained and treated in a retention pond. The site itself will be restored by grading and planting cover to prevent erosion. All other areas disturbed by construction activities will ultimately be seeded, landscaped, paved, or otherwise appropriately treated according to their future designated uses.

4.08 Placement of a new bridge for the Paducah & Louisville Railroad crossing would cause minor increases in suspended sediment levels, resulting from placement of bridge piers. This source would cease upon completion of the bridge.

4.09 Operationally, impacts of a new lock on water quality are anticipated to be insignificant. As traffic levels increase at the new lock, some minor increases in suspended solids are anticipated to occur.

4.10 For activities under Section 404(b)(1), the Corps will meet the requirements of Section 404(r) of the CWA when the EIS is presented to Congress. In addition a public notice will be issued for activities covered under Section 404(b)(1) of the CWA. For this project materials discharged as fill below ordinary high water would include limestone riprap, and clean sands, gravel, and cobble. Cofferdams would be constructed of sheet piling filled with inert gravel.

Aquatic Biota

4.11 No Action Condition. Within the lower Tennessee River the no action condition should initially benefit aquatic biota. Helper boats would somewhat reduce congestion and delays at Kentucky Lock and thereby slightly reduce turbulence caused by tows in productive littoral areas. As traffic levels increase, site specific, negative impacts to aquatic biota, particularly in the shallow overbank or shoal areas, would increase (Miller and Payne, 1989). Particularly at risk are valuable molluscan resources, which occur most prominently in these relatively shallow areas.

4.12 Within the lower Cumberland River, modification of hydropower releases would favor system stability and increased production of aquatic biota for a short period of time. Ultimately as traffic levels increase on the lower Cumberland River due to lockage delays at Kentucky Dam, there would be an increase in site specific, negative impacts to aquatic biota.

4.13 Plans A, B, and C. The area within the tailwater cofferdam will be subject to complete dessication. Mussels will be removed from the cofferdam area prior to dewatering, and relocated to another location within the tailwater mussel sanctuary.

4.14 Excavation of the right bank below the guidewall will cause the loss of some mussels. Sickel (1985) documented the existence of 14 species of mussels along the base of the riprap bordering this area. Most individuals here were old, probably nonreproducing individuals whose loss would be inconsequential to maintaining healthy downstream populations.

4.15 Proper management actions on the construction site will minimize runoff of pollutants into the lower Tennessee River which could threaten aquatic communities.

4.16 Construction of an additional lock would necessitate widening of the navigation channel above I-24. This would result in loss of a small portion of the mussel bed adjacent the existing right margin of the navigation channel. Mitigation actions planned include the creation of aquatic habitat at TRM 19.7 using materials dredged to widen the navigation channel. Aquatic biota are expected to colonize this habitat creation site. Colonization by molluscs is expected to be slower than the colonization rate for other benthos. Mussels will be removed from the dredge cut and relocated. Any mussels remaining would be lost during dredging. Placement of mooring cells adjacent the right channel margin upstream of I-24 would have only minor negative impact on mussels. Placement of two additional mooring cells in Kentucky Lake, upstream of the existing lock, would have an inconsequential impact on aquatic biota.

4.17 Construction of the bridge crossing for the Paducah & Louisville Railroad is unlikely to significantly impact aquatic biota, however mussels will be removed from bridge pier locations prior to construction.

4.18 Operational effects of a new lock will include subtle changes in hydraulic conditions over the downstream mussel bed which might affect long-term suitability of this area for continued recruitment and growth of mussels. Turbulence from tows entering and leaving the lock approach could reduce habitat suitability of the mussel bed. Reductions in tow queuing will be a positive impact of the new lock for aquatic biota. Tows will be processed more efficiently, reducing impacts in sensitive, biologically productive, littoral areas in the lower Tennessee River.

4.19 The valuable fishery of the lower Tennessee River would be unaffected by lock construction and operation.

Terrestrial Flora

4.20 No Action Condition. The no action condition would initially confer minor benefits to terrestrial flora along the lower Tennessee River by reducing bank sloughing related to mooring of tows in proximity to the banks. Loss of terrestrial flora would increase as traffic levels increase beyond the capacity of this alternative action to efficiently process traffic.

4.21 Hydropower modification on the lower Cumberland would slow the chronic loss of riparian vegetation by increasing stability in flows. As traffic levels increase due to increased lockage delays at Kentucky Dam however, loss of riparian vegetation would also increase. Wave action from tows and direct collisions of tows with riparian vegetation at higher water levels are two methods by which losses in terrestrial flora would occur.

4.22 Plans A, B, and C. Figure 9 presents the impact of project construction features on existing forest resources. Existing vegetation would be lost in proximity to Kentucky Dam primarily due to clearing for construction laydown areas, haul roads, and the railroad right-of-way. Most of these areas would be restored through seeding and landscaping to prevent erosion following completion of construction activities. Some areas around visitor use or lock operations facilities would be maintained in the future by mowing. In other areas natural plant succession will be allowed to occur. The riparian corridor along Russell Creek would be protected from disposal activities to preserve existing bottomland hardwood forest. Impacts to forests from project construction include removal of less than one acre of pines, 3.2 acres of mixed pine and hardwoods, and 23.2 acres of hardwoods. Plan A has the greatest spoil disposal requirements, (2.2 million cubic yards). The selected borrow/disposal site is a highly disturbed 45 acre area supporting only scattered tree cover and is otherwise barren ground or covered with herbaceous vegetation. Impacts on terrestrial flora of using this area are inconsequential.

4.23 Terrestrial flora would be unaffected by lock operation.

Wetlands

4.24 No Action Condition. The no action condition would have no impact on wetlands.

4.25 Plans A, B, and C. Lock construction totally avoids impacts to wetlands. Relocation of the Paducah and Louisville Railroad onto a crossing .3 miles downstream of Kentucky Dam avoids a forested wetland containing mature baldcypress on the left bank portion of Kentucky Dam Reservation. Figure 10 illustrates the relationship of construction features to wetlands.

4.26 Wetlands would be unaffected by lock operation.

Terrestrial Fauna

4.27 No Action Condition. Minor impacts to terrestrial fauna would occur in the no action condition. Any impacts would be as a result of loss of riparian habitat through bank sloughing resulting from wave wash, direct collisions of tows with timber stands, and normal water level fluctuations resulting from operation of upstream dams.

4.28 Plans A, B, and C. Lock construction and associated disturbance of wildlife habitat would be limited to areas in the immediate vicinity of Kentucky Dam. Most wildlife occurring in impacted areas consists of small mammals, birds, and reptiles. Loss of habitat during construction will reduce wildlife populations. With post-construction revegetation of impacted areas some recovery of wildlife populations would occur. Plantings of food and cover producing plants would be implemented to encourage and enhance overall wildlife populations in the area. Plan A has the likelihood for greatest adverse impact to terrestrial fauna of all lock plans due to the need for a larger disposal site.

4.29 Terrestrial fauna would be unaffected by lock operation.

Threatened and Endangered Species

4.30 No Action Condition. Some listed aquatic species are expected to continue to populate the lower Tennessee River in very low numbers. Others species which have more precarious population numbers, Obovaria retusa for example, may completely disappear from the lower Tennessee River, and could become extinct. The presence of large numbers of tows awaiting lockage at Kentucky would impact sensitive, littoral areas that support threatened and endangered species. Increases in traffic on the lower Cumberland River in the no action condition are unlikely to affect endangered and threatened species. The impact of the likely invasion of the zebra mussel on listed species is problematic. A worst case scenario of complete infestation of favorable habitat in the lower Tennessee, would result in elimination of representatives of all listed species from the area.

4.31 Plans A, B, and C. Among terrestrial species, these plans would impact small areas of suitable habitat such as mature trees with peeling bark, potentially suitable for summer maternity Indiana bat colonies. Lock construction would not impact birds such as the bald eagle or Arctic peregrine falcon. These species are transitory within the project area, the their high mobility precludes adverse impact. See Biological Assessment (Appendix B) for more information.

4.32 Lock construction would cause the loss of some individuals of freshwater mussel species documented in the lower Tennessee River. The most likely source of impact is direct excavation of the river bottom to improve or widen the navigation channel. This action could destroy individuals of the following federally endangered species: Lampsilis orbiculata, Plethobasus cooperianus, Obovaria retusa, and Cyprogenia stegaria. Though the latter two species have not been documented upstream of I-24, there is a remote possibility they could occur there. A lesser concern is the potential deposition of sediment from the construction site on productive downstream mussel habitat which may contain endangered species. Placement of two mooring cells upstream of I-24 along the right channel margin is very unlikely to impact endangered species. Individuals of two species of gastropods, Lithasia armigera and Lithasia verrucosa will be adversely impacted by modification of the aquatic environment, however these species are widespread and relatively common.

4.33 Measures to reduce impacts on aquatic threatened and endangered species include systematic diver conducted reconnaissance of the dredge area, cofferdam area, railroad bridge pier placement areas, and removal of any listed species found within these areas to a site within the mussel sanctuary removed from project impacts. Individuals so relocated would be placed in proximity to each other to increase chances for successful reproduction. Divers would also conduct a reconnaissance of the aquatic disposal area and remove any threatened or endangered species and relocate these animals (Appendix C, Biological Opinion pp. 16-18). These mitigation actions are conservative, when recent mussel studies conducted in the lower Tennessee upstream of I-24 are considered (Sickel, 1985; Sickel, 1987, Miller and Payne, 1990), which indicate very few individuals of threatened and endangered species persist even within excellent mussel habitat, and that these animals are widely scattered.

4.34 Provision of two additional mooring cells in the Kentucky Dam tailwater will end the tendency of tows to maneuver directly over the large right bank mussel bed. Tows will only be allowed to tie up to the channelward side of these cells, eliminating any turbulence impacts on the mussel bed in proximity to the cells. Provision of the additional lock chamber will lessen the tendency of tows to disturb sensitive, productive littoral areas in the tailwater.

Lessening of site specific impacts will reduce the likelihood of adverse impacts to endangered and threatened aquatic species.

Prime Farmland

4.35 No Action Condition. Under this alternative prime farmlands associated with the project area would not be significantly affected. Any impact to prime farmlands would be the continued loss of prime farmlands through bank erosion and sloughing.

4.36 Plans A, B, and C. Prime farmlands would be modestly affected by construction of the project. Small areas of prime farmland, less than 5 acres, would be permanently lost with construction of the railroad embankment and a relocated vehicular access road on the left bank. This area, part of TVA's Kentucky Dam Reservation, is not in agricultural production. Armoring of the right bank between TRM 21.1-21.6 and a portion of the opposing left bank will halt bank erosion and resultant loss of prime farmlands in that area. Figure 11 presents overall impacts of project features on prime farmlands. The proposed upland borrow/disposal area is not located in an area of prime farmland.

4.37 Prime farmlands would not be affected by lock operation.

Cultural Resources

4.38 No Action Condition. Under this alternative cultural resources associated with the project area would not be significantly affected. Any impact to cultural resources would be related to actions that result in the loss of materials buried in river banks susceptible to sloughing or erosion.

4.39 Plans A, B, and C. All lock plans would affect an eligible National Register site, the Kentucky Lock and Dam. Figure 12 presents the relationship of construction features to cultural resources, both prehistoric and historic. Lock construction would necessitate removal of the existing lock operations building and other original features of Kentucky Lock and Dam. An adverse effect, such as the removal of the lock operations building, requires the comments of the Advisory Council on Historic Preservation. Such comments result in the negotiation of a Memorandum of Agreement among the Corps, the Kentucky State Historic Preservation Officer and the Advisory Council on Historic Preservation defining measures to mitigate the adverse effect. Such a document has been initiated (Exhibit 5).

4.40 Construction of a new lock and associated rerouting of the Paducah & Louisville Railroad will not adversely effect the former community of Gilbertsville. Use of the proposed construction plant and laydown area may have an effect on sites which are located adjacent to proposed impact areas. These sites include 15Lv24, the Sanders Site, and a historic cemetery (Walker Cemetery). Additional archeological treatment of the prehistoric cemetery features and removal of both cemeteries would be required before construction use of the area. Required mitigation would be defined within the stipulations of a Memorandum of Agreement.

4.41 Cultural resources would be unaffected by lock operation.

Socio-Economic Conditions

4.42 No Action Condition. The no action condition would ultimately result in the gradual shifting away from waterborne transportation for bulk goods. As the cost of shipping materials by water increases due to lack of sufficient navigation capacity in the Kentucky-Barkley navigation system, some shippers would go out of business due to increased operational costs. Others would have to resort to moving commodities by overland means, such as trucks or by rail. The alternative shipping modes would realize economic gain, however, since overland shipping is less efficient for cargoes usually shipped by barge, costs for commodities would increase. These costs would be passed along, ultimately to the final users or consumers. The no action condition would result in reduced development facilities, such as marine terminals and slow growth and increase expenses for industries dependent on the inland waterway system.

4.43 The no action condition would preclude any benefits to the local or regional economy that would result from having a large construction project ongoing.

4.44 Plans A, B, and C. The Kentucky Lock Addition project will provide a boost to the local economy during construction and operation. During the course of construction approximately $105 million (October 1991 dollars) will be spent on labor costs. The construction work force will reach up to 500 workers during the peak of construction. Construction is expected to last approximately seven years. Given the large labor force of the impact area, virtually all the employees would be found locally. The small number that might move into the area would not significantly increase needs for community facilities and services. Provision of additional lock capacity at Kentucky will remove a major navigation bottleneck and be a great benefit to the marine transportation industry. These benefits would be felt over a broad geographic area served by the inland waterway system.

4.45 Closure of US 62/641 over Kentucky Dam for a period of 55 months will be a relatively minor inconvenience. An excellent detour route is available utilizing I-24 to accommodate vehicular traffic. The additional traffic on the interstate highway generated by the detour is well within the capacity of I-24 to handle. No businesses exist in the short section of US 62-641 to be bypassed by the detour, therefore the lengthy closure of the highway should not cause business losses or closings. Economic costs to motorists will be minimal as the detour route nearly parallels the US 62-641 route.

Air Quality

4.46 No Action Condition. The no action condition would result in increased air quality impacts caused by emissions from tows awaiting lockage. These impacts though relatively constant would be minor.

4.47 Plans A, B, and C. Air quality impacts from project construction would be minor and temporary. Dust would be generated locally from activities such as blasting, dry land excavation, operation of a concrete batch plant, and movement of heavy construction vehicles. Emissions of hydrocarbons would originate from consumption of fossil fuels in vehicles. Any open burning of non-hazardous non-toxic vegetation and debris would conform to state and local guidelines. Air quality attainment would not be threatened by project construction.

4.48 Air quality benefits would accrue during project operation due to shorter idling time for tows locking through the project.

Recreation

4.49 No Action Condition. Most recreational uses within the project area are not expected to be significantly altered by the no action condition. Recreational boating traffic would be negatively impacted by significant increases in delays for lockage at Kentucky Dam under no action.

4.50 Plans A, B, and C. Lock construction activities would have relatively minor adverse impacts on recreational fishing in the immediate tailwater of Kentucky Dam. The popular, existing boat launching ramp on the left bank is well away from any area to be impacted by construction. Most fishing activity occurs below the dam's spillway and powerhouse, rather than near the existing lock, due to the presence of constant navigation traffic and frequent lock discharges.

4.51 A portion of the right bank of the Tennessee River immediately downstream of Kentucky Dam would be closed to recreational activities during the period of construction. Some bank fishing occurs in this area presently but is not a significant activity. The right bank boat ramp will be removed during excavation of the bank to widen the lower lock approach. The permanent loss of this ramp will be mitigated by upgrading and expanding the left bank boat launching facility.

4.52 Construction activities would necessitate closure of visitor access to the Kentucky Dam Powerhouse and existing Kentucky Lock for the duration of construction. Normal visitor access would resume with completion of the project.

4.53 Relocation of the Paducah & Louisville Railroad onto a new bridge would impact fishing activities during its three year construction to some degree, due to the presence of floating plant and performance of construction activities to place bridge piers and construct the new bridge. Any adverse impacts from this construction on recreation are likely to be localized and minor, not involving the entire immediate tailwater area. Bridge piers in the heavily fished tailwater below the spillways will add a safety hazard to boaters. There is the potential for boats to drift into or collide with piers during fishing or boat operation. Obviously the piers also pose a new hazard for collisions as boats move upstream and downstream in this popular area. Presently the water surface area immediately below the powerhouse and spillway is unobstructed. Another impact of the railroad relocation is the temporary loss of the only toilet building and bank side parking lot on the left bank. These facilities would be replaced in-kind. Provision of portable toilet facilities would be appropriate during the time that a permanent toilet facility is not available.

4.54 The existing lock at Kentucky Dam will remain open and available for use by recreational craft during the construction period.

4.55 Recreational use of land areas within Kentucky Dam Reservation, especially on the right bank, will be severely curtailed due to the presence of construction activity and loss of terrestrial vegetation in affected areas. The public will be barred from entry into active construction areas for safety and security reasons. Taylor Park Campground, located just upstream of the existing lock, containing some 48 campsites and a fishing pier is currently operated by TVA on this part of the Reservation. The new lock, combined with the influences of other existing conditions such as a stone loading terminal and service area will require that this campground be relocated. The current plan is to relocate these campsites to another site on Kentucky Lake. Portions of this campground such as the restroom may continue to be used to support a small picnic ground for day use visitors and sightseers. With completion of the project, these areas will be opened once again to recreational use. Provision will be made to provide access to the Walker Cemetery.

4.56 Major adverse impacts of lock operation on recreation are not expected to occur. The most popular tailwater recreational activity is fishing. Tow traffic will remain confined to the right side of the river near the existing and future locks, well away from the most popular fishing areas. Frequent lock discharges could render a localized portion of the tailwater adjacent the right bank unusable for periods of time.

4.57 Availability of the new lock should eliminate or greatly reduce lockage times for recreational traffic. This will be a benefit for recreational boaters.

Aesthetics

4.58 No Action Condition. Aesthetic values of the project area would remain essentially unchanged under the no action condition.

4.59 Plans A, B, and C. Aesthetic values in the Kentucky Lock and Dam area would be significantly but unavoidably affected by features associated with a new lock. Addition of a new lock to the existing facilities would add to the interest and appeal of Kentucky Lock and Dam as an important navigation facility. The major impact to existing project aesthetic values would be caused by the required relocation of the Paducah and Louisville Railroad onto a bridge .3 miles downstream of the dam. The relocated bridge will block much of the downstream view of the Tennessee River from Kentucky Lock and Dam and will alter the view as one approaches via the river from downstream. Figure 13 presents a view looking upstream from the right bank at Kentucky Lock and Dam. Figure 14 dramatically illustrates how the Paducah & Louisville Railroad bridge will alter the view of the dam from downstream. This is an unavoidable impact.

4.60 Provision of an overlook on a hill above the locks will afford visitors a panoramic view of the entire complex composed of Kentucky Reservoir, the locks and dam, the Tennessee River below the dam, and surrounding lands. Kentucky Lock and Dam is first and foremost a manmade structure designed to accommodate navigation traffic and provide other benefits valued by society. Though various construction features will change the present aesthetic values of Kentucky Lock and Dam, overall the structure and associated features will continue to serve their intended purposes and function as a transportation hub and river control structure.

TABLE 4

COMPARATIVE IMPACTS OF ALTERNATIVES

Factor	"No Action" Future Without-Project Condition	Plans A, B, and C
WATER QUALITY	Initial improvement in lower Tenn R. due to decreased mooring, idling, queuing. Increased susp. sediment inputs as traffic grows beyond system capacity. Hydropower mod. at Barkley would reduce bank sloughing and susp. sediment loads. Increased traffic levels would later reverse this trend.	Minor input of sediment from construction site. Moderate but temporary inputs of suspended sediment from bank excavation and channel widening. Insignificant operational effects.
AQUATIC BIOTA	Initially beneficial due to fewer tows in sensitive near shore zone of lower Tenn R. Negative impacts to biota later as traffic levels increase.	Loss of aquatic habitat and destruction of biota from cofferdam placement, bank excavation, channel dredging, mooring cell placement bridge construction.

TABLE 4

COMPARATIVE IMPACTS OF ALTERNATIVES

continued

Factor	"No Action" Future Without-Project Condition	Plans A, B, and C
AQUATIC BIOTA	Positive impact on aquatic biots in lower Cumb. R. from hydropower modification due to greater system stability, reduction in bank sloughing, Negative impacts to biota later as traffic levels increase.	Partial recovery after construction. No traffic or operational effects.
TERRESTRIAL FLORA	Initial benefits from reduced bank sloughing in lower Tenn R. Later increased losses as traffic increases. Initial benefits from reduced bank sloughing in lower Cumb R. Later increased losses as traffic increases.	Destruction of flora within construction area. Some of impact area would be reclaimed through plantings or natural plant succession. Forest acreage losses: Pines < 1 acre Hardwoods < 25 acres Mixed < 4 acres See Figure 9
WETLANDS	No impact.	No wetland losses. See Figure 10 No operational impact.
TERRESTRIAL FAUNA	Minor through loss of riparian zone habitat resulting from bank sloughing.	Loss of wildlife in construction area. Reclamation would restore wildlife habitat in some affected areas.
THREATENED AND ENDANGERED SPECIES	No impact.	Possible loss of individuals of four federally endangered mussels. No impact on terrestrial species.

TABLE 4

COMPARATIVE IMPACTS OF ALTERNATIVES

continued

Factor	"No Action" Future Without-Project Condition	Plans A, B, and C
PRIME FARMLAND	Minor losses through sloughing principally on lower Cumberland River. Cumberland River.	Permanent loss of < 5 acres of prime farmland on left bank from P & L Railroad relocation and access road. See Figure 11.
CULTURAL RESOURCES	No impact.	Adverse effect on Kentucky Lock and Dam, an eligible National Register site. Potential impact to prehistoric sites 15Lv24, the Sanders Site, and a historic cemetery (Walker Cem.)
SOCIO-ECONOMIC CONDITIONS	Long term adverse socio-economic impacts. Reduced use of inland waterway system to growing traffic demands would increase shipping costs and limit development of facilities dependent on marine transport.	Provides long-term as well as short-term economic benefits by upgrading inland waterway system and providing jobs and payroll during construction.
	No boost to local economy is provided.	
AIR QUALITY	Minor impact from increased air pollutants emitted by awaiting lockage.	Minor impacts during construction from tows dust and particulates generated on site and escaping to surrounding areas.

TABLE 4

COMPARATIVE IMPACTS OF ALTERNATIVES

continued

Factor	"No Action" Future Without-Project Condition	Plans A, B, and C
RECREATION	Increases waiting time for recreational craft lockages, with associated inconvenience to public.	Temporary loss of bank fishing in construction areas, primarily right bank. Permanent loss of ramp on right bank. Minor disruption of popular fishing area in tailwater due to bridge construction. Loss of visitor access to lock and hydropower plant during construction. Reduces waiting times for recreational boats. Project offers an opportunity to upgrade recreational features in proximity to Kentucky Lock and Dam. Significant upgrade of left bank launch ramp planned to mitigate loss of right bank ramp.
AESTHETICS	No impact.	New lock would blend with existing structure. Relocated railroad would block downstream views from powerhouse. Railroad embankment would be a permanent intrusion on lands of Kentucky Dam Reservation. See Figures 13 and 14.

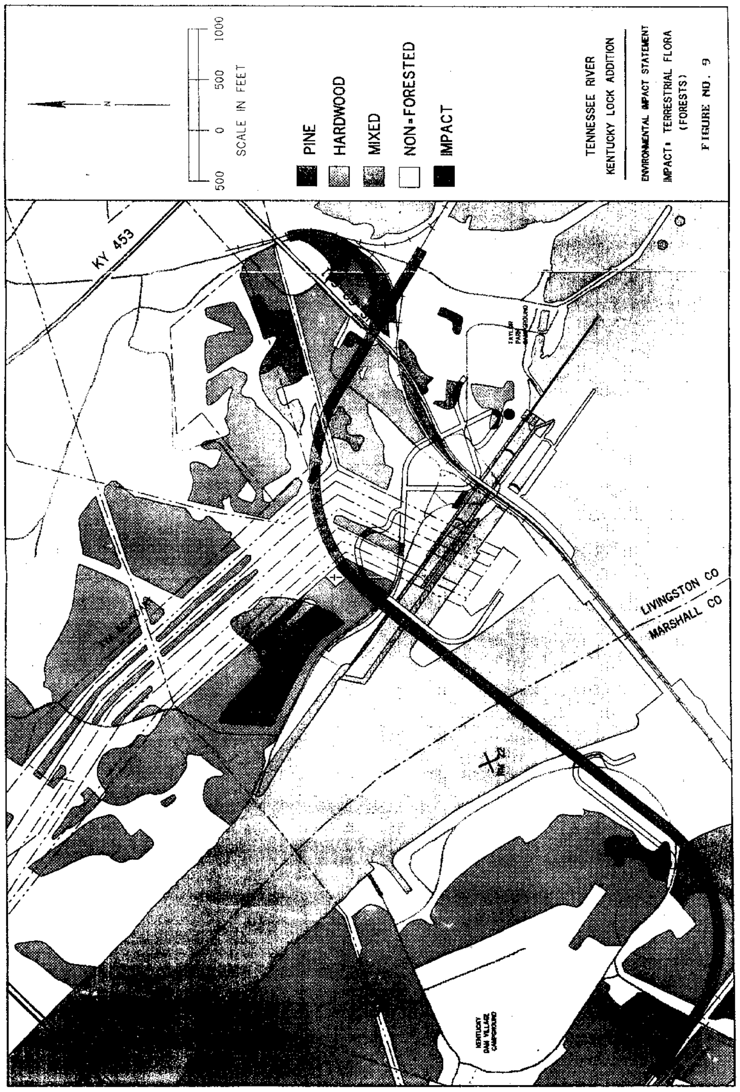
Indirect Impacts

4.61 Completion of the project will tend to encourage continued reliance upon the inland waterway system. Indirect impacts will be felt upon the natural and human environment as a result of this improvement, far beyond the immediate Kentucky-Barkley area. Industries, utilities, and other enterprises which consider water based transportation an important factor in growth and investment would be expected to take advantage of the improved transportation system provided by the project. Obvious indirect impacts on the environment would include port developments and growth in municipalities with strong dependency upon commercially navigable waterways. Industries which produce bulk products (grains, minerals, chemicals) would be expected to benefit from the project and expansion of these enterprises would impact the natural and human environment.

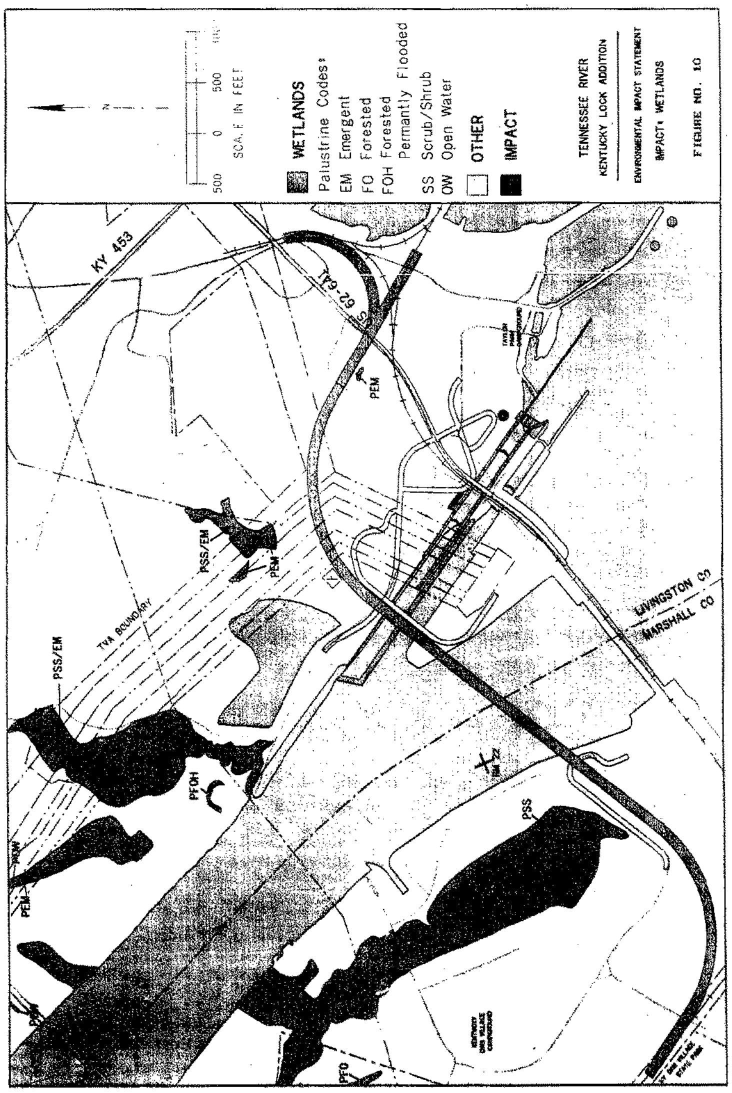
Energy Requirements and Conservation Potential

4.62 Construction of the project would require consumption of some nonrenewable resources; natural, economic, and human. Building materials, federal construction dollars, and labor would be required. Once these resources were committed to the project, they would no longer be available for other projects or purposes. Energy costs would come primarily from consumption of fuel for equipment to perform the work.

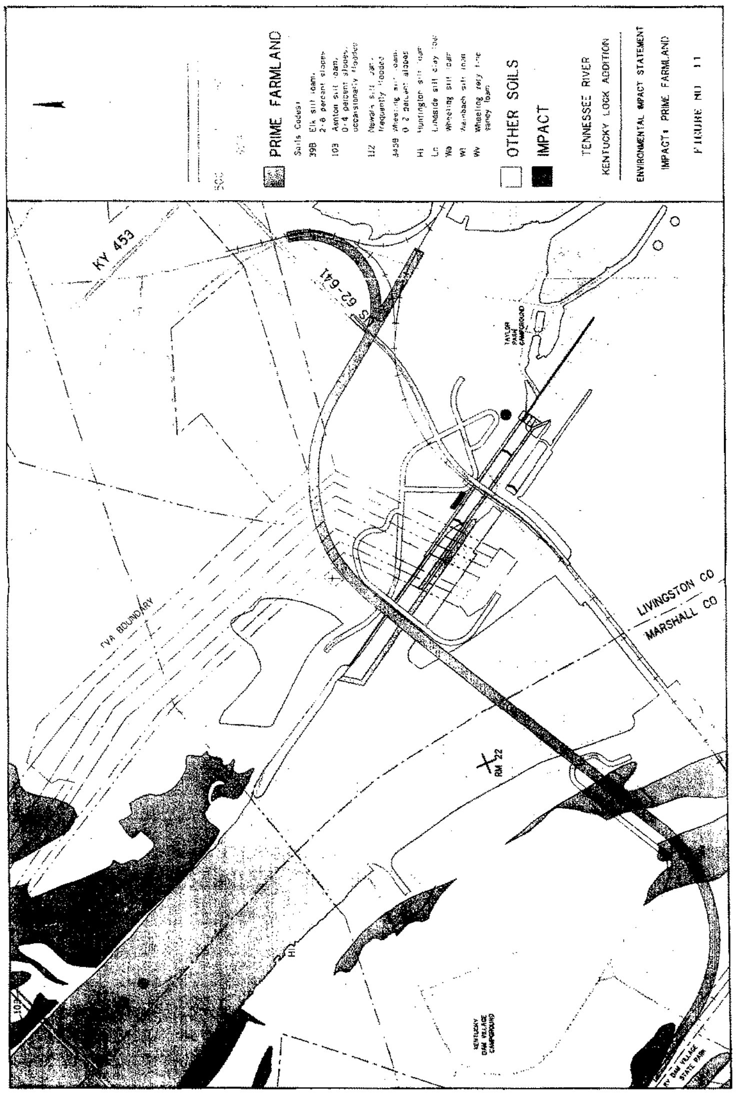
4.63 The completed lock project would require additional, committment of energy and materials for the life of the project in order to maintain its operational status and deliver expected service. Addition of a second lock chamber at the Kentucky project would encourage continued reliance and movement by shippers of suitable cargoes on the inland waterway system. Availability of improved navigation facilities on the Kentucky-Barkley Navigation System would tend to discourage shippers from using overland transportation means with poorer energy efficiencies.

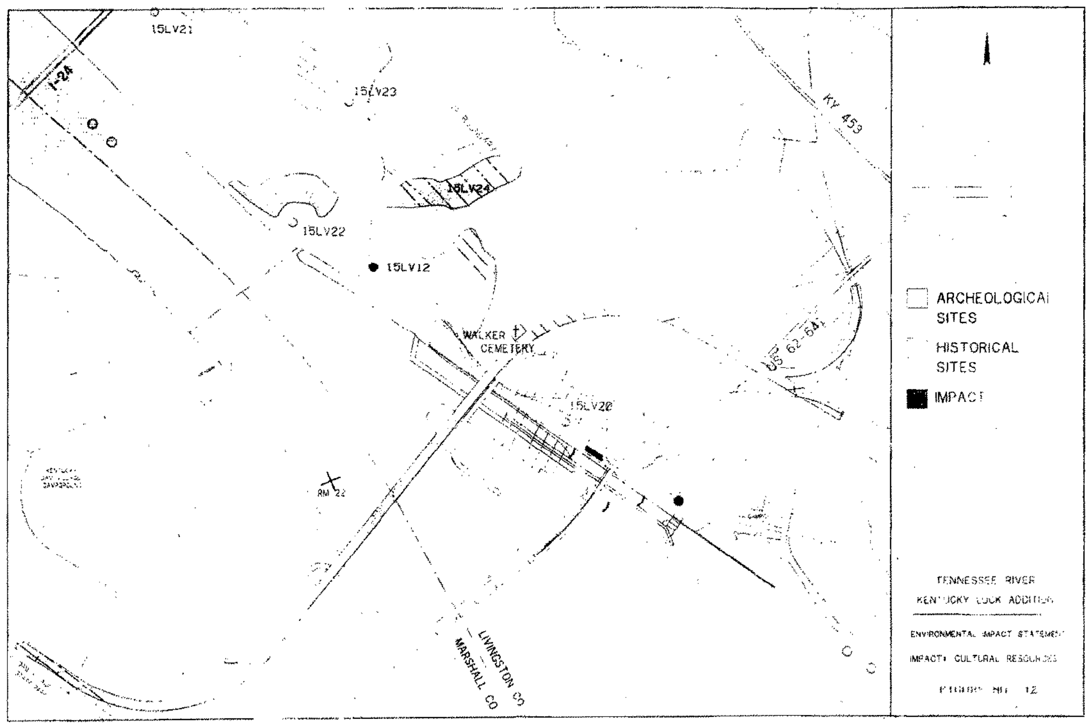


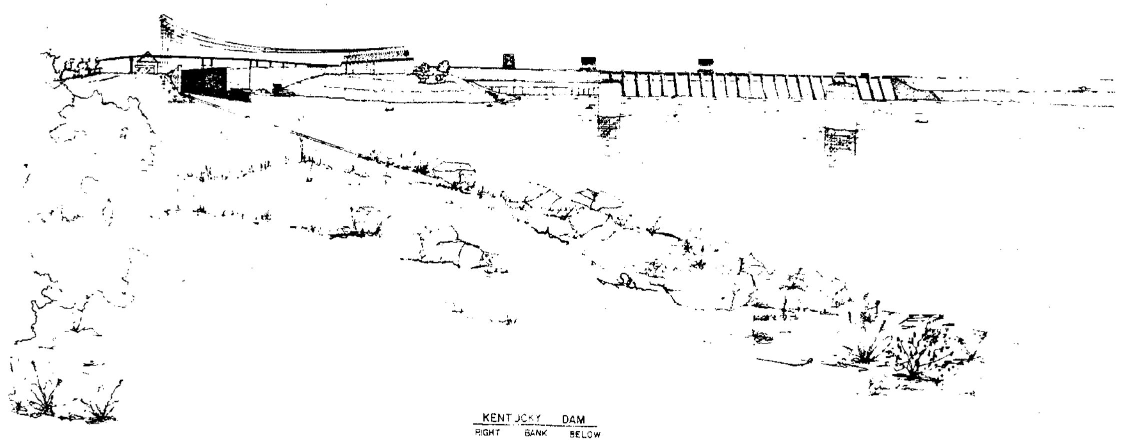
N
500 0 500 1000
SCALE IN FEET
PINE
HARDWOOD
MIXED
NON-FORESTED
IMPACT
TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
IMPACT: TERRESTRIAL FLORA
(FORESTS)
FIGURE NO. 9
KY 453
LIVINGSTON CO
MARSHALL CO



SCALE IN FEET
500
0
500
WETLANDS
Palustrine Codes:
EM Emergent
FO Forested
FOH Forested Permantly Flooded
SS Scrub/Shrub
OW Open Water
OTHER
IMPACT
TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
IMPACT: WETLANDS
FIGURE NO. 10
KY 453
US 62-641
PEM
PSS/EM
TVA BOUNDARY
PFOH
PSS
LIVINGSTON CO
MARSHALL CO
PFO

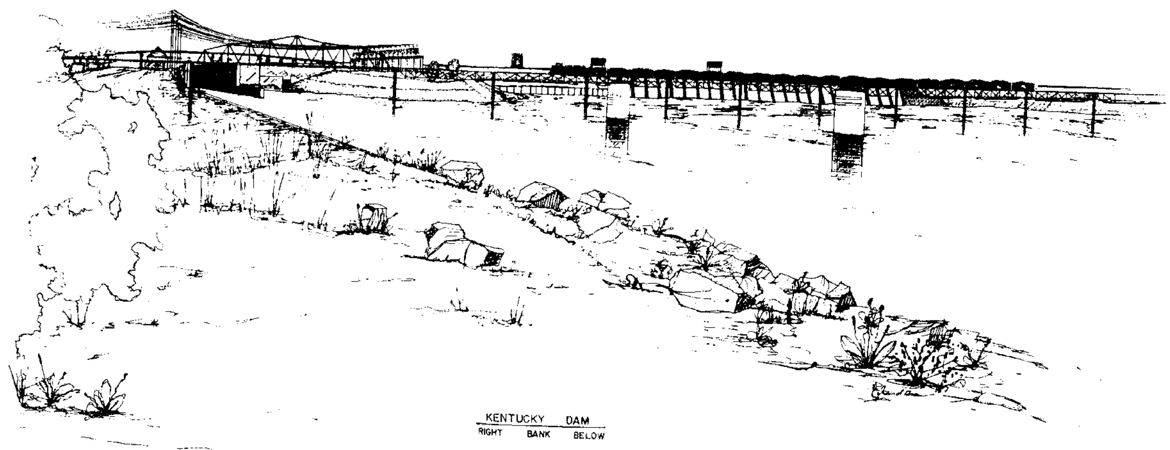

PRIME FARMLAND
Soils Codes:
39B Elk silt loam, 2-8 percent slopes
103 Ashton silt loam, 0-4 percent slopes, occasionally flooded
Hi Huntington silt loam
Wa Wheeling silt loam
OTHER SOILS
IMPACT
TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
IMPACT: PRIME FARMLAND
FIGURE NO 11
KY 453
US 62-641
TVA BOUNDARY
LIVINGSTON CO
MARSHALL CO
RM 22


15LV21
I-24
15LV23
15LV24
15LV22
15LV12
KY 453
US 62-641
WALKER CEMETERY
15LV20
RM 22
LIVINGSTON CO
MARSHALL CO
ARCHEOLOGICAL SITES
HISTORICAL SITES
IMPACT
TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
IMPACT: CULTURAL RESOURCES



TENNESSEE RIVER
KENTUCKY LOCK AND DAM
VIEW FROM DOWNSTREAM

FIGURE NO. 13



TENNESSEE RIVER
KENTUCKY LOCK AND DAM
VIEW FROM DOWNSTREAM
(WITH P & L RAILROAD)

FIGURE NO. 14

5. LIST OF PREPARERS

5.01 The following people were primary contributors or preparers for this Environmental Impact Statement:

Name	Expertise	Experience	Role in EIS Preparation
Mr. Richard Tippit	Biologist	16 years, Nashville District COE	EIS Manager and Main Author
Mr. Robert Karwedsky	Archeologist	12 years, Nashville District COE	Cultural Resources Analysis
Mr. Cliff Reinert	Landscape Architect	29 years, Nashville District COE	Recreation Design and Analysis
Mr. Joe Morrison	Landscape Architect	20 years A/E Firms, 3 years Nashville District COE	Recreation Design and Analysis, HTW Assmt.
Mr. Doug Webb	Chemist	20 years Nashville District COE	HTW Assmt.
Ms. Patricia L. Coffey	Biologist	9 years, Nashville District COE	404(b)(1) Evaluation
Mr. C. Tom Swor	Fisheries Biologist	18 years, TVA and Nashville District COE	Fisheries Analysis
Ms. Susan Neff	Landscape Architect	15 years, Nashville District COE	Project Manager
Ms. Sue Ferguson	Civil Engr.	13 years, Nashville District COE	Study Manager
Mr. David Gengozian	Environmental Health	16 years, TVA Environmental	Cooperating Agency POC
Mr. Harold Sansing	Biologist	31 years, State of Tenn. and Nashville District COE	Environ-mental Design

Name	Expertise	Experience	Role in EIS Preparation
Mr. Bryan Deem	Geographer	11 years, USAF and Nashville District COE	G.I.S. Analysis
Mr. Robert Pryor	Water Resources	18 years, TVA Environmental	Environ-mental Rev.
Mr. Roy J. Teal	Surveying Engineering	12 years, Alabama Power and TVA	G.I.S. Analysis
Mr. George Conner	Navigation Planning	25 years, TVA	Navigation Issues
Dr. Andrew Miller	Research Limnologist	11 years, WES	T&E Species Analysis
Dr. Barry S. Payne	Research Biologist	12 years, WES	T&E Species Analysis
Dr. Michael J. Harvey	Vertebrate Ecologist	31 years Academia	T&E Species Consultant
Dr. O. Ray Jordan	Vert. Natural History	29 years Academia	T&E Species Consultant
Mr. Glyn DuVall	Archeologist	16 years Consulting	Cultural Resources Consultant

6. PUBLIC INVOLVEMENT

Public Involvement Program

6.01 Extensive coordination with Government agencies, elected officials, representatives of the towing and waterway industry, and the public has occurred during the study effort. A scoping letter dated May 24, 1984 was mailed to interested parties (Exhibit 1). These included various federal, state, and local agencies and offices, navigation interests, elected officials, and the general public. A Notice of Intent to Prepare an Environmental Impact Statement was published in the Federal Register (Vol. 49, No. 170) on August 30, 1984 (Exhibit 2).

6.02 Much earlier during the study process a public meeting was held at Kentucky Dam Village State Park near the project site on January 09, 1975. This meeting gave formal notice that the Nashville District had been directed by Congress to investigate navigation conditions on the Tennessee and Cumberland Rivers, generally below Barkley Canal, and to recommend solutions to navigation problems. Another meeting on November 22, 1976 was held to discuss landowner concerns about bank erosion and high water problems on the lower Cumberland River.

6.03 In April 1983 a meeting was held in Nashville with representatives of the shipping and towing industry, representatives of the Tennessee-Cumberland System Waterways Association, US Coast Guard, Corps of Engineers, and Tennessee Valley Authority. A similar meeting was held in November 1983 with members of the Tennessee-Cumberland Waterways Council.

6.04 Individual interviews with six towing companies were conducted in January 1985. The effort was undertaken to get estimates of the delay time a Kentucky Lock that results in companies diverting to the lower Cumberland River.

6.05 A public meeting was held on June 19,1991 following release of the draft Feasibility Report which contained the draft EIS. Approximately 100 people attended the meeting held at Kentucky Dam Village State Park. Release of the draft Feasibility Report and the public meeting generated agency, industry, and public response in the form of letters and written comments summarized below:

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Affairs
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

July 18, 1991

RECEIVED JUL 22 1991

ER-91/570

Colonel James P. King
District Engineer, U.S. Army
Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Colonel King:

We have reviewed the Lower Cumberland and Tennessee Rivers Feasibility Study, Kentucky Lock Addition, Livingston and Marshall Counties, Kentucky, and have the following comments.

General Comments

For the most part, the draft environmental impact statement adequately describes the existing fish and wildlife resources present in the project area and addresses construction impacts to those resources. In addition, the Corps of Engineers (Corps) has planned the project to avoid adverse impacts to valuable fish, wildlife, and wetland resources. However, the Fish and Wildlife Service (Service) is concerned about the lack of information regarding several portions of the project that could have significant adverse impacts on aquatic resources in the project impact area.

1. Minerals found and produced in the general region include coal, clay, limestone, zinc, sand and gravel. During 1986, 34,324,000 tons of commodities were transported through the Kentucky-Barkley transportation system. Of that amount 25,458,000 tons (74%) were mineral products. Minerals likely to be adversely affected by the proposed project might be sand and gravel underlying the construction site and petroleum and gas pipelines in the vicinity that are recognized and referred to in the document. We see substantial beneficial impact and no significant adverse impacts to mineral resources and/or mineral-production facilities resulting from the proposed project.

RESPONSE

Letter From: United States Department of the Interior
Fish and Wildlife Service
July 18, 1991

Comment	Response
1.	Project construction impacts on local mineral resources will be inconsequential. Limestone rock excavated from the lock pit will be used for environmentally beneficial purposes such as bank armoring and aquatic habitat improvement. Gravel dredged from the riverbed will be used to create or enhance aquatic habitat at a downstream location. No other mineral resources will be impacted.

Specific Comments - Draft Environmental Impact Statement

2. Paragraph 2.21 - The Corps conducted a survey of the Tennessee River tailwater to determine if endangered mussels occurred in the project area. The river in the vicinity of the proposed railroad bridge relocation was surveyed by a crew of divers. However, the draft impact statement does not include results of that portion of the survey. If mussels occur in that reach of the river, construction of the railroad bridge could have significant effects on a number of mussel species. The final statement should address bridge construction impacts, if any, to freshwater mussel resources.

3. Paragraph 2.28 - Construction of a training dike along the left side of the proposed new navigation channel could impact a significant mussel bed situated adjacent to the right bank. This bed contains high quality habitat and is presently known to support up to 36 species of mussels, including at least two Federally listed endangered species. The degree of impact from construction would be directly related to the length of the dike. The Corps should initiate detailed studies to assess the impacts to aquatic resources, particularly those existing along the right side of the river. Results of these studies should be included in the final impact statement.

4. Paragraph 4.25 - The draft impact statement indicates that approximately 2.6 acres of wetlands were recently discovered within the project area. These wetlands are located in the Russell Creek drainage and the adjacent area proposed for the borrow/disposal site. These wetlands were not previously known to exist. In addition, the document does not address specific mitigation for the loss of 0.6 acres of wetland from construction of an access road to the borrow/disposal area across Russell Creek. The final statement should address all impacts to wetlands, including those discovered recently, and should contain specific plans for mitigation for all unavoidable losses.

5. Paragraph 4.51 - In its supplemental draft Coordination Act report, the Service recommended that the selected construction plan include rehabilitation of the boat launching ramp on the left side of the river and enhancement of recreational bank fish opportunities below the dam. The draft document states that the boat launching ramp on the right side will be replaced in-kind at an appropriate location along the right bank. The left bank facility would be upgraded if a location could not be found for the right bank ramp. The final

RESPONSE

Letter From: United States Department of the Interior
Fish and Wildlife Service
July 18, 1991

Comment	Response
2.	The survey for endangered mussels examined an earlier proposed railroad alignment crossing below Kentucky Dam. Since the survey, the railroad crossing has been moved upstream to the alignment noted in the draft report. This alignment has not been surveyed for mussels. We anticipate encountering mussels on the proposed alignment and will relocate mussels from bridge pier locations prior to construction of the bridge.
3.	A tailwater training dike remains under consideration as part of the project. Hydraulic modeling of a tailwater dike will be conducted during the design phase of the project to determine the efficacy of this feature. Results of the modeling will also be used to determine impacts on resident mussel populations and other biological resources. Environmental impacts of a dike and plans to mitigate adverse effects will be developed at the appropriate time as part of project NEPA compliance.
4.	The 2.6 acres of recently discovered wetlands have been field surveyed and determined not to meet established wetland criteria. The area originally proposed for borrow and disposal has been completely deleted from project plans. A new borrow and disposal area has been selected in an upland site about one mile north of Kentucky Lock and Dam, adjacent to Kentucky Highway 453 in Livingston County. Deletion of the original borrow and disposal area negates the need for a haul road across Russell Creek, thus eliminating impact to 0.6 acres of wetlands along Russell Creek. The sum of these changes is to eliminate all wetlands impacts from the project.

5. environmental impact statement should contain more specific plans describing what recreational upgrading and/or enhancement will be conducted.

Thank you for the opportunity to comment on this study.

Sincerely,

James H. Lee

James H. Lee
Regional Environmental Officer

RESPONSE

Letter From: United States Department of the Interior
Fish and Wildlife Service
July 18, 1991

Comment	Response
5.	More specific plans for recreational enhancement have been developed and are included in the final EIS. The loss of the right bank boat ramp will be mitigated by a significant upgrading of the existing left bank boat ramp and provision of associated visitor amenities.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET N.E.
ATLANTA, GEORGIA 30365

JUL 11 1991

R.J. Conner, P.E.
Chief, Engineering Division
Department of the Army
Nashville District, Corps of Engineers
P.O. Box 1070
Nashville, TN 37202-1070

Attn: Ms Sue Ferguson

Subject: Draft Environmental Impact Statement (EIS) for the Kentucky Lock Addition, Lower Cumberland and Tennessee Rivers

Dear Mr. Conner:

Pursuant to Section 309 of the Clean Air Act and Section 102 (2)(C) of the National Environmental Policy Act, EPA, Region IV has reviewed the above referenced document. The major environmental impacts of the preferred alternative (and in fact all structural options) revolve around the construction of a new lock and attendant facilities at the existing Kentucky Lock and Dam site. The new 1200-foot lock will require moving the P&L Railroad onto a new bridge about 0.3 miles downstream of the dam. Portions of US Highway 62/641 across the locks will be raised.

1. Environmental impacts of this action include immediate destruction of portions of the mussel bed adjacent to the existing right margin of the navigation channel. The significance of this loss is magnified since the bed contains individuals of at least two federally endangered species. Mitigation of what is deemed to be an unavoidable impact will be accomplished via creation of replacement habitat downstream. Monitoring will be accomplished after construction to determine the effectiveness of this mitigation.

The text details the careful planning which has already been accomplished by the principals to protect the mussel populations. Nonetheless, in addition to the direct construction impacts the operational effects of the new lock could also affect the downstream mussel beds. We suggest that the initial monitoring be continued (and expanded as necessary) to determine the actual extent/consequence of these "subtle changes in hydraulic conditions" attendant to the new lock's operation on these endangered species. Unfortunately, if

RESPONSE

Letter From: United States Environmental Protection Agency
Region IV
July 11, 1991

Comment	Response
1.	No response necessary.

1. continued recruitment and growth of mussels is adversely affected by lock operation, it is conjectural what mitigation could be done short of relocation of the bed onto new fabricated habitat.

2. In conversations with representatives of the U.S. Fish and Wildlife Service we learned that the proposed training dike will pose significant, adverse impacts to the mussel populations. It was noted in the text that this structure would alter long established flow patterns in the immediate tailwater area while reducing water velocities along the left shoreline. However, the real implications of these changes is left somewhat nebulous by merely indicating that populations and communities would redistribute themselves according to species tolerances to the new flow regime. This is true, but it overlooks the fact that for certain organisms death is the manner by which this redistribution will be accomplished. We agree with the decision that the precise impacts of this training dike be enumerated via the Section 7 consultation process. This information should be made available in the final EIS.

Approximately five acres of various wetland types will be directly impacted/removed for different construction purposes. It appears that a good faith effort was made to minimize these losses, but some mitigation will be necessary to provide functional equivalency. The text indicates that this matter will be resolved, and indicates that mitigation will be accomplished by planting appropriate wetland species and monitoring to determine success. Since there will not be an individual public notice for this action, it would be helpful if the final EIS contained the specifics regarding the location(s), species used, monitoring, etc. for the mitigation effort.

4. Similarly, we were pleased to note that the 25 acres of hardwood habitat which will also be cleared during project construction will be restored. At least, an overview of the comprehensive site and management plan noted in the EIS (p.68) should be put in the final EIS. It has been our experience that there is great variability in the effectiveness of different contractors in both initial construction and maintenance of "Best Management Practices" to control erosion and sedimentation. For EPA projects we have come to the conclusion that stringent penalties for non-performance and recurrent monitoring are the most effective means to address this situation.

On the basis of our review a rating of EC-2 was assigned. That

RESPONSE

Letter From: United States Environmental Protection Agency
Region IV
July 11, 1991

Comment	Response
1. continued	See above.
2.	See comment 3, response to U.S. Fish and Wildlife Service.
3.	See comment 4, response to U.S. Fish and Wildlife Service.
4.	Further detail of the comprehensive site and management plan is included in the final EIS.

5 is, we have a degree of environmental concern regarding the immediate, potential loss of at least two species of endangered mussels due to direct construction activities and subsequent losses resulting from indirect causes attendant to operating the new lock. Additional information is requested in the final EIS on this and a number of other issues (wetland mitigation).

If we can be of further assistance regarding this project, please contact Dr. Gerald Miller of my staff at 404-347-3776.

Sincerely yours,

Heinz J. Mueller
Chief, Environmental Policy Section
Federal Activities Branch

RESPONSE

Letter From: United States Environmental Protection Agency
Region IV
July 11, 1991

Comment	Response
5.	Additional information is provided in the final EIS on issues of concern.

CARL H. BRADLEY
SECRETARY

WALLACE G. WILKINSON
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
FRANKFORT OFFICE PARK
18 REILLY ROAD
FRANKFORT, KENTUCKY 40601

RECEIVED JUL 24 1991

July 18, 1991

Colonel James P. King
District Engineer
U.S. Army Engineer District, Nashville
P.O. Box 1070
Nashville, Tennessee 37202-1070

RE: Draft Environmental Impact Statement for the Lower Cumberland and Tennessee Rivers Navigation Feasibility Study - Kentucky Lock Addition

Dear Colonel King:

The Natural Resources and Environmental Protection Cabinet (NREPC) serves as the state clearinghouse for review of environmental documents generated pursuant to the National Environmental Policy Act. The Commissioner's Office in the Department for Environmental Protection in NREPC coordinates the review process.

1. The above referenced document was reviewed by the agencies on the attached list. Comments were received from six of these agencies. The Division of Waste Management has several questions about the two disposal areas shown in the plans - a borrow/disposal area and an aquatic disposal area. The Division would like to know what types of materials will be disposed in these areas and the duration of disposal, whether temporary or permanent in order to determine if a permit or permit-by-rule will be required from the Division for these disposal areas. Enclosed are comments from the other five agencies for your review and consideration.

If you have any questions, please contact me at 502-564-2150 or at the letterhead address.

Sincerely,

Valerie A. Hudson

Valerie A. Hudson, P.E.
Deputy Commissioner for Special Projects

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
July 18, 1991

Comment	Response
1.	The upland disposal site will receive only excavated rock and overburden from the construction site. The aquatic disposal site will receive only clean river sediments, gravel, cobble, and sand, generated by dredging to widen the lower approach to the new lock. Placement of these materials in the upland and aquatic disposal sites would be permanent.

2\.

The following State agencies were given the opportunity to review the Draft Environmental Impact Statement for the Lower Cumberland and Tennessee Rivers Navigation Feasibility Study - Kentucky Lock Addition:

1. Natural Resources and Environmental Protection Cabinet
   - a. Division of Water
   - b. Division of Waste Management
   - c. Division for Air Quality
   - d. Division of Conservation
   - e. Division of Forestry
   - f. Nature Preserves Commission
2. Department of Fish and Wildlife Resources
3. Kentucky Heritage Council/The State Historic Preservation Office
4. State Archaeologist, University of Kentucky
5. Transportation Cabinet

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
July 18, 1991

Comment	Response
2.	No response necessary.

CARL H. BRADLEY
SECRETARY

WALLACE G. WILKINSON
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

MEMORANDUM

TO: Valerie A. Hudson
State Environmental Review Officer
Office of the Commissioner

FROM: Timothy Kuryla TC
EIS Coordinator
Division of Water

DATE: July 17, 1991

1. RE: DEIS and MRIS, Additional Lock at Kentucky Dam, Tennessee River (Livingston County), EIS 91-19

Attached are the Division of Water comments on the Draft Environmental Impact Statement and Main Report Interim Study regarding an additional lock at Kentucky Dam on the Tennessee River (Livingston County).

cc: Sam Call, Ecological Support Section
Jeff Pratt, Floodplain Management Section
Jeff Grubbs, Ecological Support Section
William Schneider, Nonpoint Source Pollution Section

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
Division of Water July 17, 1991

Comment	Response
1.	No response necessary.

NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET

ENVIRONMENTAL REVIEW

Division of Water **Project Number:** 91-19

Project Title: DEIS & MRIS, Additional Lock at Kentucky Dam, Tennessee River (Livingston County)

The Division of Water has reviewed this Draft Environmental Impact Statement and Main Report Interim Study. The Division's comments address floodplain construction, construction practices, and aquatic habitat.

FLOODPLAIN CONSTRUCTION

2\. **ALTERNATIVES**

2.34 Selected Plan **Page EIS-15**

2\. The Division of Water desires to review preliminary construction plans and schedules in order to:

- Assure flood control operations will not be affected during construction, and

3\.
- Evaluate the methods and extent of excavation of existing embankments.

4\. Although this is a Corps of Engineers project, and, therefore, not under Division of Water floodplain purview, the Division asks that no dredged material be placed immediately adjoining the stream in a configuration such as a dike or levee. The Division recommends a nonfloodplain disposal site. If a floodplain site must be used, the Division recommends the material be spread in a thin layer, or otherwise in a manner not to alter normal hydraulic conditions.

CONSTRUCTION PRACTICES

4\. **ENVIRONMENTAL CONSEQUENCES**

4.04 to 4.10 Plans A, B, and C **Pages EIS-41 and EIS-43**

5\. The Division of Water recommends that the outlined U.S. Fish and Wildlife Service mitigation and protection measures (see 9.27, pages MRIS-105 to MRIS-107) be strictly followed. Those best management practices (BMPs) will control stormwater runoff and sediment damage to water quality and aquatic habitat.

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
Division of Water July 17, 1991

Comment	Response
2.	At the time the plans and specifications are prepared, the Nashville District will coordinate them with all interested agencies including the Kentucky Division of Water and Kentucky Department of Fish and Wildlife Resources. Flood control operations will receive full consideration during planning, engineering, and design of the lock addition project.
3.	Bank excavation will be performed under both wet and dry conditions. The resulting reshaped banks will be permanently protected from erosion by riprap.
4.	Up to 170,000 cubic yards of rock may be used to create a training dike adjacent to the left channel margin in the tailwater. Any training dike would be modeled extensively to determine its hydraulic effect on tailwater water surface elevations. The disposal site is located in an upland area about one mile north of Kentucky Lock and Dam in Livingston County, Kentucky. Material placed in the site will be spread to avoid impacting the floodplain of the Tennessee River or nearby Russell Creek.
5.	Recommended mitigation, protection measures and applicable BMP's will be followed to minimize environmental impact of construction activities.

AQUATIC HABITAT

4. ENVIRONMENTAL CONSEQUENCES — Pages EIS-41 to EIS-51

6. 4. The Division of Water desires the present low flow through Kentucky Dam be maintained during lock construction. This would insure that downstream water quality standards for the wastewater discharges in the Calvert City area, 5 to 7.3 river miles downstream from Kentucky Dam (Tennessee River RM 22.4), will be met.

3. AFFECTED ENVIRONMENT

3.07 Water Quality — Page EIS-19

3.19 to 3.27
Quatic Biota--Lower Tennessee River Pages EIS-22 to EIS-24

4. ENVIRONMENTAL CONSEQUENCES

4.11 TO 4.16 Aquatic Biota — Pages EIS-43 and EIS-44

The DEIS states several times that there are few mussels in the affected area and no endangered species. In support, studies are cited in which a large number of mussels were collected without finding any of the federally listed threatened and endangered species (50 CFR Pt.17). But, species are on the federal list because they are rare.

The Division of Water notes from Kentucky Dam (Tennessee River Mile 22.4) downstream (to RM 17.8) is a U.S. Fish and Wildlife Service mussel sanctuary. The sanctuary is the habitat of the following threatened and endangered species:

7. FEDERAL ENDANGERED

<u>Cyprogenia stegaria</u>
<u>Lampsilis orbiculata</u> (=<u>abrupta</u>)
<u>Plethobasis cooperianus</u> (=<u>striatus</u>)

STATE THREATENED

<u>Plethobasis cyphyus</u>

STATE ENDANGERED

<u>Obovaria retusa</u>
<u>Fusconaia subrotunda</u>
<u>Quadrula cylindrica</u>

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
Division of Water July 17, 1991

Comment	Response
6.	Environmental Consequences--Present low flows will be maintained through Kentucky Dam.
7.	The draft EIS states mussels are common to abundant in the affected area. The draft EIS stressed that individuals of federally endangered species, if they occur at all in the immediate tailwater area affected by project features, are present only as isolated, scattered individuals. Mussels will be removed from all impact sites, i.e. dredge area, cofferdam area, and bridge pier placement points, prior to construction. Mussels will be relocated to other unaffected areas of the sanctuary. The upland disposal site has been relocated and is no longer in the floodplain of the Tennessee River. Runoff from the borrow and disposal area will be contained to prevent entry into the Tennessee River.

The presence of the above listed species indicates high water quality. This Tennessee River area meets Division of Water criteria for classification as an outstanding resource water (see 401 KAR 5:031, Section 7).

7. The proposed lock and dredge work affects part of the mussel sanctuary. Also, the proposed borrow and disposal area appears from Figure 1 (page EIS-16) to be near, if not in, the floodplain above the mussel sanctuary by RM 21.2 of the Tennessee River.

The Division of Water is concerned about the above listed mussels. The Division requests the mussels be moved, before construction, to unaffected areas of the sanctuary. The Division suggests the Tennessee Valley Authority, an entity familiar with mussel relocating, do the moving. Regarding the borrow and disposal area, care must be taken to insure the borrowed and disposed materials do not reach the mussel beds.

The above stated concerns will be raised in the Division of Water responses to the:

- Corps of Engineers Public Notice.
- Corps of Engineers Request for Water Quality Certification.

Timothy Kuryla — EIS Coordinator, Division of Water — 07/17/91 Date

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
Division of Water July 17, 1991

Comment	Response
7.	See above. continued

Milo D. Bryant
Secretary
and
Commissioner of Highways

COMMONWEALTH OF KENTUCKY
TRANSPORTATION CABINET
FRANKFORT, KENTUCKY 40622

Wallace G. Wilkinson
Governor

July 11, 1991

Ms. Valerie Hudson
Commissioner's Office
Department for Environmental Protection
Natural Resources and Environmental
Protection Cabinet
18 Reilly Road
Frankfort, Kentucky 40601

Dear Ms. Hudson:

Thank you for the opportunity to comment on Public Notice 91-13, the Interim Feasibility Study for a lock addition on the lower Tennessee River. Impacts on highway transportation systems in the vicinity of the project appear to be minimal and the Environmental Impact Statement appears to adequately address environmental concerns. At this time we have no further comment.

Thank you again for this opportunity.

Sincerely yours,

D. W. Lambert, REP, CEP, LA, Director
Division of Environmental Analysis

RDD/DD

cc: D. E. Smith
R. D. Dutton

RESPONSE

Letter From: Commonwealth of Kentucky
Transportation Cabinet
July 11, 1991

Comment	Response
1.	No response necessary.

Commonwealth of Kentucky

Phone (502) 564-3400

Department of Fish & Wildlife Resources

Don R. McCormick, Commissioner

July 12, 1991

Colonel James P. King
District Engineer
Nashville District Corps of Engineers
P.O. Box 1070
Nashville, TN 37202-1070

RE: Lower Cumberland and Tennessee Rivers
Interim Feasibility Study, Kentucky Lock
Addition, Volume 1, Main Report and
Environmental Impact Statement.

Dear Colonel King:

The Kentucky Department of Fish and Wildlife Resources (KDFWR) has previously submitted comments on the above-referenced project through the Natural Resources and Environmental Protection Cabinet Clearinghouse. That letter discussed KDFWR's concern for the impacts to the local aquatic resources and sportsmen opportunities. Some general recommendations were made in that letter that would help to offset those recommendations. The purpose of this letter is to better outline some of those proposals that would help to mitigate those impacts.

1. As we have stated before in previous correspondence, the Kentucky Dam tailwater is a valuable fishing area. A creel survey of the Kentucky Dam tailwater conducted in the late 1970's found the fish harvested from that area was the highest from any waterbody in the Commonwealth of Kentucky. In fact, it was estimated that more fish were taken from this tailwater than was harvested from Kentucky and Barkley lakes and Barkley Dam tailwater combined. It was also estimated, at that time, that an average of 1.2 million man-hours of fishing was exerted on this tailwater fishery every year. Since that time, an excellent trophy striper fishery has become established in the tailwater which has resulted in even greater fishing pressure on this area and a resultant increase in the amount of fish taken from the tailwaters. It is not an uncommon site to see the area below Kentucky Dam filled with people fishing from either the bank or boats for a variety of species of fish.

RESPONSE

Letter From: Commonwealth of Kentucky
Department of Fish and Wildlife Resources
July 12, 1991

Comment	Response
1.	No response necessary.

1\. The Kentucky Dam tailwaters is also home to a diverse assemblage of freshwater mussels, some of which are federally endangered. The tailwater from Kentucky Dam downstream to Tennessee River mile 17.8 has been designated by KDFWR as a mussel sanctuary where the taking of mussels is prohibited. Studies by a variety of institutions and agencies have documented the significance of this area. In fact, Dr. James B. Sickle of Murray State University indicates this area may be one of the most significant mussel resources in the country due to the various species of mussel found and may be the only reason there is a commercial mussel fishery below this site.

As you can see, KDFWR is very concerned about this area due to its value ecologically and recreationally. We provided some general recommendations in our earlier letter as to how some of the impacts from this project could be mitigated. We would like, at this time, to provide some specific comments for changes in the plan that would offset fishing, access, and recreational losses. We have included a copy of one of the maps from the Environmental Impact Statement with our recommendations drawn in.

2\. In order to offset the loss of fishing opportunity in the tailwater area during construction of the new lock and railroad bridge, KDFWR recommends that a small rip-rap training wall with culverts be constructed at the end of the transformer peninsula. Rip-rap should also be placed on top of and behind the old railroad bridge piers below the dam and around and behind the new railroad fishing piers. A fishing pier above the dam at Taylor Park near the new upper guidewall would also increase fish usage of the dam area. Additional stairs and horizontal walkways along the west bank of the tailwater would make this area more accessible to more fishermen. These walkways should be designed so that handicapped individuals could access the excellent fishing opportunities (this is not capable presently). These walkways will also provide viewing opportunities to bird watchers who come to this area during the winter to view the diversity of gulls that winter at this site.

The boat launching facility on the west bank should be upgraded and expanded to offset the loss of similar facilities on the east bank. Not only should the ramp and parking facilities be expanded but restrooms and picnic areas should also be included since a similar facility will be lost on the right bank. A new current deflector would also be needed to provide a safe launching area for recreational users and this facility could also double as a fishing area if a walkway is provide.

We believe that fishermen access should be provided to the rip-rap area on the east bank (already proposed by your agency for bank stabilization) since this area should develop into an excellent fishing area. The haul road could be moved adjacent to the riverbank to provide access to the area and steps and walkways could be provide as safe routes of travel. Since part of the area will be used as a construction laydown area, part of it could be retained for parking following completion of the project.

RESPONSE

Letter From: Commonwealth of Kentucky
Department of Fish and Wildlife Resources
July 12, 1991

Comment	Response
1.	No response necessary.
2.	The Corps recognizes the importance of biological resources, particularly fisheries and mussels, in proximity to Kentucky Lock and Dam and has planned the lock addition to have minimal impact on these resources. Recommendations for environmental enhancement in this letter are under serious study by the Corps. We plan to use excess rock generated from construction of the lock for a variety of beneficial uses, including bank armoring and providing improved aquatic habitat. Access for bank fishermen will be improved on both banks. The loss of the right bank boat ramp will be mitigated by a major upgrading of the left bank boat ramp and provision of associated user facilities. See Figure 1 in the final EIS for details.

Finally, we would recommend that some of the excess rock material be placed along the west shore downstream of the proposed access area. This will help to stabilize that shoreline, which is in a state of dis-repair. This could help to protect the mussel sanctuary area and provide for additional fishery habitat.

2. We believe that all of the impacts from this project can be off-set with a minimal amount of effort since a majority of the material will be produced on-site. The key will be to incorporate these facilities into the early design phases of the project. Not only will the impacts be off-set, but a quality fishing and recreational experience will be maintained throughout the construction and operational phases of this project. This is important since the Kentucky Dam tailwaters is one of the premiere fishing areas in this region.

3. Members of my staff have been coordinating with members of your staff throughout this project and appreciate the cooperation of your staff members. KDFWR looks forward to continuing discussions on this project so that we may jointly protect this outstanding area and continue to provide the public with recreational opportunities.

If you or your staff should have any questions, please feel free to contact any of my staff members.

Again, I appreciate your cooperation on this project.

Sincerely,

Don R. McCormick
Commissioner

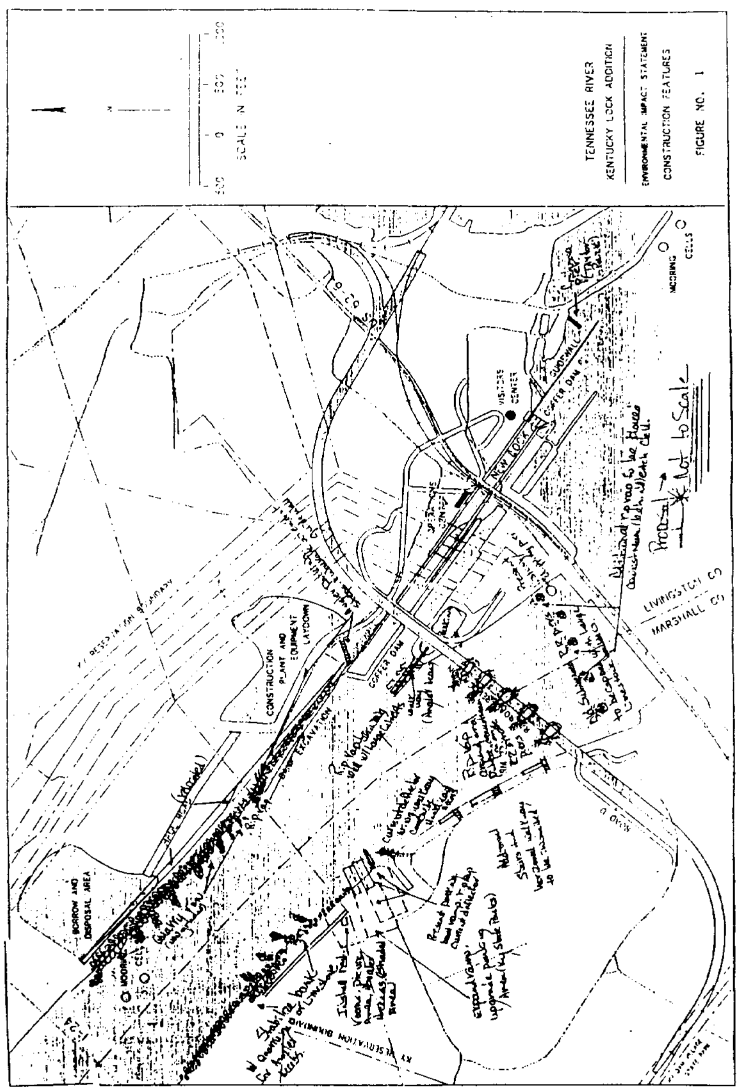
DRM/WLD/kh

cc: Peter W. Pfeiffer, Director, Division of Fisheries
Edwin F. Crowell, Asst. Director, Division of Fisheries
William N. McLemore, Western Fishery District Biologist
Lee Barclay, USFWS, Cookeville, TN
Valerie Hudson, Natural Resources and Environmental Protection Cabinet
Environmental Section Files

RESPONSE

Letter From: Commonwealth of Kentucky
Department of Fish and Wildlife Resources
July 12, 1991

Comment	Response
2. continued	See above.
3.	Early coordination and discussion of enhancement features has been initated between the Corps of Engineers and the KDFWR. Interagency coordination will continue through out the planning, engineering, design, construction, and operation phases of the project. The cooperation and input of Mr. Willian McLemore, KDFWR Western District Fisheries Biologist, and Mr. Wayne Davis, Biologist, KDFWR in developing suggested improvements for aquatic resources in the Kentucky Dam area is greatly appreciated.


TENNESSEE RIVER
KENTUCKY LOCK ADDITION
ENVIRONMENTAL IMPACT STATEMENT
CONSTRUCTION FEATURES
FIGURE NO. 1
SCALE IN FEET
BORROW AND DISPOSAL AREA
CONSTRUCTION PLANT AND EQUIPMENT LAYDOWN
VISITORS CENTER
NEW LOCK
COFFER DAM
LIVINGSTON CO
MARSHALL CO
MOORING CELLS

KENTUCKY HERITAGE COUNCIL
The State Historic Preservation Office

M E M O R A N D U M

TO: Valerie Hudson
Department for Environmental Protection

FROM: David Pollack
Staff Archaeologist

DATE: July 11, 1991

RE: Lower Cumberland and Tennessee Rivers: Interim Feasibility Study: Kentucky Lock Addition
Public Notice 91-19 and 91-71

1\. The Kentucky River Lock and Dam has been determined by the consensus of the Tennessee Valley Authority, the Corps of Engineers, and the Kentucky Heritage Council to be eligible for listing in the National Register of Historic Places and significant archaeological resources also have been identified in the project area. The Corps of Engineers has initiated consultation with the State Historic Preservation Officer to mitigate adverse effects to the Kentucky River Lock and archaeological resources eligible for listing in the National Register. This office looks forward to continuing to work with the Army Corps of Engineers on this project and to develop a Memorandum of Agreement that identifies all potential threats to significant historic properties, outlines how these properties will be treated, and stipulates how adverse effects to historic properties will be mitigated.

677 Comanche Trail
Frankfort, Kentucky 40601
Telephone
(502) 564-7005

25th
Anniversary
1966-1991

RESPONSE

Letter From: Kentucky Heritage Council
July 11, 1991

Comment	Response
1.	See Exhibit 5, final EIS, Memorandum of Agreement.

UNIVERSITY OF KENTUCKY

Anthropology

211 Lafferty Hall
Lexington, Kentucky 40506-0024

1\. It is the opinion of the Office of State Archaeology that a reconnaissance by a competent archaeologist will be required for the proposed reconstruction of the Kentucky Lock and Dam in Livingston and Marshall Counties. Our records show there are approximately five known sites within the area of construction. A survey is required for all portions of the project area which have not yet been disturbed by prior construction in order to comply with Federal guidelines established by the Advisory Council on Historic Preservation (36 CFR Pt. 800), Executive Order 11593 (16 USC 470 SUPP. k, 1971), and the Archaeological and Historic Preservation Act of 1974 (PUBLIC LAW 93-291).

A permit must be required for archaeological investigations on state, county or municipally owned land and can be obtained from the Office of STate Archeaology
Department of Anthropology
University of Kentucky
Lexington, KY 40506

in order to comply with KRS 164.720. In addition, any person who discovers an archaeological site or object of antiquity in the course of construction or otherwise shall report such discovery to the Office of STate Archaeology (606-257-5735) in order to comply with KRS 164.720.

RESPONSE

Letter From: University of Kentucky

Comment	Response
1.	A reconnaissance of the project site has been carried out and results are included in the final EIS.

TVA

Tennessee Valley Authority 400 West Summit Hill Drive, Knoxville, Tennessee 37902

JUL 22 1991

Colonel James P. King
District Engineer
Nashville District
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Colonel King:

LOWER CUMBERLAND AND TENNESSEE RIVERS, KENTUCKY LOCK ADDITION

1. In reference to your May 31 letter to W. F. Willis, enclosed are some comments of an environmental nature for your use. The May meeting referred to in your letter was most productive, and we appreciate the time and effort taken by your staff to address our earlier comments.

We understand additional borrow and spoil areas are being considered for the project. As discussed between David Gengozian of my staff and Richard Tippit of yours, we recommend our respective staffs have a site visit to review these areas.

If you have any questions, please call Mr. Gengozian at (615) 632-6666 in Knoxville.

Sincerely,

M. Paul Schmierbach, Manager
Environmental Quality

Enclosure
cc (Enclosure):
Mr. Richard Tippit
Nashville District
Corps Of Engineers
Department of the Army
P.O. Box 1070
Nashville, Tennessee 37202-1070

RESPONSE

Letter From: Tennessee Valley Authority
July 22, 1991

Comment	Response
1.	No response necessary.

Enclosure

2. A. Hazardous Waste

1. Volume 1, Page EIS-4, first complete paragraph - This paragraph should be rewritten as follows:

A review of the potential for encountering hazardous waste has been completed by the Tennessee Valley Authority (see Exhibit 4). Some materials (asbestos) in the existing lock operations building to be demolished are considered hazardous and will be handled appropriately. At this time, little likelihood exists of encountering other sources of hazardous waste on project lands.

2. In addition, Exhibit 4 should be revised as follows:

a. The title should be revised to: Hazardous Waste Environmental Baseline Study for Kentucky Lock Addition.

b. The first two sentences of the first paragraph should be revised as follows:

Data concerning potential for encountering sources of hazardous waste was requested from Tennessee Valley Authority. TVA consulted sources for this data and provided information by letter dated February 19, 1991 (Attachment 1), which indicated some potential exists for encountering hazardous waste at the project site.

c. In the second and third paragraphs, replace "HTRW" with hazardous waste.

d. Attachment 1, referenced in the first paragraph, was missing.

3. B. Water Quality

Volume 1, Page EIS-19, Section 3.08 - Because of drought conditions, turbidity measurements during 1986 were low (1-14 NTUs) and may not represent average or flood conditions.

4. C. Wetlands

Volume 1, Pages EIS-25 and EIS-45,-46 - Depending on the outcome of the July 16, 1991, site visit, additional input may be provided at a later date.

5. D. Prime Farmlands

Volume 1, Pages EIS-31 and EIS-48 - Depending on the outcome of the July 16, 1991, site visit, additional input may be provided at a later date.

RESPONSE

Letter From: Tennessee Valley Authority
July 22, 1991

Comment	Response
2.	A completely revised, fully documented HTRW preliminary assessment has been prepared by the Corps and is included as Appendix E, in the final EIS.
3.	No response necessary.
4.	See comment 4, response to Fish and Wildlife Service
5.	The data base for prime farmlands has been fully coordinated with TVA, and analysis of existing conditions and environmental consequences for prime farmlands is included in the final EIS.

E. Air Quality

6. Volume 1, Page EIS-34, Section 3.61 - Revise paragraph to indicate that both primary (health-protecting) and secondary (welfare-protecting) national ambient air quality standards (NAAQS) must be met, not just secondary NAAQS. Different averaging times have been used for primary and secondary NAAQS, so that it is possible to meet one while violating the other. Also, the NAAQS list should be revised: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide are the pollutants for which NAAQS currently exist.

F. Socioeconomics

7. 1. Volume 1, Page EIS-49, Section 4.44 - The information on the employment and payroll is helpful. We would conclude that there are no significant adverse impacts, but this should be stated. We suggest adding the following sentence:

"Given the large labor force of the impact area, virtually all of the employees would be found locally. The small number that might move into the area would not significantly increase needs for community facilities and services."

8. 2. Volume 1, Page EIS-50, Section 4.45 - There was discussion in the May review meeting that there are no businesses along the section of U.S. 62/641 to be bypassed by the detour; therefore, the extended closing would not cause business losses or closings. However, we failed to mention at the time that this should be documented.

9. Pages 94 and 95 of the Main Report discuss the economic costs to motorists from the detour. This information should be summarized in Section 4.45.

10. One final suggestion is that U.S. 62/641 should be rebuilt to accommodate foot and bicycle traffic for recreational enhancement.

G. Aesthetics

11 Volume 1, Page EIS-52, Section 4.59 - The Navigation Development staff is preparing a rendering of the new lock and relocated or adjusted bridges looking upstream from the I-24 bridge. The rendering should be ready in about two weeks and can be reduced in size to 11 by 17 inches for inclusion in the EIS if desirable. Then a phrase such as "(see Figure No. X)" could be added at the end of the next to last sentence in this section. This would give the reader a good indication of how the aesthetics of the existing site would be changed.

H. Recreation

12. 1. Volume 1, EIS-70, Section 6.09 - The facility improvements discussed for the left bank ramp area operated by the state of Kentucky would be a good addition. The existing TVA facilities on the downstream left bank (bank fishing, parking lots, walks,

RESPONSE

Letter From: Tennessee Valley Authority
July 22, 1991

Comment	Response
6.	Final EIS has been revised according to comment.
7.	Final EIS has been revised according to comment.
8.	Final EIS has been revised according to comment.
9.	Final EIS has been revised according to comment.
10.	The Corps will coordinate at the appropriate time with the Kentucky Department of Highways to ensure needs of bicyclists and pedestrians are considered in design of the new US 62/641.
11.	Final EIS has been revised to include artist renderings. See Figures 13 and 14.
12.	Appropriate facilities to serve user groups will be provided.

13 and toilet buildings) would need to be replaced since they serve different user groups. Furthermore, the spatial separation of these facilities makes sanitary facilities for this area a necessity.

13 2. <u>Volume 1, Appendix D (Environmental Component Plan), Pages 6-7</u> - The new lock approach wall and visitor center/roadway and parking relocations will adversely impact our present maintenance base and the Taylor Park campground on Kentucky Lake. The proposed changes will likely impact the aesthetic setting of Taylor Park as well as block the lake view for most of the campsites. Access to our maintenance base will likely be encumbered by both road relocations and the anticipated increased visitor traffic. In addition, the desired separation between our maintenance base and the general public will be reduced to an unacceptable level. Therefore, we recommend both Taylor Park campground and our maintenance base be relocated as part of the lock project to another site on the right bank. Relocation of Taylor Park to the right bank may present an opportunity to incorporate a launching ramp and parking area which is needed on this side of the reservoir. The opportunity for providing access facilities upstream of the present Taylor Park area on the right bank should also be explored along with relocating the fishing pier to make it accessible for disabled persons.

I. <u>Aquatic Biology</u>

14 1. <u>Volume 1, Appendix A (U.S. Fish and Wildlife Service Draft Coordination Act Report), Page 15, Item 3</u> - Timing of in-river construction activities with dam releases may not be favorable for upstream construction activities. It might be advisable to allow fine particles that are suspended due to construction upstream of the dam to settle below the turbine withdrawal zone before initiating large releases.

J. <u>Environmental Component Plan</u>

1. <u>Volume 1, Appendix D (Environmental Component Plan)</u>

15 a. The introduction to this Appendix should clarify its purpose, scope, and role in the NEPA process.

16 b. Pages 4 and 5 present information about the possible effect of a new Kentucky lock on the movement of sauger. If this is considered to be a substantial issue, it should be discussed in the body of the EIS. The apparent commitments on the part of the Corps of Engineers and TVA made in this section have not been discussed with TVA staff. Given our understanding of the extent of any sauger problem at Kentucky Dam, we suggest this material be dropped from Appendix D and the EIS.

RESPONSE

Letter From: Tennessee Valley Authority
July 22, 1991

Comment	Response
13.	The need to relocate Taylor Park Campground is recognized and a suitable relocation site is being sought that will provide an improved recreational experience for the public.
14.	Comment noted.
15.	Further information has been provided to explain the purpose, scope, and role of the Environmental Component Plan in the NEPA process.
16.	Inclusion of sauger passage in the design of a new lock is intended as a way to build environmental benefits into the new lock for the sauger population at little economic cost. The findings of recent studies of inter-reservoir movement of sauger populations on the Tennessee River led to inclusion of this proposal in the Kentucky Lock addition.

K. Boating Hazards

17 Volume 3, Appendix C, Page C-C-2, Section C-C - To construct a 3,200-foot long training dike in the downstream approach to the proposed lock would be a serious hazard to small boats at certain water levels. This potential problem should be at least acknowledged in the EIS with a statement that a system to mark the dike would be developed during the hydraulic modeling of the structure. Also, the potential for increased shoreline erosion along the left descending bank downstream from the dike should be evaluated during the model testing.

L. Other Items for Consideration

18 1. A discussion of handling and disposal of hazardous waste generated during construction of the new lock as a separate item under Chapter 4 in the EIS would be helpful.

19 2. It might be helpful to compare sediment resuspension and bank erosion before and after construction.

20 3. Improved or new tailwater fishing facilities meeting accessibility standards could be provided in the turbine discharge area. This would help compensate for loss of fishing access along the downstream right bank and in the vicinity of the hydroplant and switchyard area. By providing a fishing facility constructed to an elevation usable for much of the fishing season, a significant public need would be served.

21 4. During an onsite meeting of TVA's Land Resources staff with representatives of the U.S. Army Corps of Engineers on June 28, several downstream modifications to improve fishing were set forth. These included the following:

- Leaving the right bank haul road in place following construction
- Benching of shoreline protection riprap along the right bank for fishing access
- Installing a slotted defector wall on hydroplant/switchyard to guide discharges from the dam
- Raising the top elevation of four old railway protection cells downstream of the spillways
- Adding parking adjacent to the new railway and hydro access road
- Constructing "quarry-run" riprap groins along a portion of the left bank area

Evaluation of possible impacts of these proposals should be made as soon as more definitive information is available.

RESPONSE

Letter From: Tennessee Valley Authority
July 22, 1991

Comment	Response
17.	Comment noted. A training dike of any length will be subject to extensive study, if it is determined to be a necessary project feature.
18.	Discussion of handling and disposal of hazardous wastes has been added to the final EIS.
19.	Comment noted.
20.	Improvement of tailwater fishing facilities, including those in the turbine discharge area, is being evaluated. Any facility provided would be designed to provide the maximum public benefit inherent in its design, and TVA will be a part of the design team.
21.	Downstream modifications to improve aquatic habitat and enhance recreational features are being evaluated. Environmental improvement is an important project goal.

22. 5. The Public Safety Service firing range does not appear to be addressed even though it would be in the construction plant and equipment laydown area. This firing range has some specific safety design considerations which will likely limit where it is sited.

23. 6. Water supply and waste disposal for several facilities will be impacted by the proposed construction and will need to be addressed. The option of one disposal system with offsite treatment verses multiple onsite systems presently in place should be explored.

24. 7. We suggest that the identity of each appendix to the EIS have a unique numbering system (B-XXX) that continues throughout all of its parts and attachments.

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RESPONSE

Letter From: Tennessee Valley Authority
July 22, 1991

Comment	Response
22.	This oversight is being corrected. Alternative arrangements for the Public Safety Service firing range are being investigated and will be fully resolved during the design stage of the project.
23.	Water supply and waste disposal facilities will be addressed during the planning, engineering, and design portions of the project.
24.	Comment noted.

TVA

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902

SEP 1 6 1991

Lieutenant Colonel Stephen M. Sheppard
District Engineer
Nashville District
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Lieutenant Colonel Sheppard:

LOWER CUMBERLAND AND TENNESSEE RIVERS, KENTUCKY LOCK ADDITION

1

In reference to my July 22 letter to Colonel James P. King, enclosed are two different artist renderings showing the new lock and relocated or adjusted bridges. One rendering gives an aerial perspective and the other is at ground level. Also enclosed are additional comments we received from the staff which were previously provided to Richard Tippit informally.

Based on information from Mr. Tippit, the location of the borrow and disposal area has been identified, and EIS figures are being revised to reflect this change. Any additional input we may have regarding wetlands and prime farmland will be reflected through these figures which are being prepared by TVA.

As requested by Mr. Tippit, we investigated the possibility of Public Safety Service (PSS) using the Land Between The Lakes' rifle range for target practice. However, because of traveling distance, TVA prefers to use an area on the Kentucky Dam reservation or possibly the borrow and disposal area. Therefore, once the construction site configuration is laid out, TVA would like an opportunity to locate an area for target practice.

PSS is currently housed on the powerhouse island which will isolate them from contact with the public during construction. Some form of temporary offices should be provided during construction in the project area where public contact can be made and where they (PSS) could provide emergency medical service, security, and fire protection as was done during the recent Pickwick Lock construction. It is assumed that office space will be provided in the new visitor reception/lock operations building for PSS upon completion of the project.

RESPONSE

Letter From: **Tennessee Valley Authority**
September 16, 1991

Comment	Response
1.	**No response necessary.**

Lieutenant Colonel Stephen M. Sheppard

SEP 16 1991

2. The relocation of Taylor Campground has been discussed at some length with the Corps of Engineers (COE) staff, and during a June 19 meeting with TVA and COE staff, COE recommended the campground be relocated on the left bank of Kentucky Lake. After further review, TVA believes the campground should remain on the right bank and will be looking at two possible locations; one at the tailwater and the other on the lake. We will keep you informed of the results of our review.

If you have any questions, please call David Gengozian at (615) 632-6666 in Knoxville.

Sincerely,

M. Paul Schmierbach, Manager
Environmental Quality

Enclosures
cc (Enclosures):
Mr. Richard Tippit,
Nashville District
Corps of Engineers
Department of the Army
P.O. Box 1070
Nashville, Tennessee 37202-1070

RESPONSE

**Letter From: Tennessee Valley Authority
September 16, 1991**

Comment	Response
2.	No response necessary.

Enclosure

3. Volume 1, Main Report

We suggest the report include a section devoted to describing the existence, type, size, and significance of any wetlands. The current draft does not mention the existence of wetlands until Section 6.19, Environmental Impacts (page 83).

4. Volume 1, Main Report, Vegetation, Page 13

Section 2.13, last sentence of paragraph--Change "red elm" to "slippery elm."

Section 2.14, third and fourth lines--Following ". . . clearing bottomland for agriculture," insert "as well as reservoir construction."

Volume 1, Main Report, Wildlife, page 16

Continuation of Section 2.17, first line--Change "raptures" to "raptors."

Section 2.18, fifth line--Change "vireo's" to "vireos" and ". . . turkey and wild turkey, and black vultures" to read ". . . wild turkey, and black and turkey vultures."

Section 2.19, seventh line--Change "bank swallows" to "cliff swallows." The bank swallow is rare in this area.

Section 9.37, page 106, of the draft presents mitigation measures recommended by the U.S. Fish and Wildlife Service. We generally concur with and support stated actions that would mitigate potential adverse impacts to wetlands and important upland wildlife habitat.

5. TVA and the Kentucky Department of Fish and Wildlife Resources have designed Kentucky Dam as a wildlife observation area (WOA), due in part to the presence of thousands of wintering gulls. The lock expansion is not expected to result in long-term adverse impacts to this WOA. However, existing signs should be removed where necessary, properly stored, and reinstalled at or very near their present locations.

0090r

RESPONSE

Letter From: Tennessee Valley Authority
September 16, 1991

Comment	Response
3.	Further discussion of wetlands is included in Volume 1, Main Report in Chapter 2, Resources and Economy.
4.	Comments noted and changes have been made in Volume 1, Main Report
5.	Comments noted.

Carl H. Bradley
Secretary

Wallace G. Wilkinson
Governor

Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Department for Environmental Protection
[illegible]
Commissioner
Frankfort Office Park
18 Reilly Road
Frankfort Kentucky 40601

July 15, 1991

U.S. Army Corps of Engineers
Nashville District
Attn: William L. James
P. O. Box 1070
Nashville, Tennessee 37202-1070

Re:	Coordinated State Response
Project Number:	91-71
Applicant:	Corps of Engineers, Tennessee Valley Authority and Commonwealth of Kentucky
Proposed Activity:	Construction of facilities in conjunction with construction of new lock at Kentucky Lock and Dam, Tennessee River, mile 22.4, Livingston and Marshall Counties, Kentucky

Dear Mr. James:

The Natural Resources and Environmental Protection Cabinet has coordinated the above referenced public notice with concerned state agencies in order to prepare a statement of the Commonwealth's concerns on the proposed activity. We find the proposal unacceptable as submitted for the following reasons:

1. The required Water Quality Certification from the Kentucky Division of Water will be held in abeyance until the Division reviews the final Environmental Impact Statement and the final Section 404(b)(1) assessment. Other comments from the Division of Water include: (a) A floodplain construction permit would be exempt pending Congressional approval of the proposed activity. (b) All mussels from the proposed project area, including the cofferdam area and the new lock channel area, should be relocated. This needs to be addressed in the final EIS. (c) The dredge spoil material should not be deposited into the river channel, but rather placed outside of the floodplain. The deposition of dredged material into the river channel does not guarantee creation of mussel habitat. This needs to be addressed in the final EIS.

1.
2.

RESPONSE

Letter from: Commonwealth of Kentucky
Department for Environmental Protection
Coordinated State Response to Public Notice
July 15, 1991

Comment	Response
1.	Mussels will be relocated from all impact areas including the portion of the existing mussel bed in the area to be dredged for the lower approach, cofferdam area, and railroad bridge pier placement points. This is addressed in the final EIS.
2.	Dredged gravel, sand, and cobble from the lower approach will be placed back into the river to improve aquatic habitat. This has been successful in other locations. Previous experience indicates there is every reason to believe that the materials placed in the area will be readily colonized by mussels. Further information is provided in the final EIS.

2. The Kentucky Department of Fish and Wildlife Resources states that all permits should be held in abeyance until the final EIS can be reviewed. (See the attached memorandum for complete comments from KDFWR.)

Additional comments were received from several solicited state agencies. These comments are as follows:

3. 1. The Kentucky Transportation Cabinet states that this proposal will affect State maintained roads I-24 and US 62. Therefore, several conditions will apply. The Department of Highways does not maintain the existing bridge over the lock and dam. It would be the recommendation of the Transportation Cabinet that the agency responsible for maintenance should perform any needed inspections and perform any needed repair or rehabilitation work to the existing bridge while traffic is rerouted to I24. Also, since seismic safety is being emphasized in Kentucky at an increasing rate, and since this route has been identified as a priority route as a result of the work done by the Kentucky Transportation Center during the KYHPR-87-116 project, it investigated for possible retrofits to meet current seismic standards. The new bridge carrying US 62 across the new lock shall be designed for earthquake safety in accordance with AASHTO. The Department of Highways would like to be a party in the review and inspection of all phases of Roadway Design (preliminary and final). The maintenance of traffic shall be reviewed to insure safety and minimize unnecessary delays to the traveling public. Finally, the Division of Environmental Analysis shall also review the EIS.

4. 2. The Kentucky Division of Waste Management refers to 401 KAR 47:150, Section 1, stating the work may be done under a "permit-by-rule" for disposal of construction/demolition materials if disposal occurs at the point of generation; disposal occurs only during the period of construction; the waste do not include any materials that contain leachable hazardous materials; the wastes do not include packaging or putrescible wastes; and the disposal site complies with the Environmental Performance Standards of 401 KAR 47:030.

5. 1. The Kentucky Heritage Council states that the Corps of Engineers has initiated consultation with the State Historic Preservation Officer to mitigate adverse effects to the Kentucky River Lock and archaeological resources eligible for listing in the National Register. The Heritage Council looks forward to continuing to work with the Corps of Engineers on this project and to develop a Memorandum of Agreement that identifies all potential threats to significant historic properties, outlines how these properties will be treated, and stipulates how adverse effects to historic properties will be mitigated.

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
Coordinated State Response to Public Notice
July 15, 1991

Comment	Response
3.	The Department of Highways will be fully involved at appropriate phases of the planning, engineering, design, and construction of the Kentucky Lock addition.
4.	Comment noted. See comment 1, response to Commonwealth of Kentucky.
5.	Subject Memorandum of Agreement is included in Exhibit 5 of the final EIS.

6. No other comments or objections to the proposed activity were received from any other concerned state agencies. If you have any questions or need additional information, please contact Valerie Hudson, Deputy Commissioner for Special Projects, (502) 564-2150, ext. 119.

Sincerely,

William C. Eddins

WCE/mlb

cc: Division of Water
KDFWR
Transportation Cabinet
Div. of Waste Mgmt.
Heritage Council

RESPONSE

Letter From: Commonwealth of Kentucky
Department for Environmental Protection
Coordinated State Response to Public Notice
July 15, 1991

Comment	Response
6.	No response necessary.

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF FISH AND WILDLIFE RESOURCES
DON R. McCORMICK, COMMISSIONER

June 12, 1991

Mrs. Valerie Hudson
Department for Environmental Protection
Natural Resources and Environmental
Protection Cabinet
18 Reilly Road
Frankfort, KY 40601

RE: Public Notice No. 91-71(N), Construction of a new lock and railroad bridge, Kentucky Lock and Dam, Tennessee River, mi 22.4, Livingston and Marshall counties, Kentucky.

Dear Mrs. Hudson:

Members of my staff have reviewed the above-referenced public notice and the Draft Lower Cumberland and Tennessee Rivers Navigation Feasibility Report, Kentucky Lock Addition, Volume 1: Main Report and Environmental Impact Statement (EIS). Accordingly, we offer the following comments and recommendations.

7. The Kentucky Department of Fish and Wildlife Resources (KDFWR) is concerned about the above-referenced proposed activity and how it may impact both the fish and wildlife resources of the Tennessee River and the sportsmen who utilize that resource. The Draft EIS describes the project and how it may impact those resources. However, the Draft EIS does not necessarily correspond with the Navigation Feasibility Report and both reports tend to lessen the potential for significant impact from the project. The concerns of KDFWR are listed below.

RESPONSE

Letter From: Kentucky Department of Fish and Wildlife Resources

Coordinated State Response to Public Notice
June 12, 1991

Comment	Response
7.	No response necessary.

8. The projects primary impact will be to the mussel bed found below Kentucky Lock and Dam. This area, as outlined in the referenced documents, has been designated by this agency as a mussel sanctuary and is one of the primary reasons for the maintenance of a mussel fishery downstream in the Tennessee River. While the reports admits there will be impacts to the mussel bed from dredging, it downplays the impact the training dike or placement of bridge piers could have on this resource. The US Fish and Wildlife Service recommended that if a training dike was to be constructed, the Corps of Engineers should conduct intensive studies to determine the direct and indirect impacts on the mussel resource, especially the endangered species that are known to occur at this site. KDFWR concurs with this recommendation and believes it should be conducted before the EIS is finalized or any other permits are issued.

9. Another impact that is not adequately described in the EIS, is the impact of the placement of the bridge piers on mussels and fishermen. It was not clear in the EIS if mussels existed at the pier sites (this information was found in Appendix C) or if any mitigation would be performed to offset the loss of these individuals.

10. The EIS indicates there will be a temporary disruption of tailwater fishing during construction but gives no estimates as to the size of reduction or any measures that can be taken to offset these losses. The tailwater fishery below Kentucky Dam is one of the most important sport and commercial fisheries in Kentucky and the disruption to this fishery could have significant social and economic impacts to local sportsmen. The Final EIS should address both of these concerns.

11. One of the other issues that is not clearly resolved is the question of the fisherman access and boat ramp on the right bank. The EIS indicates the displaced facility will either be replaced in-kind or the boat ramp on the left bank will be improved. The Final EIS should decide how this issue would be resolved. It is the recommendation of KDFWR that bank fishing should be maintained on the right bank but the boat launching facility should be moved to the left bank for safety purposes.

12. Finally, there is no discussion devoted to environmental enhancement measures that could be incorporated into the project. There are several measures that could be incorporated into the project design (some at little cost) the could be beneficial to the local resources and sportsmen who utilize those resources. One feature is the construction of wing dikes extending towards the left bank from the training dike. Such features would provide for excellent fishery habitat and fishing areas for sportsmen. Another feature could be the construction of a walkway along the top of the training dike to provide for bank fishing access to the middle of the tailwater area. It is also recommended that handicap accessible fishing areas be developed for this segment of the fishing public. Currently, very little of the tailwater is accessible to the handicap.

RESPONSE

Letter From: Kentucky Department of Fish and Wildlife Resources
Coordinated State Response to Public Notice
June 12, 1991

Comment	Response
8.	See comment 3, response to U.S. Fish and Wildlife Service.
9.	See comment 2, response to U.S. Fish and Wildlife Service.
10.	Additional information is provided in the final EIS concerning disruption of tailwater fishing and the duration of time this disruption is expected to occur.
11.	See comment 5, response to U.S. Fish and Wildlife Service.
12.	Coverage of a number of environmental enhancement measures is included in the final EIS. The feasibility of providing various enhancement features is being actively investigated and the outcome will be fully coordinated with appropriate resource agencies. The input of KDFWR in developing enhancement features is greatly appreciated.

While KDFWR does not find the EIS do be deficient environmentally, there are several issues that still need to be resolved and several enhancement features that we feel need to be incorporated into the project. Therefore, KDFWR recommends that all permits be held in abeyance until the Final EIS is developed and the various resource management agencies have an opportunity to review the document.

13. KDFWR staff members have worked previously with the Nashville District on this project and others and looks forward to working with Nashville District on these concerns.

Members of my staff will be available should you or your staff have any questions regarding our comments and recommendations.

We appreciate the opportunity to comment.

Sincerely,

Don R. McCormick
Commissioner

DRM/WLD/kh

cc: Peter W. Pfeiffer, Director, Division of Fisheries
Edwin F. Crowell, Asst. Director, Division of Fisheries
William N. McLemore, Western Fishery District Biologist
Lee Barclay, USFWS, Cookeville, TN
Bill Ainslie, USEPA, Atlanta, GA
Jeff Grubs, KY Division of Water
Environmental Section Files

RESPONSE

Letter From: Kentucky Department of Fish and Wildlife Resources

Coordinated State Response to Public Notice
June 12, 1991

Comment	Response
13.	No response necessary.

US Department of Transportation
United States Coast Guard

Commander
Second Coast Guard District

MAILING ADDRESS
1222 Spruce Street
St. Louis, MO 63103-2832
Staff Symbol: (oc)
Phone: 314-539-3724
FTS 262-3724

RECEIVED JUN 28 1991

16591/22.4 Tenn R
JUN 26 1991

From: Commander, Second Coast Guard
To: Commander, U.S. Army Corps of Engineers, Nashville District, Nashville, TN

Subj: KENTUCKY LOCK AND DAM, MILE 22.4, TENNESSEE RIVER

1. This is in reply to your Public Notice No. 91-71 of May 31, 1991, concerning construction of various facilities in conjunction with the construction of a new lock at Kentucky Lock and Dam. Specifically, we refer to the proposed highway bridge across the lock and dam and the relocation of the railroad bridge downstream of the dam.

2. The General Bridge Act of 1946 requires that the location and plans for bridges over navigable waters of the United States be approved by the Commandant, U. S. Coast Guard, prior to commencing construction. The Tennessee River is considered to be a navigable waterway of the United States for bridge administration purposes at the above mentioned bridge site. Each of these bridges will require a permit.

3. Applications for bridge permits should be addressed to Commander, Second Coast Guard District, 1222 Spruce Street, St. Louis, Missouri 63103-2832, Attention: Bridge Branch. The applications must be supported by sufficient information to permit a thorough assessment of the impact of the bridges, and their immediate approaches, on the environment.

4. Under Title 40 Code of Federal Regulations, Part 1501.6, the Coast Guard should have been invited to be a cooperating agency for National Environmental Policy Act (NEPA) documentation purposes. We would then have had the opportunity to participate in determining the level of NEPA documentation required for the navigation portion of the project.

5. Although a Draft Environmental Impact Statement (DEIS) has already been written, we request that you invite us to be a cooperating agency. Without us being a cooperating agency, all NEPA documentation will have to be recirculated to meet the needs of the Coast Guard process. This could result in delay in issuing the Coast Guard Bridge Permits.

RESPONSE

Letter From: United States Coast Guard, Second District
Response to Public Notice
June 26, 1991

Comment	Response
1.	The US Coast Guard has been formally invited by letter dated August 21, 1991 to become a cooperating agency in development of the Kentucky Lock addition.

16591.1/22.4 Tenn R
JUN 2 6 1991

Subj: KENTUCKY LOCK AND DAM, MILE 22.4, TENNESSEE RIVER

1. 6. One copy of the DEIS should be immediately forwarded for our review and comment. To aid you in preparing your applications for the two bridge permits, we have enclosed a copy of our pamphlet Applications For Coast Guard Bridge Permits. If you have any questions, please call me or Mr. Bruce McLaren at (314)539-3724.

ROGER K. WIEBUSCH
Bridge Administrator
By direction of the District Commander

Encl: (1) Pamphlet

Copy: w/o encl
TVA/Mr. George Conner
Kentucky Transportation Cabinet/Mr. Doug Lambert
Paducah and Louisville Railroad

RESPONSE

Letter From: United States Coast Guard, Second District
Response to Public Notice
June 26, 1991

Comment	Response
1. continued	See above.

Scott Young
Senior Vice President
Operations

June 24, 1991

Mr. William L. James
Regulatory Branch
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, TN 37202

Re: Public Notice No. 91-71
Application No. COE-111

Dear Mr. James,

I have asked the Captains at Delta Queen Steamboat Company to examine the public notice #91-71 concerning the construction of a new lock at Kentucky Lock and Dam - Tennessee River Mile 22.4.

At first glance we see no problem for passage of our passenger steamboats DELTA QUEEN and MISSISSIPPI QUEEN. We would like to know the proposed clearance of that portion of U.S. Highway 62/641 which would pass over the lock, at upper pool elevation with the lock full? We are anxious to maintain clearance for our vessels as they lock into and out of Kentucky Lake. Thank you for your reply.

Sincerely,

Scott Young
Senior Vice President
Operations

The Delta Queen Steamboat Co.
Robin Street Wharf • New Orleans Louisiana 70130-1890
Local (504) 586-0631 • Fax (504) 585-0630
DIRECT LINE (504) 585 0627

2 3 JUN 1991

RESPONSE

Letter From: The Delta Queen Steamboat Company
Response to Public Notice
June 24, 1991

Comment	Response
1.	The information requested has been furnished by letter. Vertical clearance is 57 feet at normal pool

Thermic Engineering

3505 Dogwood Circle West
La Grange, Kentucky 40031
(502) 241-1245

July 26, 1991

U. S. Army, Corps of Engineers
P.O. Box 1070
Nashville, TN 37202-1070

Subject: Public Notice #91-71
Application # COE-111

Gentlemen:

1. Please keep informed as to the status of this project. I am interested in providing support for the successful contractor.

Sincerely yours,

Peter J. Constant, Owner

RESPONSE

Letter From: Thermic Engineering
Response to Public Notice
July 26, 1991

Comment	Response
1.	No response necessary.

GOVERNOR WALLACE G. WILKINSON
CAPITOL
FRANKFORT, KENTUCKY 40601

RECEIVED
JUL 26 1991

July 17, 1991

Colonel James P. King
Commander, Nashville District
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, TN 37202

Dear Colonel King:

It is imperative to the economic vitality of Kentucky and the Ohio Valley that the modernization of our aging navigation infrastructure proceed without delay. Toward this end, I strongly support the addition of a new 110' x 1,200' lock adjacent to the existing Kentucky Lock, Tennessee River, Kentucky.

1. The benefits of a modern facility at Kentucky Lock and Dam are vital to the distribution of Kentucky's commerce, including coal, petroleum, chemicals, aggregate, and agricultural products. The Kentucky lock, located at the mouth of the Tennessee River, must not become the next major bottleneck on the Ohio River system. The lock and dam system, which provides full navigational use of the Ohio River an d its tributaries, is only as strong as its weakest link. Today that weak link is Kentucky Lock. Hence, we urge your swift action in moving this report through the Corp of Engineers process and into the hands of the Congress for authorization.

Thank you for your attention to this matter.

Very truly yours,

Wallace G. Wilkinson

RESPONSE

Letter From: Governor Wallace G. Wilkinson
July 17, 1991

Comment	Response
1.	No response necessary.

AUSTIN J. MURPHY

Congress of the United States
House of Representatives
2210 Rayburn Building
Washington, DC 20515
(202) 225-4665

June 11, 1991

RECEIVED
JUN 13 1991

Colonel James P. King
Commander Nashville District
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, TN 37202-1070

Dear Colonel King:

1. I would like to express my support for the lower Cumberland and Tennessee Rivers Navigation Study. The study recommends adding a new 110' x 1,200' lock to the existing Kentucky Lock and Dam on the lower Tennessee River. This project is expected to cost $454 million and has a benefit-to-cost ratio of 1.5 to 1.0. When constructed, the new facility will provide $58.6 million in annual benefits. The recommended improvements by the Nashville District, U.S. Army Corps of Engineers, will eliminate shipping delays and allow traffic to travel more freely.

I am in support of these modifications and hope that this request will be favorably considered.

Very truly yours,

AUSTIN J. MURPHY
Member of Congress

AJM/bdb

U.S. ARMY CORPS OF ENGINEERS
NASHVILLE DISTRICT
EXECUTIVE OFFICE
Received 6-13-91
Action Assigned to DL-M
Suspense Date 6-20-91

RESPONSE

Letter From: Congressman Austin J. Murphy
June 11, 1991

Comment	Response
1.	No response necessary.

George E. Evans Jr.
Special Assistant
to the Governor

Wallace G. Wilkinson
Governor

GOVERNOR'S OFFICE FOR COAL AND ENERGY POLICY

July 9, 1991

REC'D JUL 15 1991

Colonel James P. King
Commander, Nashville District
U.S. Army Corps of Engineers
P. O. Box 1070
Nashville, TN 37202

Dear Colonel King:

No task is more important in improving the economy of the Ohio Valley states, including Kentucky, Tennessee, Illinois, Indiana, West Virginia, Ohio, and western Pennsylvania, than the orderly modernization of the lock and dam infrastructure on the Ohio River navigation system. Many of the locks and dams in our region are old and deteriorated; others are obsolete. Kentucky has joined with other Ohio Valley states and the business, industrial, and labor leadership in the region to promote the need for modernization of our lock and dam infrastructure. The only organized effort in the region that has taken on the leadership responsibility for expediting solutions to this need is DINAMO, the Association for the Development of Inland Navigation in America's Ohio Valley, and Kentucky's state government has been an integral part of this effort since DINAMO was launched in March 1981. I am currently a member of DINAMO's Executive Committee and Board of Directors.

1. I am writing to support expeditious modernization of the Kentucky Lock and Dam, Tennessee River, KY. The U.S. Army Corps of Engineers, Nashville District, are proposing a new 110' x 1,200' lock constructed adjacent to and landward of the existing 110' x 600' lock. The existing lock would then be used as an auxiliary chamber. We support construction of a new 1,200 foot facility for the following reasons: 1) Present and future traffice demands dictate construction of an additional 110' x 1,200' lock; and 2) The benefits of a modern facility at Kentucky Lock and Dam are vital to the distribution of Kentucky's commerce, including coal, petroleum, chemicals, aggregate, and agricultural products.

The Kentucky Lock and Dam is situated on the Tennessee River only 22 miles above the mouth and thus provides the only economical waterway access from the Mississippi, Illinois, Missouri, and Ohio Rivers to the Tennessee Valley. The Kentucky and Barkley projects represent one of the major intersections on the inland waterway navigation system. Grain is shipped from the Upper Mississippi River to grain processing mills located along the Tennessee River. Animal feeds are shipped from Tennessee River grain processing mills down the Mississippi for export. Aggregate is shipped from Tennessee and Cumberland petro-chemical complexes located on the Gulf coast to chemical plants located on the Tennessee and Cumberland rivers. Coal is shipped from West Virginia, Kentucky, Illinois, and Indiana to coal-fired electric generating plants located on both the Tennessee and Cumberland rivers. During the drought of 1988, several million tons of

RESPONSE

Letter From: Governor's Office for Coal and Energy Policy
July 9, 1991

Comment	Response
1.	No response necessary.

commodities were re-routed via the Tennessee-Tombigbee waterway. With the lower Mississippi impassable, a number of shippers were able to utilize Kentucky/Barkley and the Tenn-Tom to move their shipments into and out of the Ohio River System. Until new works can be brought into service, continued growth in this region will be impeded by mounting congestion at the Kentucky Lock.

The problem at the Kentucky Lock and Dam, simply stated, is that the existing chamber is too small to handle increasing tonnage at this site. In addition, the lack of an auxiliary chamber forces tows to use the Barkley Lock and Cumberland River during excessive delays or closures at the Kentucky Lock. However, shippers prefer the Kentucky Lock and Tennessee River to the Barkley Lock and Cumberland River due to the physical characteristics of each river.

The lower Tennessee is relatively broad and straight, whereas the lower Cumberland is narrow and sinuous. Over half the Cumberland is not safe for two-way traffic, which means tows have to wait until one-way zones are clear. Ten major bends in the Cumberland necessitate smaller tow size and slower speed. Dense fog occurs much more frequently on the lower Cumberland than the lower Tennessee, and hydropower plants along the Cumberland release water into the river, continually altering its flow and velocity. The lower Cumberland is 9 miles longer than the lower Tennessee. Tows have to travel a longer distance at slower speeds with smaller tow sizes, resulting in a $0.50 per ton higher cost.

1. The addition of a larger lock would significantly reduce delays at Kentucky Lock. With a 110' x 1,200' lock, all tows become single lockages, saving about 62 minutes per tow. The use of the existing 110' x 600 chamber as an auxiliary would eliminate the need to use the Barkley Lock as an auxiliary.

The benefits of a new Kentucky Lock are widespread. Twenty states transport commodities through Kentucky/Barkley. Traffic is projected to grow from 37.3 million tons in 1988 to 504 million tons by the year 2000. Capacity on the system, 63.1 million tons, will be reached by the year 2025. Of the 37.3 million tons moved on the system in 1988, only 4.9 million tons moved through the Barkley Lock. Most shippers use the Kentucky Lock and lower Tennessee River because it is a more economic choice, costing $0.50 per ton less than the lower Cumberland River.

This project is estimated to cost $453.9 million (October 1990 prices) and will have net annual economic benefits of $18.6 million. The project has a benefit to cost ratio of 1.5 to 1.

A crucial step toward completion of improvements at Kentucky Lock was achieved when the authority to design, fund and construct the new lock was transferred from the Tennessee Valley Authority to the U.S. Army Corps of Engineers. On January 18, 1991, TVA Board Chairman Marvin Runyon wrote to G. Edward Dickey, Acting Principal Deputy Assistant Secretary of the Army (Civil Works) recommending "USACE request congressional authorization and funding for the new lock, as well as design and construct the project." TVA will review and approve final design plans and planned construction phases. Included in the letter was a Memorandum of Agreement formalizing the request. The Memorandum

RESPONSE

Letter From: Governor's Office for Coal and Energy Policy
July 9, 1991

Comment	Response
1. continued	See above.

Colonel James P. King
July 9, 1991
Page Three

was signed by Dr. Dickey on May 10, 1991. This decision by Mr. Runyon and the Board of Directors of TVA in asking the Corps of Engineers to design, fund, and construct a new Kentucky Lock is, in my judgement, the correct and proper approach to improving the obsolete facility at Kentucky Lock.

Let's examine Kentucky coal's dependence on water transportation. In 1986 Kentucky shipped 37,996,000 tons of its coal on the Ohio River navigation system. Nearly 2/3 of this coal moved through out-dated and obsolete lock and dam facilities. This tonnage had a mine value of $978,333,000.

A more telling picture of the importance of coal shipped through old, obsolete lock and dam facilities can be gained by segmenting coal production in eastern and western Kentucky.

Eastern Kentucky waterborne coal totalled 16,748,000 tons with a mine value of $441,812,000 in 1986. The $441.8 million of mine revenues is principally income to residents of the mining areas. Some portion, of course, is paid to suppliers and investors in other localities. Very probably, however, not less than some $300 million is local income. The actual impact on the region's livelihood is about double this sum. The "multiplier" effect of local re-sending by mining personnel, local suppliers, and investors results in an aggregate
1. community income in the neighborhood of $600 million.

In 1986, 21,198,000 tons of Western Kentucky coal moved on the Ohio River and its tributaries. This coal had a mine value of $563,521,000.

A modernized river navigation system for getting Kentucky's coal to distant markets at a low cost is a substantial factor in the quality of life and public services throughout the state. These public services include schools, hospitals, street and road maintenance, police and fire protection and a variety of other services essential to the personal security and the quality of life. One estimate projected that Kentucky coal shipped on the river generated direct state and local tax revenue of at least $59.6 million and indirect tax revenues of about $108.9 million. This total amounts to $124.35 for each of the 1,355,000 households in the Commonwealth of Kentucky.

Kentucky ships more coal by river than any other state in the Union. Much that does not move by river moves by rail at water-competitive rates. The National Coal Association estimates that Ohio River mainstem coal traffic will grow from 114 million tons in 1989 to 144 million tons annually by 1995-96. Kentucky has shared in that growth and will continue to benefit from the world-wide demand for coal as long as we all work together for improvements in our region's inland navigation facilities.

In conclusion, we urge the Corps of Engineers to move forward swiftly to expedite construction of a new 110' x 1,200' lock ~~at Kentucky~~ Lock and Dam. Thank you for your attention to this matter.

Very truly yours,

George E. Evans, Jr.

RESPONSE

Letter From: Governor's Office for Coal and Energy Policy
July 9, 1991

Comment	Response
1. continued	See above.

American Commercial Barge Line Company

Box 610, Jeffersonville, Indiana 47131-0610
Area Code (812) 288-0472

W. N. Whitlock
Senior Vice President

July 22, 1991

VIA: FAX 615-736-7065
UPS OVERNIGHT

Colonel James P. King, Commander
Nashville District
U. S. Army Corps of Engineers
P. O. Box 1070
Nashville, TN 37202-1070

Dear Col. King:

American Commercial Barge Line Company is one of the largest inland waterway carriers providing transportation service on all rivers of the Mississippi River System. We have operated 15 barge tows through Barkley and Kentucky Locks and on the Lower Cumberland River for many years, thus we are very familiar with the project study area.

Upon reviewing the Lower Cumberland and Tennessee Rivers Interim Feasibility Study, "Kentucky Lock Addition Report", we feel compelled to offer the following comments:

1. (A) In light of the scarcity of dollars available in the Inland Waterways Trust Fund and the need to allocate those dollars to projects that are of greater benefit to the waterway system and the Nation as a whole, American Commercial Barge Line Company <u>is opposed</u> to the construction of a second lock at Kentucky Lock at this time.

2. The second lock at Kentucky should not be constructed until all non-structural alternatives have been fully implemented, Lower Cumberland bendways improvements
3. completed and the combined traffic levels of both Kentucky and Barkley Locks have reached 80 percent utilization.

4. (B) Capacity Utilization

- Current rated annual capacity of Kentucky Lock is 38.5 million tons.
- Current annual utilization rate of Kentucky is 75 percent.

RESPONSE

Letter From: American Commercial Barge Line Company
July 22, 1991

Comment	Response
1.	In accordance with Corps policy, all reasonable nonstructural measures were fully considered as part of the lower Cumberland-Tennessee River study. Alternatives evaluated include helper boats at Kentucky Lock, modification of hydropower releases at Barkley, one-way traffic management, a lock congestion fee, and various combination plans. These nonstructural measures also were considered in combination with the structural plans. In fact, the final report recommendations are based upon the assumption that all cost-effective nonstructural measures are implemented before and during lock construction. Selected measures include the use of helper boats at Kentucky, modified hydropower releases at Barkley and the one-way traffic management plan. These evaluations are fully documented in the final report.
2.	It would certainly be desirable to improve the bends on the lower Cumberland River from the standpoint of navigation safety. However, our studies indicate that the costs of improving the bends would far outweigh the benefits. The bends do not represent a significant restraint to the capacity of the Kentucky-Barkley system. Therefore, this alternative was eliminated from consideration.
3.	The utilization rate of the two locks is certainly an important indicator of the benefits that would be realized by the towing industry for improving Kentucky Lock. However, it is clearly not the only factor that must be considered as part of the investment decision. Corps policy requires that all of the benefits, costs and impacts of alternatives be considered in formulating a recommended plan. Obviously, the potentially major hydropower losses associated with increasing navigation use of the lower Cumberland River is a very important consideration. Even with this improvement, the lower Cumberland would still be a more expensive route than the lower Tennessee River. Also, the life- cycle cost implications of maintaining the existing projects over the 50-year period of analysis versus building a new lock is an important consideration. These are just a few examples of other factors that must be considered by the Corps in developing the best overall plan and the optimum timing for project replacement. The complete assessment is documented in the final report.

- Current rated annual capacity of Barkley Lock is 24.6 million tons.
- Current annual utilization rate of Barkley is 12 percent.

4. The current rated annual capacities of both Kentucky, and Barkley can be easily increased through the use of voluntary helper boats. Recent past history of L/D 26 tells us that lock capacity can be substantially increased through the use of helper boats by as much as 20 percent. Therefore, from a utilization standpoint, it would appear that by making it more feasible to utilize existing capacity at Barkley Lock, it would be at least 35 years or more before there would be a need to add new capacity to the Kentucky-Barkley System, based on Corps' growth factors.

(C) Tonnage Growth/Projected Traffic Demand

5. (i) The tonnage projections for Kentucky-Barkley seem to be optimistic, particularly when you consider there has been a 7 percent decline in tonnage over the last 5 years (1986 thru 1990) and a 9 percent decline over the last 4 years of record (1987 thru 1990).

6. (ii) The projected traffic demand, as discussed in paragraph 3.18 thru 3.23 of the report, lacks any detail to support the projections contained in Table 6 on page 35. The fact that tonnage on the Ohio River continues to grow does not necessarily mean that tonnage through Kentucky-Barkley System will grow at the corresponding rate. One only has to look at the recent decline in tonnage for the years of 1986 thru 1990.

7. (iii) TVA is currently pushing for nuclear power rather than fossil fuel plants for the future. Additionally, the Clean Air Act has the potential of changing many of the origin and destination pairs of coal moving throughout the Ohio River Basin. Also, the Clean Air Act could result in West Kentucky Coal being in less demand. When one considers these factors we feel tonnage as forecasted for the Cumberland and Tennessee Rivers cannot be sustained.

(D) Usage of Barkley Lock

8. (i) The utilization of Barkley could be increased by straightening some of the bendways and better control of hydropower releases from Barkley Dam. While the study for Lower Cumberland bendways improvements was found not to reach a favorable B/C ratio, it is our belief that had the capital cost and time value of

RESPONSE

Letter From: American Commercial Barge Line Company
July 22, 1991

Comment	Response
4.	Our studies show that the continuous use of helper boats would increase the capacity of Kentucky and Barkley Locks by about 16 percent and 11 percent, respectively. The helper boats at Kentucky would be economically feasible beginning in the year 2000, and are assumed to be implemented as an element of the without project condition. Helper boats at Barkley Lock were found to be infeasible.
5.	An explanation of the recent decline in traffic is presented in Section 4 of Appendix D, Systems Analysis.
6.	Additional detail on the traffic projections has been added in Section 4 of Appendix D, Systems Analysis.
7.	As documented in Section 4, Appendix D, the impact of the TVA nuclear program is reflected in the traffic demand projections. However, the impacts of the 1990 amendment to the Clean Air Act are not included in the projections. We believe it is still too early to reliably forecast the probable impacts of this legislation. The utilities themselves are still assessing compliance strategies and are unsure how their long-term coal sourcing and transportation plans will be impacted. The Ohio River Division Navigation Planning Center is in the very early stages of updating the traffic demand projections for the entire Ohio River system based upon these amendments. These projections will be used to revise the project economics during the Planning, Engineering and Design (PED) phase.
8.	As discussed in the response to comment (A)(2) above, improvement of the bends was found to be infeasible. Therefore, they cannot be used to defer the construction of a new lock at Kentucky. Controlling hydropower releases, however, would increase the volume of traffic using Barkley Lock and would produce benefits in excess of costs. Therefore, this action was included as part of the without project condition. Since the increased navigation benefits

8. money saved for delaying or foregoing a new lock at Kentucky been included, the B/C ratio would have been favorable.

9. (ii) To achieve the maximum utilization at Kentucky-Barkley we suggest a traffic control system be implemented, whereby all downbound traffic would use Barkley and all upbound traffic would use Kentucky.

(E) <u>Maintenance Closures</u>

10. (i) Much of the economic benefit for the new lock to be built at Kentucky appears to come from what we consider to be excessive maintenance closures. It should not take fifty two (52) weeks of downtime to accomplish major maintenance of Kentucky Lock in the years of 2006 thru 2009. Locks of similar size on the upper Mississippi and Illinois River undergoing similar major maintenance work do not disrupt traffic for nearly as extensive a time. It is recommended that the District conduct a more detailed investigation of determining maintenance closure time by talking to contractors and other Corps Districts with recent experience. To rely solely on District experience for estimating the length of maintenance outages is inappropriate, particularly when it is such a major component of the benefits used.

11. (ii) We question the practice and cost to dewater the locks for inspection and repair every five years, particularly when it is only an ORD recommended guideline. Other locks throughout the Mississippi River System are not afforded the luxury of being unwatered every five years.

(F) <u>Downstream Terminals</u>

12. Since BRT Terminal currently receives approximately 800,000 tons of coal inbound from the Ohio River by barge, and ships 4,000,000 tons of coal outbound to the Ohio River by barge, and ships 8,000,000 tons of coal up the Tennessee River to TVA's Pride Plant by barge, it would not benefit capacity constraints of Kentucky Lock to relocate the BRT Terminal below the existing lock. On the other hand, Reed's Quarry Dock which ships out approximately 6,600,000 tons of crushed stone and riprap downbound through Kentucky Lock, would favorably impact capacity if it were relocated below Kentucky Lock.

13. In summary, we cannot support the construction of a new lock at Kentucky at this time. We feel the limited dollars from both Federal budget and Trust Fund should be spent on those projects which offer the greatest benefit to the

RESPONSES

Letter From: American Commercial Barge Line Company
July 22, 1991

Comment	Response
8.	associated with controlling hydropower are credited to the without project condition, this action tends to reduce the need for a new lock as well as the optimum construction timing. The complete assessment of optimum construction timing is documented in the final report.
9.	A one-way traffic management plan, calling for all upbound tows to use Kentucky and all downbound tows to use Barkley was evaluated as an alternative. This plan was found to be very effective in moving traffic, particularly in the early years of the planning period, and would be economically feasible. However, this action would not defer the optimum timing for a new lock at Kentucky.
10.	The length of maintenance outages is not based solely on district experience. As described in Appendix D - Project Design, a detailed analysis of the maintenance was conducted. The schedule is based on a network of actual construction tasks and sequences. The Waterways Experiment Station (WES), Rock Island District, and Pittsburgh District were heavily relied upon for design and construction sequencing input. Kentucky and the locks on the upper Mississippi and Illinois River have chambers of 110- X 600-feet. However, Kentucky's lift ranges from 50 to 75 feet, while the lift of the other locks range from 8 to 39 feet. Thus Kentucky is more than twice as high as most of the other locks and has more surface to repair.
11.	A five-year dewatering and inspection cycle is a draft Corps-wide regulation because is has been shown to reduce total downtime and virtually eliminate unscheduled outages. It is more cost-effective than longer cycles.
12.	The comment is correct. In the report we evaluated a loading facility for crushed stone below Kentucky Lock. A downstream facility would reduce traffic through the lock. The owners of the terminal have considered this measure in some detail. However, upon consultation with state and federal environmental agencies and internalizing the costs of environmental impacts the terminal became cost prohibitive. In addition, a terminal in this area would pose a navigation

13. Inland Waterway System and the nation as a whole. We strongly recommend that non-structural alternatives be utilized to increase lock capacity and some of the bends on the Lower Cumberland River be widened to facilitate one-way downbound traffic through Barkley Lock.

Sincerely,

W. M. Whitlock

WNW/ama

RESPONSE

Letter From: American Commercial Barge Line Company
July 22, 1991

Comment	Response
12.	hazard for those entering and exiting the existing lock and impose severe and costly restrictions on construction of a new lock.
13.	No Response to summary paragraph.

CROUNSE CORPORATION

River Transportation

3626 BROADWAY
PADUCAH, KENTUCKY 42001
PHONE 502 · 444-9611

June 25, 1991

Colonel James P. King, Commander
Nashville District
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, TN 37202-1070

Dear Colonel King:

1\. Crounse Corporation supports fully, improvements to resolve congestion at Kentucky Lock, and continued improvements to the Lower Cumberland River.

The Tennessee and Cumberland Rivers have been the focal point of operations for our Company, since its inception in 1946. During this period, tow sizes have increased from two and four barge tows, up to the present 15 barge double-locking tows. These increases in tonnage, have resulted in lower transportation costs, and because of increasing delays at Kentucky Lock, higher cost to the Vessel and barge operator.

Recently, we began a large volume bulk movement down the Tenn-Tom Waterway. With the completion of Gallipolis Lock in the near future, the remaining hurdle for this being a profitable move, for both shipper and transporter, will be continued congestion at Kentucky Lock, and the Lower Cumberland River.

Please call upon us for any assistance we could render.

Very truly yours,

Lynn Sherrill
Vice President-Operations

RECEIVED
JUN 26 1991

RESPONSE

Letter From: Crouse Corporation
June 25, 1991

Comment	Response
1.	No response necessary.

HATFIELD TERMINALS, INC.
P.O. Box 14118
CINCINNATI, OHIO 45250-0118

(513) 621-4800

Colonel James P. King, Commander
Nashville District
US Army Corps of Engineers
P.O. Box 1070
Nashville, TN 37202-1070

June 10, 1991

Dear Commander King:

1. I would like to express our support for the new 110 x 1200' lock to the existing Kentucky lock and dam on the lower Tennessee River.

We see an ever increasing need for this new lock as the amount of bulk commodities, originating from and destined for the Tennessee and Cumberland River Valleys, continues to rise. The new lock will help existing traffic move more efficiently and safely and will create even more opportunities for commercial use, including transportation terminals and bulk suppliers.

Thank you for your time and efforts in reviewing this matter.

James T. Hatfield III
President
Hatfield Terminals, Inc.

RECEIVED JUN 13 1991

RESPONSE

Letter From: Hatfield Terminals, Inc.
June 10, 1991

Comment	Response
1.	No response necessary.

INGRAM BARGE COMPANY

L. E. (LES) SUTTON
PRESIDENT

July 24, 1991

Colonel James P. King, Commander
Nashville District
U.S. Army Corps of Engineers
P.O.Box 1070
Nashville, Tennessee 47202-1970

Dear Colonel King:

Ingram Barge Company is a major inland waterway carrier with extensive operations on the Tennessee River. For many years we have been the primary carrier operating out of Reeds Quarry. We also transport substantial volumes of coal into the Tennessee River to various TVA generating facilities. We also frequently make round trips from the Gulf up the Tenn-Tom and down the lower Mississippi.

1. Ingram supports the addition of a new 110' x 1200' lock at Kentucky Dam. Kentucky lock is one of the few remaining high volume facilities with only one chamber. This fact, combined with the fact that the lock is approaching 50 years of age, insures that maintenance outages will become excessive in future years.

Ingram Materials Company is a major user of the Cumberland River. Straightening the bendways AND significant control of power plant volumes are necessary before this route is a viable alternative to Kentucky locks. Of course, the reduction of power generating capabilities under this scenario would be an economic offset for this alternative.

The public support demonstrated at the June 7 hearing is a good indication of the community perception of the need for this project.

The effects of the clean air legislation are likely to result in substantial volumes of western coal moving through Kentucky locks to serve both TVA and Southeastern U.S. generating plants. Significant test shipments have already occurred.

Sincerely,

L. E. (Les) Sutton

LES:dk

MEMBER OF THE AMERICAN WATERWAYS OPERATORS, INC

RESPONSE

Letter From: Ingram Barge Company
July 24, 1991

Comment	Response
1.	No response necessary.

INGRAM BARGE COMPANY

1 WASHINGTON STREET · PO BOX 7798
PADUCAH KENTUCKY 42002

June 21, 1991

Col. James P. King - District Engineer
U. S. ARMY CORPS OF ENGINEERS
P.O. Box 1070
Nashville, TN 37202-1070

RE: <u>Lower Cumberland & Tennessee River Navigation Study</u>

Dear Col. King:

1. I attended the public meeting June 19, 1991, at the Kentucky Dam Village State Park, pertinent to the above referenced. Col. King, this was undoubtedly the best prepared, and probably one of the best presented public forums I have ever attended. The cooperative efforts of the Corps of Engineers and TVA certainly produced a professional feasibility study. It seems that every concern and possible problem has been analyzed and addressed. Your efforts have proven that projects can proceed without unduly alarming special interest, if you are prepared.

My congratulations on a fine public meeting, and on behalf of Ingram Barge Company, our appreciation for the efforts of you and your staff.

Sincerely,

INGRAM BARGE COMPANY

J. A. Tinkey
Vice President of Operations

JAT/lkm

HOME OFFICE 4400 HARDING ROAD · PO BOX 23049 · ONE BELLE MEADE PLACE · NASHVILLE, TN 37202 · TEL 615 298 8200
TELEX 55 4416 · TWX 810-371 1697

RESPONSE

Letter from: Ingram Barge Company
June 21, 1991

Comment	Response
1.	No response necessary.

INGRAM MATERIALS COMPANY

P. J. KOPCSAK
PRESIDENT AND
CHIEF EXECUTIVE OFFICER

INGRAM

10 FATHERLAND STREET
NASHVILLE TENNESSEE 37213
TEL [illegible]

June 14, 1991

Colonel James P. King
U. S. Army Corps of Engineers
P. O. Box 1070
Nashville, TN 37202

Dear Colonel King:

1. I have received Volume 1, Main Report and Environmental Impact Statement for the "Lower Cumberland and Tennessee Rivers Interim Feasibility Study Kentucky Lock Addition" dated May 1991.

As you know we have been the most frequent user of Barkley Lock for some time and have intensely studied Kentucky Lock/Barkley Lock situation for over 15 years. Our equipment has been designed for this particular bottleneck in our inland river system.

I am very pleased to see the depth of study and the quality of the study in your report which I have received and wholeheartedly applaud the conclusion which has been reached, that being the necessity to add a 110' x 1200' lock adjacent to the existing lock at Kentucky Dam.

Without question this riverway enhancement will be a significant contributor to the continued vitality and economics of our waterway system far into the future.

Sincerely,

P. J. Kopcsak

mm

RESPONSE

Letter From: Ingram Materials Company
June 14, 1991

Comment	Response
1.	No response necessary.

BRADSHAW & WEIL MARINE AGENCY, INC.
MARINE INSURANCE
621 BROADWAY
P. O. BOX 420
PADUCAH, KENTUCKY
42002-0420
TEL: 502 444-7891 · FAX: 502 443-9931

June 7, 1991

Nashville District Corps of Engineers
Planning Branch
P. O. Box 1070
Nashville, TN 37202-1070

Attn: Sue Ferguson

Gentlemen:

1\. We have reviewed your Fact Sheet regarding the situation at Kentucky & Barkley Locks and the proposed construction of a new 1200' lock at Kentucky Dam.

We strongly support this proposal which is critical to the financial welfare of the inland waterway transportation system and its shippers.

Very truly yours,

Vice President

J.S.Piers:tj

RESPONSE

Letter From: Bradshaw & Weil Marine Agency, Inc.
June 7, 1991

Comment	Response
1.	No response necessary.

DINAMO
Three Gateway Center
Pittsburgh, PA 15222
(412) 392-4550

The Association
for the Development
of Inland Navigation in
America's Ohio Valley

RECEIVED
JUL 18 1991

July 17, 1991

Colonel James P. King
Commander, Nashville District
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, TN 37202

Dear Colonel King:

1\. I am writing to associate DINAMO with the remarks of Mr. George E. Evans, Jr., Special Assistant to the Governor, Kentucky Governor's Office for Coal and Energy Policy, in his letter to you dated July 9, 1991. Mr. Evans is currently a member of the DINAMO Executive Committee and Board of Directors. We are strongly supportive of the Nashville District, US Army Corps of Engineers' recommendation for a new 110-foot by 1,200-foot lock constructed adjacent to and landward of the existing chamber at the Kentucky Lock and Dam, Tennessee River, KY.

A new, larger lock at the Kentucky Lock and Dam would keep the Tennessee and Cumberland Rivers Valley competitive well into the 21st century.

Thank you for your attention to this matter.

Very truly yours,

R. Barry Palmer

cc: Mr. George E. Evans, Jr.
Kentucky Governor's Office for Coal and Energy Policy

RESPONSE

Letter From: DINAMO
July 17, 1991

Comment	Response
1.	No response necessary.

Ashland Petroleum Company
DIVISION OF ASHLAND OIL, INC.
P.O. BOX 391 • ASHLAND, KENTUCKY 41114 • (606) 329-3333

July 25, 1991

Colonel James P. King
District Engineer, Nashville District
U. S. Army Corps of Engineers
P. O. Box 1070
Nashville, TN 37202-1070

Dear Sir:

1. Ashland Petroleum Company is in full support of the proposed addition of one 110'X1200' lock to the present Kentucky Lock & Dam facility. The current single 110'X600' lock at this facility is inadequate to efficiently pass the present and future tonnage through this crucial site. Currently, when the single 110'X600' lock is out of service for repair, traffic is stopped and/or must detour through the narrow dangerous reach of the Cumberland River and through Barkley Lock. The additional 110'X1200' lock at Kentucky Lock & Dam will solve the problem of delays and enable traffic to efficiently pass.

Ashland Petroleum Company owns and operates five (5) petroleum product terminals on the Tennessee and Cumberland Rivers which are dependent on river transportation for receipt of products. These products are needed to support the economic and industrial base of the Tennessee Valley. Failure to provide low cost efficient water transportation to this area would impede economic and industrial growth. It is paramount that this additional lock be approved.

Sincerely,

Zane G. Meek
Administrative Manager,
Marine Transportation

ZGM:mz/028/3

RESPONSE

Letter From: Ashland Petroleum Company
July 25, 1991

Comment	Response
1.	No response necessary.

TENNESSEE-TOMBIGBEE Waterway Development Authority

DONALD G. WALDON, ADMINISTRATOR

POST OFFICE DRAWER ... TELEPHONE ...
COLUMBUS, MISSISSIPPI 39703 FAX ...

June 11, 1991

Honorable Jim Sasser
UNITED STATES SENATE
363 Senate Russell Office Bldg.
Washington, D. C. 20510

Dear Senator Sasser,

We very much appreciate your requesting Senator Bennett Johnston, Chairman of the Appropriations Subcommittee on Energy and Water Development, to provide a total of $1.5 million in FY 1992 for the proposed new lock at Kentucky Dam on the Tennessee River.

This level of funding is imperative if preconstruction engineering and design is to progress unimpeded. The Administration's request and the House allowance of $501 thousand will permit only about 6 month's activity on the project during next fiscal year.

1. Frankly speaking, a growing depletion of unobligated funds from the Waterway Users Trust Fund and an ominous threat of competition for these limited funds by a major navigation improvement program now being planned for the Upper Mississippi River system make it most critical to complete design of Kentucky Lock as soon as possible. If not, chances of building this project are remote at best.

The present Kentucky Lock is the weakest link in our region's navigation system. It is already causing increasing delays and costs to shippers using the Tennessee River, including the Tenn-Tom. We, therefore, respectfully request that you continue to use your considerable influence to secure these appropriations for these much needed improvements.

With best wishes, I am

Sincerely,

Donald G. Waldon
Administrator

DGW/as

RESPONSE

Letter From: Tennessee-Tombigbee Waterway Development Authority
June 11, 1991

Comment	Response
1.	No response necessary.

TENNESSEE-TOMBIGBEE Waterway Development Authority

June 11, 1991

Honorable Albert Gore
UNITED STATES SENATE
393 Senate Russell Office Bldg.
Washington, D. C. 20510

Dear Senator Gore,

1. We would very much appreciate your requesting Senator Bennett Johnston, Chairman of the Appropriations Subcommittee on Energy and Water Development, to provide a total of $1.5 million in FY 1992 for the proposed new lock at Kentucky Dam on the Tennessee River.

The present Kentucky Lock is the weakest link in our region's navigation system. It is already causing increasing delays and costs to shippers using the Tennessee River, including the Tenn-Tom.

This level of funding is imperative if preconstruction engineering and design is to progress unimpeded. The Administration's request and the House allowance of $501 thousand will permit only about 6 month's activity on the project during next fiscal year.

Frankly speaking, a growing depletion of unobligated funds from the Waterway Users Trust Fund and an ominous threat of competition for these limited funds by a major navigation improvement program now being planned for the Upper Mississippi River system make it most critical to complete design of Kentucky Lock as soon as possible. If not, chances of building this project are remote at best.

Senator, we need your support if these additional funds are to be appropriated and keep this important project on schedule.

With best wishes, I am

Sincerely,

Donald G. Waldon
Administrator

RESPONSE

Letter From: Tennessee-Tombigbee Waterway Development Authority
June 11, 1991

Comment	Response
1.	No response necessary.

Richard J. Mole. CPA. Inc.
Andover, Ohio
44003
(216) 293-5047
1-800-272-5047

Member of Ohio and Pennsylvania State Societies of CPAs

Member of American Institute of CPAs

June 19, 1991

Colonel James P. King, Commander
Nashville District
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

RE: Lower Cumberland and Tennessee Rivers Navigation Study

Dear Colonel King:

1. As a public accountant and business confidant to my clients who are in the transportation and material handling businesses, I am well aware of their need for direct, trouble-free methods of getting their products and materials to their destination quickly and cheaply. It is for that reason that I write supporting the proposed addition of a lock to the existing Kentucky Lock and Dam on the lower Tennessee River.

In today's business climate where everyone is looking to maximize their return on their investment, the proposed construction will yield satisfactory benefits for all concerned. Any investment that "pays back" in a one-and-a-half to one fashion must be looked at seriously.

We have a great system of waterway transportation. Let's improve it. Your support for the addition to the Kentucky Lock and Dam will be appreciated.

Sincerely,

Richard J. Mole, CPA, CMA
President

cc: R. Barry Palmer, DINAMO

RESPONSE

Letter From: Richard J. Mole, CPA, Inc
June 19, 1991

Comment	Response
1.	No response necessary.

US Army Corps of Engineers
Nashville District

Kentucky Lock Public Meeting

Your Comments

West Kentucky Building and Construction Trades Council, composed of all affiliated organizations in the Building and Construction Trades industry, met and discussed the proposed lock at Kentucky Dam. Total membership within the affiliates of these organizations number approximately 16,000. The majority of workers are skilled in the construction of dams such as Barkley, Smithland Dam and the additions built to Dams 52 and 53.

After discussing the proposed Kentucky Lock project, it was the unanimous decision of the body to support this project.

Not only would it help us in our organizations by reducing our unemployment rates, but it would also greatly benefit river transportation by helping to avoid delays of barges at Kentucky Locks.

We are writing to our Senators and Congressmen from Kentucky requesting that they support appropriations for this most worthwhile project.

If we can be of any further assistance to you, please do not hesitate to contact us.

Charles Allred W.B. Sanders
Charles Allred, president & W. B. Sanders, Executive Secretary
Name

West Kentucky Building & Construction Trades, P. O. Box 3158
Street

Paducah	KY	42001
City	State	Zip

RESPONSE

Kentucky Lock Public Meeting Comments
Charles Allred and W. B. Sanders
June 19, 1991

Comment	Response
1.	No response necessary.

US Army Corps of Engineers
Nashville District

Kentucky Lock Public Meeting

Your Comments

1. I have visited the Kentucky Lock several times and have not seen a backlog of traffic in either direction. The Huge Cost of a 1200' Lock makes the project another "Pork Barrel".
But if our Government would end the wasteful spending, especially in maintaining military bases all over the world as well as in this country and divert that money to domestic improvements such as the 1200' lock, then I'm for it. Our Govt. is Trillions of Dollars in Debt.
To illustrate: If I were to spend $24,000 a day, 365 days a year; it would take me 114+ years to spend a Billion Dollars

Name Reino Kettula
Street P.O.B. 694
City Calvert City State Ky Zip 42029

RESPONSE

Kentucky Lock Public Meeting Comments
Reino Kettula
June 19, 1991

Comment	Response
1.	No response necessary.

Required Coordination

6.06 The Feasibility Review Conference (FRC) for the project took place in Paducah, Kentucky on August 07-09, 1991. The meeting included representatives of Nashville District, Ohio River Division, Office of the Chief, Board of Engineers for Rivers and Harbors, Assistant Secretary of the Army for Civil Works, Washington Level Review Center, TVA, US Coast Guard, various resource agencies, and the navigation industry. All aspects of the project were reviewed and items requiring additional effort were defined. Guidance resulted from the FRC to direct the Nashville District toward production of a draft feasibility report. The FRC included tours of the project site enabling participants to observe all significant project features.

6.07 During October 1990 TVA was requested by Nashville District to become a cooperating agency for compliance with the National Environmental Policy Act (NEPA). TVA responded positively to this request in November 1990. During the same month a joint Corps-TVA meeting was held at the Lake Barkley Resource Manager's Office, in Grand Rivers, Kentucky to raise pertinent environmental issues and concerns related to the proposed project. TVA representatives from numerous resource fields attended and voiced many issues. The Nashville District and TVA have worked closely in many areas of environmental resource concern to achieve NEPA compliance for both agencies for Kentucky Lock Addition.

6.08 During August 1991, following the May release of the Draft EIS, the US Coast Guard (USCG) requested to become a cooperating agency for NEPA compliance for the Kentucky Lock Addition. The primary USCG concern was ensuring NEPA coverage of the new bridges the Kentucky Lock Addition would require. Nashville District responded positively to this request and by letter formally invited USCG to become a cooperating agency.

6.09 Fish and wildlife and related resource concerns have been and continue to be closely coordinated with appropriate federal and state agencies. The primary agencies involved in coordination of natural resource issues are the U.S. Fish and Wildlife Service (USFWS) and Kentucky Department of Fish and Wildlife Resources (KDFWR). Review of the project has proceeded under the auspices of the Fish and Wildlife Coordination Act. The USFWS completed a Preliminary Draft Fish and Wildlife Coordination Act Report in May 1989. During May 1991 the USFWS delivered the Draft Supplemental Fish and Wildlife Coordination Act Report (DCAR) which was included in the draft EIS. The Final Fish and Wildlife Coordination Act

Report for the Lower Cumberland and Tennessee Rivers Navigation Study, October 1991, (FCAR) is included in the final EIS as Appendix A.

6.10 The FCAR is based upon a detailed description of the preferred plan, alternatives, and a future without-project condition. Detailed mapping and several resource surveys were supplied USFWS, upon which anticipated impacts described in the FCAR were calculated. The FCAR in its Conclusions and Recommendations section provides a list of 11 specific recommendations designed to protect fish and wildlife resources in and around the lower Tennessee River. These items and the Corps' response are as follows:

1. "To the maximum extent possible, construction should be done in the dry to minimize the potential for excessive sedimentation of downriver areas. "

Corps' Response: A tailwater cofferdam will dewater much of the right bank area where construction activities will occur. Lock pit excavation will be performed completely in dry conditions. Excavation of the right bank downstream of the tailwater cofferdam will be accomplished to the maximum extent possible in dry conditions, however at some point wet excavation will be necessary. Dredging of the lower approach channel will of necessity be performed under wet conditions.

2. "Construction activities should be timed to avoid critical spawning periods of valuable sport and commercial fish species."

Corps' Response: The principal activities that could affect fish spawning are right bank excavation downstream of the cofferdam and dredging of the lower approach. Every effort will be made to avoid conducting these activities during the prime fish spawning months of February - June. Data for fish spawning in the lower Tennessee River should be collected and analyzed to allow refinement of critical spawning times. Based upon this approach, scheduling of construction activities can be undertaken to avoid conducting activities which could impair fish spawning success.

3. "Whenever possible, in-river construction activities should be timed with releases from the dam to minimize impacts of siltation on downriver resources."

Corps' Response: Every effort will be made to minimize siltation resulting from in-river construction. Some release of sediment from the site is inevitable. The Corps will employ all applicable Best Management Practices (BMP's) to limit sediment releases that could harm aquatic resources.

4. "Background turbidity levels should be identified, and turbidity should be monitored during construction. If turbidity at the mussel bed exceeds normal seasonal levels, the Corps should notify the Service immediately for reevaluation and possible reinitiation of formal endangered species consultation."

Corps' Response: The Corps will review literature concerning mussel tolerances and physiological responses to elevated turbidity levels. Based upon this data critical turbidity levels can be determined at which lasting damage to mussel resources may occur. If water quality parameters meet or exceed these levels the Corps' could then initiate actions to bring values for critical water quality parameters down to acceptable levels.

5. "In-river construction of the railroad bridge and other structures should be conducted so as to minimize inpediment to access to fishing areas immediately below the dam."

Corps' Response: A safety zone will be established around construction areas to prevent unauthorized public entry and to protect the general public. Phasing of construction will allow some areas to remain open to fishing most of the time. Boat fishing in the tailwater will be hindered to a small degree in specific locations during construction of the railroad bridge. Bank fishing will be more profoundly affected, especially on the right bank, as that is the location of most construction features. Entry to all areas for the public will be reestablished as soon as the constraint of guaranteeing public safety following construction of project features allow.

6. "Construction engineers should design the railroad bridge to span the river on as few piers as possible. If not practical, the piers should be designed to minimize potential for collision by small boats."

Corps' Response: Final design of the railroad bridge has not been accomplished. Volume 3, Project Design document presents the railroad bridge crossing the Tennessee River between the switchyard island and the left bank on a total of five piers over a distance of approximately 1800 feet. Piers would be designed to obstruct a minimum area of the tailwater cross section. Design will also take into account increasing the visibility of railroad bridge piers to reduce the potential of collisions with them by small boats both during day and night. The railroad bridge crossing of the lower approach between the switchyard and right bank has no piers placed in the river.

7. "The riparian zone the be established by the Corps along the right descending bank should be composed of woody and herbaceous species beneficial to wildlife."

Corps' Response: Restoration of the right bank riparian zone will incorporate woody and herbaceous species of value to wildife. A list of proposed plant species will be determined based upon pertinent ecological factors.

8. "The haul road proposed for construction over the mouth of Russell Creek should have adequate openings, or a culvert of adequate size, to allow for normal passage of high flows, to permit free flow during periods of low flow, and to maintain the present hydrology of the wetlands upstream of the road.

Corps' Response: No haul road will be required over Russell Creek. The borrow/disposal area proposed for use in the Draft EIS has been deleted from project plans, and a different borrow disposal area is proposed on an upland area about one mile north of Kentucky Lock and Dam. The new site is adjacent Kentucky Highway 453 in Livingston County.

9. "If plans for construction of a training dike are developed, the Corps should initiate intensive studies to determine the direct and indirect impacts that would likely occur. Alterations in current velocity and vectors, changes in dissolved oxygen level and other water quality parameters, and changes in deposition of silt and fine sediments over the mussel bed should be determined."

Corps' Response: If a training dike is included in project plans the Corps will conduct complete hydraulic modeling of this structure. Coupled with hydraulic modeling will be an assessment of how such a structure would affect physical, chemical, and biological parameters of water quality. Direct impacts of the dike on the benthic community, principally molluscs would be determined through field surveys. Consultation would be reopened with the Service as needed as plans for the training dike develop.

10. "All fill placed for the railroad bridge and highway should be immediately stabilized with straw mulch, and planted in herbaceous and/or woody vegetation as soon as practicable. Also, hay bales and silt fences should be used whenever necessary."

Corps' Response: All applicable BMP's will be applied at at sites disturbed by construction. As soon as final grading is accomplished appropriate vegetative covers will be established.

11. "As mitigation for the loss of 18,000 square meters of mussel habitat along the right side of the river, the Corps should take the sand and gravel removed during dredging and place it back into the river in an area presently providing unsuitable habitat for mussels. An appropriate study should be conducted by the Corps to locate a site which would have the highest probablilty for successful creation of habitat. This created "habitat" should be monitored for a period of at least ten years to determine if mussels colonize the area, survive, and reproduce. Mussels occurring in the area to be dredged should be removed prior to dredging and placed back into the river as soon as possible to minimize stress. Any endangered species collected during this effort should immediately be placed back into the river in the existing bed in the vicinity of the I-24 bridge. If several individuals of a particular listed species are collected, they should be placed in close proximity to each other to facilitate reproduction. The Corps should also initiate an active program to develop techniques to artificially propagate mussels, using non-endangered species. Any juveniles obtained should be placed into the river in areas where they can be monitored to determine survival, growth, and reproduction."

Corps' Response: Gravel and sand dredged from the river will be placed adjacent the right bank of the Tennessee River at mile 19.7 to create replacement habitat. This created habitat will be monitored on a long-term basis to determine the rate of mussel colonization. Most mussels in the area to be dredged, dewatered by the cofferdam, or affected by bridge pier placement will be removed prior to these actions taking place. Techniques are being developed by Corps laboratories, such as Waterways Experiment Station, to facilitate successful large scale removal of mussels from sites such as the one to be dredged. Any federally listed species will be removed by divers and placed at the location specified by the Service. The Corps is cooperating with other agencies in work to perfect techniques to artificially propagate mussels. With project construction not expected to begin until the mid to late 1990's, several years of lead time is available to perform research and development tasks, and field test artificial propagation techniques.

6.11 The USFWS also recognized the opportunity the Kentucky Lock addition represents to improve recreational opportunities particularly in the Kentucky Dam tailwater. The USFWS strongly recommended upgrading of the left bank boat launch ramp as the best location to provide improved recreational facilities for anglers and boaters, and provision of associated facilities for users such as restrooms, adequate paved parking, trash pick-up service, and fish cleaning tables. Other recommendations included handicap bank fishing access be incorporated into the project, and that the development of recreational facilities be ultimately incorporated into nearby Kentucky Dam Village State Park.

6.12 As a final recommendation, the USFWS stressed the importance of continued close cooperation of all appropriate state and federal agencies throughout planning and construction of the project. Close cooperation is certainly the key ingredient to insuring that all opportunities for restoration or improvement of natural, recreational, aesthetic, and other resources are brought to fruition. The good working relationship of agencies and individuals involved to date in project planning will continue to be the most important factor as the project evolves.

6.13 The USFWS does believe that the proposed construction and operation of a new lock at Kentucky Dam will result in some loss or degradation of terrestrial and aquatic habitats. However, of alternatives considered that accomplish project purposes, the Corps has chosen the one that is least environmentally damaging. Sound environmental planning and design now incorporated into the project and close interagency cooperation has satisfactorily addressed significant impacts to fish and wildlife resources. Reflecting confidence in environmental design and planning measures that are part of the project, the USFWS determined that an incremental quantitative analysis such as Habitat Evaluation Procedure (HEP) would serve no useful purpose for the Kentucky Lock Addition. These findings are reflected in a letter from the USFWS to the Nashville District (Exhibit 4).

6.14 Consultation with the USFWS under Section 7a of the 1973 Endangered Species Act has been completed. Nashville District submitted the biological assessment (Appendix B) to USFWS in December 1990. The USFWS responded with the biological opinion (Appendix C) in April 1991. The biological opinion rendered was a "no jeopardy" opinion, with incidental take allowed for four species of federally endangered freshwater mussels in the Kentucky Dam tailwater.

6.15 Required coordination of the project's potential effect on cultural resources is underway with the Kentucky State Historic Preservation Officer. Documentation of that process is contained in EIS Exhibit 5. TVA has been fully involved as a cooperating agency in this process.

Statement Recipients

6.16 Recipients of the EIS are listed in Exhibit 6.

Public Views and Responses

6.17 Concerns of various publics have been considered throughout the study. Riparian landowners on the lower Cumberland River are one segment of the public that has expressed its views concerning navigation problems and proposed improvements in the area. The landowners are highly concerned about ongoing severe bank erosion and the impact of navigation traffic on their lands and timber holdings. Limited interest has also been shown by the public regarding the right bank tailwater boat ramp and its ultimate fate.

6.18 The commercial towing industry has a deep interest in the study. At the 1975 public meeting waterway users favored any improvement to the waterways. Several navigation interests responded to the 1984 scoping letter with appeals for the pursuit of a solution to existing and future navigation problems on the lower Cumberland and Tennessee Rivers. In return the Corps of Engineers has sought from the navigation industry their perception of the best solutions for solving existing and anticipated future navigation problems in the area.

6.19 During the June 19, 1991 public meeting a moderate amount of public comment was generated. Public comment voiced at the meeting was almost entirely favorable toward the project. Construction of the project is seen as a major economic boon to the area through provision of jobs related to construction and the boost the improved navigation facility will give to the navigation industry in general, which is an important area employer. The industry built up around recreation in the area would also benefit from the project leading to public support.

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continued

APPENDIX A

U.S. FISH AND WILDLIFE SERVICE
FINAL COORDINATION ACT REPORT

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Post Office Box 845
Cookeville, TN 38503

October 25, 1991

LTC Stephen M. Sheppard
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Colonel Sheppard:

The Fish and Wildlife Service has completed the attached Final Fish and Wildlife Coordination Act report for the Lower Cumberland and Tennessee Rivers Navigation Study in Livingston and Marshall Counties, Kentucky. Our report is submitted under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) in accordance with the Scope of Work between our respective agencies, and constitutes the final report of the Secretary of Interior as provided for by Section 2(b) of the Act.

This report also addresses issues concerning the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). However, formal Section 7 consultation has been completed separately. A biological opinion containing the Service's position that the proposed project is not likely to jeopardize the continued existence of endangered species was issued to your agency on March 29, 1991.

This report has been coordinated with the Commissioner, Kentucky Department of Fish and Wildlife Resources. A copy of his letter of comments will be provided to you when it is available.

Thank you for the opportunity to comment on this proposed action. The cooperation of your staff throughout the planning process is greatly appreciated. We commend the Nashville District for designing an environmentally sound project. Should you require additional information or input from our office, please feel free to call us.

Sincerely,

Lee A. Barclay, Ph.D.
Field Supervisor

Attachment
xc:
Assistant Regional Director, Fish and Wildlife Enhancement, Atlanta, GA
Kentucky Department of Fish and Wildlife Resources

RECEIVED
OCT 28 1991

FINAL FISH AND WILDLIFE COORDINATION ACT REPORT
for the
LOWER CUMBERLAND AND TENNESSEE RIVERS
NAVIGATION STUDY

Prepared by:

JAMES C. WIDLAK
Fish and Wildlife Enhancement
U.S. Fish and Wildlife Service
Cookeville, Tennessee

October, 1991

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INTRODUCTION

This report addresses the Nashville District, Corps of Engineers' (Corps) ongoing investigation of navigation problems on the lower Cumberland and Tennessee Rivers below Barkley Canal in Kentucky. The investigation is being conducted under the authority of two resolutions adopted by the United States Senate Committee on Environment and Public Works. The first, dated October 2, 1972, requested an investigation on navigation improvements on the Cumberland River and Tennessee River below Barkley Canal. The second resolution, adopted on September 9, 1982, directed the Nashville District to evaluate the entire Tennessee River to determine the advisability of implementing navigation improvements.

The Fish and Wildlife Service's (Service) comments are provided under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). Comments provided and recommendations made are intended to assist the Nashville District in its planning efforts.

Alternatives originally considered to remedy navigation problems on the lower Cumberland and Tennessee Rivers would only have had significant impacts on the Cumberland River below Barkley Dam. A Draft Coordination Act Report addressing impacts to fish and wildlife resources and recommending appropriate mitigation for unavoidable losses was submitted to the Corps of Engineers in April, 1989. However, subsequent planning and coordination indicated that the Cumberland River alternatives were not feasible, and maintenance work consisting of removal of rock ledges had remedied some of the major navigation problems on the lower Cumberland River. Therefore, the bendway modification alternatives were dropped from consideration. The only structural alternative presently under consideration would impact resources in the lower Tennessee River below Kentucky Dam. Therefore, the information and environmental assessment provided in this report will include only the Tennessee River below Kentucky Dam in Livingston, McCracken, and Marshall Counties, Kentucky.

STUDY AREA SETTING

The study area (Figure 1) includes approximately 70 square miles in southwestern Kentucky along the lower 22 miles of the Tennessee River between Kentucky Dam and the Ohio River. The river originates at the junction of the Holston River and French Broad River near Knoxville, Tennessee. From Knoxville it flows southwesterly to Guntersville, Alabama, and then turns to the west for approximately 80 miles to Florence, Alabama. From there the river flows northward through northeastern Mississippi, back into Tennessee, and then into Kentucky. At Calvert City, Kentucky, the river flows westward for 22 miles where it converges with the Ohio River at the city of Paducah, Kentucky (ORM 935). The Tennessee River has a drainage area of 40,910 square miles and is commercially navigable for its entire length of 652 miles. Lock facilities also provide navigation up three of the river's major tributaries: the Clinch River, Hiwassee

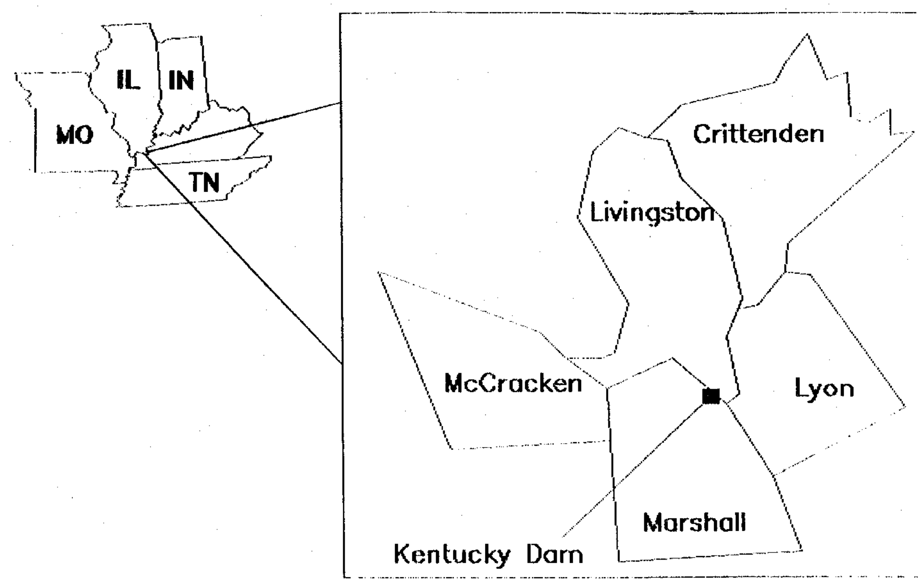

Figure 1. Lower Tennessee and Cumberland Rivers Study Area

River, and Little Tennessee River. The total fall of the river is about 550 feet, with an average slope of 0.84 feet per mile.

The study area contains a diverse physiography, lying within two physiographic regions, the Interior Low Plateau and the Coastal Plain Provinces (Figure 2). The Interior Low Plateau Province is characterized by erosion-resistant bedrock and contains two plateaus: the Mammoth Cave Plateau on sandstone and the Pennyroyal (Mississippian) Plateau consisting of low-relief karst plain with a high degree of sinkhole development. The Jackson Purchase Region of the Coastal Plain Province includes three distinct subregions: one of moderate relief with well-developed dendritic drainage patterns; a highly dissected strip of deeply washed, steeply sloping lands; and hilly uplands with broad, deep alluvial valleys. The majority of soils in the study area are derived from mixed stream alluvium washed from limestone, cherty limestone, sandstone, shale, sand, gravel, clay, and loessal material. One group, the Grenada-Calloway, was formed in loess 5 to 15 feet in thickness. Hydric soils in the area include the Henry, Rosebloom, Melvin, Ashton, and Wheeling silt loam soils. The latter two soils are considered hydric because they are frequently flooded for long periods of time.

Agriculture accounts for approximately 75 percent of the land use in the study area. Mean annual precipitation is 48 inches and the frost-free period lasts for approximately 200 days. Limestone quarrying is another important activity in the lower Tennessee River region. The area contains a number of active and abandoned quarries. There is also significant industrial use in the study area. Numerous oil terminals, tug services, and fleeting facilities exist along the Tennessee River below Kentucky Dam at Paducah, and a large chemical complex operates in Calvert City. The only major urban center in the area is Paducah, Kentucky, located at the confluence of the Tennessee and Ohio Rivers. Several other small communities exist along the Tennessee River, but they are considered small residential communities with only basic supportive services.

The study area lies within the Western Mixed Mesophytic Forest Region. This forest type represents a transition between the Mixed Mesophytic Forest to the east and the Oak-Hickory Forest to the west. The majority of the area has been cleared for agricultural, residential, or industrial purposes, but scattered tracts of undisturbed forest still remain in alluvial areas or in bottomland and riparian areas along the streams and rivers. Upland forest exists at higher elevations on hills, bluffs, and slopes, and consists primarily of white oak, red oak, post oak, shagbark hickory, pignut hickory, shellbark hickory, sugar maple, and red elm. Of 22,700 acres of floodplain in the study area, an estimated 20 percent is still forested. Land use is predominantly agricultural with row crop farming being the primary activity.

Alluvial forests also exist in the area, within and adjacent to river and stream floodplains. This forest type is rapidly disappearing due to clearing and bank sloughing. The alluvial forest community consists primarily of sycamore, silver

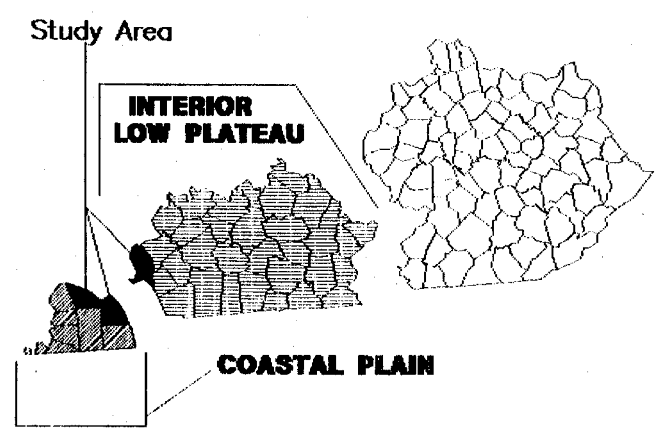

Figure 2. Physiographic Regions in the Study Area

maple, river birch, sweetgum, hackberry, and cottonwood. In addition, a small portion of the study area supports a bald cypress community.

CURRENT ENVIRONMENTAL PROBLEMS

Leasing of Tennessee Valley Authority lands adjacent to the Tennessee River for agricultural purposes has led to substantial loss of riparian vegetation, and resulted in the present bank-sloughing problem. Construction of the interstate highway across the river resulted in the dissection of a stream drainage, and possibly the hydrology of a wetland area adjacent to the right bank. These activities have likely resulted in declines in numbers of many populations of aquatic and terrestrial species.

Other existing problems in the area include the lack of proper facilities at a boat launching ramp on the left descending side of the river. This has resulted in deposition of trash and waste material in and adjacent to a cypress slough area. In addition, runoff and discharges from industrial and commercial developments along the river could potentially result in water quality degradation which could have significant adverse impacts on aquatic organisms throughout extensive areas of the lower Tennessee River.

FISH AND WILDLIFE RESOURCES

The finfish populations of the lower Tennessee River have not been extensively surveyed since the construction and operation of Kentucky Lock and Dam, but the value of the recreational and commercial fisheries is rated very good throughout the entire lower reach of the river. A fish survey (Sickel et al. 1981) conducted in association with an evaluation of the Asiatic clam population of the lower Cumberland River provides some knowledge of that river's fishery. Gizzard shad, emerald shiner, and yellow bass were the most abundant fish species collected. Finfish species of commercial importance included smallmouth buffalo, largemouth buffalo, paddlefish, freshwater drum, and carp. Principal sport fish species included blue and channel catfish, largemouth bass, white and black crappie, white bass, bluegill, and sauger. The composition of the commercial and recreational fisheries in the lower Tennessee River is likely similar to that found in the lower Cumberland River.

A recent report prepared by the Tennessee Valley Authority (1988, unpublished) indicated that the lower Tennessee River is much wider and straighter than the lower Cumberland River and does not undergo extreme fluctuations in water level or flow. However, as does the Cumberland, the lower Tennessee River presently undergoes significant bank sloughing, and the Tennessee River also contains a scarcity of instream cover and shallow water habitat that is important as spawning, feeding, and nursery habitat for numerous fish species. This habitat type is also important for perpetuating populations of benthic invertebrates that serve as food organisms for fish. Because there is a scarcity of cover, the lower Tennessee River may support a less diverse and less abundant fish community than would be anticipated. Although there is not sufficient information available to reveal long-term trends, it is assumed that no significant changes will occur in the existing fisheries during the next several years. However, unlike the lower Cumberland River, the lower Tennessee River supports a major recreational fishery and annually receives heavy fishing pressure.

Creel surveys conducted in the Kentucky Dam tailwater area revealed that blue catfish dominated the sport fishery harvest, followed by white crappie, channel catfish, white bass, sauger, and bluegill (McLemore 1981). It was estimated that over 645,000 man-hours of fishing occurred during April 1979 through March 1980, and that this effort resulted in the catch of over 528,100 fish. The highest success rates generally occurred between August and December when large numbers of crappie were harvested. No creel surveys have been conducted for the Kentucky Dam tailwater since 1980 and none are scheduled until 1992, but recreational fishing has likely increased significantly since that survey, particularly since 1985, because fishermen have begun catching striped bass that have apparently moved up the Tennessee River toward Kentucky Dam from the Ohio River. Initial catches were primarily undersized fish, but within the past three years, more legal-sized fish have been harvested.

The lower Tennessee River apparently contains high-quality habitat for freshwater mussels. The river bottom immediately below Kentucky Dam consists of clean-swept bedrock which is unsuitable for mussels. However, habitat conditions improve downstream as river flows moderate, allowing the formation of stable gravel and sand substrate. Surveys conducted since 1931 have reported the presence of from twenty-seven to thirty-six species of mussels, but a total of thirty-eight species have been found to occur in the river. Mussels in the lower Tennessee River occur in dense mussel beds. Highest densities were reported at river miles 22.0, 13.5, 14.7, 17.8, 21.5, and 21.6. The most extensive beds occur between river miles 20.5 and 21.5, and evidence of successful reproduction and recruitment was found at miles 21.2 to 21.6, 17.8, 14.7, 14.5, and 13.5.

Wildlife resource values of the lower Tennessee River are rated high to extremely high. Species diversity and population sizes in and around Livingston, Marshall, and McCracken Counties make them unique and important areas. The Kentucky Department of Fish and Wildlife Resources ranks this region as one of the best in the State for wildlife resource values. However, much of the floodplain and riparian areas have been cultivated and, as a result, only scattered forested areas remain. These areas are generally in close proximity to natural waterways or where a high water table makes cultivation unprofitable. Consequently, the wildlife populations consist principally of those species that are compatible with a mixture of cropland and forested habitats. Wildlife population densities and species diversities are generally high in areas where there is a combination of forested lands, croplands, and various successional stages of feral lands at a high level of interspersion. Although the Tennessee River floodplains represent only a small percentage of those habitat types that historically existed there, remaining forested wetlands, riparian, floodplain, and upland forests provide habitat for a variety of wildlife species. Principal nongame species which utilize these terrestrial habitats are common crow, meadowlark, mockingbird, starling, bluejay, Kentucky warbler, pileated woodpecker, downy woodpecker, great-horned owl, red-tailed hawk, turkey vulture, raccoon, red fox, chipmunk, opossum, small-footed bat, evening bat, little brown bat, voles (several species), southeastern shrew, least shrew, garter snake, milk snake, ringneck snake, rat snake, painted turtle, box turtle, gray treefrog, green frog, spring peeper, northern cricket frog, dusky salamander, spotted salamander, eastern newt, and American toad.

Resident game species of principal interest that occur within the study area include white-tailed deer, gray and fox squirrels, bobwhite quail, and eastern cottontail. Populations of these game species range from moderate to high. The floodplain forest also provides habitat that supports a moderate population of gray squirrels. Past roadside surveys have indicated that eastern cottontail populations were generally moderate in the study area when compared to the remainder of the State, while quail populations were generally the highest in the State. The mixture of forest areas and cropland habitats also contributes to a relatively high density of white-tailed deer. The population of wild turkey is increasing within the study area because the Department of Fish and Wildlife Resources has an active turkey stocking program and in the past few years has stocked turkeys in the study area.

In addition, the floodplain provides habitat for wintering migratory waterfowl during periods of high water, which in turn supports some recreational use. Although it is not a prime waterfowl area, as compared with areas farther to the west, an average of over 3,400 ducks and geese are harvested from the study area annually. The riparian forest and wetlands also provide habitat for resident waterfowl, principally wood ducks, which utilize the shoreline timber for nesting and rearing areas. Recent wood duck surveys indicate that the lower Tennessee River provides breeding habitat similar to that found along other streams in Kentucky.

Wildlife resources are expected to remain relatively stable during the next several years. However, the population levels of some game species such as deer and turkey may increase due to the management efforts of the Kentucky Department of Fish and Wildlife Resources.

Endangered, Threatened, and Candidate Species

Among the fish and wildlife resources that occur in and along the lower Tennessee River are many endangered, threatened, and rare species. Some of the listed species are only present during migration and/or wintering periods. This is true for the northern and southern bald eagles and the arctic and American peregrine falcons. There have been no verified reports of nesting activity in the study area by the latter two species, but nesting bald eagles have recently been observed to the west in Kentucky along the Ohio and Mississippi Rivers, as well as to the south at Land Between the Lakes. Since suitable nesting habitat for eagles exists within the study area and eagles defend large nesting territories, pairs of mated eagles may begin to establish nesting territories along or in the vicinity of the lower Tennessee River as available habitat to the west and south is occupied.

The gray bat, Indiana bat, and southeastern bat are not known to occur in the immediate study area, but they occur seasonally in caves along the lower Cumberland River. These caves are used as hibernacula by these three species, and may also be used by summer colonies. In addition, the mature riparian forest, forested wetland areas, and associated upland forests along the lower Tennessee River provide suitable habitat for Indiana bat maternity colonies, particularly for females emerging from the caves to the east. Furthermore, the Tennessee River and/or other streams in the study area may be utilized as foraging habitat by one or more of these bat species.

Other species, such as fish and aquatic invertebrates, occur year-round in the lower Tennessee River area. Occurrence of some rare fish species such as the eastern sand darter, lake sturgeon, and blue sucker are based on historical records; these species may or may not presently inhabit the lower reaches of the river. Evidence does indicate, however, that at one time the lower Tennessee River contained a diverse mussel fauna; thirty-eight species have been reported from the lower reaches of the river, including at least two species that are presently listed as endangered.

Two endangered mussel species and one candidate snail are known to occur in the Tennessee River below Kentucky Dam (Sickel 1985). The pink mucket pearly mussel and orange-footed pearly mussel are Federally listed endangered species. The armored rocksnail is presently a candidate for listing. Two additional mussel species, the fanshell and ring pink, have been collected in the lower reach of the river within the past ten years, and both species were recently added to the official list of endangered species. Historical records indicate, however, that several additional endangered species may occur in the lower Tennessee River. Since suitable habitat still exists, the white wartyback pearly mussel, rough pigtoe, fat pocketbook pearly mussel, and tuberculed-blossom pearly mussel may still occur in the area at extremely low densities. Although these species have not been collected below Kentucky Dam, the lower Tennessee River is within the known range of all four species. This, plus results of a recent survey of the lower Cumberland River that revealed the presence of the fat pocketbook pearly mussel, suggests that remnant populations or scattered individuals may exist wherever there is suitable habitat in the river. Although many of the endangered mussels have no commercial value, harvest of mussels often results in incidental collection and mortality of listed species. In order to provide some measure of protection for what may be one of the Tennessee River's few remaining remnants of the pre-impoundment riverine mussel fauna, and endangered species, the Department of Fish and Wildlife Resources has designated Tennessee River Miles

17.8 to 22.4 as a State mussel sanctuary. Because no commercial harvest of mussels is permitted within this river reach, it is thought to serve as a source of juveniles that replenishes depleted, harvested mussel beds downriver.

Wetlands and Sensitive Areas

The Fish and Wildlife Service's National Wetlands Inventory maps reveal that numerous palustrine forested, emergent, and scrub-shrub wetlands exist in the study area. Most occur as remnant riparian or bottomland forest along tributaries to the Tennessee River, but there are some larger tracts to the west and northwest of Kentucky Dam. One wetland, located adjacent to a public boat ramp on the left side of the river, has an overstory characterized by the presence of bald cypress, a rare species that is at the northern limits of its range in western Kentucky. Another, the riparian zone along Russell Creek on the right side, is a mature bottomland hardwood forest.

PROJECT ALTERNATIVES AND POTENTIAL IMPACTS

Description of Selected Plan

Barges operating on the lower Cumberland River between Lake Barkley and the Ohio River have experienced severe navigational difficulties. Significant water level fluctuations and swift currents resulting from hydropower releases, in conjunction with several sharp river bends and areas of narrow channel widths, present difficult maneuvering conditions for barge operators. With the opening of Barkley Canal, tow operators have begun to bypass Barkley Lock and travel through Kentucky Lock, even though longer travel times are involved and long delays are sometimes encountered. An array of alternative plans to lessen or relieve the navigation difficulties encountered on the lower Cumberland River and to minimize traffic delays at Kentucky Dam has been developed by the Corps of Engineers. Nonstructural alternatives include: changing lock operation policy, using helper boats, implementing congestion fees, and adding a new terminal below Kentucky Dam.

Five lockage and three helper boat procedures were evaluated by the Nashville District. Because of high cost, the one up-one down procedure has been dropped from consideration, but the three up-three down and six up-six down procedures were carried forward. Use of helper boats is still under consideration, as is implementation of a congestion fee at Kentucky Lock.

Kentucky Lock and Dam is located at Tennessee River Mile 22.4. It is 8,422 feet in length and 206 feet high. The spillway, powerhouse, and navigation lock are concrete gravity structures, and the dam has earthen embankments. The navigation lock is 110 feet wide by 600 feet long and has a normal lift of 56 feet. Kentucky Lake provides a navigable, 9-foot channel for 184.2 miles to Pickwick Landing Dam; 2.5 miles of dredged navigable channel are available in the river below the dam. The lock services both commercial and recreational traffic, and has an average locking time of 40 minutes. However, since its opening in July, 1966, the amount of commercial and recreational traffic and the size of tows have increased dramatically. Large tows must break and double-lock, resulting in delays of up to several hours. Tows passing through Barkley Canal to avoid navigation difficulties on the Cumberland River compound the traffic and delay problems.

The selected plan, and the only structural alternative presently under consideration to relieve navigation problems on the lower Cumberland and Tennessee Rivers, is the construction of a new navigation lock at Kentucky Dam. Various lock sizes were considered during the plan formulation process: 600, 800, and 1,200 feet long by 110 feet wide. In addition, the Corps has evaluated the feasibility of constructing a new lock as compared to enlarging the existing lock. Additional formulation and project planning narrowed the alternatives down to two--construction of a 600-foot or 1,200-foot lock at Kentucky Dam--with the latter selected as the preferred alternative.

The new lock would be constructed adjacent to and landward of the existing lock, requiring the removal and relocation of the existing lock operations center and visitor facilities. Both construction alternatives would require regrading of Highway 62 and relocation of the CSX Railroad line that presently cross the river on the dam. The site of the proposed railroad relocation has changed several times, but the present proposal is to construct a new bridge downriver from the dam across a small spit of land at approximately river mile 22.1 (Figure 3). The bridge will span the new lock and cross the remainder of the river on piers. Fill will be needed in order to achieve adequate grade for the highway over the dam and the railroad line on each side of the river. Original plans called for borrow for the highway and railroad construction to come from a previously cultivated field on the right side of the river at mile 21.3. Material excavated from the lock chamber and approaches would be disposed of in the same field. This alternative would also require construction of an equipment staging area and several access roads: one across Russell Creek to the proposed borrow/disposal area, another adjacent to the proposed railroad bridge for access to the switchyard, and additional roads and parking areas for the operations and visitor centers. However, the Corps subsequently altered plans for the borrow/disposal area. Present plans include a borrow/disposal area located to the northeast of the original site on 45 acres of land owned by the Reed Crushed Stone Company. This area consists primarily of herbaceous ground cover, with scattered second-growth trees. The Corps has also acquired a 22-acre tract adjacent to the proposed borrow/disposal area to be used for mitigation purposes. This change will eliminate the need for construction of the access road across Russell Creek, but a road will be constructed across the mouth of Russell Creek to haul riprap to the eroded right bank. This road will cross the stream on a culvert, and will be left as a permanent structure to allow access to public lands downstream following project completion. The Corps has indicated that construction of the new lock will generate materials that could be used to riprap eroding banks, provide improved fish habitat, and angler access. These enhancement and

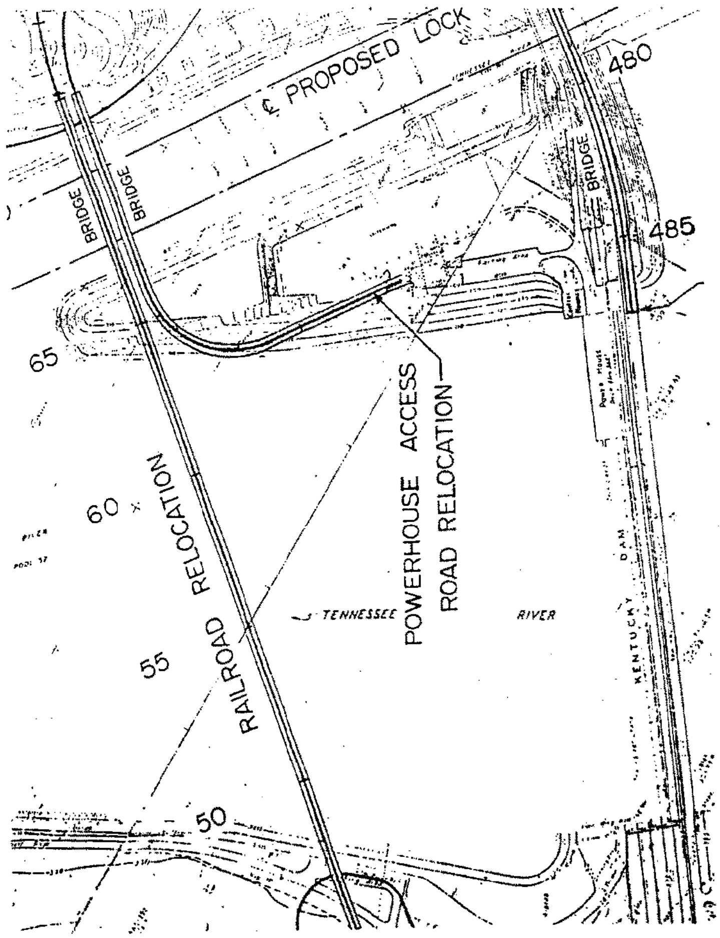

Figure 3. Site of the Proposed Railroad Relocation

improvement features will be considered and evaluated during future planning stages. Construction will also have significant adverse impacts on a public campground on the lake side of the dam. The Corps will coordinate with the State of Kentucky to relocate this facility to a suitable location.

The Nashville District is also considering construction of a training dike to moderate river flows in the new navigation channel. Although no final plans have been made to date, the proposed dike could be as long as 3,200 feet in length, and would extend two feet above normal pool elevation of 302 feet.

Description of Impacts

Although it is a nonstructural alternative, addition of a barge terminal facility below Kentucky Dam would have significant adverse impacts on fish and wildlife resources. The nearshore areas along the majority of the lower Tennessee River contain mussel beds, some of which support substantial numbers and diversity of mussel species. Heavy barge activity over and adjacent to these beds would cause scouring of the river bottom, suspension and deposition of silt on the beds, and possibly physical damage to the mussels. These impacts would likely eliminate the mussels and render the habitat unsuitable for recolonization. Inadvertent spills or runoff of various toxic materials from the terminal facility would also have negative effects on the mussels. Barge activities and related water quality degradation could result in abandonment of areas in the river by fish which serve as glochidial hosts, which would also affect the mussels and could result in long-term declines in their populations.

Implementation of the preferred alternative, construction and operation of an additional navigation lock at Kentucky Dam and related activities, could have significant adverse impacts on fish and wildlife resources in and around the lower Tennessee River. The project is likely to affect a variety of habitat types, including wetland, riverine, riparian, and upland forest. These habitats support a diversity of both aquatic and terrestrial species. In accordance with the Fish and Wildlife Service's Mitigation Policy, the Fish and Wildlife Service would consider the wetland habitats as Category 2 resources and the upland forest as Category 3. Although the Service considers most warmwater riverine habitat a Category 3 resource, we believe that those riverine habitats supporting significant mussel resources warrant a Category 2 rating. Category 2 resources are high value resources that are, or are becoming, scarce on a national basis. The mitigation goal for these resources is that there be no net loss of in-kind habitat value. Category 3 resources are of medium to high value and are relatively abundant on a national or ecoregion basis. Mitigation recommendations for Category 3 resources are designed to avoid net loss of habitat value while minimizing loss of in-kind value.

Much of the excavation for the proposed lock will be accomplished in an area that is presently occupied by the lock operation and visitor center facilities and a riprapped river bank. These areas are not likely used to a great extent by significant numbers of wildlife species. Cofferdams will be constructed prior to excavation of the lock to facilitate construction in the dry and to minimize sedimentation of downriver areas. Regrading of Highway 62 will be done on the existing maintained right-of-way. The proposed lock operations center will be located in an area that contains the present access roads and highly maintained rights-of-way. The visitor center will be constructed upslope of the upper end of the proposed lock. This area primarily consists of access road and maintained, grassed field. However, some upland forest does occur on the site and will likely be impacted by construction of the facility and associated access roads and parking areas. These portions of the proposed project are not anticipated to have serious adverse impacts on any significant terrestrial resources.

Relocation of the railroad bridge will require clearing of a new right-of-way for the tracks. Construction of the railroad line from the existing line to the proposed crossing will require clearing of approximately 2.75 acres of mature upland forest. This area probably supports good populations of mammals, songbirds, reptiles, and amphibians. Although this forest is already bisected by a number of transmission lines, clearing for the railroad will result in further fragmentation of the habitat. Species preferring forest opening and edge habitat will incur some benefit, but those requiring closed canopy will be adversely impacted. In addition, clearing will remove mature trees that could provide nesting and denning sites to a variety of cavity-dwelling species, as well as roosting and nesting sites for birds. Placement of bridge piers in the river will usurp aquatic habitat and will, to a certain degree, alter flow patterns downriver. Since most recreational and commercial fishermen employ drift fishing methods between the dam and boat ramp, bridge piers could pose a potential safety hazard, particularly during periods of swift river currents.

Construction of the bridge during fish spawning periods could result in the loss of significant portions of one or more year classes of valuable sport and/or commercial fish species. Blasting and/or pile driving could destroy benthic organisms, demersal eggs, or larval fish. Placement of fill on the left side of the river for the railroad line could lead to significant amounts of sediment entering the river as a result of runoff. Construction activities could also obstruct access to the tailwater by recreational and commercial fishermen.
A haul road is presently proposed to be located along the river bank across the mouth of Russell Creek. Negative impacts could occur if placement of the fill material and culvert resulted in hydrologic alteration of the upstream wetland habitat or the input of sand into the Tennessee River.

Construction of the new lock will also necessitate dredging near the right bank to achieve a navigation channel of adequate depth and width. Approximately 18,000 square meters (4.4 acres) of river bottom will be dredged. The proposed dredging will destroy a part of one of the best remaining freshwater mussel beds in the entire Tennessee River Basin. A high diversity of species, including at least two endangered species, inhabit the bed and exhibit good reproduction and recruitment. Sand substrate washed down from Russell Creek may also provide suitable spawning habitat for resident fish and mussel species. Adverse impacts will occur as a result of physical removal of habitat, and will be perpetuated by the operation of barges in the area. Areas of the mussel bed adjacent to the proposed navigation channel may also be affected by scour and sediment deposition generated by propeller turbulence. Significant declines in numbers of some fish species may occur directly as a result of barge-induced siltation impacts to eggs or larval fish. Negative impacts to the fish populations would also affect the mussels indirectly because of their role as hosts for larval mussels.

Additional negative impacts to aquatic resources would occur if the Corps of Engineers proceeds with development and finalization of plans to construct a training dike along the left margin of the navigation channel. The purpose of the dike would be to reduce the velocity of the river current to increase ease of maneuverability in the navigation channel, particularly for tows attempting to achieve proper alignment to enter the lock. The degree of impact would likely be directly related to the length of the dike. The result would be a significant alteration of flow along the right river bank, deposition of fine sediments and silt, and possibly changes in dissolved oxygen levels. These impacts to the habitat could have devastating long-term effects on the mussel community. Reduction of flow over the mussel bed would result in a concomitant reduction in the amount of suspended food items available to the mussels. Deposition of silt could smother both adult and juvenile mussels, resulting in significant reductions in the populations. Also, if the area were rendered unsuitable for feeding and spawning by fish, significant reduction in mussel recruitment could result. Both endangered and non-endangered mussel species could potentially be eliminated from the entire portion of the mussel bed above the I-24 bridge and possibly even farther downriver.

CONCLUSIONS AND RECOMMENDATIONS

Although the Nashville District has, through environmental planning and coordination with State and Federal agencies, selected the least environmentally damaging construction alternative, some significant impacts to fish and wildlife resources are still likely to occur. The implementation of some of the nonstructural alternatives (helper boats, change of locking procedures, or congestion fees) would result in the lowest degree of impact to fish and wildlife populations and their habitats than any of the construction alternatives. Those nonstructural alternatives would be expected to have no significant adverse impacts on the resources. Therefore, the Service would support the implementation of any or all of them, and recommends that those alternatives be given full consideration as preferred alternative solutions to the navigation problems on the lower Tennessee and Cumberland Rivers.

Primary objectives of the project should include the protection of existing fish and wildlife resources and the control of loss of valuable wetland and other wildlife habitat due to bank erosion and construction activities. In addition, the Service recommends that the Corps of Engineers actively pursue implementation of measures to realize the opportunities identified by the Corps to enhance fish and wildlife habitat, and recreational use of the Kentucky Dam tailwater.

If the preferred alternative is selected, the Fish and Wildlife Service offers the following recommendations to protect fish and wildlife resources in and around the lower Tennessee River:

1. To the maximum extent possible, construction should be done in the dry to minimize the potential for excessive sedimentation of downriver areas.

2. Construction activities should be timed to avoid critical spawning periods of valuable sport and commercial fish species.

3. Whenever possible, in-river construction activities should be timed with releases from the dam to minimize impacts of siltation to downriver resources.

4. Background turbidity levels should be identified, and turbidity should be monitored during construction. If turbidity at the mussel bed exceeds normal seasonal levels, the Corps should notify the Service immediately for reevaluation and possible reinitiation of formal endangered species consultation.

5. In-river construction of the railroad bridge and other structures should be conducted so as to minimize impediment to access to fishing areas immediately below the dam.

6. Construction engineers should design the railroad bridge to span the river on as few piers as possible. If not practical, the piers should be designed to minimize the potential for collision by small boats.

7. The riparian zone to be established by the Corps along the right descending bank should be composed of native woody and herbaceous species beneficial to wildlife.

8. The haul road proposed for construction over the mouth of Russell Creek should have adequate openings, or a culvert of adequate size, to allow for normal passage of high flows, to permit free flow during periods of low flow, and to maintain the present hydrology of the wetlands upstream of the road.

9. If plans for construction of a training dike are developed, the Corps should initiate intensive studies to determine the direct and indirect impacts that would likely occur. Alterations in current velocity and vectors, changes in dissolved oxygen level and other

water quality parameters, and changes in deposition of silt and fine sediments over the mussel bed should be determined.

10. All fill placed for the railroad bridge and highway should be immediately stabilized with straw mulch, and planted in herbaceous and/or woody vegetation as soon as practicable. Also, hay bales and silt fences should be used wherever necessary.

11. As mitigation for the loss of 18,000 square meters of mussel habitat along the right side of the river, the Corps should take the sand and gravel removed during dredging and place it back into the river in an area presently providing unsuitable habitat for mussels. An appropriate study should be conducted by the Corps to locate a site which would have the highest probability for successful creation of habitat. This "created" habitat should be monitored for a period of at least ten years to determine if mussels colonize the area, survive, and reproduce. Mussels occurring in the area to be dredged should be removed prior to dredging and placed back into the river as soon as possible to minimize stress. Any endangered species collected during this effort should immediately be placed back into the river in the existing bed in the vicinity of the I-24 bridge. If several individuals of a particular listed species are collected, they should be placed in close proximity to each other to facilitate reproduction. The Corps should also initiate an active program to develop techniques to artificially propagate mussels, initially using non-endangered species. Any juveniles obtained should be placed into the river in areas where they can be monitored to determine survival, growth, and reproduction.

The Service also recognizes that an excellent opportunity exists to enhance recreational use of the Kentucky Dam tailwater. Presently, a single boat ramp on the left side is the only practicable access to the river for boaters. A ramp does exist on the right bank, but it is in an extreme state of disrepair and, if used upon project completion, would likely be an extreme safety hazard since boats would launch directly into the proposed navigation channel. Therefore, we recommend that the Corps actively pursue the reconstruction and enhancement of the facility on the left bank. The ramp should be repaired as needed, or replaced; and adequate paved parking, trash disposal, and restroom facilities should be provided. Additional facilities might include lighting of the ramp and parking area, and installation of fish-cleaning tables. Access for bank fishermen to the existing boat harbor adjacent to the ramp should be provided or improved. In addition, access should be provided and facilities developed for handicapped fishermen at the boat harbor and/or at several locations along the left bank. The Service recommends that, upon completion of facility development, the Corps work with TVA and the State to incorporate these facilities into the State Park system.

Above all, the Service believes that it is imperative that the Corps maintain close coordination with all appropriate State and Federal agencies throughout the advanced engineering and design stages of planning, and throughout the construction phase. The purpose of coordination should be to provide these agencies an opportunity to review and comment on any future project changes.

The Fish and Wildlife Service supports the Corps of Engineers' efforts to restore wetland habitat in the project area. If it is determined during future planning that the originally and presently proposed borrow/disposal areas can be reclaimed and wetlands established, the Service would be willing to work with the Corps and provide technical assistance during the advanced planning stages to develop a plan to design wetlands that would provide adequate functional values and maximum benefits for fish and wildlife resources.

Section 7 of the Endangered Species Act requires all Federal agencies to ensure that projects they authorize, fund, or carry out do not jeopardize the continued existence of federally listed or proposed endangered or threatened species. Agencies must assess potential impacts to listed species and determine if the proposed project may affect them. A determination of "may affect" may require initiation of formal consultation; a determination of "likely to jeopardize" a proposed species requires a formal conference. The Nashville District has conducted a biological assessment for the proposed lock construction and determined that several endangered mussels and an endangered bat may be affected. Formal consultation was initiated on January 2, 1991, and a "no jeopardy" biological opinion was issued by the Service on March 29, 1991. However, the Corps should reinitiate consultation if any changes are made in the project, if plans to include the training dike are finalized, or if construction of a barge terminal below Kentucky Dam is selected as the alternative to be implemented.

REFERENCES

McLemore, William N. 1981. Creel census at Barkley Lake tailwater and at Kentucky Lake tailwater during 15 April 1978 through 31 March 1980. Kentucky Department of Fish and Wildlife Resources. 40 pp.

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Sickel, James B. 1985. Biological assessment of the freshwater mussels in the Kentucky Dam tailwaters of the Tennessee River. Report to Kentucky Division of Water. 42 pp.

Tennessee Valley Authority. 1988. TVA input to Cumberland and Tennessee Rivers below Barkley Canal Navigation Study (construction impacts to aquatics only). Unpublished Report. 49 pp.

APPENDIX B

BIOLOGICAL ASSESSMENT

BIOLOGICAL ASSESSMENT FOR PROPOSED KENTUCKY LOCK ADDITION TENNESSEE RIVER MILE 22.4

Prepared By:

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U.S. Army Engineer District, Nashville
Engineering Division
Environmental Resources Branch

December 1990

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**BIOLOGICAL ASSESSMENT FOR
PROPOSED KENTUCKY LOCK ADDITION
TENNESSEE RIVER MILE 22.4**

I. INTRODUCTION

Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) requires that activities authorized, funded, or carried out by Federal agencies not jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. Federal agencies undertaking actions that have potential for impacting listed species or critical habitats engage in a process of data collection, analysis, coordination, and consultation with the appropriate Federal resource agency (Fish and Wildlife Service or National Marine Fisheries Service).

II. PROJECT BACKGROUND

The Nashville District, Corps of Engineers is studying plans to improve navigation features and capacity of the Kentucky-Barkley navigation system. The recommended plan of action is addition of a new 110' wide by 1200' long lock, placed just landward of the existing 110' by 600' lock at Kentucky Lock and Dam (TRM 22.4). The proposed action is described in detail within the project feasibility report. The project's environmental setting and review of earlier studies concerning listed, proposed, and candidate species are synopsized within the EIS portion of the feasibility report.

A compilation of listed or proposed species was formally requested by Nashville District by letter on June 22, 1990 from Fish and Wildlife Service, Cookeville, Tennessee office. The July 18, 1990 letter of response (Exhibit 1) provided listed, proposed, and candidate species (those being considered for future listing). Three additional species not included in the letter, were considered by Nashville District during conduct of the biological assessment. These are the endangered fanshell mussel, Cyprogenia stegaria, and two candidate species, the spectacle case mussel, Cumberlandia monodonta, and Rafinesque's big-eared bat, Plecotus rafinesquii.

III. ASSESSMENT METHODOLOGY

In order to obtain up-to-date, site specific information for preparing this biological assessment a variety of information sources and/or experts with knowledge of pertinent species were consulted. Appendixes A-E listed below are the analytical reports assessing project impacts on species of concern.

Appendix A	"Field Reconnaissance for Federally Listed Bats in Proximity of the Proposed Kentucky Lock Project"
Appendix B	"A Survey for Threatened or Endangered Birds and Reptiles in Proximity of the Proposed Kentucky Lock Project"
Appendix C	"An Investigation of Freshwater Mussels (Unionidae) in the Tennessee River Below Kentucky Lock and Dam"
Appendix D	"Review of Occurrence Records for Rare Fish Species in Proximity of the Proposed Kentucky Lock Project"
Appendix E	"Survey for Rare Plants in Proximity of the Proposed Kentucky Lock Project"

Each report provides accounts of species historical occurrence in the project area, sample methods used for the studies, study results, discussion, conclusions, and references.

IV. DETERMINATIONS

A determination of affect was made after examining evidence available for each species under consideration in this biological assessment. Corps of Engineers determinations are presented in Tables 1 and 2. Determinations for listed and proposed species are provided in Table 1, while Table 2 provides like findings for candidate species.

Will not affect determinations resulted if project impacts on the environmental baseline were judged likely not to cause loss of individuals of that species. Individuals of transient or highly mobile species such as the bald eagle, arctic peregrine falcon, lake sturgeon, and blue sucker would probably leave the project area, if disturbed. For most mussel species receiving a will not affect finding, the lack of their documented existence in recent times (last 15 years) in proximity to the project area was given the greatest weight in the determination analysis. An exception is the spectacle case mussel, recently (1990) documented for the first time in the lower Tennessee River by Dr. Jim Sickel (pers. comm.). The species was discovered several miles downstream of the project site, in a habitat typical for the species, among boulders and large rocks. Based upon habitat requirements and earlier studies which did not reveal the species, the spectacle case mussel received a will not affect determination.

In the case of the gray bat, a year-round cave dweller, the lack of any impact on area caves resulted in a will not affect finding. Plant species were evaluated based upon habitat requirements and results of a walking survey of the project area.

Will affect determinations resulted if project impacts on the environmental baseline were judged to have any likelihood to cause loss of individuals of that species. For the three bat species, Indiana, Rafinesque's, and Southeastern, a will affect determination resulted primarily from the tendency of these animals to roost in hollow or exfoliating dead trees, often in a bottomland hardwood forest setting. Trees in this condition, though not proven roosts, are present in bottomland hardwood forest in proximity to areas to be impacted by the project.

The four mussel species listed under may affect are placed because they have been recorded within the past 15 years within the overall project area. Considering this time frame, of the endangered mussels, only the pink mucket has been recorded between the Interstate 24 bridge and Kentucky Lock and Dam. The orange-footed pearly mussel has been recorded just downstream of the Interstate 24 bridge. Both species appear to be widespread though very rare components of mussel fauna in the major rivers of the area. The fanshell mussel and ring pink mussel are extremely rare within the Tennessee River below Kentucky Dam.

The mussel survey conducted as part of this biological assessment (Appendix C) and earlier surveys all provide a high degree of assurance that portions of the Tennessee River likely to be impacted by the project do not harbor significant remnants of any endangered mussel populations. It is however virtually impossible to sample a large population and be absolutely certain that individuals of an endangered species are not present.

The armigerous river snail and varicose rocksnail will be impacted by construction activities, particularly dredging of the lower lock approach. The other two snails, muddy rocksnail and ornate rocksnail, while not found in the 1990 survey (Appendix C) have been recorded in scattered locations within the 22.4 mile reach of the lower Tennessee River. Evidence indicates the two latter species to be much less common in the lower Tennessee River than the armigerous river snail and varicose rocksnail. The documented occurrence of two snail species and the reasonable likelihood of the remaining two species occurring within project impact areas resulted in a may affect for all four candidate snails.

Based upon habitat requirements, a may affect determination was derived for Bachman's sparrow. This bird occupies disturbed lands and is sometimes associated with pine woods. Habitat matching these requirements will be impacted by construction activities. A will not affect determination was made for the copperbelly water snake based upon lack of impact on its preferred wetland type habitat.

V. PROTECTIVE MEASURES

Measures to mitigate potential adverse impacts on listed species are planned. mitigative measures include:

1. Removal of mussels from areas to be dredged. Mussels to be relocated to areas of suitable substrate.

2. Construction of replacement gravel bar type habitat in the lower Tennessee with materials dredged from the new lock's lower approach.

3. Placement of rock on the right descending bank below Russell Creek to stabilize the eroding bank.

4. Avoidance of identified wetland areas by construction activities.

5. Establishment of buffer zone along Russell Creek and adjoining bottomland hardwoods to prevent loss of this important habitat.

6. Creation of wetlands or similar type habitat in the right bank borrow/disposal area between Russell Creek and Interstate 24.

7. Planting of a riparian zone adjacent the right descending bank of the Tennessee River between the mouth of Russell Creek and Interstate 24.

VI. CONCLUSION

The conclusions of this biological assessment are presented in Tables 1 and 2. They are based upon the best technical information available on known distribution, habitat requirements, and other life history factors for species evaluated. May affect determinations resulted from the overall unlikely but still possible potential for environmental consequences of Kentucky Lock addition project to adversely impact species considered in this biological assessment. Absolute certainty concerning impacts of an activity upon a given species is difficult to achieve, therefore these conclusions are grounded in a reasoned analysis of potential avenues of impact upon those species evaluated.

TABLE 1

DETERMINATIONS FOR
LISTED AND PROPOSED SPECIES

Species	Status	Will Not Affect	May Affect
Gray bat, Myotis griscens	E	X	
Indiana bat, Myotis sodalis	E		X
Rafinesque's big-eared bat, Plecotus rafinesquii	T		X
Bald eagle, Haliaeetus leucocephalus	E	X	
Arctic peregrine falcon, Falco peregrinus tundrius	T	X	
Rough pigtoe pearly mussel, Pleurobema plenum	E	X	
Orange-footed pearly mussel, Plethobasus cooperianus	E		X
White-wartyback mussel, Plethobasus cicatricosus	E	X	
Pink mucket pearly mussel, Lampsilis orbiculata	E		X
Ring pink, Obovaria retusa	E		X
Fat pocketbook pearly mussel, Potamilus capax	E	X	
Tuberculed-blossom pearly mussel, Epioblasma torulosa torulosa	E	X	
Fanshell mussel, Cyprogenia stegaria	E		X
Price's potato bean, Apios priceana	T	X	

TABLE 2

DETERMINATIONS FOR CANDIDATE SPECIES

Species	Will Not Affect	May Affect
Southeastern bat, *Myotis austroriparius*		X
Bachman's sparrow, *Aimophila aestivalis*		X
Lake sturgeon, *Acipenser fulvescens*	X	
Blue sucker, *Cycleptus elongatus*	X	
Copperbelly water snake, *Nerodia erythrogaster neglecta*		X
Armigerous river snail, *Lithasia armigera*		X
Ornate rocksnail, *Lithasia geniculata*		X
Varicose rocksnail, *Lithasia verrucosa*		X
Muddy rocksnail, *Lithasia salebrosa*		X
Salamander mussel, *Simpsonaias ambigua*	X	
Spectacle case mussel, *Cumberlandia monodonta*	X	
Lake cress, *Armoracia aquatica*	X	
Appalachian bugbane, *Cimicifuga rubifolia*	X	

EXHIBIT 1

Fish and Wildlife Service Listing Letter

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Post Office Box 845
Cookeville, TN 38503

July 18, 1990

Mr. R. J. Connor, P.E.
Chief, Engineering Division
U.S. Army Corps of Engineers
P. O. Box 1070
Nashville, Tennessee 37202-1070

Dear Mr. Connor:

Your letter of June 22, 1990, regarding plans to improve navigation conditions in the Kentucky-Barkley navigation system, was received June 25, 1990. We have reviewed the project as requested with regard to endangered and threatened species.

According to our records, the following listed and proposed species may occur in the project impact area:

Gray bat - Myotis grisescens (E)
Indiana bat - Myotis sodalis (E)
Bald eagle - Haliaeetus leucocephalus (E)
Artic peregrine falcon - Falco peregrinus tundrius (T)
Rough pigtoe pearly mussel -Pleurobema plenum (E)
Orange-footed pearly mussel - Plethobasus cooperianus (E)
Pink mucket pearly mussel - Lampsilis orbiculata (E)
Ring pink - Obovaria retusa (E)
Fat pocketbook pearly mussel - Potamilus capax (E)
White wartyback pearly mussel - Plethobasus cicatricosus (E)
Tuberculed-blossom pearly mussel - Epioblasma torulosa torulosa (E)
Price's potato bean - Apios priceana (T)

In addition, there are species that, although not presently listed or proposed, are being considered for listing in the future. Candidate species that may be found in the vicinity of the project are:

Southeastern bat - Myotis austroriparius
Bachman's sparrow - Aimophila aestivalis
Lake sturgeon - Acipenser fulvescens
Blue sucker - Cycleptus elongatus
Copperbelly water snake - Nerodia erythrogaster neglecta
Armigerous river snail - Lithasia armigera
Ornate rocksnail (=geniculate river snail) - Lithasia geniculata
Varicose rocksnail (=verrucose river snail) - Lithasia verrucosa
Muddy rocksnail (=rugged river snail) - Lithasia salebrosa
Salamander mussel - Simpsonaias ambigua
Lake-cress - Armoracia aquatica
Appalachian bugbane - Cimicifuga rubifolia

Section 7 of the Endangered Species Act requires federal agencies to ensure that actions they authorize, fund, or carry out do not jeopardize the continued existence of federally listed or proposed species. You should assess potential impacts to the listed and proposed species and determine if the project may affect them. A "may affect" finding may require formal consultation. Although candidate species are not legally protected, we would appreciate anything you do to avoid impacting them.

Thank you for the opportunity to comment at this stage in project development.

Sincerely,

Lee A. Barclay, Ph.D.
Field Supervisor

JCW/b

APPENDIX A

Final Report

to

Environmental Resources Branch
U. S. Army Engineer District
Nashville, Tennessee

FIELD RECONNAISSANCE FOR FEDERALLY LISTED BATS IN PROXIMITY OF THE PROPOSED KENTUCKY LOCK PROJECT

December 1990

Principal Investigator
Michael J. Harvey
Department of Biology
Tennessee Technological University
Cookeville, Tennessee 38505

FIELD RECONNAISSANCE FOR FEDERALLY LISTED BATS IN PROXIMITY OF THE PROPOSED KENTUCKY LOCK PROJECT

Michael J. Harvey

PREFACE

Section 7 of the Endangered Species Act requires federal agencies to insure that actions they authorize, fund, or carry out do not jeopardize the continued existence of federally listed or proposed species.

The U.S. Army Engineer District, Nashville, plans to construct a 1200 ft lock near the existing 600 ft lock at Kentucky Lock and Dam. Plans call for the existing navigation channel to be shifted toward the right descending bank. In addition to excavation for the additional lock, a large amount of material will be removed from a dredge cut along the right descending bank of the river. Dredged material will be placed at a disposal site below the dam. Two new mooring cells will be constructed between the lock and the I-24 bridge. The railroad bridge crossing the existing lock below the lower gate will be relocated downstream and a new bridge constructed.

Because of the possible impact of the proposed project on federally listed species, it was necessary to conduct inventories of listed species which might possibly be impacted. This report deals with federally listed bats possibly occurring in the vicinity of the proposed project.

INTRODUCTION

Four bat species listed by the U.S. Fish and Wildlife Service as endangered or under review for possible listing as endangered or threatened may occur in the proximity of the proposed project. They are *Myotis grisescens*, gray bat (endangered); *Myotis sodalis*, Indiana bat (endangered); *Myotis austroriparius*, southeastern bat (under review); and *Plecotus rafinesquii*, Rafinesque's big-eared bat (under review).

The purpose of this study was to conduct a field reconnaissance to determine if suitable habitat for these bat species exists in the vicinity of the project and to gather information concerning the presence of these species in the project area by reviewing the literature and by contacting persons with knowledge about these species.

SPECIES ACCOUNTS

The following accounts contain information on the four bat species found in the Kentucky Dam area that are listed by the U.S. Fish and Wildlife Service as endangered or under review for possible listing as endangered or threatened.

Gray bat - *Myotis grisescens*

The range of the endangered gray bat is concentrated in the cave regions of Arkansas, Missouri, Kentucky, Tennessee, and Alabama, with occasional colonies and individuals found in adjacent states. The present total gray bat population is estimated to number over 1,500,000; however, about 95% hibernate in only eight caves -- three in Missouri, two in Tennessee, and one each in Alabama, Arkansas, and Kentucky. Although gray bat numbers are relatively high, their total population has decreased significantly during recent years.

Gray bats are cave residents year-round, although different caves are usually occupied in summer and winter. Few have been found roosting outside caves. They hibernate primarily in deep vertical caves with large rooms that act as cold air traps. Gray bats hibernate in clusters of up to several thousand individuals, about 170 bats per square foot. They choose hibernation sites where temperatures average 42 - 52 F.

During summer, female gray bats form maternity colonies of a few hundred to many thousands of individuals, often in large caves containing streams. Maternity colonies prefer caves that, because of their configuration, trap warm air (usually 58 - 77 F) or that provide restricted rooms or domed ceilings capable of trapping the combined body heat from clustered individuals. Because of their highly specific habitat requirements, fewer than 5% of available caves are suitable for gray bat occupation. Male gray bats, along with non-reproductive females, form summer bachelor colonies.

Gray bats occupy a wider variety of caves during spring and autumn transient periods. During all seasons, males and yearling females seem less restricted to specific cave and roost types. Summer caves, especially those occupied by maternity colonies, are rarely located more than 2 mi., and usually less than 1 mi., from rivers or lakes. Each summer colony occupies a home range that often contains several roosting caves scattered along as much as 50 mi. of river or lake shore.

Mating occurs in September and October when gray bats arrive at hibernation caves. Females enter hibernation immediately after mating. Males remain active for several weeks, replenishing fat supplies depleted during breeding activities. Juveniles and adult males enter hibernation several weeks later than adult females. Adult females emerge from hibernation in late March or early April, followed by juveniles and adult males.

Females store sperm through the winter and become pregnant soon after emerging from hibernation. A single pup is born in late May or early June. Growth rates of young vary with temperatures at maternity roosts; pups in warmer roost situations grow more rapidly. Most begin flying within 20-25 days after birth.

Gray bats forage primarily over water along rivers or lake shores. Most foraging occurs within 15 ft of the surface. Mayflies are apparently a major item in the diet, but like most bat species, they often feed on other insects as well. Longevity data indicate life spans of at least 14-15 yr.

Estimating gray bat population declines is possible because of the presence of guano deposits and ceiling stain left in the caves by roosting bats. Historical estimates based on guano and ceiling stain have indicated an 89% decline in Kentucky, a 72-81%

decline in Missouri, a 61% decline in Arkansas, and a 76% decline in Tennessee and Alabama.

Indiana bat - *Myotis sodalis*

The range of the endangered Indiana bat is in the eastern U. S. from Oklahoma, Iowa, and Wisconsin east to Vermont and south to northwestern Florida. Distribution is associated with major cave regions and areas north of cave regions. The present total population is estimated at less than 400,000, with more than 85% hibernating at only seven locations -- two caves and a mine in Missouri, two caves in Indiana, and two caves in Kentucky.

Indiana bats usually hibernate in large dense clusters of up to several thousand individuals, in sections of thehibernation cave where temperatures average 38 - 43 F and with relative humidities of 66 - 95%. They hibernate from October to April, depending on climatic conditions. Density in tightly packed clusters is usually estimated at 300 bats per square foot, although as many as 480 per square foot have been reported.

Female Indiana bats depart hibernation caves before males and arrive at summer maternity roosts in mid May. A single offspring, born during June, is raised under loose tree bark, primarily in wooded streamside habitat. During September they depart for hibernation caves. The summer roost of adult males is often near maternity roosts, but where most males spend the day is unknown. Other males remain near the hibernaculum. A few males can be found in caves during summer.

Until relatively recently, little was known about the summer habitat and ecology of the Indiana bat. The first maternity colony was discovered in 1974, under the loose bark on a dead bitternut hickory tree in east-central Indiana. The colony, numbering about 50 individuals, also used an alternate roost under the bark of a living shagbark hickory tree. The total foraging range of the colony consisted of a linear strip along approximately 0.5 mi. of creek. Foraging habitat was confined to air space from 6 ft to ca. 95 ft high near the foilage of streamside and floodplain trees.

Two additional colonies were discovered during subsequent summers, also in east-central Indiana. These had estimated populations of 100 and 91 respectively, including females and pups. Habitat and foraging area were similar to the first colony discovered. Additional evidence gathered during recent years indicates that, during summer, Indiana bats are widely dispersed in suitable habitat throughout a large portion of their range.

Through the use of radio telemetry techniques, several additional maternity colonies have recently been discovered and studied at several locations in Illinois. These studies reinforced the belief that floodplain forest is important habitat for Indiana bat summer populations. However, maternity colonies were also located in more upland habitats. It was also discovered that Indiana bats exhibited fidelity to specific roosting and foraging areas to which they returned annually.

Between early August and mid September, Indiana bats arrive near their hibernation caves and engage in swarming and mating activity. Swarming at cave entrances continues into mid or late October. During this time, fat reserves are built up for hibernation.

It is thought Indiana bats feed primarily on moths. A longivity record of 13 yr 10 mo has been recorded for this species.

Hibernating bats leave little evidence of their past numbers, thus it is difficult to calculate a realistic estimate of the overall population decline for this species. However, population estimates at major hibernacula indicated a 34% decline in the total Indiana bat population from 1983 to 1989.

Southeastern bat - *Myotis austroriparius*

The southeastern bat is found throughout much of the southeastern U.S., from coastal North Carolina to eastern Oklahoma and north into Illinois, Indiana, and Kentucky. In Florida cave regions, caves are favorite roosting sites, although buildings and other shelters are sometimes used. Maternity colonies numbering in the thousands inhabit caves. Throughout much of the south, these bats reside in buildings and hollow trees. In the northern part of their range, they roost primarily in caves. Southeastern bats are usually associated with bodies of water, over which they feed. They forage very low, close to the surface of the water.

Data on reproduction for this species are available only for southern populations. The mating time is unknown. Parturation begins in late April and peaks in mid May. Approximately 90% of pregnant females bear twins. This is unique among U.S. *Myotis* bats; all other species normally produce a single pup. Clusters of young are often located separate from females during the day. Pups can fly when 5 - 6 wk old.

Rafinesque's big-eared bat - *Plecotus rafinesquii*

Rafinesque's big-eared bat occurs in the southeastern U.S. from Texas and Oklahoma to the east coast and north to Illinois, Indiana, Ohio, West Virginia, and Virginia. In the northern part of their range, they hibernate in caves, mines, or similar habitats, including cisterns and wells. In contrast, they are not usually found in caves during winter in the more southern parts of their range. These bats appear widespread in distribution, but are abundant nowhere.

Maternity colonies are usually found in abandoned buildings, sometimes in rather well-lighted areas. They usually consist of a few to several dozen adults. Maternity colonies are more rarely found in caves and mines. Males are generally solitary during summer, roosting in buildings or hollow trees.

Rafinesque's big-eared bats emerge late in the evening to forage, usually after dark. Almost nothing is known about their feeding behavior. Little information is available concerning reproduction in this species. Females usually bear one pup, in late May or early June. Rafinesque's big-eared bat is perhaps the least known of all eastern U.S. bats.

METHODS

A 1-day field reconnaissance was conducted on 9 November 1990. Three areas of concern were visited. The first area visited (Site 1) was the proposed site for borrow and disposal. It consisted primarily of a large bottomland field bounded by a wooded area comprising the buffer zone along Russell Creek. The creek is a steep sided, mud banked stream that meanders before entering the Tennessee River at the boat ramp on the right bank.

Site 2 was an upland wooded area near Walker Cemetary that would be impacted by the proposed relocation of the railroad.

Site 3, on the left bank, consisted of a pine forest that would be impacted by railroad construction and a cypress slough on either side of the access road to the boat ramp.

In addition to the field reconnaissance, pertinent literature was reviewed and persons knowledgeable about the possible presence of listed bat species in the area were contacted. Those persons contacted were Mr. John MacGregor, U.S. Forest Service, Daniel Boone National Forest (until recently with the Kentucky Department of Fisn and Wildlife Resources); Mr. Brainard L. Palmer-Ball, Kentucky Nature Preserves Commission; and Mr. James E. Gardner, Illinois Natural History Survey.

RESULTS AND DISCUSSION

All four bat species of concern could possibly occur in the proposed project area during the warmer seasons of the year. All four species are known to occur in the general area of the proposed project site.

Although gray bats roost almost exclusively in caves during both summer and winter, they usually feed over water, and sometimes travel several miles from roost sites to foraging areas. Summer gray bat colonies are known to occur in Hardin Co., Illinois and Trigg Co., Kentucky. Also, it is possible that small numbers of gray bats may inhabit caves near Smithland in Livingston Co., Kentucky, during summer, only a few miles from the site. Since gray bats, if present, would be there only to forage over the lake, the proposed project would not likely be detrimental to this species.

Approximately 160 Indiana bats hibernate in Shaw Hill Cave near Smithland; smaller colonies hibernate in other caves in the vicinity of the project area. However, hibernating bats at these locations would not be impacted by the proposed project.

There are several recent records of summer colonies or of individual Indiana bats from nearby areas, especially in southern Illinois. The streamside lowland habitat along Russell Creek and in the cypress slough area appear to be typical preferred Indiana bat summer habitat, i.e., riparian forest with numerous dead trees with exfoliating bark, as well as living shagbark hickory trees and other hollow trees. Indiana bats could very possibly inhabit these two wooded areas, as well as the upland wooded area near Walker Cemetary.

Small colonies of southeastern bats also hibernate in several caves in Livingston Co., Kentucky. Researchers in southern Illinois recently reported finding small summer colonies of southeastern bats in hollow trees. Rafinesque's big-eared bats were also discovered in hollow trees in the same area. The area where these two bat species were found is only ca. 12 mi. north of the Ballard Co. (Kentucky) Wildlife Management Area, located a few miles west of the project site.

The presence of southeastern bats and Rafinesque's big-eared bats in hollow trees in that nearby area indicates the possibility that one or both species might also inhabit hollow trees in wooded areas at the project site.

It is thus possible that all four listed species may occur at or near the project site. Summer colonies of Indiana bats, southeastern bats, and Rafinesques's big-eared bats could inhabit the forested areas at the site, while all four species might possibly forage in the area.

The only feasible way to be certain that any of these bat species are actually present in the area during summer would be by mist netting at selected sites during the summer months.

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APPENDIX B

A SURVEY FOR THREATENED OR ENDANGERED BIRDS AND REPTILES IN PROXIMITY OF THE PROPOSED KENTUCKY LOCK PROJECT

Principal Investigator

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Associate Professor
Department of Biology
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FINAL REPORT

to

U.S. Army Corps of Engineers
Nashville District
Environmental Resources Branch
Nashville, TN

December, 1990

INTRODUCTION

Due to the proposed construction of a new lock on the Tennessee River at Kentucky Dam by the United States Army Corps of Engineers, it became necessary to examine the possible impact such construction might have on species now listed as endangered or threatened by the federal government. To this end, three avian and one reptilian species which may occur in the area to be disturbed by the proposed construction project were considered.

The purpose of this investigation was to determine, through field and literature surveys, the presence of suitable habitat for, and the presence of, any federally endangered or threatened species. Those proposed for such listing in the future were also examined. The species here reviewed, and their current status are: (1) bald eagle, Haliaeetus leucocephalus (endangered); (2) Arctic peregrine falcon, Falco peregrinus tundrius (threatened); (3) Bachman's sparrow, Aimophila aestivalis (under review); and (4) copperbelly water snake, Nerodia erythrogaster neglecta (under review).

SPECIES ACCOUNTS

The following accounts relate pertinent life history information for those species mentioned above. General information, as well as specific habitat requirements, are presented.

Class Aves

Order Falconiformes

Family Accipitridae

Bald Eagle, Haliaeetus leucocephalus (Linnaeus)

General:

Since 1782, the bald eagle has been the American national symbol. Its numbers have been reduced to a few remaining populations in the forty-eight contiguous United States, due chiefly to habitat loss and pesticide use. The species is native only to North America and once was wide ranging over the continent. Two subspecies are recognized by some biologists. These are the northern race, Haliaeetus leucocephalus alaskanus, and the southern form, Haliaeetus leucocephalus leucocephalus. These differ essentially in size only (Stalmaster, 1987). The northern subspecies, probably the one most often found in Kentucky, is generally larger. Recent attempts to restore the bald eagle population in Tennessee and Kentucky through relocation programs have been summarized by Jordan (1988, 1989, 1990).

Habitat:

Bald eagles frequent the environs of lakes, rivers and seacoasts. In Kentucky, these are known from areas bordering the Ohio, Mississippi, and Green Rivers, as well as Kentucky Lake (Mengel, 1965). Funkhouser (1925) lists records from Paducah and Livingston County but gives no details. The number of birds increases in winter due to the southern migration of great lakes birds. Barbour, et al. (1973) indicates the species to be most abundant in the state from mid-October through late April, but also states that it may occur at all seasons on the larger rivers and impoundments.

Physical Appearance:

Bald eagles are large (35-43" long), long-winged (to 8'), soaring birds. They have yellow beaks, tarsi, and eyes as adults and are dark brown with a white head and tail. Immatures are nearly as large, but lack the white head and tail as well as the yellow beak and eye. These are gradually acquired with sexual maturity at about four and one-half to five years of age. The species, being predatory, bear large, powerful talons and beaks.

Nesting:

Bald eagles, according to Mengel (1965), may occasionally nest in suitable localities anywhere in Kentucky. Barbour, et al. (1973) states that there was no evidence, at that time, of breeding in Kentucky since the 1950s. Old nests of this species are quite large, with a diameter of perhaps six to eight feet and a weight of several hundred pounds. These nests may be added to and reused for several years. The construction is essentially an accumulation of sticks heaped upon one another, with an occasional lining of moss, grass, weeds and/or sod. This structure is normally located in a large tree, perhaps 80-100 feet from the ground. The nest is rarely far from water and usually within sight of it.

One to three dull white eggs are laid and hatch in about 35 days. Both sexes incubate the eggs and care for the young, which do not leave the nest until about 10 weeks of age.

Food:

Bald eagles are flesh eaters and prefer fish. They may, however, feed on a variety of appropriately sized animals, including turtles, snakes, rodents, aquatic birds, and carrion.

Class Aves

Order Falconiformes

Family Falconidae

Peregrine Falcon, Falco peregrinus Tunstall

General:

Peregrines are rare, local falcons frequenting coasts, mountains, and woodlands. It is perhaps best known, if at all, for its speed, having been clocked at over 200 miles per hour (Cassidy, 1990). Barbour, et al. (1973) believed it extinct in Kentucky and Mengel (1965) indicated no specimens had ever been taken from the state. He also believed any breeding birds in Kentucky were of the subspecies Falco peregrinus anatum and that the "arctic form" (Falco peregrins tundrius) only occurred as a migrant. Peterson (1980) and Scott (1983) believe the eastern U.S. population to be in serious decline or exterminated by pesticides.

Habitat:

Peregrine falcons are noted for their apparent preference for high perches, especially cliffs, ledges, bridges and even tall buildings. Observations often place them near water, as did Audubon's sightings on cliffs along the Green River. Mengel (1965) lists several records of Kentucky sightings (none in Livingston or Marshall Counties) and places them in association with large streams or cypress swamps. He also states that no active eyrie has been found in Kentucky, and Funkhouser indicated that there was no breeding records for this species in the state as early as 1925.

Physical Appearance:

This falcon is a relatively large predatory bird with a length of about 15-20 inches and a wingspan of 40 inches or so. It is slate gray or brown (immatures) on the dorsum and white to buff, heavily streaked with black or brown below. They have a dark cap with equally dark facial marks ("sideburns" extending below the eyes) (Peterson, 1980). In flight, long, pointed wings and a long tail are evident. It flies with distinctive rapid, "rowing" wingbeats.

Nesting:

The nest of the peregrine falcon is as unimpressive as the bald eagle is impressive. The female scrapes a one to two inch deep depression on a cliff ledge -- hardly a nest at all -- in which to lay her three to five brown blotched, white eggs. These are incubated for 20-35 days, and the young fledge at about six weeks of age. Mengel (1965) notes that these falcons are known to also nest in the tops of hollow cypress trees at Reelfoot Lake. In fact, the last known nesting of this species in neighboring Tennessee was at Reelfoot in 1947 (Robinson, 1990).

Food:

These swift flying falcons often feed on smaller birds which they catch in flight. They are known also by the common name "duck hawk" in some regions due to their predation on certain waterfowl. Small mammals and large insects occasionally supplement their avian fare.

Class Aves

Order Passeriformes

Family Emberizidae

Sub-Family Emberizinae

Bachman's Sparrow, Aimophila aestivalis (Lichtenstein)

General:

Bachman's sparrow is the only member of the genus Aimophila to occur in the eastern U.S. At least four other species (rufous-crowned, rufous-winged, Botteri's and Cassin's sparrows) are related by genus and all are chiefly inhabitants of the arid southwest. Bachman's sparrow is, therefore, most likely to be confused with the field sparrow (Spizella pusilla) because of their superficial similarity in appearance, as well as their frequent association in the same habitat.

Habitat:

The habitat of Bachman's sparrow is perhaps best described by Mengel in his classic 1965 monograph:

"The choicest locations are about fifty to one hundred yards down from the ridge tops in old deserted fields. A typical territory is a circle 150 feet each way from an eroded gulley which has healed and is now well covered with miscellaneous trees, shrubs, and particularly blackberry brambles. The territory is more attractive after about five percent of the open grasslands adjacent to the gullies are dotted with blackberry briars. Usually the center of the territory is close to the upper end of the gulley, and the abundant plants are the dry soil goldenrods and asters, wild oat grass (Danthonia spicata), and various other grasses, composites, and miscellaneous weeds typical of dry, eroded slopes."

Mengel indicated also that the previous description was "typical" but some variations were known:

"....aberrant territories were on flat ground in oak-scrub at the edge of a broomsedge field adjoining the cypress fringes of Reelfoot Lake; in a flat, poorly tended orchard encroached upon by dense grassy ground cover, with no blackberries or erosion gullies, in McCracken County; in a small brushy area at the junction of fences where grazed and ungrazed fields adjoined, in Kenton County; and on a gentle slope along the brush-grown fence row between a cornfield and a meadow largely of timothy, in Laurel County."

One habitat type frequently mentioned by other workers, but omitted by Mengel, is that of pine woods. In fact, the bird was once known by the common name "pine woods sparrow", indicating its preference for and presence in such habitat. Peterson (1947) and Hon (1963) list only "open pine woods" as the habitat while "open pine or oak woodlands, brushy pastures...." are described by Cassidy (1990). Robbins, et al. (1966) give "abandoned fields with scattered shrubs, pines or oaks, usually in dense ground cover" as the habitat. James and Neal (1986) also indicate a strong preference for pines in Arkansas. Here, the largest number of individuals appear to occur in young (one to three year old) pine plantations, developed after forest clear-cutting. Some, however, were found in mature pine forests where fire had eliminated the understory. Robinson (1990) substantiates the above for Tennessee with his statement "....old fields with and interspersion of bare ground and herbaceous cover (prefers Panicum and Andropogon grasses); also uses clear-cut areas replanted to pines."

Physical Appearance:

Bachman's sparrow is a small (5 3/4" total length), long-tailed bird with a reddish-brown dorsum and an unmarked, gray venter. The breast is often buff colored. Its crown and back are marked with longitudinal dark stripes. Some southern populations (Georgia and Florida) have black to dark brown streaked backs and tails. A reddish-brown eye stripe, dark upper mandible, and yellow bend of the wing are further identifying marks.

Nesting:

The nest of this species is constructed of grasses, and ordinarily well concealed on the ground in dense cover, such as greenbriar, grasses, ragweed, small trees and shrubs, and brambles. Nests are usually cup shaped, but occassionally cylindrical and domed with a side entrance. The eggs are white, number from 3-5 and hatch in 12-14 days (Funkhouser, 1925; Hon, 1963; Mengel, 1965; Barbour, et al., 1973; Harrison, 1975; James and Neal, 1986; and

Cassidy, 1989). Mengel (1965) suggests that some pairs may rear two broods in Kentucky and Harrison (1975) indicates this to be typical for the species.

Food:

Bachman's sparrow apparently feeds upon various insects, anachnids and seeds (Cassidy, 1989).

Class Reptilia

Order Squamata

Sub-Order Serpentes

Family Colubridae

Northern Copperbelly Water Snake

Nerodia erythrogaster neglecta Conant

General:

Members of this genus (Nerodia) are those snakes familiar to many and which commonly occur in a variety of aquatic situations in both the New and Old Worlds. These are the "water moccasins" feared and often killed by fishermen and others who invade their habitats. Many are relatively large, stout-bodied snakes which may be seen basking on logs, rocks or muddy banks (occasionally on an overhanging branch) near water on warm, sunny days.

The northern copperbelly water snake is one of four closely related races of the species Nerodia erythrogaster recognized and described by Cochran and Goin (1970), Conant (1975) and Behler and King (1979). Its three close relatives are the red-bellied water snake (N. e. erythrogaster), the yellow-bellied water snake (N. e. flavigaster) and the blotched water snake (N. e. transversa). Being only subspecies, any of these may interbreed where their ranges overlap. Mount (1975) describes such crosses between N. e. erythrogaster and N. e. flavigaster in Alabama.

Barbour (1971) recognizes two of these subspecies (N. e. flavigaster and N. e. neglecta) as occurring in Kentucky. He lists its distribution in the state as "the central and northeastern sections of the Jackson Purchase and the Land Between the Lakes, thence up the Ohio River at least into Henderson County." Brainered Palmer-Ball (personal communication), however, indicated that the nearest "true" N. e. neglecta populations are recorded from Calloway County, on the western side of Kentucky Lake.

Habitat:

Northern copperbelly water snakes appear to favor a habitat of rather sluggish waters associated with sloughs, floodplain pools and woodland or river bottom swamps. They are known to have a pronounced tendency to wander away from water in hot, humid weather and hide under various kinds of surface debris. Rainy nights may find them moving into flooded ditches and temporary pools where amphibians congregate to breed.

Physical Appearance:

The copperbelly race of N. erythrogaster. like its close relatives, may become a rather large and robust serpent. They are about 10" long at birth and may grow to be four to five feet as adults. Immatures are tan above with brown lateral blotches alternating with mid-dorsal ones of the same color. They, like the adults, have an orange-red belly with dark pigment invading the ventral scutes. Adults are plain dark brown or black above. Scale rows at midbody range from 21 to 25. They have keeled scales which gives them a rough-textured appearance, and the anal plate is normally divided.

Breeding:

These snakes apparently emerge from hibernation in April. I have seen the species at Murphey's Pond in Hickman County on the first weekend of April. They probably copulate in May and bring forth 10-30 live young in September or October.

Food:

Northern copperbelly water snakes feed upon various aquatic animals, perhaps utilizing those most abundant at a particular season. They are known to capture fish, frogs, toads, and salamanders. Barbour (1971) reported that they were known to congregate near the spillway of an impoundment and take fish washed over the dam.

METHODS

On November 9, 1990, a one-day, on-site survey was conducted in the company of M. J. Harvey, a Tennessee Tech professor, and Richard Tippit, a USACE biologist. Three terrestrial areas to be primarily impacted by the proposed construction were visited. These were:

A. Borrow and disposal site. This area (Livingston County) consisted of a large, open, grassy field bordered by Russell Creek and its associated hardwoods.

B. Railroad relocation site. Here, a hardwood forest (also Livingston County), somewhat elevated above the previous site and near Walker Cemetery, was examined.

C. Cypress swamp/pine plantation site. This area, located across the Tennessee River from the two previous sites was in Marshall County. It consisted of a planted pine woods which would likely be disturbed by the railroad relocation and a small cypress swamps that would probably not be disrupted by the construction project.

A later literature review was completed and persons likely familiar with the area and its specific inhabitants were contacted. Paul Hamel, zoologist with the Division of Ecological Services, Tennessee Department of Conservation; Brainard Palmer-Ball with the Kentucky Nature Preserves Commission; and David Pitts, University of Tennessee at Martin, were consulted.

RECOMMENDATIONS

It is certainly possible that the two species already listed by the U.S. Department of the Interior's Fish and Wildlife Service may occur within close proximity of the proposed construction site. It is my considered professional opinion that these (bald eagle and Arctic peregrine falcon) would be affected minimally, if at all, by such construction. Both are highly mobile species and would be using the area for foraging only. There is no evidence of nesting by either in the immediate area. Their foraging efforts could easily, and likely would, be shifted upstream or downstream with increased human activity.

Bachman's sparrow, the third avian species considered in this study, could perhaps be impacted. Although I was unable to find records for this sparrow in the vicinity of the construction site, its habitat requirements (see species account) may well be met in the "borrow and disposal site." It is a secretive species and might currently occur in the area. The TVA power line right-of-way near the borrow and disposal site is also possible Bachman's sparrow habitat. Then too, another possibility exists with this sparrow. It is highly attracted to areas of disturbed soil. The disturbed, post-construction site, especially if partially replanted with pines, could easily provide preferred nesting habitat for the species. The possiblity certainly exists for habitat enhancement due to the USACE construction.

The last species considered, the northern copperbelly water snake, presents a somewhat similar situation. Again, there is no concrete evidence of its presence in the immediate area. The most suitable existing habitat is the cypress swamp on the Marshall County side of the Tennessee River. This, however, is not now being considered as an impacted area. Habitat enhancement for this water snake is also a possibility as a result of the proposed construction. The newly created "wetland" suggested for the borrow and disposal site would perhaps provide suitable habitat for this species of Nerodia.

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APPENDIX C

TECHNICAL REPORT EL-90

AN INVESTIGATION OF FRESHWATER MUSSELS (UNIONIDAE) IN THE TENNESSEE RIVER BELOW KENTUCKY LOCK AND DAM

by

Andrew C. Miller and Barry S. Payne

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-6199

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PO Box 631
Vicksburg, MS 39181-0631

An Investigation of Freshwater Mussels (Unionidae) in the Tennessee River below Kentucky Lock and Dam

Miller, Andrew C. and Payne, Barry S.

Final Report December 1990

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA. 22161

Freshwater mussels
Commercial navigation traffic

Abstract

A survey to assess community characteristics, density, population demography of dominant species, and the likelihood of finding endangered species of freshwater mussels (Unionidae), was conducted between river miles (RM) 22.29 and 19.7 in the lower Tennessee River, 31 Aug-3 Sep, 1990. Data were collected to analyze impacts of construction and operation of a second lock at Kentucky Lock and Dam, RM 22.4. Twenty-three species and 4,768 freshwater mussels were obtained in 287 qualitative collections. The bivalve fauna was dominated by two thick-shelled species, Amblema plicata (39.43%) and Fusconaia ebena (39.41%). Six species comprised 1 to 10% of the collection and 15 species made up less than 1% of the collection. No federally-listed endangered species were found. Species diversity ($Log_{2.3026}$) was moderate (0.995 - 1.764) and evenness was low (0.377 - 0.589). Unionid density at six sites in the area to be dredged ranged from 9.2 - 128.0 individuals/ sq m. Corbicula fluminea density ranged from 6.0 - 26.4 individuals/sq m, which was considerably less than values reported in this river reach in 1969. The total commercial value of four species (A. plicata, M. nervosa, F. ebena and Q. quadrula) within the area that will be dredged was estimated at $101,707.00. Total density of snails ranged from 8.0 to 86.8 individuals/sq m; the fauna was dominated by Pleurocera canaliculatum with lesser numbers of Lithasia armigera and L. verrucosa. Impacts due to construction and operation of the second lock can be partially offset by creating submerged habitat with dredged material along an eroding bank downriver of the lock and dam (RM 19.0-21.0).

PREFACE

A mollusc survey was conducted by the US Army Engineer Waterways Experiment Station (WES) on 31 August - 3 September, 1990, for the US Army Engineer District, Nashville (CEORN). The purpose was to search for endangered species of freshwater mussels, and to obtain community and population data on a reach of river immediately below Kentucky Lock and Dam on the lower Tennessee River, miles 22.4 - 19.0. Data are being used to assess the environmental effects of construction and operation of a second lock at Kentucky Lock and Dam at RM 22.4.

Divers were Larry Neill, Mitchell Marks, Steve McKinny, and Dennis Baxter from the Tennessee Valley Authority (TVA). Assistance in the field was provided by Mr. Richard Tippit, CEORN, Dr. John Jenkinson, TVA, and Dr. Jim Sickel, Murray State University, Murray, Kentucky. Mr. Phil Pierce, Office of the Chief of Engineers, Mr. Joe Cathey, CEORN, Mr. Richard Biggins, US Fish and Wildlife Service (USFWS), Asheville, North Carolina, and Mr. Jim Widlak, USFWS, Cookeville, TN, were also present. This report was edited by _________ of the WES Information Products Division, Information Technology Laboratory.

During the conduct of this study Dr. John Harrison was Chief, Environmental Laboratory, Dr. C. J. Kirby was Chief, Environmental Resources Division, and Mr. E. Theriot, was Chief of the Aquatic Habitat Group at WES. Authors of this report were Dr. Andrew C. Miller and Dr. Barry S. Payne, WES.

Commander and Director of WES during publication of this report was COL Larry Fulton, CE, and the Technical Director was Dr. Robert W. Whalin.

This report should be cited as follows:

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CONTENTS

PART I: INTRODUCTION

Background

A rich, dense, and commercially harvestable assemblage of freshwater mussels (Family: Unionidae) occurs in the lower Tennessee River (LTR) between Kentucky Lock and Dam (River Mile (RM) 22.4) and the Ohio River (Isom 1969, Williams 1969, Sickel 1985). The bed is located between Kentucky Lock and Dam and RM 11.0 (Sickel 1985) and provides habitat for approximately 35 species of unionids including at least two federally-listed endangered species. With the exception of a few species, composition of the assemblage remains similar to that reported by earlier workers (Ortmann 1925, van der Schalie 1939) prior to completion of major hydropower dams upriver. This river reach has extensive stable sand and gravel shoals that are kept free of sediment by continuous flow of water from Kentucky Dam. Kentucky Lock and Dam is a multiple purpose project that was completed in September, 1944.

The US Army Engineer District Nashville (CEORN) proposes to construct a 1200 foot lock on the landward side of an existing 600 foot lock at Kentucky Lock and Dam. The navigation channel will be shifted toward the right descending bank (RDB) to provide a safe entrance and exit to the lock. In addition to excavation for the new lock and approach channel, approximately 59,000 cubic yards of material will be removed from a dredge cut located at RM 21.50 on the right descending bank (RDB) of the river. A suitable site for disposal of dredged material will be found downriver of the dam. Two new mooring cells will be located between the lock and the I-24 Bridge, RM 21.1. The Paducah and Louisville Railroad, which crosses the dam downriver of the lower lock gate, will have to be relocated. A railroad bridge will be constructed just downriver of the dam. The CEORN is concerned that the impacts of construction of the lock and operation of commercial navigation vessels could negatively affect freshwater mussels in this river reach.

Purpose and Scope

The purpose is to describe community composition, density, areal extent, recruitment rates, and presence of endangered species of freshwater mussels in areas in the LTR likely to be affected by construction and operation of the second lock at Kentucky Lock and Dam.

PART II: STUDY AREA AND METHODS

The Study Area

The Tennessee River originates at the junction of French Broad and Holston rivers near Knoxville, Tennessee. It flows southwest into Alabama, then north through Tennessee and Kentucky to Paducah, Kentucky where it enters the Ohio River at River Mile (RM) 933. The river is 652 miles long with an average discharge of 64,794 cubic ft/sec at Paducah (66 years of record, Tom et al. 1986). The river consists of a series of run of the river reservoirs used for commercial navigation and hydropower generation. Kentucky Lock and Dam, located at RM 22.4, is the last dam on the Tennessee River before its confluence with the Ohio River.

Sampling Areas

Mussels were collected at six areas in the LTR on 31 Aug - 3 September, 1990 (Figure 1, Table 1). Study areas were located immediately below the dam down to RM 19.70. All study areas were within a state mussel sanctuary, located between RM 17.8 and 22.4, where commercial shell harvesting is prohibited. The following is a brief description of each area:

Cofferdam. Four qualitative samples were taken from an area where a cofferdam (CD), will be placed for construction of the second lock. Samples were collected between RM 22.34 and 22.04 on the RDB. The bottom consisted of crushed unionid and *Corbicula* shells, coarse and fine particulate material and bedrock. Logs, brush, and trash were also present. The divers searched for mussels in the base of the riprap along the shore, but found no live mussels. Four sites were surveyed in this area (Figure 2).

Bank Excavation Zone. Three qualitative samples were collected from a bank excavation zone (BE) located between RM 22.00 and 21.66, RDB. The bottom consisted of areas of clay, as well as sand and coarser materials. Three qualitative samples were taken (Figure 3).

Dredge Cut. Qualitative collections for mussels were obtained from 10 sites in the dredge cut (DC), between RM 21.72 and 21.06, RDB. No live mussels were found at Sites 1 and 2; the remaining 8 sites supported moderate to high mussel densities. In addition, 10 quantitative samples were obtained at each of six sites in the DC (Figure 4). Substrate in the DC consisted of fine to coarse sand, medium-sized gravel nearshore, and coarse sand farther offshore.

Near Shore Zone. On the landward side of the DC, four qualitative samples were obtained from a nearshore zone (NS) close to the RDB (Figure 4). Substrate consisted of fine to coarse sand and gravel.

Bridge Relocation Area. Qualitative samples were obtained at five sites in an area proposed for relocation of the railroad bridge (BR) (Figure 5). Samples were collected on a transect beginning at RM 21.60 on the LDB and on line with RM 21.75 on the RDB. Mussels were common to abundant at the four sites closest to the LDB. Live mussels were virtually absent at Site 5, located approximately 650 ft from the LDB.

Dredged Material Disposal Area. Downriver of the I-24 Bridge two qualitative samples were obtained from a potential dredged material disposal area (DD). Mussels were collected at RM 19.70 and RM 19.80 (Figure 1). Substrate consisted of sand with small amounts of gravel, detritus, and logs.

Methods

Preliminary Reconnaissance. All underwater work was accomplished by a dive crew equipped with surface air supply and communication equipment. Before intensive sampling was initiated, a single diver made a preliminary survey to obtain information on substrate type, water velocity, and presence of mussels. Intensive sampling was initiated if the substrate appeared stable and if there was moderate to high mussel density (i.e., greater than 3-5 individuals/sq m).

Qualitative Mussel Collections. The majority of the qualitative samples were obtained by having three divers working simultaneously. Each diver placed a specific number of live mussels in each of four nylon bags; five mussels were placed in the first bag and 20 mussels were placed in each of three other bags. Divers were instructed to obtain mussels without bias. In addition, they attempted to exclude the Asiatic clam, *Corbicula fluminea*, from qualitative samples. If *C. fluminea* was inadvertently collected, it was later eliminated. All mussels were brought to the surface, counted, and identified. Data were recorded on standard data sheets and returned to the WES for analysis and plotting. Shells of voucher specimens for each species were placed in plastic Ziploc bags and labeled with high rag content paper. Mussels not needed for voucher were returned to the river. Methods for sampling mussels are based on techniques described in Coker (1919); Brice and Lewis (1979); Miller and Nelson (1983); Isom and Gooch (1986); Kovalak, Dennis, and Bates (1986); and Miller and Payne (1988). Mussel identification was based on taxonomic keys and descriptive information in Murray and Leonard (1962), Parmalee (1967), Starrett (1971), and Burch (1975).

Quantitative Mussel Collections. Ten quantitative samples (that included unionids as well as *C. fluminea*), were obtained at each of six sites in the DC. At each site 0.25 sq m quadrats were positioned approximately 1 m apart and arranged in a 2 x 5 matrix. A diver excavated all sand, gravel, shells, and live clams to a depth of 10-15 cm. Material was sent to the surface in a 20 l bucket and transported to shore. Sediment was screened through a sieve series (finest screen with apertures of 6.4 mm). All live mussels and *C. fluminea* removed from samples were placed in 4 l Ziploc bags. Each bivalve was then identified and total shell length (SL) measured to the nearest 0.1 mm with vernier calipers.

Data Analysis. Species diversity was determined with the following formula:

$$H' = - \sum p_j \log p_j$$

where p_j is the proportion of the population that is of the jth species (Shannon and Weaver 1949). Natural logarithms ($Log_{2.3026}$) were used as suggested by Magurran (1988).

All calculations were done with programs written in BASIC or SAS (Statistical Analytical System) on an IBM XT or AT personal computer. Discussion of statistical procedures that were used can be found in Green (1979), Hurlbert (1984), and Magurran (1988). Species area curves and dominance-diversity curves were constructed from qualitative and quantitative biological data. More information on these methods can be found in McNaughton and Wolf (1973), Isom and Bates (1986), Kovalak, Dennis, and Bates (1986), Hughes (1986), and Miller and Payne (1988).

PART III: THE BIVALVE COMMUNITY

Unionid Community Characteristics

Twenty-three species and 4768 freshwater mussels (Family: Unionidae) were obtained in 287 qualitative collections between the I-24 Bridge and Kentucky Lock and Dam (Table 2). The fauna was dominated by two thick-shelled species, Amblema plicata and Fusconaia ebena, which represented 39.43 and 39.41% of the fauna and were taken in 95.47 and 90.24% of the samples, respectively. Six species comprised from 1 to 10% of the collection, and 15 species comprised less than 1% of the collection. With the exception of A. plicata and F. ebena, all remaining unionids were found in less than 50% of the samples; 14 species were found in less than 10% of the samples. Thin-shelled species, Anodonta grandis, A. imbecillis, Lampsilis teres and Leptodea fragilis, usually associated with fine sand or silt substratum, were uncommon and together comprised 0.5% of the assemblage. No live specimens of the two endangered species, Lampsilis abrupta and Plethobasus cooperianus, previously collected in this river reach (Sickel 1985), were found.

Based on a comparatively small collection taken at two sites downriver of the I-24 bridge (24 samples and 446 individuals were collected), two additional mussels, Arcidens confragosus and Fusconaia flava, were added to the species list (Table 3). Pleurobema cordatum was uncommon above the bridge (0.25% and a rank of 17), whereas it was more common below the bridge (2.69% with a rank of 6). However, the same four species, F. ebena, A. plicata, Quadrula pustulosa and Q. quadrula, dominated at both locations and together comprised 87.56% and 83.63% up- and downriver of the bridge, respectively. With the exception of a slightly higher species richness, and minor differences in relative abundances of some species, the unionid assemblage was relatively similar up- and downriver of the bridge.

The relative abundances of the two dominant unionids, A. plicata and F. ebena, varied among the six sampling areas (Figure 6). Fusconaia ebena was strongly dominant in the nearshore zone, whereas A. plicata was strongly dominant in the cofferdam area. In this area A. plicata dominated at upriver sites (1 and 2), but became less common downriver (Sites 3 and 4, Figure 6). The cofferdam area was unique in that it supported comparatively low percentages of Q. pustulosa and Q. quadrula (Figure 7). It was similar only to the bank excavation zone in than it supported relatively low percentages of Q. reflexa and P. cordatum (Figure 7). Relative species abundance and frequency of occurrence for all five sampling areas appear in Tables 4 and 5, respectively.

Species diversity ($Log_{2.3026}$) ranged from 0.995 to 1.764 and evenness ranged from 0.377 to 0.589 (Figure 8 and Table 4). Low and high values for both indices characterized mussel assemblages in the cofferdam and dredged material disposal areas. The relationship among abundances can be illustrated graphically by plotting species rank with its individual abundance (Figure 9). The low diversity and evenness at the cofferdam was primarily the result of extreme dominance of a single species, A. plicata. Low values at the bank excavation zone are primarily the result of dominance by two species. The remaining four areas exhibited moderately high species diversity and evenness (see Figure 9).

The relative similarity of species assemblages among sampling areas was quantified with the Jaccard Coefficient (Table 6). Based upon presence of similar species within both areas, the nearshore and dredged material disposal area were most similar (0.947). Community characteristics in the cofferdam area differed greatly from all other sites; comparatively low values 0.609, 0.684, 0.619, 0.632, 0.619 related this area to the dredge cut, nearshore zone, bank excavation zone, bridge relocation area, and dredge disposal area, respectively. In addition to very low species richness, percentages of A. plicata and E. crassidens were comparatively high, and percentages of F. ebena, Q. pustulosa, and Q. quadrula were comparatively lower in the cofferdam than in the other sampling areas (Table 4).

A plot of cumulative species versus cumulative individuals illustrates the relationship between sampling effort and the ability to find uncommon species. Considering mussels from all areas upriver of the I-24 Bridge, a total of 4768 individuals and 23 species were collected (Table 2). However, as Figure 10 illustrates, after 1,200 individuals had been collected, 23 species, the total number collected during this survey, had been identified. It is unlikely that additional species would be found with more sampling effort. If species were present and not collected, they would have comprised less than 0.02% of the assemblage. The relationship between sampling effort and species identified is similar for all sites with the exception of the bank excavation zone (Figure 11). This site, and to some extent the nearshore zone, is characterized by a high dominance of A. plicata and F. ebena (Figure 9). Dominance of these two unionids had an effect on the ability of obtaining new species.

Bivalve Density

Ten quantitative (0.25 sq m) total substrate samples were taken at each of six sites between RM 21.66 and 21.53 in the DC (Table 1, Figure 4). Total unionid densities were moderate to high at Sites 1-4 (46.8 - 128.0 individuals/ sq m, see Table 7 and Figure 12). Sites 5 and 6, downriver of RM 21.56, exhibited comparatively low density (9.2 and 10.4 individuals/sq m). Densities of C. fluminea were low and ranged from 6.0 to 26.4 individuals/sq m (Table 7 and Figure 12).

Demographic Analysis of Dominant Bivalve Populations

Amblema plicata. Individuals of this population range from 6 to 128 mm total shell length (SL) (Figure 13a). The most abundant mussels occurred in two broad ranges: 10 to 52 mm (63% of total population) and 56 to 88 mm (31%). Several overlapping cohorts (year classes) were included within each of these two SL ranges. Among smaller mussels a recently recruited cohort (probably the 1989 year class) was apparent with an average SL of 12-16 mm. Mussels ranging from 20 to 46 mm SL probably represented three largely overlapped cohorts. Two relatively abundant cohorts centered at 22-26 mm and 36-44 mm SL, and an intermediate and less abundant cohort with average SL between 28 and 34 mm. Individual cohorts could not be distinguished among the moderately large mussels ranging from 56 to 88 mm. However, peaks of abundance at 56-58 mm, 62-64 mm, and 72-74 mm may represent the average SL of the three relatively abundant cohorts. The relative paucity of mussels from 46 to 56 mm in this river reach is probably the consequence of one or two consecutive years of poor recruitment. Individuals greater than 100 mm comprised less than 2% of the total population. Although A. plicata can grow to well over 100 mm, few individuals appear to survive long enough to attain this size.

Fusconaia ebena. The size structure of the Fusconaia ebena population was similar to that of A. plicata (Figure 13). Fusconaia ebena was characterized by two relatively abundant and broad size classes, each comprised of multiple but indistinct cohorts. The smaller of these two groups included mussels ranging from 12 to 56 mm and comprised 70% of the population (compared to 63% in 10 to 52 mm range of A. plicata). Mussels from 56 to 88 mm accounted for 28% of the total sample (compared to 31% in the 56 to 88 mm range of A. plicata). Individuals greater than 92 mm accounted for only 2% of the population.

The general similarity of size structure among the two most abundant populations, F. ebena and A. plicata, may reflect interspecific similarity in temporal variation in recruitment. The paucity of mussels from 50 to 60 mm (relative to abundant size classes above and below this 10 mm SL range) both populations may correspond to a interspecific simultaneity of a poor year or two of recruitment.

Obliquaria reflexa. Obliquaria reflexa attains moderate size and age compared to both A. plicata and F. ebena. This species ranged in total SL from 12 to 52 mm, but the majority of the population consisted of individuals 24 to 48 mm (14a). It appears that four consecutive year classes might be included among individuals within this size range: a moderately abundant cohort with average SL equal to 26 to 28 mm; two slightly more abundant cohorts with average SL of 32 to 36 and 38 to 42 mm, respectively; and a moderately abundant cohort with average SL of 44 to 48 mm. However, such detailed interpretation of size structure of overlapping cohorts of this moderately large sample (75 individuals) is speculative. If correctly interpreted, these cohorts are spaced at intervals of 6 to 7 mm. This spacing may correspond to an annual increment of SL increase of 24 to 48 mm SL.

Quadrula pustulosa. The population of Quadrula pustulosa consisted of relatively equal abundance of several cohorts spanning 14 to 68 mm (Figure 14). Detailed analysis of cohort structure was not possible for this population. The relatively equal abundance of many different size classes suggests that annual recruitment has been reasonably consistent for this species of moderate size and longevity.

Truncilla donaciformis. Population size demography of this small and short-lived unionid indicated a single abundant cohort from 16 to 26 mm (Figure 14). A minor cohort may occur with average SL of 12 to 13 mm, but too few individuals were collected to positively determine that more than a single year class comprised this population.

Corbicula fluminea. This low density population (Table 7) consisted almost entirely of very small individuals between 4 to 13 mm (Figure 15). These small bivalves probably represent spring recruits. Corbicula fluminea generally shows spring and fall peaks of recruitment (McMahon 1983) unlike native unionids that have a single recruitment period per year. Larger C. fluminea (18 to 24 mm) probably represent recruitment from the fall of 1989. Stable and thriving populations of C. fluminea sampled during the late summer usually show three to five cohorts, including many individuals from 20 to 35 mm. The lack of complex size structure and large individuals plus the low density indicates a population supported only by a low recruitment rate with subsequently poor survival.

Snails in the Project Area

Snails were counted and identified from the quantitative samples collected at six sites in the dredge cut. Total density of snails ranged from 8.0 to 86.8 individuals/sq m (Table 7). The fauna was dominated by Pleurocera canaliculatum with lesser numbers of Lithasia armigera and L. verrucosa. No endangered species of snails were found.

The Commercial Value of Mussels in the Dredge Cut

Construction and operation of the new lock will require removal of 59,000 cubic yards of material, most from the upper end of the dredge cut between Stations 61+00 (RM 21.38) and 45+00 (RM 21.70) (Figure 4). The total area of river bottom to be dredged will be approximately 21,148 sq m. Based on this information, and data from the quantitative collections, an estimate of the value of four commercial species (A. plicata, M. nervosa, F. ebena, and Q. quadrula) has been made (Table 8).

Total density in the dredge cut for these species is: A. plicata (4.4 individuals/sq m), M. nervosa (0.0667 individuals/sq m), F. ebena (4.6667 individuals/sq m) and Q. quadrula (0.4667 individuals/sq m). The minimum harvestable size for each species was obtained from the Kentucky Department of Fish and Wildlife Resources, and the average SL and total mass for harvestable individuals was based on data from this survey and the upper Mississippi River, respectively. Based on prices of "green" (unshucked) mussels, the total value of A. plicata, M. nervosa, F. ebena and Q. quadrula was estimated at $53,576.00, $1,749.00, $43,022.00, and $3,360.00, respectively. The total commercial value of these three species was estimated to be $101,707.00 (Table 8).

PART IV: DISCUSSION

Characterization of the Bivalve Community

The Unionid Assemblage. The mussel assemblage in the LTR consisted almost entirely of thick-shelled species. The fauna was dominated by A. plicata, F. ebena and Quadrula spp, with lesser numbers of Elliptio spp., M. nervosa., and P. cordatum. Thin- and moderately thick-shelled species (L. fragilis, P. alatus, and Anodonta spp.) were uncommon and comprised less than 1% of the qualitative collection. Within their range these thin-shelled species are found in appropriate substrate in large rivers (Murray and Leonard 1962, Parmalee 1967, Starrett 1971). Each species has multiple fish hosts (Fuller 1974) and would be more common in the LTR if suitable conditions of substrate and velocity existed. However, coarse gravel substrate and erosive flows at high discharge will stress thin-shelled species. If present, few are likely to reach adult size. The mussel assemblage in the LTR would probably support more thin-shelled species if mean water velocities were less and sediments contained a higher percentage of silt and sand.

In comparing data collected during this survey with those of previous authors (see Sickel 1985), it is apparent that the basic community structure, i.e., dominance of thick-shelled species such as F. ebena, A. plicata, and Quadrula spp., has remained virtually unchanged since the early 1900's. Selected species (Q. metanevra, Plethobasus cooperianus, and Pleurobema cordatum) appear to now be less common, or even absent, in this river reach. It is however, difficult to compare community data among surveys in which different collecting methods were employed.

The Presence of C. fluminea. Williams (1969) sampled the LTR between Kentucky Lock and Dam and the Ohio River with an eight foot brail and a Peterson dredge. Based on quantitative samples he estimated that C. fluminea comprise 99.41% of the bivalve community; densities ranged from 17 to 1,147 individuals/sq yard (14.2 to 959.0 individuals/ sq m). In the present survey, density ranged from 6.0 to 26.4 individuals/sq m in the dredge cut (Table 7 and Figure 12). Although quantitative data on C. fluminea was not collected throughout the LTR, it is apparent that its densities have diminished considerably since the survey conducted by Williams (1969). Physical conditions in this reach of the LTR have not changed since that survey (i.e., Kentucky Lock and Dam was operational in September, 1944). This recent change in bivalve community composition must be related to biotic rather than abiotic factors. The exact cause of the decline in Corbicula has not been determined.

Species Richness. Total species richness in the survey area is similar to that at other mussel beds in large rivers. In the lower Ohio River near Olmsted, Illinois 23 species of freshwater mussels were collected (Payne and Miller 1989). In a survey of the upper Mississippi River Miller et al. (1989) collected over 15,000 bivalves in 667 qualitative samples at 58 locations and identified 34 species. However, total species richness at any one location was usually between 15 and 25. Smaller rivers usually support fewer species. Using quantitative techniques at dense beds in the Sunflower River and Big Black River in central Mississippi, 13 and 15 species were identified, respectively (Miller and Hartfield, Payne and Miller unpublished information).

Relative Species Abundance. The fauna in this mussel bed exhibit moderate to low evenness. Evenness can range from near zero to near 1.0; at these sites values ranged from 0.377 to 0.557. Low evenness was the result of relatively high abundances of the dominant species (38.9% to 73.4%, Table 4 and Figure 9). Based on similar qualitative collections at six sites in a dense and diverse mussel bed in the Ohio River near Cincinnati, Ohio, evenness ranged from 0.756 to 0.817 (Miller and Payne 1990). Abundances of the dominant species in the Oho River ranged from a low of 22.44% to a high of 33.33% (i.e., the fauna was not strongly dominated by one or two species).

Density. In comparison with other large-river mussel beds, the range in unionid density (9.2-128.0 individuals/m^2 with an overall average of 63.0 individuals/sq m) can be considered low to high. At an inshore and offshore site in the LTR at RM 18.6 on the LDB sampled in 1986, (32 quantitative samples were collected at each) total mussel density was 187.7 and 79.7 individuals/m^2, respectively (Way, Miller, and Payne 1990). In a survey of the upper Mississippi River, Miller et al. (1989) reported that total mussel density ranged from 5.2 to 333.2 individuals/m^2 at 16 sites (10 quantitative samples were taken at each). At half of the sites total density was greater than 50 individuals/m^2 and at four sites it was greater than 100 individuals/m^2. In the Big Black River in central Mississippi, unionid density was 84.4 and 112.0 individuals/m^2 at the upstream and downstream slope of a gravel shoal, respectively (Payne and Miller, unpublished information).

The Presence of Endangered Species. This reach of the LTR is within the reported range the following federally listed endangered or threatened freshwater mussel species *Pleurobema plenum*, *Plethobasus cooperianus*, *Lampsilis abrupta*, *Obovaria retusa*, *Potamilus capax*, *Plethobasus cicatricosus*, *Cyprogenia irrorata* and *Epioblasma torulosa torulosa* (USFWS 1987). However, only two species (*P. cooperianus* and *L. abrupta*) have been collected in this reach of the LTR. Three specimens of the former species were found at RM 20.7 by Sickel (1985). This species was also found in this reach of the LTR in 1931 by Ellis (van der Schalie 1939). Sickel (1985) reported one specimen of *L. abrupta* at RM 14.75 and one at RM 21.3 (Sickel 1987). The only other report of this species from the Kentucky Dam tailwater was at RM 22.0 (Tennessee Valley Authority 1978 as reported by Sickel 1985).

Miller, Payne and Siemsen (1986) collected *P. cooperianus* at a rich and dense mussel bed in the lower Ohio River near Cairo, Illinois. In the fall of 1990 they obtained two live specimens in three samples of 200 individuals. It is apparent that *P. cooperianus* continues to exist in specific reaches of large rivers in densities high enough to be easily collected. However, in the LTR immediately downriver of Kentucky Lock it is likely that it is either absent or extremely uncommon (i.e., less than one individual per 10,000 organisms).

In the present survey almost 5,000 mussels were collected using qualitative and quantitative techniques. After 1,000 individuals had been taken a total of 23 species had been identified; collecting an additional 4,000 individuals yielded no new species. The relationship between cumulative species and cumulative individuals (Figure 10), suggests that over 10,000 mussels would have to be collected to obtain a list of 32 species. Sickel (1987) reported collecting 34 species of mussels below Kentucky Lock. However, he collected nearly 10,000 live mussels and extensively worked the reach below the I-24 bridge which contains species not found immediately below the dam. It is possible that even if 10,000 individuals were collected between the I-24 Bridge and Kentucky Lock and Dam that no new species would be found.

The Disposal of Dredged Material

The results of this study indicate that it would be difficult to select a disposal area that does not support a dense and diverse mussel assemblage. One alternative for disposal would be to dredge and dispose material during slightly high stage conditions so that material could be placed at the toe of the steep and eroding right bank in a reach downriver of the I-24 Bridge (RM 19.0 - 21.0). A zone exists from the toe of this bank out toward the channel that has unsuitably fine-grained substrate for riverine unionids. No mussels presently live in this shallow zone; thus, disposal along the toe of the bank would not harm a resident community. Furthermore, such a disposal operation might have two beneficial aspects: 1) bank protection to prevent or lessen erosion, and 2) creation of additional mussel habitat. Such benefits of shoreline disposal have been observed in the lower Tennessee River near Wolf Island (Payne and Tippit 1989).

During dredging for the new lock it may be possible to first remove only the topmost layer of sediment (e.g., 12 inches), and take live mussels from this material as it is dredged. Assuming that mussel survival would be high, such a harvest during dredging would provide mussels that could be placed at newly created habitat.

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Table 1

Areas Sampled for Freshwater Mussels in the Lower Tennessee River, Aug-Sep, 1990. All Samples Were Collected on the RDB Except Those from the Bridge Relocation Area Which Were from the LDB

Sample Area	Site No.	RM	Station	Distance to Shore (ft)	No. of Samples
Cofferdam (CD)	1	22.29	15+50	50	12
	2	22.21	19+50	50	12
	3	22.13	23+50	50	12
	4	22.05	27+50	50	12
Bank Excavation (BE)	1	21.94	33+00	75	12
	2	21.86	37+00	75	12
	3	21.74	43+00	75	12
Dredge Cut (DC) Qualitative	1	21.30	65+00	400	0
	2	21.38	61+00	300	0
	3	21.47	56+50	200	8
	4	21.51	54+75	150	12
	5	21.55	52+50	125	12
	6	21.57	51+57	100	12
	7	21.59	50+75	100	12
	8	21.60	50+00	100	12
	9	21.62	49+00	100	12
	10	21.65	47+50	100	12
Dredge Cut Quantitative	1	21.66	47+00	100	10
	2	21.63	48+50	100	10
	3	21.61	49+50	125	10
	4	21.58	51+00	150	10
	5	21.56	52+00	200	10
	6	21.53	53+75	250	10
Nearshore (NS)	1	21.16	72+00	100	12
	2	21.26	67+00	100	12
	3	21.36	62+00	100	12
	4	21.46	57+00	100	12
	5	21.56	52+00	100	3
	6	21.64	48+00	100	12
Bridge Relocation (BR)	1	21.75	42+50	200	12
	2	21.75	42+50	350	12
	3	21.75	42+50	400	12
	4	21.75	42+50	425	12
	5	21.75	42+50	650	0
Dredge Disposal (DD)	1	19.70	NA	100	12
	2	19.80	NA	100	12

Notes:
Station - refers to 100 ft increments along the shore, see Figures 2-5.
NA - Not available
Abbreviations (CD, BE, etc.) refer to Figure 1
No qualitative samples were taken at Sites 1 and 2 in the dredge cut because of low densities.

Table 2

Summary of Relative Species Abundance and Frequency of Occurrence for Freshwater Mussel Collected Using Qualitative Techniques at Five Study Areas Upriver of the I-24 Bridge (see Figure 1) in the Lower Tennessee River Miles 22.2-21.2, Aug-Sep 1990

Species	Total Mussels	%	Total Sites	%	Specie Rank
Amblema p. plicata (Say, 1817)	1880	0.3943	274	0.9547	1
Fusconaia ebena (I. Lea, 1831)	1879	0.3941	259	0.9024	2
Quadrula p. pustulosa (I. Lea, 1831)	241	0.0505	141	0.4913	3
Quadrula quadrula (Rafinesque, 1820)	175	0.0367	113	0.3937	4
Obliquaria reflexa Rafinesque, 1820	165	0.0346	82	0.2857	5
Megalonaias nervosa (Rafinesque, 1820)	73	0.0153	58	0.2021	6
Cyclonaias tuberculata (Rafinesque, 1820)	59	0.0124	51	0.1777	7
Elliptio crassidens (Lamarck, 1819)	57	0.0120	47	0.1638	8
Elliptio dilatata (Rafinesque, 1820)	35	0.0073	31	0.1080	9
Ellipsaria lineolata (Rafinesque, 1820)	30	0.0063	27	0.0941	10.5
Truncilla truncata Rafinesque, 1820	30	0.0063	26	0.0906	10.5
Potamilus alatus (Say, 1817)	27	0.0057	23	0.0801	12
Truncilla donaciformis ((I. Lea, 1828)	26	0.0055	22	0.0767	13
Quadrula nodulata (Rafinesque, 1820)	18	0.0038	18	0.0627	14
Leptodea fragilis (Rafinesque, 1820)	17	0.0036	17	0.0592	15
Tritogonia verrucosa (Rafinesque, 1820)	16	0.0034	15	0.0523	16
Pleurobema cordatum (Rafinesque, 1820)	12	0.0025	9	0.0314	17
Ligumia recta (Lamarck, 1819)	9	0.0019	9	0.0314	18
Lampsilis teres (Rafinesque, 1820)	7	0.0015	6	0.0209	19
Anodonta imbecillis (Say, 1829	4	0.0008	4	0.0139	20
Quadrula metanevra (Rafinesque, 1820)	3	0.0006	3	0.0105	21.5
Anodonta grandis Say, 1829	3	0.0006	3	0.0105	21/5
Lasmigona c. complanata (Barnes, 1823)	2	0.0004	2	0.0070	23

Total samples 287
Total mussels 4768
Total species 23

Table 3

Relative Species Abundance and Frequency of Occurrence for Freshwater Mussel Collected Using Qualitative Techniques at Two Locations Considered for Disposing Dredged Material in the Lower Tennessee River Miles 19.7, September 1990

Species	Total Mussels	%	Total Samples	%	Species Rank
F. ebena	178	0.3991	24	1.0000	1
A. plicata	130	0.2915	23	0.9583	2
Q. pustulosa	41	0.0919	19	0.7917	3
Q. quadrula	24	0.0538	14	0.5833	4
M. gigantea	23	0.0516	10	0.4167	5
P. cordatum	12	0.0269	8	0.3333	6
O. reflexa	10	0.0224	7	0.2917	7
E. crassidens	4	0.0090	3	0.1250	8.5
E. dilatata	4	0.0090	4	0.1667	8.5
E. lineolata	3	0.0067	2	0.0833	11
T. truncata	3	0.0067	3	0.1250	11
L. fragilis	3	0.0067	3	0.1250	11
P. alatus	2	0.0045	2	0.0833	14.0
T. donaciformis	2	0.0045	2	0.0833	14.0
L. teres	2	0.0045	2	0.0833	14.0
C. tuberculata	1	0.0022	1	0.0417	18
Q. nodulata	1	0.0022	1	0.0417	18
A. confragosus	1	0.0022	1	0.0417	18
F. flava	1	0.0022	1	0.0417	18
L. recta	1	0.0022	1	0.0417	18

Total species	20
Total mussels	446
Total samples	24
Diversity (H')	1.764
Evenness (J)	0.589

Note:
A. confragosus - Arcidens confragosus (Say, 1829)
F. flava - Fusconaia flava (Rafinesque, 1820)

Table 4

Relative Species Abundance for Freshwater Mussels
Collected Using Qualitative Techniques at Each of Five Study Areas Upriver
of the I-24 Bridge (see Figure 1) in the Lower
Tennessee River Miles 22.2-21.2, Aug-Sep 1990

	Dredge Cut		Near-Shore		Cofferdam		Bank Excavation		Bridge Relocation	
	N	%	N	%	N	%	N	%	N	%
A. plicata	593	0.3899	224	0.2168	588	0.7341	264	0.4444	211	0.2548
F. ebena	545	0.3583	595	0.5760	119	0.1486	236	0.3973	384	0.4638
Q. pustulosa	100	0.0657	66	0.0639	6	0.0075	18	0.0303	51	0.0616
Q. quadrula	74	0.0487	35	0.0339	16	0.0200	12	0.0202	38	0.0459
O. reflexa	48	0.0316	21	0.0203	2	0.0025	2	0.0034	92	0.1111
M. gigantea	28	0.0184	19	0.0184	11	0.0137	10	0.0168	5	0.0060
C. tuberculata	19	0.0125	15	0.0145	7	0.0087	12	0.0202	6	0.0072
E. crassidens	5	0.0033	9	0.0087	29	0.0362	12	0.0202	2	0.0024
E. dilatata	8	0.0053	6	0.0058	9	0.0112	8	0.0135	4	0.0048
E. lineolata	13	0.0085	10	0.0097	0	0.0000	3	0.0051	4	0.0048
T. truncata	13	0.0085	4	0.0039	0	0.0000	2	0.0034	11	0.0133
P. alatus	12	0.0079	3	0.0029	8	0.0100	2	0.0034	2	0.0024
T. donaciformis	16	0.0105	6	0.0058	1	0.0012	0	0.0000	3	0.0036
Q. nodulata	5	0.0033	5	0.0048	1	0.0012	1	0.0017	6	0.0072
L. fragilis	7	0.0046	3	0.0029	0	0.0000	3	0.0051	4	0.0048
T. verrucosa	11	0.0072	0	0.0000	0	0.0000	2	0.0034	3	0.0036
P. cordatum	2	0.0013	6	0.0058	2	0.0025	2	0.0034	0	0.0000
L. recta	6	0.0039	1	0.0010	0	0.0000	1	0.0017	1	0.0012
L. teres	3	0.0020	3	0.0029	0	0.0000	1	0.0017	0	0.0000
A. imbecillis	4	0.0026	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Q. metanevra	2	0.0013	0	0.0000	0	0.0000	1	0.0017	0	0.0000
A. grandis	1	0.0007	0	0.0000	1	0.0012	1	0.0017	0	0.0000
L. complanata	2	0.0013	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Total species	23		18		14		20		17	
Total mussels	1517		1031		800		593		827	
Diversity (H′)	1.674		1.435		0.995		1.400		1.577	
Evenness (J)	0.534		0.496		0.377		0.467		0.557	

Table 5

Frequency of Occurrence for Freshwater Mussels
Collected Using Qualitative Techniques at Each of Study Areas Upriver
of the I-24 Bridge in the Lower
Tennessee River Miles 22.2-21.2, Aug-Sep 1990

	Dredge Cut		Near-Shore		Cofferdam		Bank Excavation		Bridge Relocation	
	N	%	N	%	N	%	N	%	N	%
A. plicata	89	0.9674	59	0.9365	48	1.0000	34	0.9444	44	0.9167
F. ebena	87	0.9457	61	0.9683	28	0.5833	36	1.0000	47	0.9792
Q. pustulosa	52	0.5652	38	0.6032	6	0.1250	13	0.3611	32	0.6667
Q. quadrula	47	0.5109	22	0.3492	12	0.2500	9	0.2500	23	0.4792
O. reflexa	32	0.3478	16	0.2540	2	0.0417	2	0.0556	30	0.6250
M. gigantea	21	0.2283	14	0.2222	9	0.1875	10	0.2778	4	0.0833
C. tuberculata	16	0.1739	12	0.1905	7	0.1458	11	0.3056	5	0.1042
E. crassidens	5	0.0543	8	0.1270	20	0.4167	12	0.3333	2	0.0417
E. dilatata	7	0.0761	5	0.0794	7	0.1458	8	0.2222	4	0.0833
T. truncata	13	0.1413	2	0.0317	0	0.0000	2	0.0556	10	0.2083
E. lineolata	12	0.1304	7	0.1111	0	0.0000	3	0.0833	4	0.0833
P. alatus	10	0.1087	3	0.0476	6	0.1250	2	0.0556	2	0.0417
T. donaciformis	13	0.1413	5	0.0794	1	0.0208	0	0.0000	3	0.0625
Q. nodulata	5	0.0543	5	0.0794	1	0.0208	1	0.0278	6	0.1250
L. fragilis	7	0.0761	3	0.0476	0	0.0000	3	0.0833	4	0.0833
T. verrucosa	10	0.1087	0	0.0000	0	0.0000	2	0.0556	3	0.0625
L. recta	6	0.0652	1	0.0159	0	0.0000	1	0.0278	1	0.0208
P. cordatum	2	0.0217	4	0.0635	2	0.0417	1	0.0278	0	0.0000
L. teres	3	0.0326	2	0.0317	0	0.0000	1	0.0278	0	0.0000
A. imbecillis	4	0.0435	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Q. metanevra	2	0.0217	0	0.0000	0	0.0000	1	0.0278	0	0.0000
A. grandis	1	0.0109	0	0.0000	1	0.0208	1	0.0278	0	0.0000
L. complanata	2	0.0217	0	0.0000	0	0.0000	0	0.0000	0	0.0000
Total samples	92		63		48		36		48	

Table 6

Jaccard's Similarity Index for Areas Surveyed in the Lower Tennessee River, Aug-Sep, 1990

	DC	NS	CD	BE	BR	DD
DC	1.000	0.783	0.609	0.870	0.739	0.720
NS		1.000	0.684	0.810	0.842	0.947
CD			1.000	0.619	0.632	0.619
BE				1.000	0.762	0.739
BR					1.000	0.762
DD						1.000

DC - Dredge Cut
NS - Nearshore zone, landward of DC
CD - Cofferdam
BE - Bank Excavation
BR - Bridge Relocation
DD - Dredge Disposal

Table 7

Relative Species Abundance and Summary Statistics for Results of 10 Quantitative (0.25 sq m) Total Substrate Samples Collected in the Dredge Cut (see Figure 1), Lower Tennessee River, Aug-Sep 1990.

Species	1	2	3	4	5	6	Total
F. ebena	0.3932	0.2370	0.3938	0.4274	0.0769	0.3478	0.3577
A. plicata	0.2479	0.3270	0.2750	0.2742	0.5000	0.3043	0.2899
T. donaciformis	0.0769	0.1469	0.1219	0.0685	0.1154	0.1739	0.1090
O. reflexa	0.1453	0.0806	0.0750	0.0524	0.1154	0.0435	0.0794
Q. pustulosa	0.0598	0.0900	0.0469	0.0927	0.1154	0.0435	0.0720
Q. quadrula	0.0171	0.0379	0.0156	0.0202	0.0000	0.0000	0.0212
L. fragilis	0.0085	0.0284	0.0125	0.0121	0.0385	0.0435	0.0169
T. truncata	0.0427	0.0095	0.0156	0.0121	0.0000	0.0000	0.0159
E. dilatata	0.0000	0.0190	0.0125	0.0121	0.0385	0.0000	0.0127
E. lineolata	0.0000	0.0000	0.0156	0.0081	0.0000	0.0000	0.0074
A. imbecillis	0.0000	0.0095	0.0063	0.0040	0.0000	0.0435	0.0063
M. nervosa	0.0000	0.0000	0.0031	0.0081	0.0000	0.0000	0.0032
T. verrucosa	0.0085	0.0047	0.0031	0.0000	0.0000	0.0000	0.0032
C. tuberculata	0.0000	0.0000	0.0031	0.0040	0.0000	0.0000	0.0021
Q. nodulata	0.0000	0.0047	0.0000	0.0040	0.0000	0.0000	0.0021
L. teres	0.0000	0.0047	0.0000	0.0000	0.0000	0.0000	0.0011
Total individuals	117	211	320	248	26	23	945
Total species	9	13	14	14	7	7	16
Diversity (H')	1.644	1.872	1.706	1.66	1.54	1.58	
Evenness (J)	0.748	0.73	0.647	0.629	0.792	0.811	
Unionid density (No./sq m)	46.8	84.4	128.0	99.2	10.4	9.2	
Snail Density (No./sq m)	29.6	69.2	86.8	68.0	8.0	9.2	
C. fluminea density (No./sq m)	7.2	6.0	6.0	11.6	26.4	14.8	

Table 8

An Estimate of the Commercial Value of Three Species of Harvestable Mussels That Will be Lost by Dredging to Construct and Operate a Second Lock at Kentucky Lock and Dam

	A. plicata	*M. nervosa*	*Q. quadrula*	*F. ebena*
Minimum harvestable size:				
Inches	2.75	3.75	2.50	2.5
Millimeters	69.8	95.25	63.5	63.5
Number of mussels in DC = or > than harvestable size:				
(No./sq m)	4.4	0.0667	0.4667	4.6667
Total No. in the DC	93,051	1411	9869	98691
Morphometric characteristics:				
Average SL of an individual harvestable mussel in the DC (mm)	80.8	114.0	66.8	74.0
Average mass of an individual harvestable mussel in the DC (gm)	163.2	281.1	103.8	197.7
Total mass of harvestable mussels in the DC:				
Grams	$1.58x10^7$	$3.96x10^5$	$1.02x10^6$	$1.95x10^7$
Pounds	33484.9	874.6	2100.0	43022.0
Commercial value (unshucked):				
Price per pound ($)	1.60	2.00	1.60	1.50
Value of Mussels in the DC	$53,576.00	$1749.00	$3360.00	$43,022.00

Total value for all 4 species: $101,707.00

Notes:
1. Only the northern section of the cut will be dredged; see text for details.
2. Average density and size of mussels in the dredge cut was estimated from quantitative data and length frequency histograms from this survey:
3. Total mass (TM) and shell length (SL) relationships, developed from collections made in the upper Mississippi River, are as follows:

A. plicata	$TM = 0.0005741 * SL^{(2.8593)}$	R = 0.9803
M. gigantea	$TM = 0.0001292 * SL^{(3.0812)}$	R = 0.9833
Q. quadrula	$TM = 0.0004174 * SL^{(2.957)}$	R = 0.9827

4. Total mass (TM) and shell length (SL) relationships, developed from collections made in the lower Tennessee River (in 1986), are as follows:

F. ebena $TM = 0.0008668 * SL^{(2.8665)}$ R = 0.9858

Figures for Lower Tennessee River Report

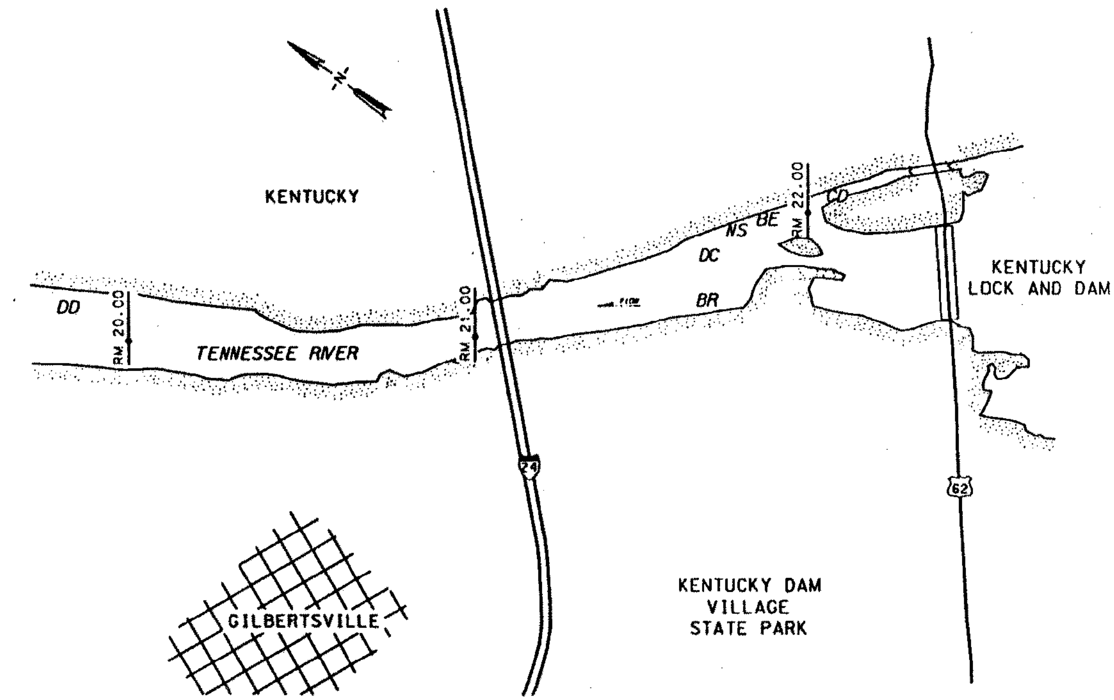


Figure 1. Study areas on the lower Tennessee River, Aug-Sep 1990.

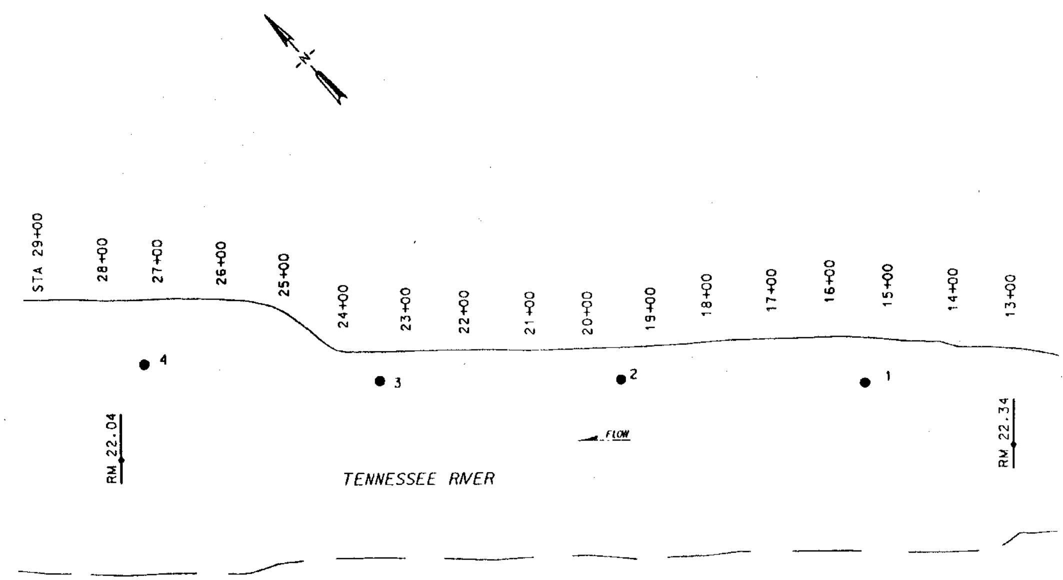


Figure 2. Sites sampled in the cofferdam area.

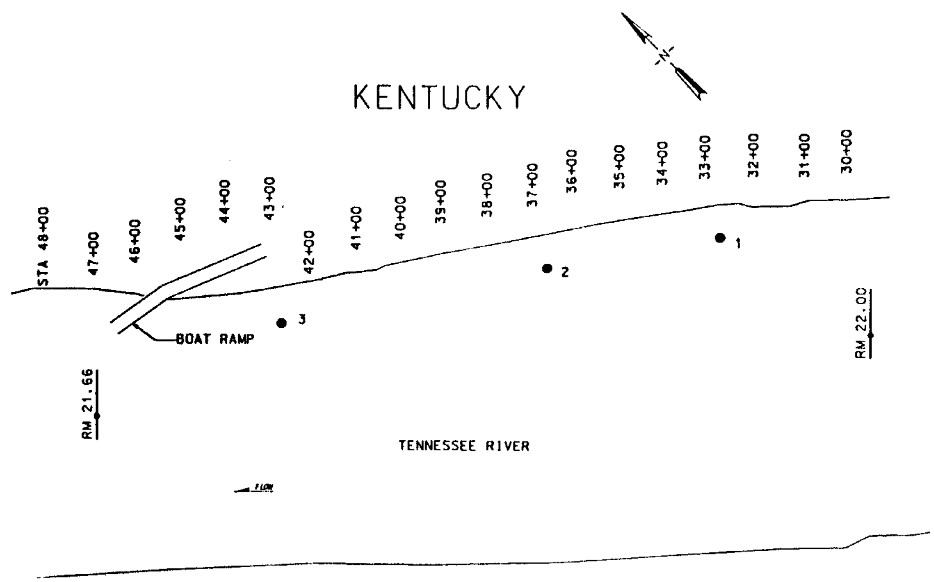


Figure 3. Sites sampled in the bank excavation area.

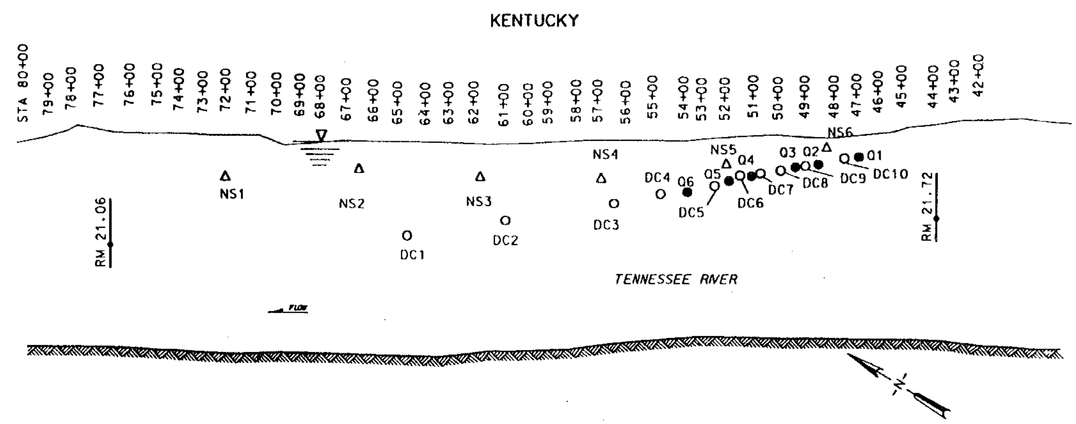


Figure 4. Sites sampled in the nearshore zone and dredge cut area (qualitative and quantitative).

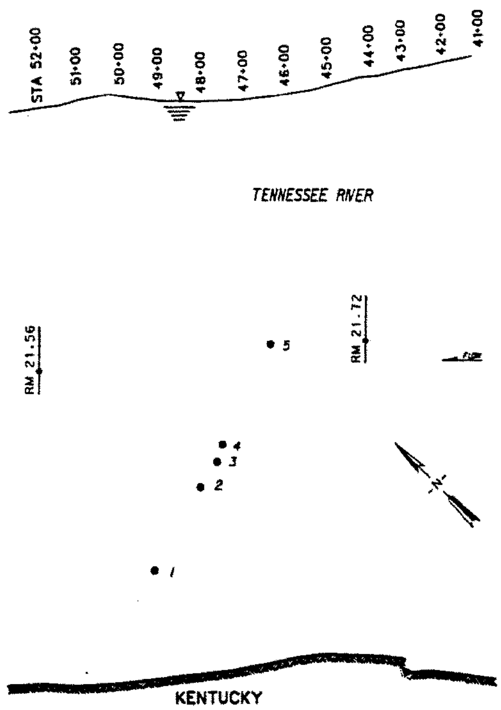


Figure 5. Sites sampled in the bridge relocation area.

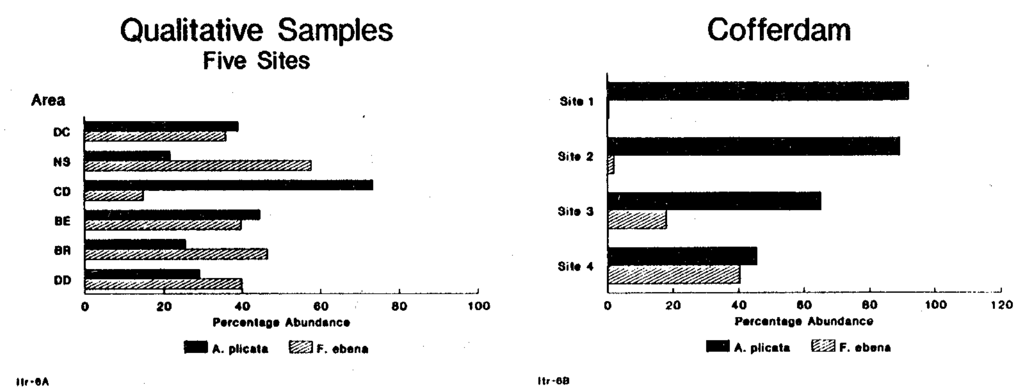


Figure 6. Percentage abundances of *A. plicata* and F. *ebena* in the lower Tennessee River.

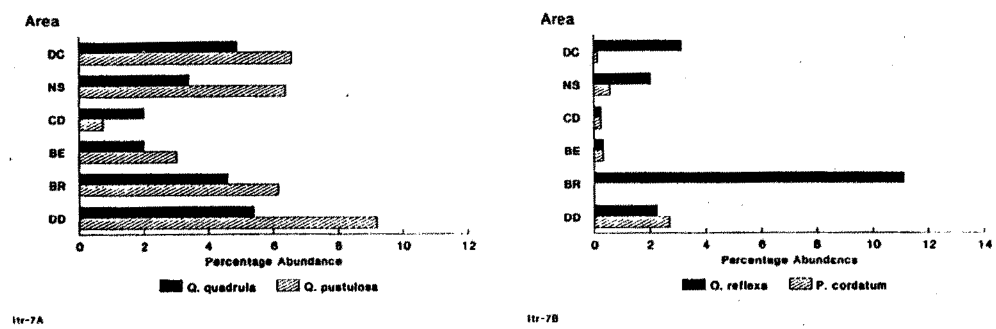


Figure 7. Percentage abundance of Q. quadrula and Q pustulosa, O. reflexa and P. cordatum at six study areas in the lower Tennessee River.

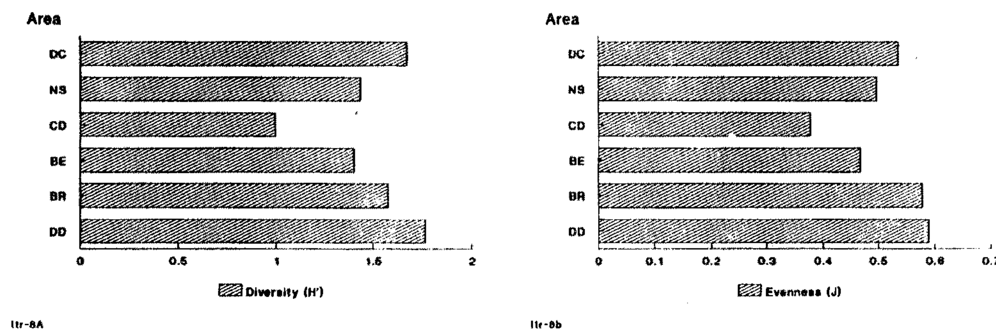


Figure 8. The relationship between percentage abundance and species rank at six study areas in the lower Tennessee River

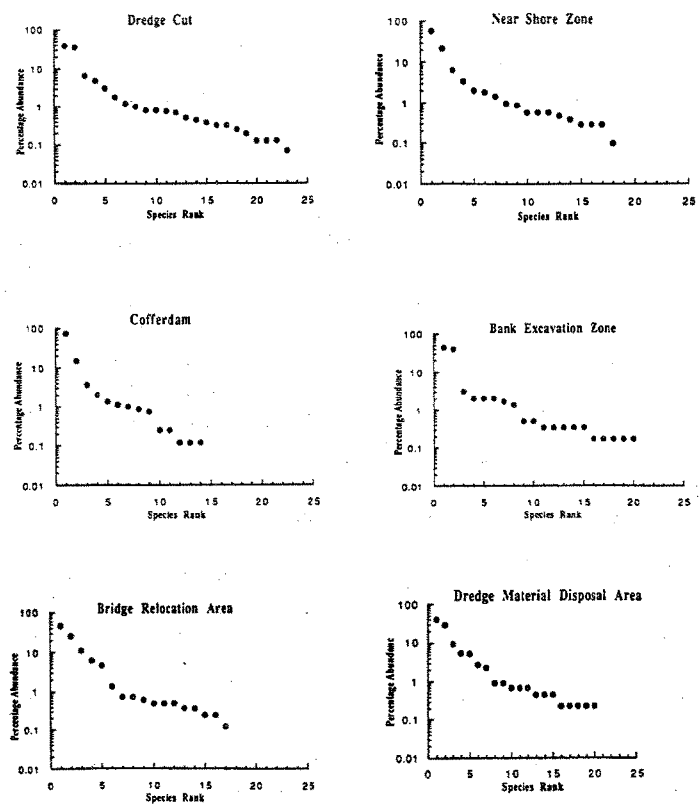


Figure 9. The relationship between percentage abundance and species rank at six study areas in the lower Tennessee River

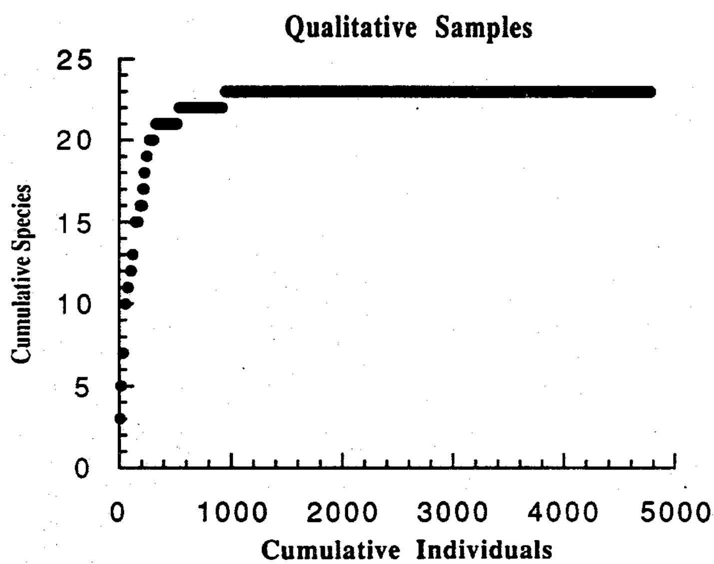


Figure 10. The relationship between cumulative species and cumulative individuals for all sites sampled qualitatively in the lower Tennessee River upriver of the I-24 Bridge.

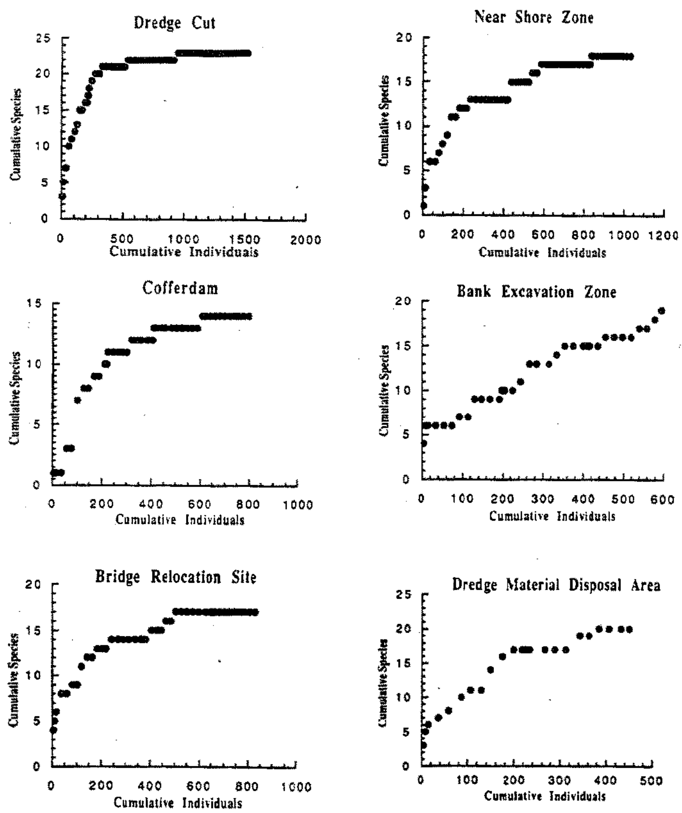


Figure 11. The relationship between cumulative species and cumulative individuals at six study areas in the lower Tennessee River.

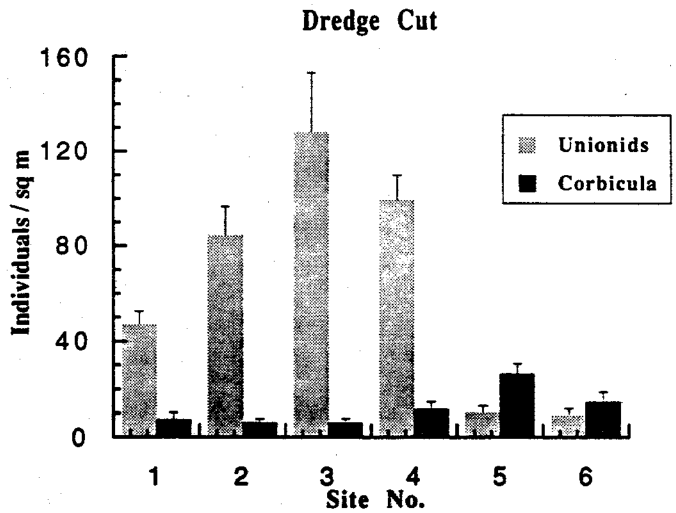
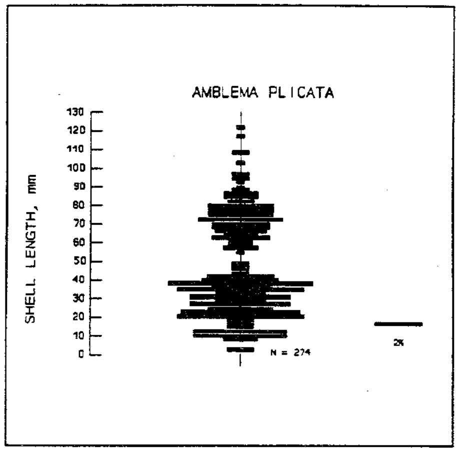


Figure 12. Total density (individuals/sq m) of unionide and Corbicula fluminea at six sites in the dredge cut, lower Tennessee River.



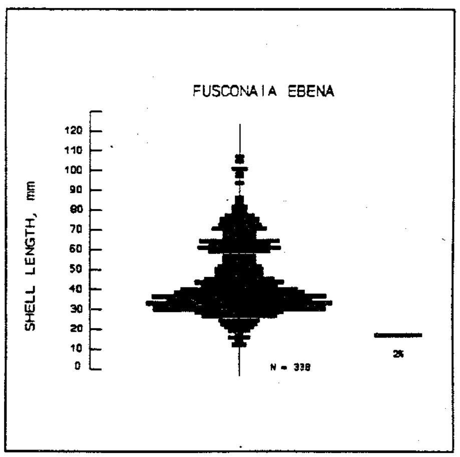


Figure 13. Shell-length frequency histograms for A. plicata. and F. ebena.

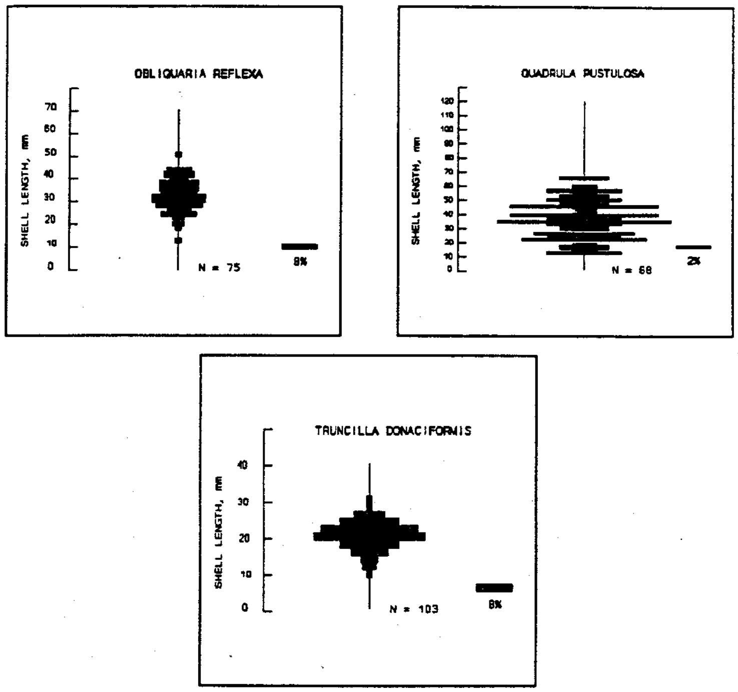


Figure 14. Shell-length frequency histograms for O. reflexa, Q. pustulosa, and *Truncilla donaciformis*.

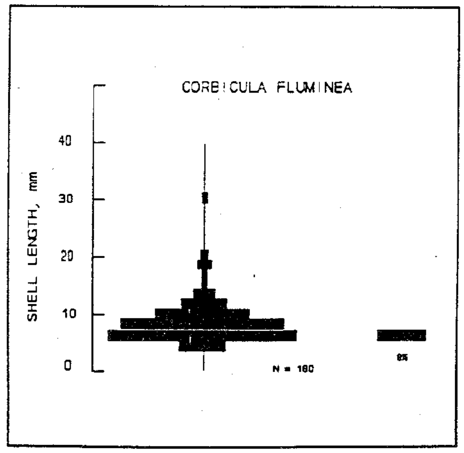


Figure 15. Shell-length frequency histograms for *C. fluminea*.

APPENDIX D

REVIEW OF OCCURRENCE RECORDS FOR RARE FISH SPECIES IN PROXIMITY OF THE PROPOSED KENTUCKY LOCK PROJECT

December 1990

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Lake Sturgeon (*Acipenser fulvescens*)

Lake Sturgeon is one of only two species of the family Acipenseridae found in the Ohio River drainage. In general, sturgeons were fairly abundant in North America and supported a commercial fisheries for a number of years. Populations began a sharp decline in the early 1900's, however, due to overharvest, pollution, and dam construction. Sturgeons are especially vulnerable to overharvest because of their slow growth, age at sexual maturity, and infrequent spawning. Lake Sturgeon are very long-lived fish that have been reported to attain a length of 8 feet, weight over 300 pounds, and an age of 152 years.

Historically, Lake Sturgeon occupied a range that included much of Canada and the Central United States as far south as the Coosa River in Alabama and a large part of the Mississippi River drainage. These fish are typically bottom dwellers that inhabit large, moderately clear streams and lakes. They are found over a variety of substrates. Lake Sturgeons migrate up to 250 miles to littoral areas and tributaries to spawn.

Once abundant in the Ohio River, Lake Sturgeon have not been reported for over 30 years. In Kentucky, the species was collected in the Ohio, Tennessee, and Cumberland Rivers. However, over the last 30 years their have been four reports (3 confirmed) of Lake Sturgeon in Tennessee. Of these, only two were from the Tennessee River, one from Fort Loudoun Reservoir about 1960, and one (unconfirmed) from Indian Creek (upper end of Kentucky Reservoir) in 1964. No recent occurrences in the Lower Tennessee, Cumberland, or Ohio Rivers are known.

Lake Sturgeon spawn in the spring, usually when water temperatures are between 14.0 °C to 15.5 °C. Peak spawning is usually over a period of three to four days. In rivers, eggs are deposited in areas of swift water or rapids, in outside bends of river banks where current is upwelling or slowly boiling, and sometimes at low falls or dams that prevent further upstream movement. Eggs are deposited over hard substrates of rock, sand, clay, shale, or even coal cinders at depths from one foot to 30 feet. Reports of the number of eggs a female can carry vary considerably, but extrapolations indicate a 200 pound female could carry 3,000,000 eggs. Several years are required after eggs appear in a female before they are actually spawned.

Sexual maturity of Lake Sturgeon has been reported from eight to 22 years for males and 12 to 33 years for females.

Lake Sturgeon often do not spawn before reaching 30 to 40 years of age. Individuals do not spawn every year. Females spawn at intervals of four to six years, and males usually spawn every other year. Successful incubation of eggs is best at temperatures from 14 °C to 16 °C. Incubation period is 7 to 9.6 days at 15 °C.

Eggs adhere to substrate at the spawning site, but may become bouyant and drift away from the area. Yolk-sac larvae may drift with water currents or seek shelter under gravel. Post yolk-sac larvae are not pelagic and frequent shallow bays with little current. Juveniles are found on gravelly shoals near mouths of rivers in depths 3 to 4.5 m or in bays and eddies in shallow water and slow currents. Larvae feed on zooplankton, and juveniles are benthic carnivores. Fingerlings are strictly bottom feeders, consuming primarily insect larvae, leeches, molluscs, isopods, and crustacea. Adults are bottom dwellers.

Because Lake Sturgeon have not been reported from the lower reaches of the Tennessee, Cumberland, or Ohio Rivers in over 30 years, it is very unlikely that impacts from construction and operation of a new lock at Kentucky Dam would occur to the species or the habitats it uses. Though unlikely, possible impacts to Lake Sturgeon spawning habitat could result from dredging associated with the downstream approach for a new lock at Kentucky Dam. Dredging would occur in an area of gravel substrate between the right (descending) shoreline and the present navigation channel. Dredging would increase depths in this area, but would not likely change substrate types. Increased depths would still be in the reported suitable range for spawning. Disposal of dredged material at the designated location downstream of I-24 would improve substrate conditions at this location, making the area more suitable for spawning.

Construction and operation of a new lock at Kentucky Dam would not appreciably alter temperature or hydrologic regimes in the Kentucky Dam tailwater to an extent that would preclude Lake Sturgeon from using the area. Based on habitat requirements for the species, the area appears suitable for adult Lake Sturgeon occupation and possibly even for spawning. It appears less suitable for occupation by early life stages of the species, which tend to occur in areas of reduced currents.

Blue Sucker (*Cycleptus elongatus*)

Blue Sucker is a highly regarded food fish that was once of commercial importance throughout its range. Blue

Sucker occur from the Rio Grande River to Mobile Bay and north in the Mississippi, Missouri, and Ohio River drainages. Blue Sucker abundance has declined dramatically, likely due to dam construction, siltation, and innundation of spawning and feeding substrates, reduction of preferred velocities, and pollution.

Little is known of Blue Sucker habits. The species inhabits deep areas with swift currents over firm substrates (sand, gravel, and rock). Adults have been found over limestone bedrock where velocities ranged from 1 to 2.6 m/sec. The species is highly mobile and makes strong migratory runs in spring, and to a lesser extent in autumn.

From 1970 through 1982, only six occurrences of Blue Sucker were reported from the mainstem Ohio River (ORM 54 to 744), though there have been recent collections from several large tributaries to the Ohio River. Recent occurrences have been sporadic in the Tennessee and Cumberland Rivers and their tributaries.

Blue Sucker spawn in riffles one to two meters deep over cobble and limestone bedrock substrates. Mean velocity at spawning sites is reported to be 1.8 m/sec. Spawning occurs in spring with adults in breeding condition as early as February (Missouri) and March (Missouri and Alabama). In Iowa, males were reported to be ripe at water temperatures from 13.4 °C to 16.4 °C. Sexual maturity is reached at ages from three to six years. The spawning act has not been described.

No reports of collection of Blue Sucker eggs are known. Larvae have been collected in a few locations and were seined from swift current (0.45+ m/sec) over clean swept gravel, sand, and mud in the Mississippi River in Tennessee. Juveniles occupy areas of shallow, swift currents, though generally shallower and less swift than frequented by adults. In laboratory studies, juveniles consistently occupied strongest currents available to them (1 - 1.2 m/sec). Young-of-year Blue Sucker feed on small insect larvae (dipterans and caddisflies).

Because of its preference for swift water, Blue Sucker would not be likely to occur in reservoir conditions of lower Kentucky Lake. However, this species could occur in the Kentucky tailwater from Kentucky Dam to the confluence of the Tennessee and Ohio Rivers. Though not recently reported from the Kentucky Dam tailwater, should it occur, it would likely be found in the vicinity of hydroelectric turbine discharges below the dam where velocities would be greatest and bedrock substrate more likely than in the vicinity and downstream of the lock area.

Although spawning habitat and early life stage habitat requirements appear to be present in the Kentucky Dam tailwater, no documentation of spawning in this stretch of river is available. If spawning were to occur in the tailwater, it would likely take place in areas other than those at the downstream lock and approaches. Channel modifications for the new lock would not likely change velocities and substrate characteristics sufficiently to affect use of the area by Blue Sucker in either a positive or negative manner.

APPENDIX E

SURVEY FOR RARE PLANTS IN PROXIMITY OF THE PROPOSED KENTUCKY LOCK PROJECT

December 1990

Richard N. Tippit
Biologist
U.S. Army Engineer District, Nashville
Nashville, Tennessee

SURVEY FOR RARE PLANTS IN PROXIMITY OF THE PROPOSED KENTUCKY LOCK PROJECT

Richard N. Tippit

INTRODUCTION

The preferred plan for improvement of navigation facilities and capacity within the Kentucky-Barkley navigation system is addition of a new lock at Kentucky Lock and Dam. Construction activities associated with the new lock will disturb or alter lands included in TVA's Kentucky Dam Reservation.

Nashville District received in a July 18, 1990 letter from Fish and Wildlife Service's, Cookeville, Tennessee office an account of listed, proposed, and candidate plant and animal species that could occur in proximity to the proposed Kentucky Lock addition project. The list included three vascular plants; Price's potato bean Apios priceana, Appalachian bugbane Cimicifuga rubifolia, and Lake cress Armoracia aquatica.

METHODS

With receipt of the FWS letter an information request was made via telephone to the Kentucky State Nature Preserves Commission (pers. comm. Tom Bloom). The Commission maintains a state-wide data base of occurrences for rare plants. Data is recorded in the form of Element Occurrence Records (EOR). Each EOR cites detailed knowledge concerning the status of a single population of a species. EORs were requested for the above three plants.

Following receipt of the EORs typical habitat requirements were established for the plants as well as their documented patterns of occurrence and preferred habitat in proximity to the project area. Published reference materials were further consulted for life history particulars and identification features. During August 1990 the author visited a colony of Apios priceana in Montgomery County, Tennessee and viewed vegetative and reproductive features Price's potato bean in detail. Photographs were made of the plants for use later in the field as identification aids.

A field reconnaissance of Kentucky Dam Reservation was conducted by the author on October 15, 1990. The survey was accomplished during favorable weather conditions and consisted of thoroughly walking and observing areas of suitable habitat for the three plant species in locations that could be altered by construction of the lock and other features.

SPECIES ACCOUNTS

Following is an account of life history particulars and occurrence records for plant species evaluated in this report.

Price's potato bean - *Apios priceana*

This plant grows as a vine and seems to favor areas affording part sun and part shade. Plants at the Montgomery County, Tennessee site occurred primarily along a streambank, where a moderate amount of sunlight was available. Occurrence records from Kentucky confirm the preference of this species for edge type habitat, rights-of-way, and forest-open area ecotones. EORs list the western Kentucky counties of Lyon, Livingston, and Trigg.

Appalachian bugbane - *Cimicifuga rubifolia*

Occurrence records provided by Kentucky Nature Preserves Commission indicate this plant occurs most commonly on rocky terrain such as bluffs, cliffs, and outcrops. Western Kentucky counties of occurrence include Caldwell, Crittenden, Livingston, and Lyon.

Lake cress - *Armoracia aquatica*

Lake cress is an aquatic plant found primarily in areas of little or no flow such as oxbows, lakes, ponds, and ditches. It has been recorded in the western Kentucky counties of Ballard, Fulton, and Livingston.

RESULTS AND CONCLUSIONS

The field survey concentrated heavily upon locations judged to be suitable habitat for the subject plant species. For each species a fairly strong pattern of habitat preference emerged from Kentucky occurrence records. Photographs of *Apios priceana* were utilized as reference material during the field search.

Results of the literature and site record search and field survey did not elucidate any representatives of the three species on Kentucky Dam Reservation. With the emphasis placed upon searching preferred habitats for these plants, the possibility of occurrence of these plants on Kentucky Dam Reservation is unlikely. In conclusion, construction of an additional lock at Kentucky Lock and Dam will not affect populations of the three subject plant species.

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APPENDIX C

BIOLOGICAL OPINION

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Post Office Box 845
Cookeville, TN 38503

March 28, 1991

IN REPLY REFER TO:
4-C-90-304

APR 1 1991

Colonel James P. King
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Colonel King:

A. Introduction

This letter presents the biological opinion of the U.S. Fish and Wildlife Service (Service) regarding impacts to Federally listed endangered and threatened species from construction of a new navigation lock at Kentucky Lock and Dam in Livingston and Marshall Counties, Kentucky. It responds to your letter of December 28, 1990, transmitting a biological assessment and requesting formal Section 7 consultation. This letter only addresses the requirements of Section 7(a)(2) and Section 7(b)(4) of the Endangered Species Act of 1973, as amended (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), and does not include requirements of other environmental statutes such as the Fish and Wildlife Coordination Act or National Environmental Policy Act. The Nashville District, U.S. Army Corps of Engineers (Corps), has determined that the proposed project may affect the following five listed species:

1. Indiana bat - Myotis sodalis (E)
2. Orange-footed pearly mussel - Plethobasus cooperianus (E)
3. Pink mucket pearly mussel - Lampsilis orbiculata (E)
4. Ring pink - Obovaria retusa (E)
5. Fanshell - Cyprogenia stegaria (E)

The Nashville District also considered impacts to eight other endangered and threatened species and a number of State-listed and Federal candidate species, and made "no effect" determinations for them based on the species' ability to avoid the construction area, or on the absence from collection of individuals in the project area for over 15 years.

Section 2(b) of the Endangered Species Act describes the purposes for which the Act was passed, one of which is to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Recent rediscoveries of populations of endangered species in areas from which they were thought to have been extirpated (e.g., collection of snail darters in the lower Holston River; collection of tan riffleshell in the Duck River), and discoveries of populations of listed species where they were not previously thought to occur at all (e.g., discovery of maternity colonies of Virginia big-eared bats along sandstone cliffines in Kentucky), leads the Service to believe that even extremely rare endangered or threatened species that have not been found for long periods, or those that may be considered extinct, could potentially occur in any area within the species' historic range, provided that suitable habitat capable of sustaining populations still exists. In addition, based upon the above-stated purpose of the Act, we believe that impacts to the species' habitat constitute impacts to the species. Therefore, since the Tennessee River below Kentucky Dam still provides excellent habitat for a diverse, abundant, and reproducing mussel community, this document will include the Service's biological opinion on whether or not the proposed action is likely to jeopardize the continued existence of the following four additional endangered species:

1. Rough pigtoe pearly mussel - Pleurobema plenum (E)
2. White wartyback pearly mussel - Plethobasus cicatricosus (E)
3. Fat pocketbook pearly mussel - Potamilus capax (E)
4. Tuberculed-blossom pearly mussel- Epioblasma torulosa torulosa (E)

B. Project Description

Construction of the Barkley Canal in 1967 created the Kentucky-Barkley navigation system, an important link in the inland waterway transportation system. The system consists of both the Kentucky Lock and Dam, Barkley Lock and Dam, Barkley Canal, the lower 30.6 miles of the Cumberland River, the lower 22.4 miles of the Tennessee River, and the Ohio River from Smithland to Paducah. Lock and dam facilities on the Cumberland River provide navigation from the river's mouth at Smithland, Kentucky, upriver to Celina, Tennessee, a distance of approximately 381 miles. Nine facilities on the Tennessee River provide navigation for a length of 652 miles to Knoxville, and for up to 60 miles further up three of its major headwater tributaries, the Clinch River, Hiwassee River, and Little Tennessee River. Between 1967 and 1986, the tonnage of goods shipped on the Kentucky-Barkley system increased significantly from 13 million tons to 34 million tons. Commodities presently transported consist primarily of coal, aggregates, and grains, but significant amounts of steel, chemicals, and ores are also shipped. In 1989, approximately 40,600 barges in 4,700 tows moved through Kentucky and Barkley Locks. Ninety percent of the barges measured 195 feet long by 35 feet wide. Average tow size over the past four years was thirteen to fifteen barges. The Corps of Engineers projects that by the year 2050 traffic demand on the Kentucky-Barkley system will more than double to 89 million tons. This increase in traffic, coupled with operational procedures, could potentially cause significant traffic problems on the waterway. Closure of Kentucky Lock in 1986 for maintenance resulted in a 76% delay rate increase through the system. Projected increases in barge traffic will likely result in serious and more lengthy delays in the future, particularly when locks are closed for periodic and major maintenance.

In order to prevent undue delays in water traffic, the Corps of Engineers has investigated the feasibility of implementing improvements to the Cumberland/Tennessee navigation system. Initially, modification of sharp bendways on the Cumberland River was evaluated. However, other considerations, namely significant fluctuations in water levels with concomitant increases in current velocities due to discharge resulting from hydropower generation, rendered this alternative infeasible. These water level fluctuations and strong current velocities make travel on the lower Cumberland difficult and dangerous. However, completion of the Barkley Canal allowed tows to avoid use of Barkley Lock despite increases in travel time. At present, the majority of traffic utilizing Barkley Lock consists of empty barges moving downriver. The currently proposed project (addition of a lock at Kentucky Dam) was considered during the initial planning stages of the project, but was dismissed from consideration for a time.

Construction of an additional navigation lock at Kentucky Dam is the preferred alternative to resolve navigation problems on the lower Cumberland and Tennessee Rivers. Several lock sizes have been evaluated, and the selected plan calls for the construction of a 110-foot X 1200-foot lock landward of the existing lock. The proposed lock would be a concrete gravity structure with steel miter gates. An emergency gate would be constructed upstream of the upper miter gate and stoplogs would be provided downstream. Slots and seals would be included for dewatering of the lock chamber for maintenance. Guidewalls would also be concrete gravity type structures. The downstream wall would be 1200 feet long and the upstream wall would extend for 700 feet upstream of the existing approach wall. Four new mooring cells would be constructed, two in the reservoir and two near the I-24 bridge on the right descending side of the navigation channel downstream from the existing cells. Construction of the lock chamber and downstream guidewall would occur in the dry behind cofferdams at both upstream and downstream ends. Placement of the new lock will necessitate relocation of a railroad line across the river. The present line crosses the river on the dam. However, trains would be unable to negotiate the grade of a raised track in the same location. A new railroad bridge will be constructed downstream from the dam at river mile 22.1. The bridge will span the new lock to a small peninsula, cross the remainder of the river on piers, and will be atop an earth embankment on the left side of the river. The Corps of Engineers is also considering construction of a training dike downstream from the peninsula to moderate river currents in the new navigation channel. Although no definite plans have been made for this structure, the dike could be up to 3,200 feet long.

Approximately 1,700,000 cubic yards of material will be excavated from dry land on the right bank during construction of the lock proper, and 527,000 cubic yards will be removed from the lower approaches. If a bottom longitudinal filling/emptying system is selected an additional 62,000 cubic yards of excavation will be required upstream of Kentucky Dam. Excavation requirements for the highway and railroad relocations are 148,500 and 153,000 cubic yards, respectively. The proposed project would also require approximately 980,000 cubic yards of borrow for these two portions of the project, most of which would be placed on the left descending side. The source of borrow and the site for disposal of excavated material are proposed for an open pasture area adjacent to river mile 21.2 on the right descending side. To obtain an adequate depth and width in the proposed navigation channel upstream of I-24, approximately 73,400 cubic yards of sand and gravel will be dredged from the river bottom and right bank. Of this amount, 59,400 cubic yards will be disposed of in the river downstream from the project. The remainder will be placed in an upland disposal site.

Construction and operation of a new navigation lock at Kentucky Dam, and actions associated with the construction (railroad relocation, riverbank and channel excavation, etc.), could have significant adverse impacts on all of the listed species mentioned above for which the Corps has made "may affect" determinations. Excavation required for lock construction and channel dredging will significantly affect the aquatic habitats and will result in loss of a portion of a substantial mussel bed along the right descending bank. In addition, construction of a training dike, depending on the length, will impact the mussel bed and other aquatic resources on the right side by altering present river flows and sediment deposition over the area. Construction activities could also result in spills of pollutants or toxicants, or runoff of these materials into the river. Adult and juvenile mussels could suffer direct mortality from being excavated with river substrate. Since excavated material is proposed for disposal on an upland site, mussels removed would not survive. Even if the material were disposed of in the river, it is likely that the stress of being dislodged or physical damage to the shells would result in high mortality. Direct mortality could also result from spills or runoff of pollutants or toxicants. Excessive and/or prolonged sediment loads resulting from construction activities settling out over the bed could also smother mussels of all ages and cause potential fish hosts to abandon the area.

Barges navigating within the proposed navigation channel will have to maneuver close to the right descending bank to achieve proper alignment into the lock, to safely pass between the I-24 bridge piers, or to tie up to two proposed mooring cells. Silt raised by propellers and waves generated by tow wakes will likely settle on the mussel bed adjacent to the channel. Although the number of tows may not increase as a result of the new lock, the average size of tow is likely to increase. This could result in a significant increase in the amount of silt that settles out on the mussel bed in and adjacent to the navigation channel. In addition, Russell Creek may serve as a source of sand that provides substrate suitable for growth and survival of juvenile mussels. Placement of fill and a culvert across the stream may impede flow of sand onto the mussel bed, which may result in a decline in reproduction and recruitment. Also, the projected doubling of tonnage shipped on the lower Tennessee River could potentially make the area more attractive to commercial or industrial developers for construction and operation of loading and/or fleeting facilities. These developments could result in additional adverse impacts to aquatic and terrestrial communities.

Construction of a training dike would likely modify river flows in downriver reaches, the degree of modification dependent on the length of the dike. With significantly reduced flow along the right descending bank, barge-related siltation of the mussel bed on the right bank would increase and could result in significant reductions in reproduction, recruitment, and survival of mussels. In time, the mussels now existing in this bed would probably be eliminated. Although no specific plans have been proposed for construction of this dike, the Corps of Engineers is considering addition of this structure to the project plans.

Construction of access roads, equipment staging areas and construction platforms will result in the removal of several acres of forested habitat. Removal of riparian and bottomland forest from the river banks, the banks of adjacent Russell Creek, or upland forest areas could result in loss of potential maternity sites for breeding bats, or loss of important canopy cover that provides sheltered travel corridors between the maternity trees and foraging areas. Both impacts would likely result in reproductive failure and a subsequent decline in numbers of bats. Fill and installation of a culvert across Russell Creek could result in ponding of the stream, significant mortality to riparian trees, and siltation of the stream. This could destroy potential bat maternity and foraging habitat.

The Nashville District will implement measures to avoid or minimize adverse impacts to the mussel resources and potential bat habitat below Kentucky Dam. Prior to construction, cofferdams will be built so that excavation and construction of the navigation lock and lower guidewall can be accomplished in the dry. Excavation of the right bank downstream of the guidewall and dredging the proposed navigation channel could result in excessive siltation of downstream areas. However, the Corps will implement measures to keep sediment loads to a minimum. Whenever possible, dredging will be timed to correspond with high flows or hydro releases that will disperse silt and help prevent it from settling onto the mussel bed. Other silt control and/or containment measures will be employed to the extent possible. The original site for the railroad bridge relocation has been changed to avoid impacts to a cypress slough. Also, project activities (construction, spoil disposal, etc.) will avoid a bottomland hardwood forest and riparian area along Russell Creek. An equipment staging area has been relocated from its original proposed location to avoid adverse impacts to portions of a mature upland forest. The Corps will place rock riprap and establish riparian vegetation to stabilize the badly eroded right descending bank. A culvert on Russell Creek that will be placed under an access road to the area to be used for borrow/disposal will be designed so as not to impede streamflow during low water conditions, and will allow complete passage of water and sand during high flows. The Corps will also investigate the feasibility of grading the borrow/disposal area to create wetland acreage that eventually could, through succession, provide additional bottomland hardwood habitat.

Prior to dredging, the Corps will remove as many mussels as possible from the river bottom to be impacted. Mussels removed will immediately be relocated downriver to areas within the same mussel bed, or to another area containing suitable habitat. Dredged material is anticipated to consist primarily of sand and gravel. This material will be transported downriver and disposed of in an area presently supporting sparse populations of mussels in an attempt to create additional mussel habitat within the designated mussel sanctuary. Because the area adjacent to the proposed disposal site contains a moderately dense mussel community, the Corps will have divers survey the disposal site thoroughly, before disposal occurs, to determine if endangered mussels are present. The proposed right channel margin will be heavily buoyed to alert tow operators, and tows will not be allowed to maneuver to the landward side of the proposed mooring cells. Lock operators will monitor traffic to the extent possible to ensure compliance with all measures implemented to protect the mussels and habitat above I-24.
If and when plans for the training dike are finalized, the Corps will conduct hydrologic studies to determine the level of river flow modification over the mussel bed and the degree of impact to the mussels from reduced flow and silt deposition. Results of these studies will be submitted to the Service, along with a determination of potential effects to endangered mussels. If "may affect" determinations are made for one or more listed species, the Corps will reinitiate consultation and the Service will issue a new biological opinion or a supplement to this biological opinion with appropriate alternatives presented for any "jeopardy" findings, and modification of the "Incidental Take" section, if necessary.

C. Consultation History

The Nashville District, Corps of Engineers, initiated Section 7 consultation for proposed bendway improvements on the Cumberland River by letter of November 20, 1984, addressed to Mr. Warren Parker of the Service's Asheville, North Carolina, Field Office. The Service's response, dated January 22, 1985 (delay of the Service's response was apparently due to loss of the Corps' letter), indicated that six listed species (two bats, one bird, three mussels) might occur in the project impact area. The Corps concluded that the proposed action would not affect two of the mussels (based on a 1982 survey of the Cumberland River), the bald eagle, and two listed bat species. A biological assessment was submitted to the Cookeville Office on May 2, 1988, with a finding of "no effect" to the third mussel species. The assessment reported that two candidate snail species did occur in areas proposed for rock ledge removal, and the Corps proposed to transplant individuals to other areas in the river containing suitable habitat. The Service concurred with the Corps' finding by letter of May 16, 1988.

In June, 1990, the Corps released a Draft Interim Feasibility Study for the project. The scope of the project had changed dramatically; the only alternative under consideration was construction of a new lock at Kentucky Dam. The Service informed the Corps that reinitiation of consultation would be necessary, and that a new biological assessment would be needed. Consultation was reinitiated on June 22, 1990. The Service response, dated July 18, 1990, presented a list of twelve endangered and threatened species that might occur in the project area. The Nashville District submitted a biological assessment on January 2, 1991, with "may affect" findings for five species: the Indiana bat and four mussels. "No effect" determinations were made for one bat, two birds, four mussels, and one plant. The assessment was accompanied by a request for formal consultation.

A copy of this consultation is on file and available for review during normal business hours at the Fish and Wildlife Enhancement Office, U.S. Fish and Wildlife Service, 9 East Broad Street, Cookeville, Tennessee 38501; telephone 615/528-6481.

D. Biological Opinion

Although construction of Kentucky Lock and Dam, U.S. 62 and I-24, the I.C.G. Railroad, and other agricultural, commercial, and residential development has significantly affected the terrestrial and aquatic habitats, the project area still contains areas of bottomland and upland forest and aquatic habitat that support a diversity of fish and wildlife resources, including species which are presently listed as endangered or threatened. Upon review of the biological assessment, the Fish and Wildlife Service believes that the assessments for the gray bat (Myotis grisescens), bald eagle (Haliaeetus leucocephalus), arctic peregrine falcon (Falco peregrinus tundrius), and Price's potato bean (Apios priceana) are adequate and support the determinations of "no effect", with which we concur. Therefore, requirements of Section 7 of the Endangered Species Act have been fulfilled and no further consultation is needed for these species at this time. Since Section 7 requirements do not apply to status review species, no consultation is needed for the seven candidate species for which "may affect" findings were made. However, we commend the Nashville District for including these species in the biological assessment, and we request that you include protective measures for them during the planning stages of the project.

- Indiana bat

The Indiana bat, Myotis sodalis, is a medium-sized member of the genus, closely resembling the little brown bat. However, the Indiana bat differs in having a keeled calcar, smaller feet, and a sagittal crest on the skull. It is a monotypic species that historically occupied a large range in the eastern half of the United States. Large populations and individual records are known from Indiana, Virginia, Missouri, Kentucky, Arkansas, Connecticut, Florida, Georgia, Illinois, West Virginia, Iowa, Maryland, Oklahoma, Michigan, New Jersey, New York, Massachusetts, Alabama, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Mississippi, and Wisconsin. The species is known primarily from information gathered at hibernacula. The Indiana bat is selective about its hibernacula as evidenced by the fact that two caves and an abandoned mine provide winter habitat for approximately 90% of the total known population. Information on summer habitat and distribution of M. sodalis is largely unknown.

Indiana bats migrate between winter and summer habitats. Swarming activity and mating occur in the autumn, prior to hibernation. Females enter hibernacula directly after mating, some by October. Males remain active for a longer period, but all are hibernating by early December. The bats hibernate in tight clusters of several thousand in areas of the cave with average temperatures of 3-6 degrees Celsius and relative humidities of 66-95 percent. Depending on climatic conditions, hibernation lasts from October through April. Upon emergence, males migrate to summer caves and females establish small maternity colonies (50 to 100 individuals) in cracks or under loose bark of mature trees in riparian or upland forest. Females exhibit strong site fidelity to maternity trees, returning year after year. Young are born in June or July and are capable of flight within 30 days.

Optimum foraging habitat consists of streams with approximately 70 to 90 percent mature riparian forest canopy cover, and adjacent upland forest. The bats feed at heights of 2 to 30 meters in the riparian or floodplain forest, or over upland fields. Aquatic insects and Lepidoptera comprise the primary prey of M. sodalis. Roost trees are not necessarily within the foraging area, and individuals have been reported to fly up to 3.5 kilometers to feeding areas. Home ranges of 54 hectares for pregnant females, 94 for lactating females, 212 for post-lactating females, 28 to 37 hectares for juveniles, and 57 for adult male Indiana bats have been reported (Gene Gardner, Illinois Natural History Survey, personal communication).

The Indiana bat population is presently estimated to consist of approximately 550,000 individuals. Some areas within the species' range have exhibited stable or increasing population trends, particularly in the eastern and northeastern portions of the range, due to the discovery of new colonies. However, many known Indiana bat colonies have undergone significant declines in numbers within the past fifteen years, despite the fact that most large hibernacula have been identified and protected, and intensive cave management programs have been initiated in some areas. The population in Missouri's third largest hibernaculum has declined from 72,000 in 1960 to 33,000 in 1980. Population censuses indicate that Kentucky's population has declined almost 75% since 1960.

Human disturbance is likely the leading factor in the decline of Myotis sodalis throughout its range. Bats enter hibernation with only enough stored fat reserves to last until spring. Human entry into hibernacula results in arousal of the bats, causing depletion of stored reserves. A single arousal may result in loss of up to 30 days of fat supply. Frequent arousal likely causes the bats to leave the cave before insect prey is available, resulting in starvation. Vandalism is also a leading cause of mortality. In 1960, several individuals entered a hibernaculum in Kentucky and trampled or stoned an estimated 10,000

Indiana bats. Many other examples of this type of activity have been reported in other parts of the species' range.

Natural hazards are also a potential threat to the species, and have caused high mortalities in some colonies. In a cave in Mammoth Cave National Park, flooding of the Green River apparently resulted in the drowning of 300,000 bats. Ceiling collapse is another hazard. Subsidence of an abandoned mine in Missouri threatens the largest known Indiana bat hibernaculum. Severe winter weather may also cause high mortality in hibernating colonies of M. sodalis because the species tends to hibernate in cool portions of caves near the entrance.

Deforestation and stream channelization may also be contributory factors in the decline of the Indiana bat in many portions of the species' range. Destruction of riparian and associated upland forest, and channelization of streams significantly alter the habitat. The species prefers to forage over streams with good canopy cover. Deforestation eliminates riparian vegetation that helps maintain good water quality and results in declines in aquatic and terrestrial insect populations. Also, deforestation would remove trees that do, or potentially could, serve as roost sites for maternity colonies. Destruction of maternity sites would likely result in elimination of the colony, given the species' strong site fidelity.

Other factors thought to contribute to the species' status and threaten its continued existence are pesticide use, indicriminate handling by biologists and researchers, commercialization of hibernacula, alteration of cave microclimate, and inundation of caves by reservoirs. Indiana bat numbers in the two largest hibernacula in Kentucky declined significantly because gates designed to protect the bats were poorly conceived and installed, resulting in alteration of the microclimate of the caves.

A cave near Smithland in Livingston County, Kentucky, supports a hibernating colony of approximately 160 M. sodalis, approximately ten miles from Kentucky Dam. Construction activities and operation of a new navigation lock are not likely to have any significant adverse effects on this colony. However, there are areas within the project impact area that could potentially support summer maternity colonies. Although there are no confirmed records of Indiana bats in the project area, the riparian and bottomland forest along Russell Creek and associated upland forest adjacent to the right descending bank, as well as a cypress slough near the boat ramp on the left descending side of the river, appear to contain suitable summer roosting and foraging habitat. Since the site of the proposed railroad relocation has been moved upriver, the Service does not anticipate any adverse impacts to the cypress slough habitat. However, construction of an access road near the mouth Russell Creek, including placement of fill and installation of a culvert, would affect the forest along that stream. In addition, the new railroad right-of-way will result in bisection of a mature upland forest associated with the bottomland and riparian forest along Russell Creek.

The Nashville District has stated that the railroad relocation through the left bank cypress slough has been dropped from consideration. Also, they have agreed not to conduct any activities that would adversely affect the riparian and bottomland forest along Russell Creek, and that the culvert under the proposed access road will be designed to allow free flow of Russell Creek at all times. Therefore, although the project will result in the loss of a portion of, and will bisect, a tract of mature upland forest, it is the biological opinion of the Service that the proposed construction and operation of a navigation lock, relocation of a railroad bridge, construction of an access road, and (possible) construction of a training dike along the proposed navigation channel on the Tennessee River are not likely to jeopardize the continued existence of the endangered Indiana bat.

- Freshwater mussels

Because of its age and the fact that it did not undergo glaciation, the Tennessee River Basin has long been known as a primary center of freshwater mussel speciation. Over 100 species historically occurred and evolved in the Tennessee River and its tributaries. Since 1800, however, populations of many species have undergone significant declines, some to extinction and others reduced to remnants restricted to isolated portions of their former ranges. Several species in the genus Epioblasma have not been recorded from any stream in the entire Tennessee or Cumberland River drainages for over 50 years and are presently believed to be extinct. At present, however, over 60 species may still inhabit streams and rivers in the basin, 26 of which are officially listed or proposed as endangered species. Within the Tennessee River Basin, mussels are found in the main stem of the river, as well as in large tributaries and medium-sized and small headwater streams. Some species are more tolerant than others, occurring in mud-bottomed pool habitats. However, most are found in riffle or shoal habitat with relatively swift current over substrate consisting of mixed sand, gravel, and cobble. Swift currents maintain high levels of dissolved oxygen and sweep the bottom clean of silt and other settleable materials. Being filter feeders, mussels consume algae, zooplankton, diatoms, detritus, and other matter suspended in the water column.

Reproduction among mussels is unique. Sperm are released into the water column by males and are siphoned from the water by females during normal respiration and feeding activity. Fertilized eggs are stored in specially modified gills (marsupia) that act as brood pouches for the developing larvae (glochidia). Fully developed glochidia are released into the water and drift with stream currents. Within three or four days, they must attach to a suitable fish host, encysting on gill filaments, opercles, or fins. Those glochidia not successfully attaching to a host fish probably settle to the bottom eventually and perish or serve as prey for fish or invertebrate predators. During the period of encystment, which lasts up to several weeks depending on water temperatures and other factors, the glochidia metamorphose. When metamorphosis is complete, the glochidia detach from their host and, again drifting with the current, settle to the bottom as fully developed, free-living juvenile mussels. It is thought that there are two stages in this complex life cycle that are critical: attachment to the host and settling to the bottom after detachment. Significant mortality likely occurs at both stages as a result of glochidia attaching to unsuitable hosts (some species are extremely host-specific) or not successfully attaching, and from settling onto unsuitable habitat.

A number of factors have been identified as causes in the decline of freshwater mussel populations in the Tennessee River Basin. Construction of impoundments altered miles of riverine habitat and eliminated significant populations of riffle-dwelling mussel species in portions of the Tennessee River. Prolonged or excessive siltation causes mussels to cease siphoning, inducing significant stress as a result of reduced feeding and respiration. Pollutants such as pesticides and heavy metals cause mortality directly, or accumulate in body tissues and result in stress-related mortality. Over-harvest of mussels for shells used in cultured pearl production has resulted in significant population declines. In addition, recently reported die-offs of unknown cause have significantly reduced remaining populations. Many endangered mussel species now exist only in river reaches below dams, and in unimpounded streams and rivers in the headwater areas. Although species of mussels that are tolerant of lentic conditions still exist or have recolonized habitats in the upper reaches of some reservoirs, these communities are neither as abundant nor diverse as those existing prior to impoundment.

The Tennessee River from river mile 17.8 to 22.4, including the entire project area, has been designated by the State of Kentucky as a mussel sanctuary. Although this reach of river supports diverse and abundant mussel populations, no commercial harvest of mussels is allowed. Habitat immediately below the dam is marginal for mussels, due to swift currents that sweep the bottom clean of silt, sand, and gravel. As current velocities moderate downriver, mussels increase in numbers. Since the project area consists of a portion of the last free-flowing riverine habitat in the main stem of the Tennessee River, it supports one of the best remaining preimpoundment mussel communities in the Tennessee River Basin. Various surveys conducted between 1931 and 1978 revealed that 38 species of mussels once inhabited the lower Tennessee River, and reported the presence of up to 27 species in this reach. However, a survey done in 1985 by Dr. James Sickel recorded the presence of 36 species, including two endangered species. The lower end of the project area contains a portion of one of the most extensive mussel beds in this reach of river; twenty-four species were found in this bed and good recruitment was reported. Mean mussel density in the bed was calculated to be 10 mussels per square meter, with a range of 1 to 66 per square meter. Dr. Sickel hypothesized that sand washed from Russell Creek provides and perpetuates excellent habitat for mussels, particularly the juveniles.
Mussels in the sanctuary area (TRM 17.8 to 22.4) exhibit excellent reproduction and recruitment because they are protected from commercial harvest. The beds within the sanctuary likely serve as sources of juveniles that contribute to the replenishment of depleted, commercially harvested beds downriver. Also, the area serves as a refuge for rare and endangered species.

o Tuberculed-blossom pearly mussel

The tuberculed-blossom pearly mussel, Epioblasma torulosa torulosa, is an Ohioan (Interior Basin) species. It was historically widespread in the Tennessee, Cumberland, Ohio, and St. Lawrence river drainages. Epioblasma t. torulosa once occurred in the Tennessee, Elk, Duck, Paint Rock, Nolichucky, Cumberland, Ohio, Kentucky, Kanawha, and Scioto Rivers. The species was reported to be relatively common in the Tennessee River, but extremely rare in the Cumberland. It has also been reported from the St. Marys River in Indiana; Grand, Black, Clinton, Detroit, Huron, and Raison Rivers in Michigan; and the Syndenham River in southern Ontario. The tuberculed-blossom pearly mussel is thought to be the inflated, large-river form that intergrades into the subspecific headwater forms: the green-blossom, E. t. gubernaculum (Clinch River), and northern riffleshell, E. t. rangiana (Ohio River). It occurs in shoal and riffle reaches with swift current and sand and gravel substrate, but unlike the other large-river mussels described, it inhabits relatively shallow water in depths up to six feet. Studies done on other Epioblasma species reveal that the tuberculed-blossom may be a long-term breeder, breeding in early August and releasing glochidia by September. Fish hosts for the species are unknown. The lower Tennessee River lies within the species' range, but six surveys conducted from 1931 to 1985 failed to collect the tuberculed-blossom from the project area. Although suitable habitat still exists in parts of the species range, E. t. torulosa has not been collected in over fifteen years and is believed by some malacologists to be extinct.

o White wartyback pearly mussel

The white wartyback pearly mussel, Plethobasus cicatricosus, is another Ohioan species occurring in the Ohio, Cumberland, and Tennessee River systems. Historical records indicate that the species occurred in the Tennessee River, Cumberland River, Ohio River, Holston River, Wabash River, and Kanawha River. It has always been uncommon throughout its range, and the only recent collections of this species have been from the mainstem of the Tennessee River. However, surveys conducted by Ellis (1931), Williams (1969), Isom (1969), Bates (1975), Miller (1990), and Sickel (1985) did not report P. cicatricosus from the project area. Since no young specimens have been found in recent years, the species may be facing imminent extinction. The white wartyback is a big-river species, inhabiting shoal and riffle areas with sand and gravel substrate. Its life history is unknown, but it may be a short-term breeder as is its congener, P. cyphyus. Fish hosts for the species are also not known.

o Orange-footed pearly mussel

The orange-footed pearly mussel, Plethobasus cooperianus, is also an Ohioan species, but it is more widely distributed than P. cicatricosus. Historically, the orange-footed mussel occurred in the Ohio, Kanawha, Wabash, Rough, Tennessee, Duck, French Broad, Holston, Clinch, and Cumberland Rivers. It was reported to be an abundant species in the Ohio, Wabash, and Cumberland Rivers; however, it was rare in the Tennessee River and its tributaries above Knoxville. Presently, P. cooperianus is known to occur in the Tennessee River for an undetermined number of miles below Pickwick Dam; the Cumberland River at Bartlett's Bar and Rome Landing; and the lower Ohio River near Metropolis and Olmstead, Illinois, and McCracken County, Kentucky. Of these three populations, only the one in the Tennessee River is known to be reproducing. The orange-footed mussel is also a large-river, shoal-inhabiting species. It is found in gravel and sand substrate in water from 15 to 29 feet in depth. The species' life history is unknown, but gravid females have been collected during the summer, indicating that the species is a short-term breeder. The glochidia are undescribed and the fish hosts are unknown.

o Rough pigtoe pearly mussel

The rough pigtoe pearly mussel, Pleurobema plenum, is an Ohioan species that was historically widespread in the Ohio River, Cumberland River, and Tennessee River systems, and it was reported to occur in large rivers in Arkansas and southwest Kansas. The rough pigtoe presently occurs only in the Tennessee River, Cumberland River, Clinch River, Green River, and Barren River. In the Tennessee River, the species is thought to occur for an undetermined number of miles below Pickwick, Wilson, and Guntersville Dams, and is believed to be reproducing below Pickwick. It is also thought to be reproducing in the Green River and upper Clinch River. Pleurobema plenum is considered to be a rare species in the Cumberland River. Sampling by TVA in 1976 failed to find any live specimens in the Cumberland. Surveys done in the Green and Barren Rivers indicate that the rough pigtoe occurs in the Green River from lock and dam 5 (Glenmore, Kentucky) to lock and dam 4 (Woodbury, Kentucky), and in the Barren River from the mouth to lock and dam 1 (BRM 15.0). Since this population is considered to be abundant, reproduction and recruitment are likely occurring. Although the project area lies within the species' range, it has not been found in the river below Kentucky Dam since before 1931. The species' life history is not known, but studies done on other Pleurobema species indicate that P. plenum is a short-term breeder. Fish hosts are unknown.

o Pink mucket pearly mussel

The pink mucket pearly mussel, Lampsilis orbiculata (=Lampsilis abrupta), like the other species addressed, is an Ohioan species with a relatively wide range. Historical records include large rivers in Tennessee, Alabama, Kentucky, Ohio, Pennsylvania, West Virginia, Indiana, Illinois, Virginia, Iowa, Arkansas, and Missouri. Presently, known populations occur only in the Ohio River, Tennessee River, Cumberland River, Kanawha River, Osage River, Meramec River, Paint Rock River, Clinch River, Green River, Big River, Black River, Little Black River, Current River, and Gasconade River. Only four populations have shown recent evidence of reproduction: the Tennessee, Paint Rock, Meramec, and Cumberland Rivers. However, some taxonomists have recently postulated that the reproducing populations west of the Mississippi River are not Lampsilis orbiculata, but rather are subspecies of another endangered species, Lampsilis higginsi. If this is true, then only three known reproducing populations of L. orbiculata are extant. Although it has a relatively wide distribution and is apparently more tolerant than other listed mussel species, the pink mucket is reported to be rare where it occurs. It is a large-river mussel, inhabiting primarily shoal areas with swift current at depths of 0.5 to 8.0 meters. Nonetheless, L. orbiculata appears to have adapted to lentic conditions in the upper reaches of some impoundments. Life history aspects of this species are presently unknown, although it may be a long-term breeder, as are other Lampsilis species. Glochidia are undescribed and fish hosts are unknown.

- Fat pocketbook pearly mussel

The fat pocketbook pearly mussel, Potamilus capax, like the pink mucket, has a relatively wide distribution, but is extremely rare where it occurs. Although there are only a few published records for the distribution of the fat pocketbook, available information indicates that the species once occurred in the Mississippi River from Minnesota to Missouri. It was also found in the Des Moines River in Missouri; Wabash River and Ohio River, Indiana; Niagara River, New York; and the Illinois River, Illinois. Until 1987, the only verified extant population of P. capax occurred in the St. Francis River, Arkansas. Since 1987, however, Ron Cicerello from the Kentucky Nature Preserves Commission has found fresh dead and live specimens in the Ohio River at the mouth of the Wabash River and in the lower Ohio River between lock and dam 53 and the Mississippi River. James Sickel from Murray State University collected live specimens in the lower Cumberland River (CRM 0.6) in Livingston County, Kentucky, during a survey in 1987. The fat pocketbook may, therefore, inhabit the Ohio River from the mouth of the Wabash River to the Mississippi River. Populations may also exist in the Wabash River and White River in Indiana. Unverified collection records of fat pocketbook pearly mussels exist from the Green River, Kentucky; Neosho River, Kansas; and Verdigris River, Oklahoma. These are likely misidentified specimens since all three are based on single records that have not been verified, and no subsequent collections of the species have been made from any of these rivers. The species has recently been found in the lower Ohio River and lower Cumberland River, but it has not been collected in the Tennessee River below Kentucky Dam in recent years.

Potamilus capax is a large-river mussel that requires flowing water in areas ranging from a few inches to eight feet in depth, and having mud, sand, or fine gravel substrate. Many aspects of the species' life history are unknown, but it is thought to be a long-term breeder. Gravid females have been collected in June, July, August, and October. Although fish hosts for P. capax are unknown, studies conducted on other species of Potamilus reveal that the fish host for P. alata, P. purpurata, and P. laevissima is the freshwater drum; the white crappie also serves as a host for glochidia of P. laevissima.

○ Ring pink

The ring pink (formerly known as the golf stick pearly mussel), Obovaria retusa, is also an Ohioan species. Historically, it was a wide-ranging species, occurring in the Ohio, Cumberland, and Tennessee River systems in Pennsylvania, West Virginia, Ohio, Illinois, Indiana, Kentucky, Tennessee, and Alabama. It is presently found in only four river reaches: the Tennessee River in Livingston, Marshall, and McCracken Counties, Kentucky; the Tennessee River in Hardin County, Tennessee; the Cumberland River in Wilson, Trousdale, and Smith Counties, Tennessee; and the Green River in Edmonson and Hart Counties, Kentucky. Also, in December 1990, an eight-year-old specimen was collected in the upper Kanawha River. However, no evidence of reproduction or recruitment has been reported for any of the populations in recent years, and the continued existence of the species is questionable. Obovaria retusa was collected in the lower Tennessee River in 1985, but it was not found in the project area. The ring pink is a shoal species inhabiting riffle areas in large rivers with mixed sand and gravel substrate. The species' life history and fish hosts are unknown.

○ Fanshell

The fanshell, Cyprogenia stegaria, is another Ohioan species that was described as a medium-to-large-river mussel. Historically, it had a wide distribution in the Ohio, Wabash, Cumberland, and Tennessee River drainages in Pennsylvania, Ohio, West Virginia, Illinois, Indiana, Kentucky, Tennessee, Alabama, and Virginia. Over the past ninety years, however, the species has undergone significant population declines throughout its range. Presently, reproducing populations are thought to occur only in the Clinch River, Hancock County, Tennessee, and Scott County, Virginia; the Green River, Hart and Edmonson Counties, Kentucky; and the Licking River, Kenton, Campbell, and Pendleton Counties, Kentucky. Remnant, non-reproducing populations still exist in Tygarts Creek, Greenup and Carter Counties, Kentucky; Cumberland River, Smith County, Tennessee; and Tennessee River, Rhea, Meigs, and Hardin Counties, Tennessee; as well as the Muskingum River in Ohio, Wabash River in Illinois and Indiana, East Fork White and Tippecanoe Rivers in Indiana, and the Kanawha River in West Virginia. Like most other mussel species, the fanshell is an inhabitant of riffles and shoals in the mainstem of large rivers and their larger tributaries and, like the other species addressed in this opinion, most aspects of its life history are unknown.

The Corps conducted a freshwater mussel survey in the project area in September of 1990. Qualitative and quantitative samples taken from the proposed dredge area revealed the presence of mussels, but no individuals of any of the eight endangered species were collected from this area. Also, no specimens of six of the species included in this opinion have been reported from the lower Tennessee in recent years, despite the fact that the area has been surveyed several times since 1985. The only recent reports of endangered mussels from this mussel bed were the collection of a gravid female L. orbiculata in 1987 in the vicinity of the I-24 bridge and collection of three specimens of P. cooperianus in 1985 at river mile 20.6. The Service believes that construction activities will result in the loss of a portion of the habitat in the mussel bed, and dredging may directly result in the loss of individual mussels. However, until evidence of the presence of O. retusa, P. cicatricosus, P. plenum, C. stegaria, P. capax, and E. torulosa torulosa in the area is confirmed, and because the bed provides excellent habitat for other mussel species, we must conclude that the area is unsuitable or extremely marginal as habitat for these six species and that if they do occur in the area, they occur in densities well below that which would be needed to sustain viable populations. Therefore, upon review of available information, it is the biological opinion of the Fish and Wildlife Service that construction and operation of a new navigation lock at Kentucky Dam, and associated construction activities, are not likely to jeopardize the continued existence of the ring pink, white wartyback, rough pigtoe, fanshell, fat pocketbook, and tuberculed-blossom pearly mussels.

Individuals of the pink mucket and orange-footed pearly mussels have been collected in the project impact area within the past five years. Information from past surveys indicates that the mussel bed below Russell Creek provides excellent habitat for mussels, including these two endangered species. The bed contains a diverse mussel community, and reproduction and recruitment are reported to be excellent. Furthermore, the lower Tennessee River may be one of only a few areas where both of these species are still reproducing. Loss of the population in the lower Tennessee could threaten the survival of both species. However, based on measures to be implemented by the Corps to protect the mussel bed in the project area, and upon review of available information, it is the biological opinion of the Fish and Wildlife Service that construction and operation of a navigation lock, relocation of a railroad bridge, and construction of an access road--as presented by the Nashville District and described in Section B above--are not likely to jeopardize the continued existence of the pink mucket or the orange-footed pearly mussels, provided that all protective measures presented in Section B of this opinion are implemented and stringently enforced. However, construction of a training dike would likely have significant impacts on all of the listed mussel species that occur, or possibly occur, in the area.

E. Incidental Take

This section of the biological opinion addresses incidental take of Myotis sodalis, Plethobasus cooperianus, Lampsilis orbiculata, Obovaria retusa, Cyprogenia stegaria, Pleurobema plenum, Plethobasus cicatricosus, Potamilus capax, and Epioblasma torulosa torulosa resulting from project activities and presents the Service's estimate of the allowable level of take. In meeting the provisions of Section 7(b)(4) of the Endangered Species Act, we have reviewed the biological information and other available information relative to this action. Based on the nature of the proposed project and proposed protective measures to be implemented, it is anticipated that incidental take of the Indiana bat should not occur. However, if the Nashville District anticipates that incidental take may occur in the future as a result of the discovery of new information, consultation should be reinitiated for the reassessment of these impacts and the development of an incidental take statement pursuant to provisions of Section 7(b)(4) of the Act.

The Corps of Engineers has agreed to remove as many mussels as possible from the impact areas prior to dredging. We believe that it is not reasonable to expect every individual mussel to be removed from dredging sites, so there is a potential for incidental mortality to endangered mussels.

In order to provide a navigation channel of suitable depth and width, dredging near the right descending bank will be necessary. A total of 59,388 cubic yards (45,432 cubic meters), or roughly an area of 17,733 square meters will be dredged. The biological assessment included results of six quantitative samples taken from within the proposed dredge cut that revealed mussel densities of 9.2 to 128 mussels per square meter, or an average of 63 per square meter. However, the Corps estimates that approximately 33 percent of the proposed dredge area consists of well-scoured substrate unsuitable for mussels. Therefore, approximately 11,900 square meters contain suitable mussel habitat. Also, the mussels in this area are nonrandomly distributed; patches of substrate containing high mussel density are interspersed with areas of low density. Assuming that the average density estimate adequately accounts for the patchy distribution reported in the biological assessment, an estimated 749,700 mussels occur in the proposed dredge cut. The survey did not report collection of individuals of any of the 8 endangered mussel species that may occur in the lower Tennessee River in the project area. However, the assessment did state that, if any of the endangered species were present, they would occur in densities of less than 0.02 percent of the total mussel community. The lowest species abundance reported in the assessment for the proposed dredge cut was 0.001 percent (yellow sand shell, Lampsilis teres). Since no listed species were found during the survey, it is reasonable to assume that the eight endangered species occur in densities as low as or even lower than the lowest reported. Therefore, assuming that all eight endangered species occur in the proposed dredge cut at individual densities of 0.001 percent (1 in 100,000 individuals), there would be a total of 60 individual endangered species present.

Since the river bottom in the area consists of sand and gravel, it should be relatively easy to remove a large number of the total mussel community. The Service believes, and the Corps agrees, that 70 percent of the mussels (524,800 individuals) can be removed prior to dredging. Therefore, the anticipated level of incidental take is 18 mussels inclusive of all eight species, or no more than two individuals per species.

Reasonable and Prudent Measures - As reasonable and prudent measures to minimize incidental take of the endangered mussels addressed in this biological opinion, the Nashville District should provide this office with proposed plans for removal of mussels, including methods of collection, handling, and relocation. The plan should also provide information as to where the mussels will be placed and details of monitoring that will be conducted. In addition, qualified malacologists should be directly involved with the removal and relocation of mussels. Numbers and identification, including size measurements and age estimates, of all endangered species should be recorded, and all mussels should be placed back into the river within 24 hours after removal. The Service recommends that all mussels be relocated to suitable habitat within the existing mussel bed in the vicinity of the I-24 bridge. Any endangered species collected should be placed in close proximity to each other to increase the potential for successful fertilization. If the Corps wishes to place the mussels into areas other than the existing bed, we recommend that this office be contacted prior to the relocation.

Disposal of dredged material at the proposed downriver site could possibly result in incidental take of listed mussels. However, since no quantitative samples were taken in that area, it is not possible to specify the level or extent of take anticipated. Nevertheless, as a final reasonable and prudent measure to minimize take, the Corps should survey the disposal area thoroughly before the material is deposited. Any endangered species found should be immediately relocated to the nearest suitable habitat. Conspecifics should be placed in close proximity to each other.

Any dead endangered mussels should be reported to this office immediately, and to the Special Agent, U.S. Fish and Wildlife Service, P.O. Box 849, Louisville, Kentucky 40201, telephone 502/582-5989. Instructions for handling and disposal will be provided by this office.

F. Conservation Recommendations

Because the river reach below Kentucky Dam has been designated by the State of Kentucky as a sanctuary to protect one of the last remaining areas in the Tennessee River Basin containing reproducing populations of the pre-impoundment mussel fauna, the Fish and Wildlife Service believes that this area warrants an extremely high level of protection from any adverse impacts. Although (1) the proposed project will result in destruction of only a small portion of the mussel bed along the right descending bank, (2) no endangered species were collected in the project impact area, and (3) the Corps of Engineers has agreed to remove mussels and create mussel habitat downriver, there is no guarantee of successful relocation of mussels or colonization of the newly created habitat. Also, the Corps is considering the construction of a training dike that could have significant adverse impacts on the bed. Furthermore, potential Indiana bat summer habitat will be impacted by project activities. Therefore, in accordance with Section 7(a)(1) of the Endangered Species Act, we recommend that the following measures be implemented to promote the conservation of the Indiana bat and the eight endangered mussels considered in this biological opinion.

The Corps should determine if the riparian/bottomland forest and associated mature upland forest are used as summer habitat by Indiana bats. Mist netting should be conducted between June 1 and August 1 along Russell Creek. If the species is present and if the proposed disposal area is used to create a wetland, the Corps should monitor the area to determine if and to what degree the bats utilize the artificially-created wetland.

To date, there is a general lack of information regarding the success of mussel transplants and relocations, particularly concerning whether or not transplanted mussels survive and reproduce. Several transplant studies conducted by TVA and Virginia Polytechnic Institute have reported positive results, but both also reported relatively high levels of mortality at some transplant sites, and neither provided conclusive evidence that mussel transplants do not adversely affect the individuals or the populations. In addition, only limited information regarding colonization of newly created mussel habitat is available. To determine success of transplants and of creating suitable mussel habitat apparently requires long-term monitoring, which most agencies are unable or unwilling to do. If relocated mussels exhibit low survival and inadequate recruitment, or if mussels do not colonize artificially created habitat, then both activities may actually result in adverse impacts to endangered species, not the intended avoidance of adverse impacts.

If the mussels removed from the proposed dredge cut will be moved only a short distance downriver to a different part of the same mussel bed within a short time of their removal, we believe that, if proper methods of removal and transport are employed, there is little potential for stress or other adverse impacts. Unless they were placed in an area that was not inhabited by other mussels, it would not be possible to identify relocated mussels in the bed for any length of time, and monitoring of relocated mussels would not be possible. However, there is an opportunity to gain valuable information with regard to relocation if the mussels were placed in a suitable area outside of the existing bed. Information could also be gained concerning colonization of artificially created mussel habitat. The Service therefore recommends that, if the Corps decides to move the mussels to an area away from the existing bed, they implement a long-term monitoring program to determine if suitable mussel habitat can be successfully created and if successful relocation of portions of an existing mussel community is possible. The dredge disposal area at river mile 19.7, and the relocation site (if appropriate), should be monitored to determine if mussels colonize the area, and if they do, the densities achieved, species composition, survival rates, and evidence of reproduction and/or recruitment. Results should be made available to the Service and other agencies/universities in the form of informal reports or published articles. In order to make the above determinations, both the relocation site and the created habitat should be monitored for a period of not less than ten years.

In addition to the proposed lock construction project, the Corps of Engineers conducts and issues permits for many activities that have significant impacts on aquatic communities and habitats. Cumulatively, these actions, along with actions conducted and permitted by other agencies, have contributed to the present endangered status of a number of species. However, we believe that the Corps has the means to play a leading role in the protection and recovery of endangered aquatic species. The Service recommends that the Corps conduct, or cooperate in, long-term studies to determine the effects of transplants and relocations on mussels, and to determine the success of artificially creating mussel habitat.

Seven of the species addressed in this biological opinion are extremely rare, and no evidence of recent reproduction has been reported for two others throughout their ranges. The eighth species may already be extinct. None of these endangered species are likely to recover naturally in the foreseeable future, if at all. The only potential for recovery of these and other endangered mussel species may lie in the development of technology to artificially propagate juveniles and introduce them into suitable habitats within their historic ranges. Several attempts at artificial propagation have been made, with limited success. Since the Corps has existing research facilities (e.g., Waterways Experiment Station), the Fish and Wildlife Service recommends that the Corps actively pursue, or cooperate with other resource agencies in, development of technology for the artificial propagation of freshwater mussels, introduction of propagated individuals into suitable habitats, and monitoring of introduced individuals. Non-endangered mussels should be used until successful propagation and introduction techniques are developed. Information gained from monitoring created habitat and artificial propagation efforts would significantly promote the recovery of the species addressed in this opinion and other endangered mussel species, and may contribute to recovery of candidate species, eliminating the need to protect them through listing under the Endangered Species Act.

This concludes formal Section 7 consultation for the proposed Kentucky Navigation Lock Project. Reinitiation of consultation will be required if (1) the amount or extent of incidental take specified in this biological opinion is exceeded, (2) new information reveals that the proposed project may affect listed species in a manner not previously considered, (3) the identified action is subsequently modified in a manner or to an extent that was not considered during this consultation, or (4) new species are listed or critical habitat designated that may be affected by the project. In addition, consultation should be reinitiated if and when final plans for the training dike and/or results of a new assessment addressing impacts to listed species are available. The Fish and Wildlife Service will review the additional information and, if necessary, issue either a separate biological opinion or a supplement to this opinion.

Thank you for the opportunity to comment on this project. Your concern for the protection of endangered, threatened, and candidate species is greatly appreciated.

Sincerely,

Lee A. Barclay Ph.D.
Field Supervisor

xc:
Director, FWS, Washington, D.C.
Assistant Regional Director, FWE, FWS, Atlanta, GA
(Attn: Augie Valido)

APPENDIX D

ENVIRONMENTAL COMPONENT PLAN

1.00 Introduction.

The environmental component plan specifies the environmental features and commitments designed into the Kentucky Lock Addition and how they will be implemented. The environmental component plan is intended to provide a ready and concise reference concerning environmental commitments and mitigation arrived at through the NEPA process. The features of the plan will be applied at various stages of project construction. The plan specifies how materials generated from construction of the lock (rock, dredged gravel and sand, etc.) will be utilized for environmentally beneficial purposes. Best management practices (BMP's) would be applied to control runoff from areas impacted by construction. Introduction of water and air pollutants would be controlled by implementation of appropriate practices on the construction site. Any hazardous wastes generated on site or brought into the area would be handled or treated to prevent their entry into the environment.

2.00 Specific Features.

Borrow and Disposal

Borrow and disposal areas are normally an inherent requirement of large construction projects such as the Kentucky Lock addition. Preliminary plans for this project thus far have identified a single 45 acre borrow and disposal site in an upland area, about one mile north of Kentucky Lock and Dam, adjacent to Kentucky 453, in Livingston County. After a reconnaissance of a number of candidate sites, this site was selected because it would cause the least possible environmental damage while fully meeting project needs for borrow and disposal. The site is highly disturbed due to earlier activities carried out during nearby quarrying operations.

Specific restoration plans for the borrow and disposal area will be based on the extent of borrow or disposal expected, ultimate shaping or grading of the site, and its intended post construction use. Construction access and use limitations will also be required. Strict measures will be placed on the construction activity to insure adjacent wooded and wetland areas are protected. Monitoring of construction will be necessary to make adjustments to the plans as unforseen situations occur. The following checklist will be used in preparing and implementing plans for borrow and disposal sites:

a. Access roads to borrow and disposal areas would be located to cause the least amount of damage to existing environmental features as possible. At the completion of the project, access roads and associated features (culverts, fill materials) would be removed. Areas affected by roads would restored to original contours and revegetated with woody or herbaceous vegetation beneficial to wildlife.

b. Subsurface soil characteristics and hydrology would be determined in borrow and disposal areas. This data would be used to determine appropriate buffer zones to prevent changes in soil moisture content that could lead to changes in adjacent wetlands or wooded sites.

c. Borrow and disposal areas would be restored as soon as possible and in accordance with a specific plan for each site utilized.

d. Future maintenance and management requirements will be included and clearly stated in restoration plans.

Riparian Habitat Restoration and Bank Protection

Construction of the downstream navigation access channel will require removal of existing right bank riprap protection and a small portion of the riparian zone just downstream of the mouth of Russell Creek. The right bank of the Tennessee River between the mouth of Russell Creek and I-24 is badly eroding, resulting in a steady loss of remaining riparian woody vegetation in this approximately 3000' linear reach.

To prevent future erosion of the right bank between the lower end of the downstream guidewall and the I-24 bridge, riprap would be placed from top of slope to toe of slope, effectively armoring this bank. Some of the existing riprap on the right bank would be salvaged and reused on the newly excavated bank. In addition the remainder of the bank protection downstream of Russell Creek would be accomplished using rock excavated from the lock pit. This measure would reduce the total requirement for disposal. Rock would be placed in a manner not to bury any of the densely populated mussel bed known to exist in proximity to the right bank downstream of Russell Creek. Armoring of the bank would effectively protect the remaining strip of woody vegetation now being lost through erosion. These techniques have been used within the last five years on the nearby Cumberland River below Barkley Dam to protect steep, critically eroding banks, and have performed well with no evidence of failure.

The left bank downstream of the existing launching ramp is also a candidate for armoring with rock from the lock. This bank is also eroding and could be stabilized with placement of rock.

The approximately 3000 linear feet of riparian zone between Russell Creek and I- 24 would be augmented with plantings of woody plants typical of riparian forests in the area. The width of the riparian zone would be 50-100 feet. The total acreage involved in the restoration effort would be 3.5 to 7 acres. Plantings would be designed to include species favored by wildlife. The riparian restoration effort will include combinations of sizes of plants from balled, branched, and burlapped trees to container and bare root material. Seeds and bioengineering techniques may be included in the ultimate restoration plan. An annual maintenance-management plan will be prepared to guide management activities and insure long-term success in the restoration of this riparian zone.

Aquatic Habitat Creation

Approximately 59,400 cubic yards of clean gravel and sand will be dredged from the river bottom between the dam and I-24 in order to provide a suitable lower approach. This material will be utilized in a beneficial manner to create replacement aquatic habitat. Prior to dredging, the site will be thoroughly searched for federally endangered mussels. Any that are found will be removed to a safe location in the lower Tennessee River. The remaining mussels will be removed from the dredge cut, probably through use of a hydraulic dredge skimming off the top foot of river bottom. This material containing live mussels will be deposited at a suitable site in the lower Tennessee River not presently supporting large populations of mussels (possibly a maintenance dredging disposal site).

The remainder of the material will be removed and taken downriver to an aquatic disposal site located adjacent the right bank at TRM 19.7. Substrate at this site is generally fine grained with much debris and relatively few mussels. Dredged materials would be deposited at this site and shaped to blend into existing upstream and downstream gravel habitat known to support populations of mussels.

Placement of gravelly dredged materials over fine grained sediments at other locations in the Tennessee River has been documented to provide or improve mussel habitat. It is anticipated that the aquatic habitat created by dredged material disposal at TRM 19.7 will be colonized by mussels in a few years. This habitat will be monitored on a long-term basis (ten years) to determine colonization rates for the site.

If feasible, some rock will be used to improve fish habitat in the tailwater by placing it along the left bank to form short jetties, or in the river to improve habitat diversity. Placement of rock to improve habitat will be governed by its affect on existing resources (i.e. mussels), availability of suitable size material, and other engineering considerations.

Artificial Mussel Propagation

Healthy stocks of mussels occur in the lower Tennessee River, however not all species are doing well. Mussel species being listed as federally endangered or threatened include some species found in the lower Tennessee. Recovery of a mussel species is a slow and uncertain task in the environment. Artificial propagation of freshwater mussels offers hope of providing a viable means of producing seed stocks which can be placed in the environment in hopes of eventually providing new, reproducing populations. The Kentucky Lock Addition offers an opportunity to channel resources into mussel propagation, which if successful, could transfer benefits to other Corps projects where mussel resources and endangered shellfish are a concern. Tennessee Valley Authority has an active mussel propagation program underway. A wise use of monetary resources would be to support TVA in these efforts. This would also be a reasonable offshoot of the Corps-TVA cooperation observed so far on the Kentucky Lock Addition.

Fish Migration and Spawning

Riverine spawning fish species such as sauger and paddlefish are economically important to the region. Paddlefish are extensively harvested, especially for their eggs, which are processed into caviar. Sauger is a highly sought-after game fish valued for its excellent flavor.

During winter months, sauger fishing constitutes the major angling activity below most of the dams on the mainstem Tennessee and Cumberland Rivers. At this time of the year, sauger have migrated upstream prior to spawning and are concentrated in tailwaters below dams.

Previous studies have demonstrated this strong upstream migratory nature of sauger (Cobb, 1960). Recent studies on the upper Tennessee River have revealed that sauger populations are not isolated to a particular reservoir (Hevel and Scott, 1991).

Sauger frequently migrate through navigation locks from one reservoir to another, passing in both upstream and downstream directions. For this reason, the concept of distinct reservoir populations functioning independently of each other is being dismissed in realization that sauger constitue a river population utilizing several reservoirs, with travel among these reservoirs common.

Certain locks and dams on the Tennessee River appear to favor this inter-reservoir movement, while others do not (Hevel and Scott, 1991). Sauger concentrating below Kentucky Dam pass through Kentucky Lock and migrate up both the Tennessee and Cumberland Rivers contributing to fisheries in several reservoirs of both rivers.

An important fisheries concern in the area of Kentucky Dam is possible effects on the sauger population. Though not determined, it is likely that actual spawning grounds for sauger congregating in the tailwater are well downstream of areas affected by construction. However, since sauger frequently pass through Kentucky Dam (Cobb, 1960), fisheries impacts could occur at several locations on the Tennessee and Cumberland Rivers if passage were to become restricted by construction and operation of a new lock at Kentucky Dam. Although the existing lock at the dam would still be operational, it is expected that most lockages would occur through the new lock. Therefore it is important that the new lock be designed to facilitate passage of sauger.

Specifically, the location and design of discharge ports are important (Hevel and Scott, 1991). In general, lock discharges that allow sauger to swim directly into the lock chamber, without having to swim down through a complex grid of openings, appear to favor upstream passage. From an operational perspective, it may be desirable to provide slight flows through the lock discharge when water level in the lock chamber is at the tailwater elevation to encourate sauger entry via the discharge into the chamber.

Studies are planned by TVA to be conducted at Watts Bar Lock to develop design and operational criteria to provide for sauger passage. Criteria resulting from these studies would be incorporated into design and operation of a new lock at Kentucky. If necessary, criteria development would be accelerated to meet schedules for preparation of design memoranda for Kentucky Lock, or it may be desired to conduct these studies at Kentucky Lock.

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Hevel, K. W. and E. M. Scott. 1991. A brief history of dam passage by sauger (Stizostedion canadense) through Tennessee River mainstream lock and dams and its ramifications. Tennessee Valley Authority, River Basin Operations, Water Resources. 13 pp.

Boat Launching Facilities

Plans for the additional lock at Kentucky will permanently eliminate the existing boat launching ramp in the tailwater on the right bank at the mouth of Russell Creek. The proximity of the new lock and the high traffic usage in the lock's lower approach near the right bank preclude relocation of a ramp in the immediate right bank tailwater area. Loss of this ramp will be mitigated by a significant upgrading of the existing, heavily used left bank boat ramp. The existing launching area on the left bank is in poor condition and needs upgrading. Therefore, it is proposed to improve this area by widening and resurfacing the ramp and expanding and improving the parking area as mitigation for loss of the right bank ramp. This option has been coordinated and accepted by both TVA and the Commonwealth of Kentucky.

Bank Fishing Facilities

Bank fishing is always very popular in tailwater areas because of the high concentration and diversity of fishing opportunity throughout much of the year. Convenient vehicular access is provided to both banks in the Kentucky Dam tailwaters. Existing improvements for tailwater fishing include a pier and some steps down riprapped banks. Although these serve anglers needs to some extent, experience in such areas over the years has resulted in better designs that could be incorporated into this project. These designs are for the most part safer and more effectively meet the needs of anglers and sightseers in the tailwaters. Analysis of the current and estimated future quantity and types of activity will provide the basis for the amount and type of improvements. Interviews and observations on site will be made to determine optimum elevations and locations for replacement and/or modification to the existing bank fishing accommodations. Rock excavated from the new lock will be used whenever possible to improve the tailwater fish habitat on the left descending bank.

Other Recreational/Visitor Facilities and Landscaping

Adding the new navigation lock at Kentucky will disrupt other existing public use facilities such as the tailwater picnic area, popular viewing areas at the existing lock, and other features. These impacts will require preparation of a comprehensive new site plan for the entire Kentucky Reservation. The majority of the changes will be on the lock side, however, the railroad relocation will also influence activities and facilities on the left descending bank (removal of a restroom building and parking lot).

A small campground called Taylor Park and a fishing pier are located on the right bank just upstream of the existing lock. Although only portions of these facilities will be directly impacted by the new lock construction, their use would no longer be desirable. The current proposal is to replace these facilities. The existing improvements will be converted, where possible, to serve sightseers and possibly some picnicking also associated with sightseeing.

A landscaping plan will be developed that sets forth objectives in restoration of construction areas and final landscape treatments will be part of the revised site plan. Additional detailed planting plans will be prepared for specific areas such as parking lots, visitors center, the lock structure and entrance, and circulation roads. Throughout the evaluation of an overall site plan, every opportunity for visitor interpretation and information will be explored and included in the plan as appropriate. Provisions will be made to protect and interpret prehistoric or historic features in or around the site.

APPENDIX E

PHASE 1 PRELIMINARY HTRW ASSESSMENT

KENTUCKY LOCK ADDITION

LIVINGSTON AND MARSHALL COUNTIES, KENTUCKY

U.S. Army Corps of Engineers

Nashville District

Nashville, Tennessee

November 1991

Kentucky Lock
Phase 1 Preliminary HTRW Assessment Outline

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1. BACKGROUND INFORMATION

Tennessee/Cumberland River System

1.01 The Tennessee River, with 650 miles of navigable waterway, and the Cumberland River, with over 380 miles of navigable waterway, are the largest tributaries of the Ohio River. The 1967 construction of Barkley Canal connected the Tennessee and Cumberland Rivers, creating the Kentucky-Barkley Navigation System. This system is comprised of Barkley Canal, Kentucky Lock and the lower Tennessee River, Barkley Lock and the lower Cumberland River, and a short section of the Ohio River. The system is bounded on the Ohio River by Smithland's twin 1200-foot locks and the authorized twin 1200-foot locks at Olmsted. To traverse the Kentucky-Barkley system, tows must squeeze through the 600-foot lock at Kentucky or 800-foot lock at Barkley.

1.02 The Kentucky-Barkley system gives shippers direct access to the Ohio River and the Tennessee-Tombigbee Waterway. These waterways link the system with markets in Mid-America, the Gulf Coast, and the lower Mississippi River Valley. As one of the major intersections on the inland waterway, the system serves commerce from 20 states. Primary commodities include coal (representing almost half the traffic), aggregates, grain, chemicals, iron and steel, ores and minerals, and petroleum products.

Commercial River Traffic

1.03 Over the five year period of 1985-1989, an average of 33.5 million tons of cargo traversed the Kentucky-Barkley system. During this period, almost 90 percent of the traffic used Kentucky Lock, due in part to the more restrictive alignment of the Cumberland River below Barkley Dam. This high use of Kentucky Lock causes significant congestion and delay to shippers using the Tennessee-Cumberland system. Between 1985 and 1989, over 80 percent of all tows using Kentucky Lock experienced delays that averaged 3-1/2 hours per tow. This delay time adds to an already excessive processing time (most tows are large enough to require double lockages), and results in an average transit time of about 5-1/4 hours - one of the highest in the Ohio River system.

1.04 Commercial traffic on the Kentucky-Barkley system is projected to grow at the same rate as the Ohio River system. By the year 2005, the traffic demand for Kentucky-Barkley is projected to reach 53.0 million tons of cargo, extending lock delays even more.

2. FEASIBILITY STUDY

Authority of Study

2.01 An October 2, 1972 resolution, adopted by the U.S. Senate Committee on Public Works, requested the Corps of Engineers investigate the advisability of navigation improvements on the Cumberland and Tennessee Rivers, generally below the connecting Barkley Canal. The current feasibility study responds to the 1972 resolution and is an interim or partial response to another resolution adopted on September 9, 1982 by the U.S. Senate Committee on the Environment and Public Works. This resolution requested the Corps of Engineers evaluate the entire Tennessee River with a view to determining whether any modifications to improve navigation are advisable.

2.02 Major objectives of the feasibility study were threefold: (1) to reduce transportation costs to the nation; (2) to provide safe and dependable commercial navigation throughout the study period (2005-2054); and (3) to conserve fish, wildlife and other natural resources in the Tennessee and Cumberland Rivers. The concerns and interests of the navigation industry, environmental and conservation interests, and the general public were sought and considered throughout the study.

Study Recommendations

2.03 The study alternatives included six locations for a new lock at the Kentucky Project, a plan to modify bendways on the lower Cumberland River, and three canal schemes to connect the lower Cumberland and Tennessee Rivers. Only adding a new lock at Kentucky Dam proved to be economically viable and met the objectives of the feasibility study.

3. PURPOSE AND SCOPE OF THIS ASSESSMENT

Proposed Plan

3.01 The proposed plan used as a basis for this report is to add a 1200-foot lock to the Kentucky Project. The new lock will be constructed along the right descending bank adjacent to the existing lock. Construction of the new lock will require relocation of the Paducah and Louisville Railroad, as well as several access roads in the adjacent area. In addition, an existing campground and boat ramp on the right descending bank will be impacted by the new lock to such an extent, that they will be relocated.

Purpose and Scope

3.02 The purpose of this preliminary assessment is to determine the likelihood of encountering Hazardous, Toxic and Radiologic Wastes (HTRW), in the course of constructing the new lock and associated improvements at Kentucky Dam.

3.03 This assessment is based primarily on the information contained in existing documents, telephone and on-site interviews, and on-site observations.

HTRW Defined

3.04 For purposes of this report, HTRW is defined to include: any hazardous substance regulated under the Comprehensive Environmental, Compensation and Liability Act, 42 U.S.C. 9601 et seq, as amended. Hazardous substances regulated under CERCLA include "hazardous wastes" under the Resource Conservation and Recovery Act, "hazardous substances" identified under Section 311, of the Clean Air Act, 33 U.S.C. Section 1321, "toxic pollutants" designated under Section 307 of the Clean Water Act, 33 U.S.C. Section 1317, hazardous air pollutants designated under Section 112 of the Clean Air Act, 42 U.S.C. Section 7412, and eminently hazardous chemical substances or mixtures that EPA has taken action on under Section 7 of the Toxic Substance Control Act, 15 U.S.C. Section 2606, but does not include petroleum, unless already included in the above categories, or natural gas.

Corps Policy on HTRW

3.05 Construction of Civil Works projects in HTRW contaminated areas should be avoided where practicable. This can be accomplished by early identification of potential problems in reconnaissance, feasibility, and PED phases. Where HTRW contaminated areas cannot be avoided, response shall be acceptable to U.S. Environmental Protection Agency (EPA) and the State regulatory agencies. For Federal projects without non-Federal cost sharing, where Federal funds are spent for response actions, the costs will be a project cost.

3.06 The plan for and execution of each Civil Works project will routinely include a phased and documented review to provide for early identification of HTRW potential at Civil Works project sites.

4. PROJECT ENVIRONMENTAL SETTING

Stream and Topographic Features

4.01 The drainage area above Kentucky Dam, 40,200 square miles, comprises about 98 percent of the total drainage area of the Tennessee Valley watershed. The reservoir is situated in Livingston, Marshall, Lyon, Calloway, and Trigg Counties in Kentucky and in Humphreys, Benton, Decatur, Hardin, Wayne, Henry, Henderson, Perry, Stewart, Houston, and Carroll Counties in Tennessee.

4.02 The headwaters of the Tennessee River are in eastern Tennessee, western Virginia, North Carolina and northern Georgia. The main river begins just above Knoxville, Tennessee, at the confluence of the Holston and French Broad Rivers. It flows in a southwesterly direction through Tennessee, crosses into northern Alabama, forms a small portion of the northeastern boundary of Mississippi, and then flows north through western Tennessee and western Kentucky to empty into the Ohio River at Paducah, Kentucky, a distance of about 650 miles. The Tennessee River drains an area of 40,910 square miles-about equal to the area of Ohio, or to 4/5 the area of England. The headwaters are in the Smokey Mountains and the Blue Ridge Mountains. The mountain region is in striking contrast to the flat lands of northern Alabama and the rolling hills of western Kentucky.

4.03 Between the headwaters in the upper Valley and the outlet of the Tennessee River into the Ohio, the water falls from an elevation of more than 3,000 feet to about 300 feet.

4.04 In the vicinity of the Kentucky Dam site, the Tennessee River cuts through a 1-1/2 mile wide flood plain in a northwesterly direction. Paralleling the river on the east is a ridge rising to about elevation 500, some 200 feet above the flood plain, which forms the divide between the Tennessee and Cumberland Valleys. To the west of the river the gently rolling terrain rarely exceeds elevation 500.

Geology

4.05 The foundation bedrock at the Kentucky Dam site is made up of a dense, dark grey, cherty Fort Payne limestone covered by thick river alluvium-maximum thickness of about 115 feet-found along the left flood plain. Overlying the Fort Payne limestone is a blanket of yellow residual clay and chert, and generally 40 to 50 feet of course, clean chert gravel or sand and chert gravel derived from the Mississippian limestone formations. Immediately above the gravel is 30 to 40 feet of fine, clean, brown and grey sand. In both the sand and gravel are many lenses of sandy blue clay. In the limestone many chert-filled solution channels were found.

4.06 The bedrock has been subjected to much weathering at joints and bedding planes. In the channels, which occur along the joints, weathering has progressed to depths of 2 feet to more than 300 feet; and along the bedding planes the penetration is as great as a mile or more down the dip of the strata from the outcrop.

Hydrology

4.07 Rainfall in the region averages about 51 inches per year and is fairly well distributed throughout the year. The average annual runoff above the Kentucky Dam site, based upon discharges from 1889 to the present is approximately 22 inches, or about 1.62 cubic feet per second per square mile of drainage area.

Land Use/Vegetation

4.08 Land use and associated vegetative cover of the project region is primarily rowcrop agriculture, interspersed with wooded areas and fence rows. Steeper slopes and ridges are generally wooded with second growth forest, principally oak-hickory. The Kentucky Dam Reservation is characterized by mixed upland woodlands, characterized by various oaks and hickories; lower lying alluvial areas supporting red maple, sweetgum, river birch, baldcypress, etc. The remainder of the Reservation is consists of mowed areas, leased agricultural lands, landscaped areas and developed areas.

4.09 The exception to the described land use and associated cover is the large aggregate mining operation (Reed Crushed Stone) adjacent to the reservation's northern boundary. Most of this adjacent area is an open pit limestone gravel mine, with associated storage and loading operations. With the exception of some buffer areas along the actual reservation boundary, most of this area is devoid of any landscape cover.

5. STUDY SITE

Site Limits

5.01 For purposes of this Phase 1 Preliminary HTRW Assessment Study, the site considered includes the Kentucky Dam Reservation and the adjacent borrow/disposal site on Reed Crushed Stone property, all as depicted in Figure 1.

Current Usage

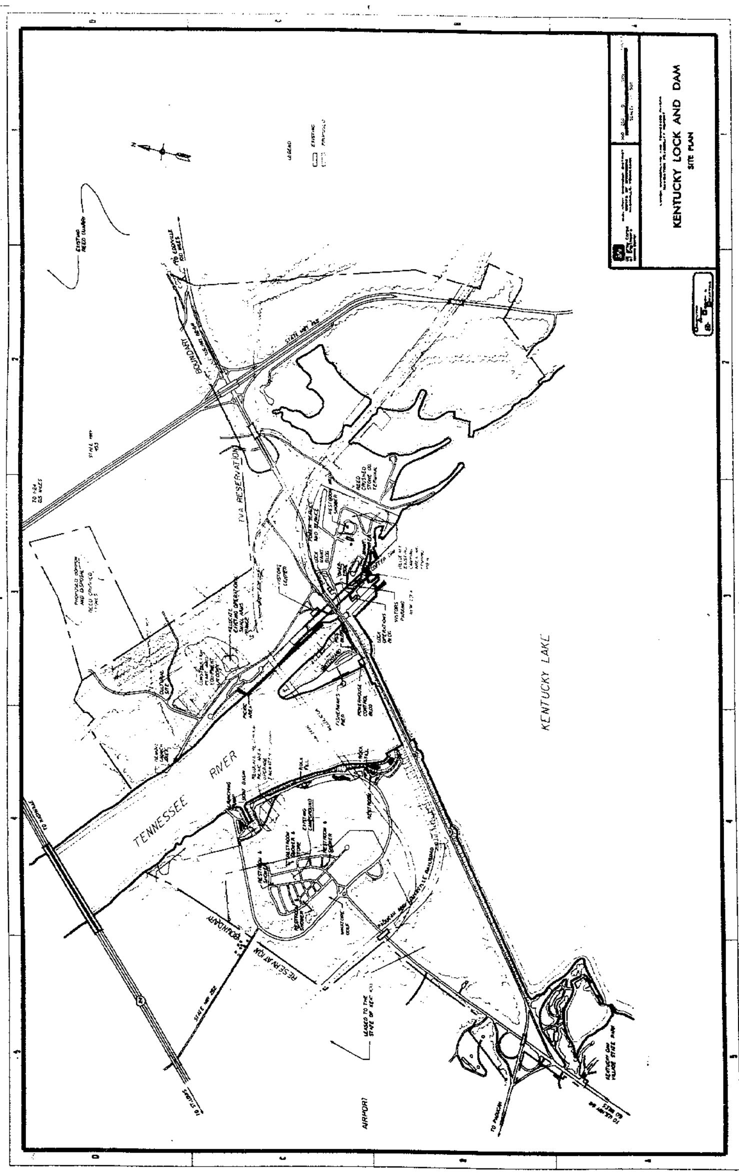
5.02 Current site usage is generally indicated in Figure 1. For purposes of this discussion and a more specific overview of usage, we have divided the site into four quadrants, divided by the river/reservoir and Kentucky Dam/Highway 62.

5.03 The northeast quadrant contains the existing lock, and adjacent lock operations building. Visitors parking, as well as a public overlook are located nearby. A small lock maintenance building is situated in the same area, adjacent to the railroad and Highway 62. TVA has developed two maintenance facilities east of the visitors area, accessible by a road which departs from the main lock area entrance road. Further along this maintenance road to the east, TVA maintains a public campground with approximately 48 campsites, a washhouse and fishing pier. Most of the land surrounding the embayment east of the campground is leased to Reed Crushed Stone for use as a barge and rail shipping terminal for their aggregate operation. A spur line of the Paducah and Louisville Railroad bisects this quadrant to give access to the Reed Terminal and beyond to the community of Grand Rivers.

5.04 The northwest quadrant contains a small peninsula emanating from the dam which contains the powerhouse and associated switchyard. This peninsula also provides visitor parking for the powerhouse, bank fishing, and a tailwater fishing platform. The main land mass in this quadrant is primarily undeveloped and is composed of open fields and woodlands. Exceptions to this are a primitive picnic area and boat ramp which exist along the right descending bank, a TVA firing range which is located near the picnic area, and a historic cemetery (Walker Cemetery) atop a nearby ridge. It should also be pointed out that a documented cultural resource known as the Sanders Site exists in this quadrant near Russell Creek. The designated borrow/disposal site, presently owned by Reed Crushed Stone Co., adjoins the northern boundary of this quadrant. According to Reed representatives, this site's only current use is as a ponding/settling area for a portion of the stormwater runoff from their quarry operation.

5.05 Existing development within the southwest quadrant is primarily recreation oriented. TVA maintains a tailwater fishing area along the left descending bank, with associated visitors parking and comfort station. Downstream, a launch ramp and parking area is leased to, and maintained by, the Commonwealth of Kentucky Department of Transportation. The remainder of the quadrant is leased to the Commonwealth of Kentucky Department of Parks, which maintains a large campground in the area. Other uses include a small sewage treatment plant located near the campground and a water treatment plant south of the campground. The Paducah and Louisville Railroad main line bisects this quadrant.

5.06 The final quadrant (southeast), shows a small land area leased to the Commonwealth of Kentucky Department of Parks. This parcel is currently used as a day-use/beach area within Kentucky Dam Village State Park.


KENTUCKY LOCK AND DAM
SITE PLAN
TENNESSEE RIVER
KENTUCKY LAKE
TVA RESERVATION
AIRPORT

6. SITE HISTORY

Pre Lock and Dam Construction

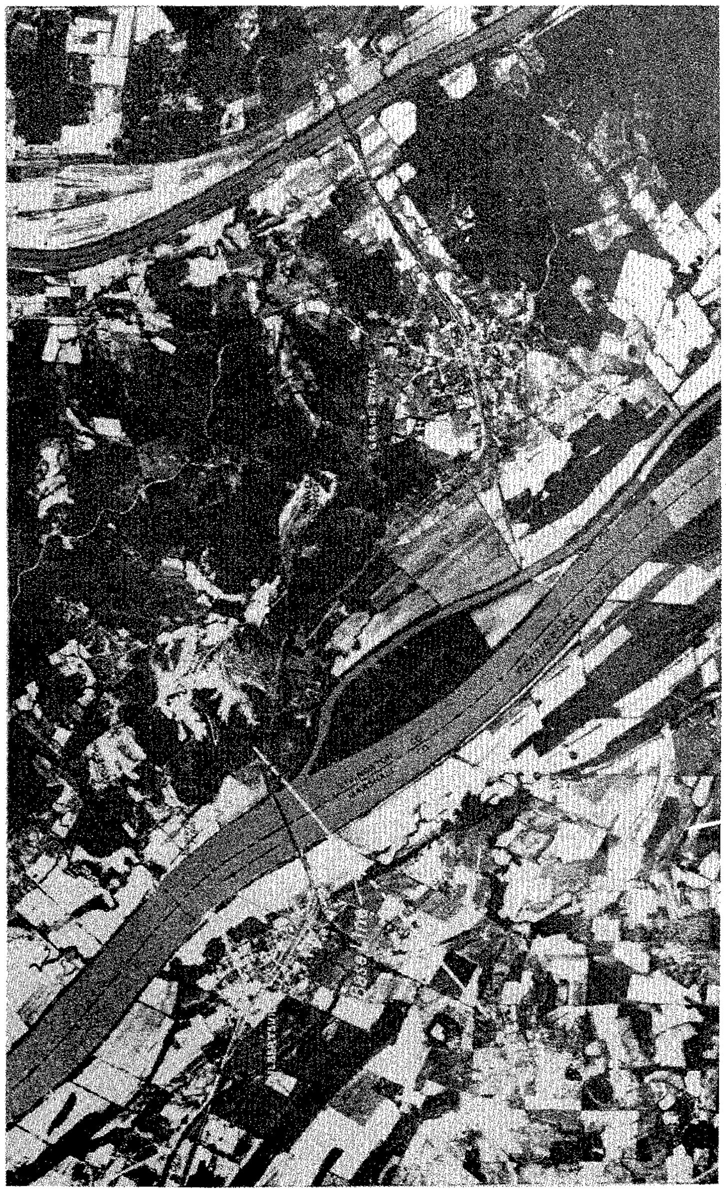
6.01 A great deal of the historic information contained in this report was obtained from the TVA document The Kentucky Project, Technical Report No. 13, originally published by the U.S. Government Printing Office in 1951.

6.02 The land within this assessment site - the lock and dam reservation - has been owned by TVA since the late 1930's. The obvious exception to this statement is the previously referenced borrow/disposal site, presently owned by Reed Crushed Stone Company.

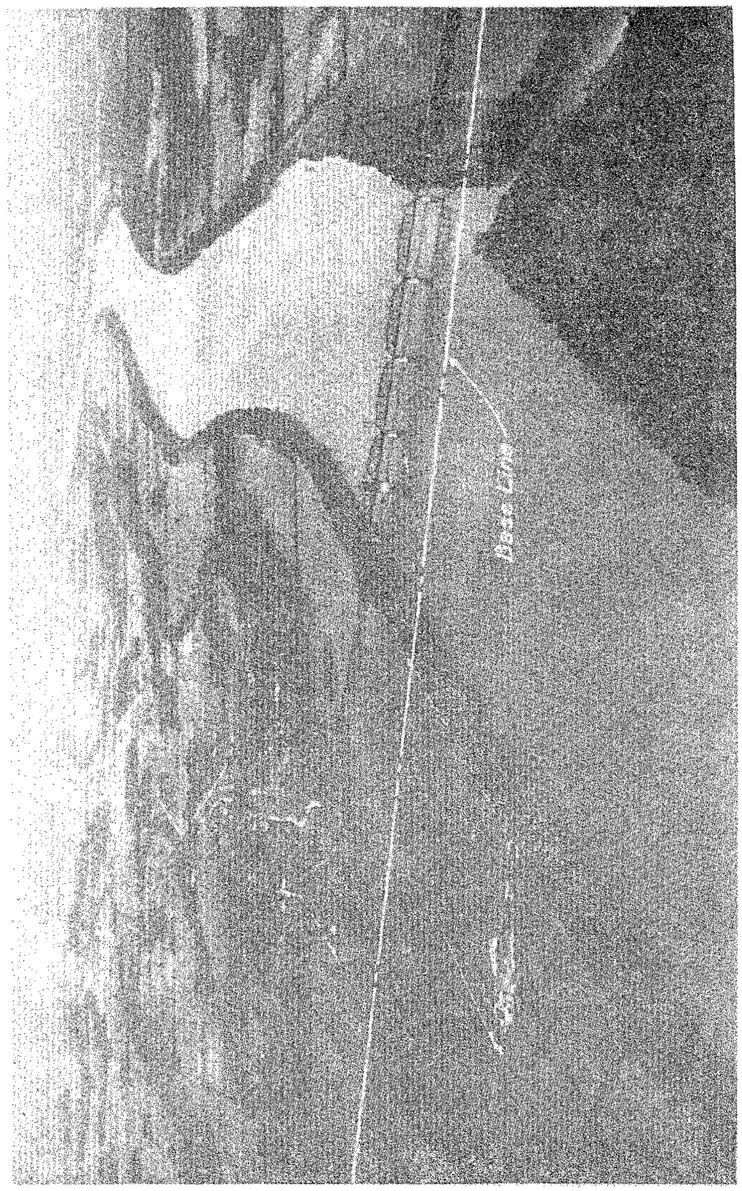
6.03 As illustrated by the aerial photos which pre-date construction of the dam (Figures 2 & 3), most land use in the area prior to construction of the lock and dam was related to either agricultural or forest production. Generally the flatter land south of the river was more agriculturally oriented, while the steeper topography north of the river contained more timberland. Apparently a smaller gravel operation existed even at this early date, on the north side of the river, in fact a spur rail line (gravel switch) is indicated on Figure 2, between the damsite and the community of Grand Rivers.

6.04 At that time, what is now the Paducah and Louisville Railroad crossed the Tennessee River downstream of the present damsite (where it now crosses).

6.05 The community of Gilbertsville at that time had a population of approximately 300, and was located on either side of the railroad south of the river. The Kentucky Dam Village campground presently occupies what was then the northern half of the town. As part of the construction of the Kentucky Project, the Town of Gilbertsville was relocated downstream to it's present location. This area was evacuated by the end of 1939, except for those families which remained as renters from TVA.



Kentucky Reservation Aerial Photo (Pre Lock & Dam)
FIGURE 2



Kentucky Lock & Dam Site Oblique Aerial Photo (Pre Lock & Dam)
FIGURE 3

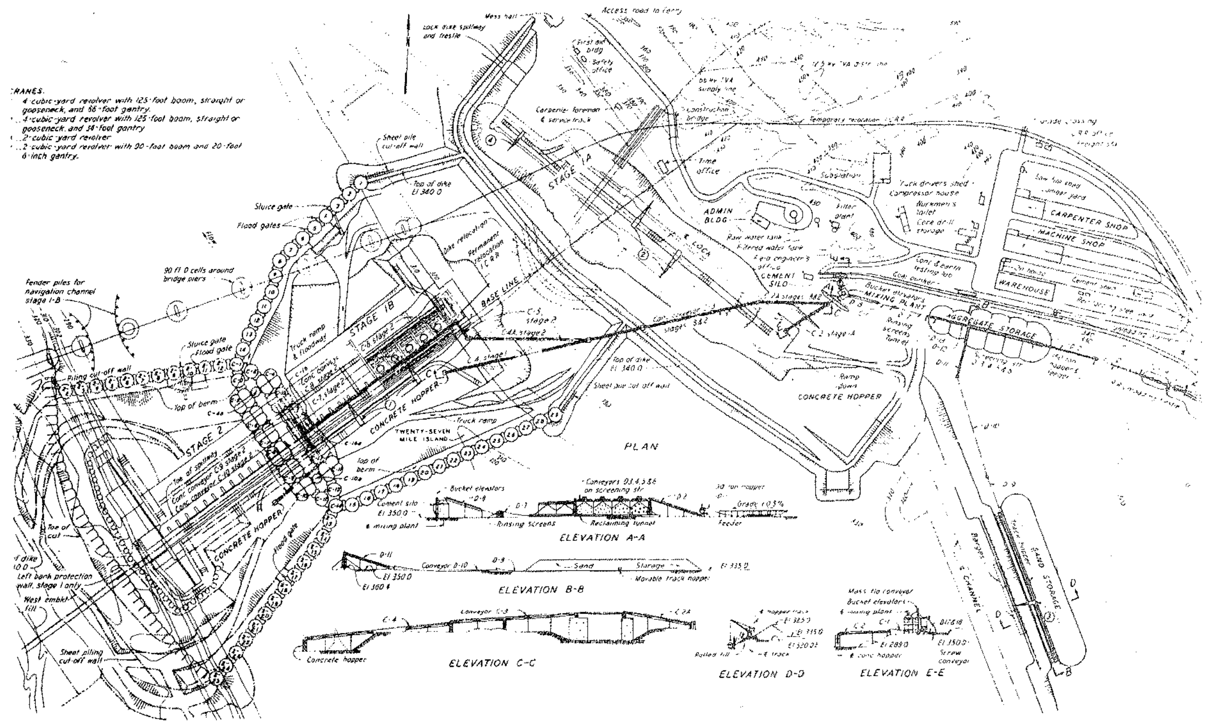
Kentucky Lock and Dam Construction

6.06 Funds for construction of the Kentucky Project were made available by the Independent Offices Appropriation Act for 1939, approved May 23, 1938; and preliminary construction was started July 1, 1938. Construction of Kentucky Dam was accomplished in 6 years, from July 1938 to reservoir impoundment in September 1944. The lock was opened for navigation on September 12, 1944; power operations started on September 14, 1944 and the last of the five generating units was placed in operation January 16, 1948.

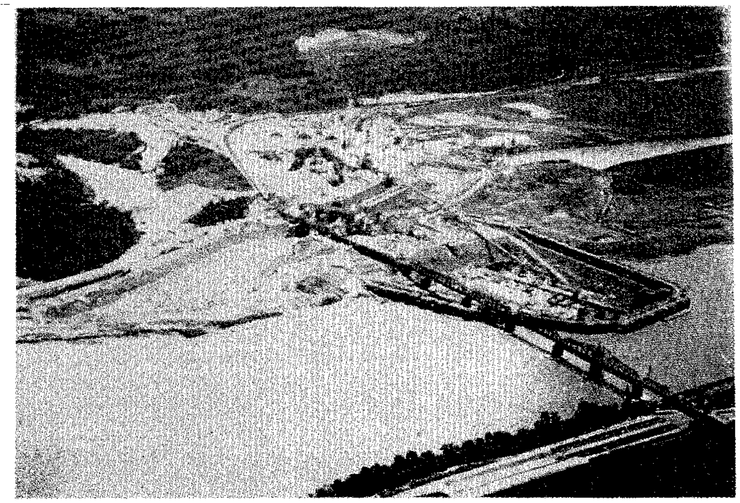
6.07 In preparation for construction of the Kentucky Project, 46 houses in the old town of Gilbertsville were purchased and rehabilitated by TVA; and a new construction camp and village was built approximately 1-1/2 miles upstream from the old town. This left bank construction village ultimately became the site of Kentucky Dam Village State Park, in fact some of the original buildings still exist in the park.

6.08 Where the left bank contained most of the housing and associated structures, the right bank included the actual construction plant for the lock and dam. A line drawing of the layout for this area is provided in Figure 4. An accompanying oblique aerial photo (Figure 5) shows the dam and lock area during construction. Aggregate for construction of the project was mined and processed at a TVA operated stone quarry some 7-1/2 miles upstream from the actual construction site. Sand was mined from the river in the vicinity of the dam site. Unfortunately, the referenced document: The Kentucky Project did not indicate the location of construction landfills or disposal sites.

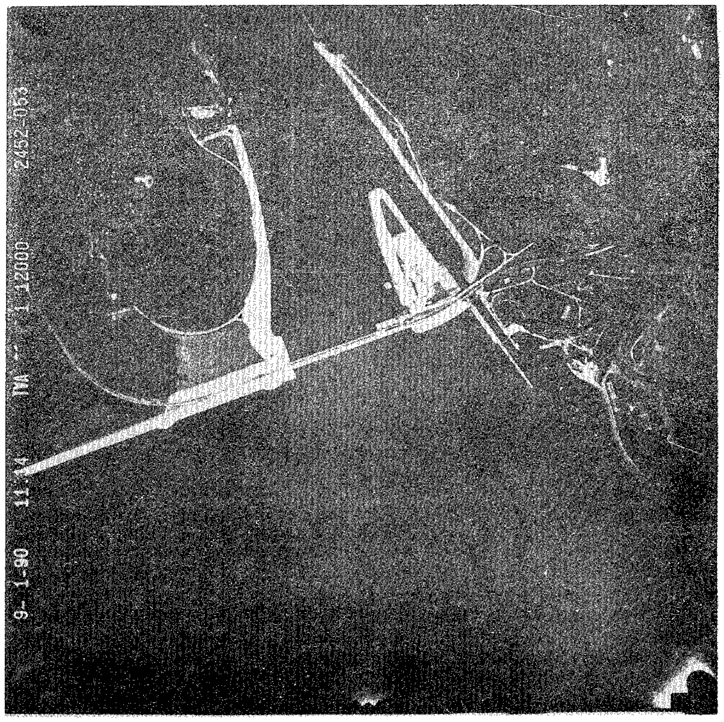
6.09 The aerial photo included as Figure 6, shows the lock and dam reservation as it appears today.



General Lay-out of Construction Plant (Kentucky Lock & Dam)
FIGURE 4



Aerial View of First Stage Cofferdam
FIGURE 5



Kentucky Reservation Aerial Photo (Sept. 1, 1990)
FIGURE 6

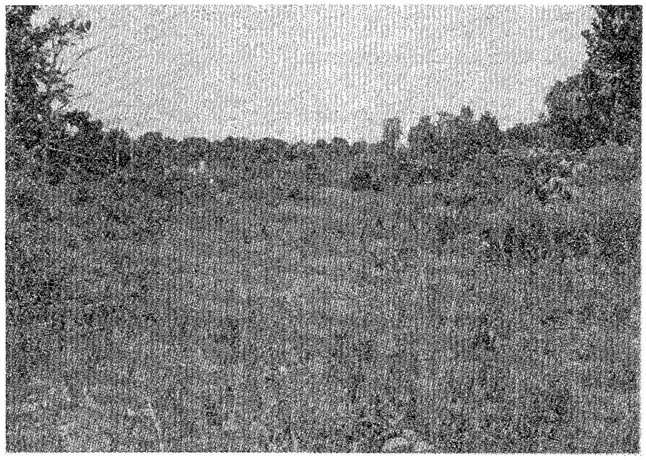
7. SITE INSPECTION

Kentucky Lock and Dam Reservation

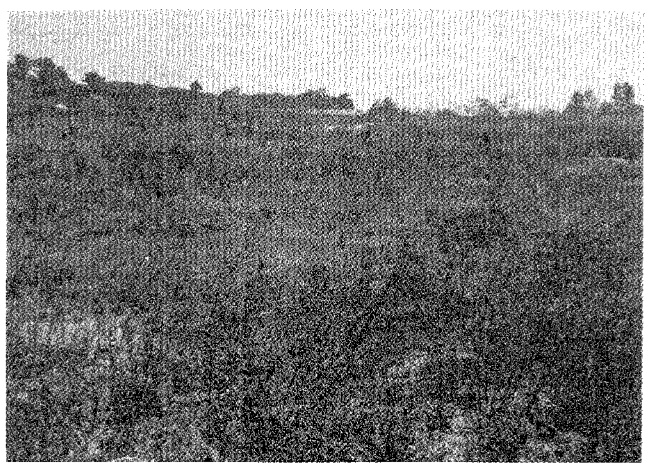
7.01 On October 15, 1990, Mr. Richard Tippit, Biologist with the Nashville District Environmental Resources Branch, conducted a visual site survey of areas on both banks of Tennessee River/Kentucky Lake which will be affected by the proposed project construction. The survey included a proposed borrow/disposal area on the right bank between I-24 and Russell Creek that has since been deleted from the project plans. The survey was conducted on foot in favorable weather. A close visual scrutiny was made, in each area to be impacted by construction, for indications of contamination. No evidence of contamination which could be revealed by this type of survey method was indicated.

Borrow/Disposal Site (Reed Crushed Stone Property)

7.02 The latest proposed borrow/disposal area is located on a 45-acre parcel of land presently owned by Reed Crushed Stone Company. The site is located about one mile north of Kentucky Lock and Dam, adjacent to Kentucky Highway 453, in Livingston County. On August 15, 1991, Mr. Richard Tippit, Mr. Paul Bluhm, Civil Engineer with the Nashville District Geotechnical Branch, and Mr. Jeffrey Major, Geologist with Reed Crushed Stone Company, met and conducted a walkover of the referenced site. Approximately half of the site nearest Kentucky Highway 453 has been cut to it's present grade and is essentially devoid of vegetation. Scattered small piles of gravel occur on this portion of the area. The remainder of the site consists of earth and rock fill placed by Reed Crushed Stone during overburden stripping operations that occurred during the 1950's. This filled portion supports mostly herbaceous vegetation. No evidence of contamination which could be revealed by this type of survey method was observed. Some debris was present on the site, which included abandoned construction equipment, two old tanker truck bodies, and roofing tin. No evidence of leakage or staining was observed in the vicinity of the tankers.



Borrow/Disposal Site (Reed Crushed Stone Property)
View from southern half of site, looking toward river.
Figure 7



Borrow/Disposal Site (Reed Crushed Stone Property)
View from southern half of site looking north.
Figure 8

8. INTERVIEWS AND DOCUMENTATION

Tennessee Valley Authority

8.01 As property owners for the Kentucky Project for the past 50+ years, we have looked to TVA for much of the background information relative to HTRW potential on this site.

8.02 One of the earliest inquiries in this regard was made by Mr. Richard Tippit of the Nashville District on December 5, 1990 to Mr. M. Paul Schmierbach, Manager of Environmental Quality for TVA. Mr. Schmierbach's response, dated February 19, 1991 is attached as Exhibit 1. Among the other items discussed in this letter, Mr. Schmierbach stated with regard to HTRW, "...we are not aware of any hazardous materials near the proposed lock from recent past activities or underground storage tanks. Old clay tile leading to a sanitary field system that is no longer being used may be encountered as well as some old wire cable from construction waste in a backfill location. Some small amounts of asbestos will be encountered in the Lock Operations Center. Test results of pipe and electrical wire insulation showed positive results for asbestos. Floor tile which has been carpeted over has not been tested, but is assumed to be asbestos."

8.03 The Nashville District also received a copy of TVA's Environmental Compliance Audit Report for Kentucky Lock and Dam, dated May 30, 1990. A copy of this report is included as Exhibit 2. The audit was conducted by the Environmental Quality Staff (EQS) to evaluate compliance with environmental regulatory requirements and TVA environmental policies and procedures. As indicated in the overall compliance statement, "No major environmental impacts were observed during the audit. However, several PCB and hazardous waste recordkeeping and documentation nonconformances were noted which could result in enforcement action if found by a State or EPA inspector." One item of note contained in the Observations section of this document is that the sewage system for the dam and powerhouse includes an absorption field north of the road to the ferry and west of the access road on the right descending bank. By this description, the absorption field will either be impacted by the proposed lock and/or the proposed construction plant and equipment lay-down area.

8.04 Most recently, Mr. Paul Schmierbach provided additional HTRW information to Mr. Richard Tippit by cover letter dated November 8, 1991. This letter along with five enclosures is included as Exhibit 3.

8.05 The first enclosure, a memorandum from Mr. L. W. Fielding to Mr. R. D. Davis, dated November 6, 1991, references the files searched for HTRW information. This search revealed that a sanitary landfill license for 13-acres in the northwest quadrant was in place from October 1, 1963 until August 7, 1968. Since this search did not indicate if the landfill was ever used or what it's contents might be, Mr. Joe Morrison of the Nashville District contacted Mr. Fielding for more information. Mr. Fielding indicated the landfill license was with Mr. A. J. Shulthise of Kentucky Lake Disposal Service. Mr. Morrison contacted Mr. Shulthise by telphone November 27, 1991. In this conversation, Mr. Shulthise indicated some random dumping by the general public occurred during this period, but that he never did use the landfill, and that he volutarily surrendered the license to TVA, when they requested.

8.06 The second enclosure, a memorandum from Mr. G. V. Downer to Mr. M. W. Hines, dated October 15, 1991, pointed out with reference to HTW, "the only two suspected problems are: (1) the asbestos in the Lock Operation Center on the electrical wire insulation and possibly the floor tile which has been carpeted, and (2) the septic lines coming from the hydro plant." Mr. Downer repeated earlier disclosures that old wire cable and construction debris used for backfill could be encountered during site excavation. A new reference was made to the only known reported HTW release, which occurred on September 24, 1990, when an extensive cleanup occurred to remove lead-containing sandblast material generated when the bridge was sandblasted and painted.

8.07 The third enclosure (an electronic mail response from Mr. George Conner to Mr. David Gengozian) references the "General lay-out of construction plant and cofferdam arrangement" figure from The Kentucky Project, which is included in this report as Figure 4. Mr. Conner points out that the cement silo, mixing plant, cement shed, and oil house could be possible problem areas. He also referenced a conversation with Mr. George Palo, retired manager of TVA's Office of Engineering, Design and Construction, who referenced a freezing process used in the removal of earth - but he couldn't remember any details.

8.08 The fourth enclosure is a copy of references to the employee housing village as described in The Kentucky Project. The fifth and final enclosure is a copy of the Environmental Compliance Audit Report, which is included in this report as Exhibit 2.

Paducah and Louisville Railroad

8.09 The Paducah and Louisville Railroad presently crosses the Tennessee River on a bridge attached to Kentucky Dam. For vertical clearance reasons, construction of the new lock will require relocation of the railroad to a separate bridge, downstream of the dam. With this in mind, Mr. Joe Morrison of the Nashville District contacted Mr. W. H. Sandefur of the Paducah & Louisville Railroad on October 4, 1991. Mr. Sandefur was asked about any accidents or incidents relating HTRW along this section of track in the past. Mr. Sandefur indicated the only accident he knew of in this area was the derailing of a coal train some six years ago - but that only coal was spilled. He indicated he had been employed by the railroad for some 22 years and had lived in the area before that, and that he knew of no other accidents or incidents. A follow up letter from Mr. Sandefur is included as Exhibit 3.

Kentucky Division of Waste Management

8.10 Mr. Doyle Mills of the Kentucky Division of Waste Management was contacted by phone by Mr. Joe Morrison of the Nashville District on October 24, 1991. Mr. Morrison asked Mr. Mills if they had any record of underground storage tank problems in the area. Mr. Mills indicated that they had no record of any problems in the area, and considering the length of time the property had been in the hands of TVA and the fact that regulations were not in place until 1986, it was unlikely that any record of underground tanks pre-dating TVA exist. Mr. Mills was also asked about land fills in the area, and more specifically for the original Town of Gilbertsville. The same basic response was given - that with the absence of regulations no one would have registered such operations before TVA's time.

Reed Crushed Stone Company

8.11 The proposed borrow/disposal site for the Kentucky Lock Project is on land presently owned by Reed Crushed Stone Company. As indicated earlier, Mr. Richard Tippit and Mr. Paul Bluhm of the Nashville District walked over this site with Mr. Jeffrey Major of Reed Crushed Stone Company on August 15, 1991. As a follow up, Mr. Joe Morrison of the Nashville District called Mr. Major on October 3, 1991 to request background information on the borrow/disposal site. Specifically, Mr. Morrison asked for a copy of the environmental study Mr. Major had recently compiled for Reed Crushed Stone's merger with Vulcan Materials Company. Mr. Major responded that "they don't give out environmental information - it isn't public information." When Mr. Morrison mentioned that the Corps needed background information on this site prior to purchase, Mr. Major responded that "Reed doesn't sell land period - they buy it, but they don't sell it."

9. SUMMARY AND CONCLUSIONS

Kentucky Lock and Dam Reservation

9.01 As pointed out earlier in this report, with the exception of the proposed borrow and disposal site, all of the property to be impacted by the lock addition and related improvements has been under the ownership of TVA since the late 1930's. Since completion of the lock and dam in 1944, most of the reservation property has been used for recreation, fish and wildlife management and operations activities.

9.02 Most of the impact from the lock addition will be felt on the right bank. The existing lock operations and maintenance buildings and associated improvements will be removed; and the existing campground, picnic area, boat launch ramp, firing range and the P&L Railroad will all be relocated to accommodate the new lock, construction plant and equipment laydown area.

9.03 As indicated in the correspondence from TVA, they do not know of any hazardous materials or underground storage tanks near the proposed lock. However, asbestos exists in the lock operations building and an old sanitary tile field system as well as some old wire cable from construction waste in a backfill location in the area will likely be encountered during construction (the right bank area was the location of the construction plant and lay-down area for the original lock and dam construction). In addition, TVA's property search revealed that a 13-acre site in this same area was licensed as a sanitary landfill for approximately five years, but was never officially used.

9.04 The only known hazardous episode to occur in the area occured on September 24, 1990, when an extensive cleanup occurred to remove lead containing sandblast material generated when the bridge was sandblasted and repainted.

9.05 Left bank impacts will be limited to relocation of the P&L Railroad, access road realignment, a comfort station relocation; plus some bank fishing and boat launch ramp improvements. Information obtained from TVA and Mr. Richard Tippit's walkover, does not reference any hazardous materials in this area. However, it is possible some old sewer lines and/or sanitary fields may be encountered from the old Town of Gilbertsville site.

Borrow/Disposal Site (Reed Crushed Stone Property)

9.06 Current plans are for the Corps to purchase the designated borrow/disposal site from Reed Crushed Stone Company. Borrow material will be hauled from this site to construct the new embankment for the P&L Railroad and fill from the new lock excavation operation will be disposed of on the same parcel.

9.07 Reed Crushed Stone Company recently compiled an in-depth environmental inventory for their merger with Vulcan Materials Company. Although Reed's representative is unwilling to share the results of his most recent environmental inventory for the quarry operation, including this site, the walkover by Mr. Richard Tippit on August 15,1991, revealed no evidence of contamination.

EXHIBIT 1

TVA

Tennessee Valley Authority 400 West Summit Hill Drive Knoxville Tennessee 37902

FEB 19 1991

Mr. Paul D. Robinson, P.E.
Chief, Engineering Division
Department of the Army
Nashville District
Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Mr. Robinson:

ENVIRONMENTAL RESOURCES BRANCH

Please refer to your December 5, 1990, letter to M. Paul Schmierbach. We understand from Richard Tippit of your staff that the information you requested in items 1 and 2 of the referenced letter has been provided. Regarding the third item, we are not aware of any hazardous materials near the proposed lock from recent past activities or underground storage tanks. Old clay tile leading to a sanitary field system that is no longer being used may be encountered as well as some old wire cable from construction waste in a backfill location. Some small amounts of asbestos will be encountered in the Lock Operation Center. Test results of pipe and electrical wire insulation showed positive results for asbestos. Floor tile which has been carpeted over has not been tested, but is assumed to be asbestos. The HVAC system and ceiling tile did not contain asbestos. We will keep you informed of additional information that may become available regarding hazardous materials.

Mr. Tippit also asked if we had any visitation data for Kentucky Dam. Taylor Park Campground experienced 4724 campers in calendar year (CY) 1990. Registered visitors (sign-ins) at the dam will vary quite a bit from year to year. For example, in CY 1989 about 82,000 registered and in 1990, 59,000. Therefore, we believe a good average over the last couple of years is about 70,000 registered visitors. This does not consider those who visit for fishing, picnicking, etc., and who do not register at the dam. Taking these visitors into account, we estimate the total average visitation (registered and non-registered) at the dam per year to be about 750,000.

We hope this information is helpful. If you need additional information or have any questions on the above, please call David R. Gengozian at (615) 632-6666 in Knoxville.

Sincerely,

M. Paul Schmierbach

M. Paul Schmierbach, Manager
Environmental Quality

EXHIBIT 2

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL QUALITY STAFF

Environmental Compliance Audit Report

Power Production, Hydro Operations
Kentucky Hydro Plant/Kentucky Lock

April 24-25, 1990

Audit No. KYH/KL-AWSO-90-04-24

Released MAY 30 1990

TENNESSEE VALLEY AUTHORITY

Environmental Quality Staff

Environmental Compliance Auditing Program

ENVIRONMENTAL COMPLIANCE AUDIT REPORT — Audit No.: KYH/KL-AWSO-90-04-24

Audit Date: April 24-25, 1990

FACILITY/ACTIVITY AUDITED: Kentucky Hydro Plant (KYH)/Kentucky Lock (KL)

AUDIT SUBJECT: Management Audit of Environmental Compliance Conditions

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AUDIT TEAM: J. R. Thurman, Lead Auditor
M. L. Iwanski
M. J. Ketelle

OBJECTIVE AND SCOPE

The audit was conducted by the Environmental Quality Staff (EQS) to evaluate compliance with environmental regulatory requirements and TVA environmental policies and procedures. It consisted of document and records review; personnel interviews; and a site inspection to evaluate air, water, and solid/hazardous waste practices. Source documents and references, areas examined, and persons contacted during the audit are shown in the Appendices.

Prepared by:	[signature] Lead Auditor	5/21/90 Date
Reviewed by:	[signature] Manager, Environmental Auditing Department	5/21/90 Date
Approved by:	[signature] Manager of Environmental Quality	Date

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Audit Findings and Observations Requiring Responses

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

OVERALL COMPLIANCE STATUS

No major environmental impacts were observed during the audit. However, several PCB and hazardous waste recordkeeping and documentation nonconformances were noted which could result in enforcement action if found by a State or EPA inspector. Additional training of plant staff in these areas as well as oil spill control is needed. Also, improvement in filing of environmental records and documents is needed. The plant manager's and staff's attitude toward and commitment to environmental compliance were excellent.

FINDINGS

B-1 The 15-minute maximum holding time for pH determination is not being met.
B-2 Hazardous waste contingency planning and personnel training requirements are not being met.
B-3 The 1988 Annual Hazardous Waste Report did not identify wastes shipped in 1988, and annual reports were not available at the plant.
B-4 Several hazardous waste storage requirements are not being met.
B-5 A shipment of PCB waste was not identified in the 1988 annual PCB report.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Findings

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

Finding No.: B-1

Auditor: J. R. Thurman

References:

1. NPDES Permit No. KY0033561, November 22, 1986, Kentucky Hydro Plant
2. 40 CFR Part 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants"
3. 49 Fed. Reg. 54343, October 26, 1984, "Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Rule and Proposed Rule"
4. Tennessee Valley Authority - Environmental Compliance Procedures (ECP), Kentucky Hydro Plant - "NPDES Requirements," WP-1
5. Letter, M. Paul Schmierbach to Jack A. Wilson, June 29, 1989, re: Elimination of pH monitoring requirements

Finding:

The 15-minute maximum holding time for pH determination is not being met.

Details:

Reference 1 specifies pH limits for the station sump (discharge serial number 001) at KYH. To determine compliance with NPDES limits, pH samples are collected and then sent to TVA's environmental chemistry laboratory in Chattanooga for analysis. However, Table II of Reference 2 requires pH to be analyzed immediately; and Reference 3, Section E, defines "immediately" to be as soon as the sample is collected and labeled, generally within 15 minutes. Table 2 of ECP WP-1 (Reference 4) also notes that the maximum acceptable holding time is 15 minutes. Although there are no plant records which indicate the average time between sample collection and analysis, the time period obviously exceeds 15 minutes.

TVA has requested that Kentucky eliminate the requirement for pH monitoring at KYH (Reference 5). However, until State approval is received, TVA must comply with the maximum holding time for pH samples or obtain a variance for the requirement.

Recommendation:

Analyze pH samples within 15 minutes after samples are collected or obtain a variance on this requirement until the NPDES permit is renewed.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Findings

Audit No.: KYH/KL-AWSO-90-04-24 Facility/Activity Audited:

Date Conducted: April 24-25, 1990 Kentucky Hydro Plant/Kentucky Lock

Finding No.: B-2

Auditor: M. L. Iwanski

References:

Kentucky Natural Resources and Environmental Protection Cabinet, Department of Environmental Protection, Kentucky Administrative Rules, Title 401, Chapter 32, "Standards Applicable to Generators of Hazardous Waste"

Finding:

Hazardous waste contingency planning and personnel training requirements are not being met.

Details:

The referenced hazardous waste regulations require small quantity generators to meet specific contingency planning and personnel training requirements, including:

- Preparing a written contingency plan describing emergency procedures and arrangements with local emergency response organizations; and listing emergency response coordinators and onsite emergency response equipment.
- Submitting copies of the plan to local emergency response organizations.
- Conducting and documenting introductory and annual training of all plant personnel involved in managing hazardous wastes.
- Preparing job descriptions for these personnel which reflect their duties and training requirements.

KYH does not have a written contingency plan. While hazardous waste training has been provided for some KYH personnel, other employees involved in handling hazardous waste have not been trained, and job descriptions for employees do not reflect their hazardous waste management duties. Environmental Affairs stated that Power Production intends to have written contingency plans in place at all hydro plants within the next year.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Findings

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

Finding No.: B-2 (cont'd)

Recommendations:

Prepare a written contingency plan and submit it to local emergency response organizations.

Train employees involved in managing hazardous waste and document the training.

Include hazardous waste management duties and training requirements in employee job descriptions.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Findings

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

Finding No.: B-3

Auditor: M. L. Iwanski

References:

1. Kentucky Natural Resources and Environmental Protection Cabinet, Department of Environmental Protection, Kentucky Administrative Rules, Title 401, Chapter 32, "Standards Applicable to Generators of Hazardous Waste"
2. Letter, M. Paul Schmierbach to Don Harker, February 27, 1989, re: Tennessee Valley Authority, 1988 Annual Hazardous Waste Report

Finding:

The 1988 Annual Hazardous Waste Report did not identify wastes shipped in 1988, and annual reports were not available at the plant.

Details:

State regulations (Reference 1) require that a generator which ships waste offsite submit an annual report to the State and keep copies of these reports at the facility for three years. KYH shipped seven drums of hazardous waste to the Hazardous Waste Storage Facility in Muscle Shoals on March 1, 1988. KYH submitted its 1988 annual report (Reference 2) to the State stating that no hazardous wastes were generated in 1988. Copies of the last three annual reports were not available at the plant.

Recommendations:

File an amended 1988 annual report with the State.

Maintain copies of the previous three annual reports at the plant.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Findings

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

Finding No.: B-4

Auditor: M. L. Iwanski

References:

Kentucky Natural Resources and Environmental Protection Cabinet, Department of Environmental Protection, Kentucky Administrative Rules, Title 401, Chapter 32, "Standards Applicable to Generators of Hazardous Waste"

Finding:

Several hazardous waste storage requirements are not being met.

Details:

The referenced regulations identify several requirements for generators which store hazardous waste, including:

- Containers of hazardous waste in storage for disposal must be dated.
- Containers of hazardous waste must always be closed during storage, except when it is necessary to add or remove waste.
- Storage areas must be inspected at least weekly and results of inspections must be documented.

Four drums were observed in the hazardous waste storage area. Two of these drums were paint wastes recently moved to storage. These wastes were suspected of containing solvents and were labeled as hazardous waste; however, they had not been sampled and were not dated. The other two drums were hazardous waste accumulation drums that had recently been moved to storage and sampled for hazard identification. The plant is awaiting laboratory results. These drums were labeled as hazardous but were not dated. One of these containers had an open funnel in its bung opening.

According to KYH staff, the hazardous waste storage area is inspected each shift by a senior operator. However, operator inspection records documents do not identify the status of the hazardous waste storage area.

Recommendations:

Date all drums in the hazardous waste storage area.

Keep all hazardous waste drums closed except when adding or removing waste.

Document hazardous waste storage area inspections.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Findings

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

Finding No.: B-5

Auditor: M. L. Iwanski

References:

1. 40 CFR Part 761 - "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibition"
2. Memorandum, Richard D. Urban to Those listed, July 6, 1989, "Distribution and Disposition of Polychlorinated Biphenyl (PCB) Materials at TVA Facilities - Annual Report - Calendar Year 1988"

Finding:

A shipment of PCB waste was not identified in the 1988 annual PCB report.

Details:

PCB regulations (Reference 1) require facilities that use or store PCBs to prepare a written annual document log which identifies, among other things, PCBs and PCB items in service, in storage for disposal, and transported for disposal. This document must be available at the facility for at least three years after the facility ceases using or storing PCBs and PCB items.

In April 1988, two shipments of PCB oil from retrofilling a PCB-contaminated transformer were manifested by PPM, Inc., to Tucker, Georgia. The 1988 annual PCB report (Reference 2) did not identify these PCB wastes. Previous PCB annual reports for KYH were not available at the plant.

Recommendations:

Prepare an addendum to the 1988 annual report identifying the wastes shipped by PPM, Inc.

Keep copies of the annual document at the plant for at least three years after the facility ceases using or storing PCBs and PCB items.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Observations

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

OBSERVATIONS

1. Recordkeeping--KYH's system for filing environmental records does not allow for ready retrieval of documents, and some records are incomplete. Readily retrievable and complete environmental compliance records are a valuable asset if a facility receives an environmental compliance inspection by a regulatory agency. Also, well organized records are helpful in avoiding recordkeeping nonconformances such as the missing information from annual reports noted in Findings B-3 and B-5.

   KYH should implement a filing system that allows for easy retrieval of environmental documents. Documentation should be readily available to show how environmental requirements are met. (Auditor: M. L. Iwanski)

2. PCB Spill Cleanup Records--Records for a PCB spill cleanup did not include all of the documentation required by EPA's spill cleanup policy. Plant records indicate that eight drums of PCB solids were manifested to TVA's Hazardous Waste Storage Facility on July 12, 1988. Plant records also include laboratory results from a July 21, 1988 wipe test following cleanup of a spill from a PCB-contaminated transformer. Documentation not available in plant files, needed to meet cleanup policy guidelines, includes estimates of when the spill occurred, when the cleanup was completed, how the site was cleaned up, and certification that cleanup was completed. While it is not a regulatory requirement, EPA strongly incourages facilities to follow all of the steps set forth in the policy. Also, Power Production's new PCB compliance procedure will contain guidance for maintenance of PCB spill records. (Auditor: M. L. Iwanski)

3. Risks From Failure of PCB and PCB-Contaminated Equipment--KYH management has requested funding to replace the six PCB transformers in the Powerhouse with non-PCB equipment. This replacement would eliminate KYH's risk from failure of this equipment. The auditor commends this initiative. Plant records indicate that there are nine PCB-contaminated items in the Switchyard which drains to the river through an underground drain field. Therefore, this PCB-contaminated equipment presents a risk of contaminating the river. The auditor recommends that Power Production evaluate the risks of contamination from failure of both the PCB and PCB-contaminated equipment and take steps to minimize the risk. (Auditor: M. L. Iwanski)

4. SPCC (Spill Prevention Control and Countermeasures) Training--Federal regulations (40 CFR Part 112 - "Oil Pollution Prevention") require that facilities train personnel in oil spill control and prevention at intervals frequent enough to assure adequate understanding of the SPCC plan. Two senior operators interviewed

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
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OBSERVATIONS (cont'd)

by the auditors were aware of their responsibilities for emergency reporting in the event of a spill, but neither had received formal training. To more fully protect TVA and its employees, operators should be given formal SPCC training (the auditor suggests annual training). This training should be documented and include mock drills. (Auditor: J. R. Thurman)

5. Contingency Planning for Large Oil or Chemical Spills at KYH--Because of the highway and rail track that cross the dam and barge traffic through the lock, the prospect of a large oil or chemical spill at KYH poses a real threat. At present, spill cleanup equipment at the dam and lock consists of absorbent pads and 20-40 feet of boom material. If a large spill were to occur in or near the lock, the Corps would attempt to locate a contractor in Nashville or another metropolitan area. In all likelihood, several hours would lapse before a contractor could get to the site.

   TVA is currently preparing a Valley-wide contingency plan which will place the agency in a more favorable position to quickly respond to such an event. This plan should be finalized and submitted for Board approval as quickly as possible so that TVA will be able to respond quickly and effectively to oil or chemical spills at its facilities. (Auditor: J. R. Thurman)

6. Future Sewage System Needs--The KYH sewage system consists of a 2,000 gallon septic tank in the Powerhouse, a lift station, and an absorption field north of the road to the ferry and west of the access road. The plant manager expressed concern that, if plans for a new lock come to fruition, the absorption field would need to be replaced. He is also concerned about system failure during periods of high use. It seems timely for Power Production to consider modifying or replacing the current sewage system. (Auditor: J. R. Thurman)

7. PE&C (Power Engineering and Construction) Activities at KYH-PE&C personnel are involved in two projects at KYH: (1) repainting the bridge; and (2) replacement of the "Oil-O-Static" system (oil-filled electrical cables connecting the Powerhouse with the Switchyard). No environmental problems were identified with these projects; however, an EDR (Environmental Decision Record) was not completed by PE&C for the painting job. An EDR was completed for the "Oil-O-Static" replacement action. KYH ECP (Environmental Compliance Procedures) GP-1, "Environmental Requirements for Construction and Modification of Facilities," requires that EDRs be completed for actions to document that the proper NEPA (National Environmental Policy Act) review was completed. Controls need to be implemented to ensure that all contractor activities (TVA or non-TVA) are reviewed in accordance with ECP GP-1 requirements. (Auditor: J. R. Thurman)

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Observations

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
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OBSERVATIONS (cont'd)

8. Operator Training Program--Power Production has developed a new training program for fossil and hydro plant operators. The old SGPO (Student Generating Plant Operator) program did not include environmental compliance training. The new program, Operations and Maintenance Training, will include a small amount of environmental training. The auditor recommends that Power Production evaluate the level of environmental training that will be offered and determine if it is sufficient. (Auditor: J. R. Thurman)

9. Kentucky Lock--A minor air pollution source, a paint spray booth, was identified at the lock. The auditor advised the Lockmaster to contact the State and determine if a permit would be required. No other areas of concern were noted. (Auditor: J. R. Thurman)

10. Status of Findings from the Previous Audit--There were no findings identified in the previous audit, Audit No. KYH-WSO-86-06-26.

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A P P E N D I C E S

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Appendix A

Audit No.: KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
Date Conducted: April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock

DEFINITIONS

1. Audit Finding--Nonconformance with any environmental laws, regulations, TVA environmental policy, or TVA procedures.

   (a) Class A Finding--A nonconformance requiring immediate corrective action. This includes nonconformances that may (1) endanger public health; (2) significantly impact the environment; (3) pose substantial risk of regulatory, civil, or criminal penalty or could involve litigation or serious financial loss; or (4) have been identified in previous audits as a Class B finding and have not been corrected in a timely fashion.

   (b) Class B Finding--A nonconformance requiring corrective action that does not meet the definition of a Class A finding.

2. Observation--A condition noted during the audit not classified as a finding but deemed worthy of mention. Observations may (1) identify program deficiencies such as lack of procedures or training; (2) warn of potential nonconformances; (3) highlight exceptional environmental programs; (4) point out noteworthy accomplishments; or (5) document current conditions or project status that in the opinion of the audit merit monitoring. Observations should not be considered less important than findings and often warrant greater management attention than findings.

3. Responses--For each Finding of nonconformance a written response to the Manager of the Environmental Quality Staff (EQS), indicating corrective actions taken or scheduled, is required within 30 working days after receiving the report. Copies of the response should be provided to the Chief Operating Officer, the Vice President of the operating organization, the General Counsel and other management as needed. EQS will track each Finding until its closure. EQS may require responses to certain observations.

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Appendix B

Audit No.: KYH/KL-AWSO-90-04-24 Facility/Activity Audited:

Date Conducted: April 24-25, 1990 Kentucky Hydro Plant/Kentucky Lock

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AREAS EXAMINED

KENTUCKY HYDRO

Powerhouse

a. Battery Room
b. Hazardous and PCB Waste Storage Area
c. Machine Shop
d. Oil Room
e. PCB Transformers
f. Pipe Gallery
g. Station Sump

161-kV and 69-kV Switchyard

KENTUCKY LOCK

Audit No.: KYH/KL-AWSO-90-04-24	Facility/Activity Audited:
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SOURCE DOCUMENTS AND REFERENCES

1. Federal Insecticide, Fungicide, and Rodenticide Act
2. Clean Air Act, as Amended
3. Clean Water Act, as Amended
4. National Environmental Policy Act
5. Resource Conservation and Recovery Act, as Amended
6. Toxic Substances Control Act
7. Superfund Amendments and Reauthorization Act
8. Comprehensive Environmental Response, Compensation, and Liability Act, as Amended
9. Executive Order 12088, Federal Compliance with Pollution Control Standards, October 17, 1978
10. 40 CFR Part 61, Subpart M - "National Emission Standard for Asbestos"
11. 40 CFR Part 110 - "Discharge of Oil"
12. 40 CFR Part 112 - "Oil Pollution Prevention"
13. 40 CFR Part 116 - "Designation of Hazardous Substances"
14. 40 CFR Part 117 - "Determination of Reportable Quantities for Hazardous Substances"
15. 40 CFR Part 122 - "National Pollutant Discharge Elimination System"
16. 40 CFR Part 125 - "Criteria and Standards for the National Pollutant Discharge Elimination System"
17. 40 CFR Part 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants"
18. 40 CFR Part 165 - "Regulations for the Acceptance of Certain Pesticides and Recommended Procedures for the Disposal and Storage of Pesticides and Pesticides Containers"
19. 40 CFR Part 260 - "Hazardous Waste Management System: General"
20. 40 CFR Part 261 - "Identification and Listing of Hazardous Waste"
21. 40 CFR Part 262 - "Standards Applicable to Generators of Hazardous Waste"
22. 40 CFR Part 263 - "Standards Applicable to Transporters of Hazardous Waste"
23. 40 CFR Part 264 - "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities"
24. 40 CFR Part 265 - "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities"
25. 40 CFR Part 266 - "Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities"
26. 40 CFR Part 268 - "Land Disposal Restrictions"
27. 40 CFR Part 280 - "Technical Standards for Corrective Action Requirements for Owners and Operators of Underground Storage Tanks"
28. 40 CFR Part 300 - "National Oil and Hazardous Substances Pollution Contingency Plan"
29. 40 CFR Part 302 - "Designation, Reportable Quantities, and Notification"
30. 40 CFR Part 355 - "Emergency Planning and Notification"

Audit No. KYH/KL-AWSO-90-04-24 Facility/Activity Audited:

Date Conducted: April 24-25, 1990 Kentucky Hydro/Kentucky Lock

SOURCE DOCUMENTS AND REFERENCES (cont'd)

31. 40 CFR Part 370 - "Hazardous Chemical Reporting: Community Right-To-Know"
32. 40 CFR Part 761 - "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibition"
33. 49 Fed. Reg. 54343, October 26, 1984, "Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Rule and Proposed Rule"
34. Kentucky Environmental Protection Law
35. Kentucky Natural Resources and Environmental Protection Cabinet, Department of Environmental Protection - Kentucky Administrative Rules, Title 401
    - Water Quality Regulations, Chapter 5
    - Sanitary Engineering Regulations, Chapter 6
    - Waste Management Regulations, Chapters 30-49
    - Air Quality Regulations, Chapters 50-63
36. NPDES Discharge Monitoring Reports (DMRs), August 1987 - January 1990, Kentucky Hydro Plant
37. KPDES Permit No. KY0033561, November 22, 1986, Kentucky Hydro Plant
38. TVA Code IX ENVIRONMENTAL QUALITY
39. TVA Instruction IX ENVIRONMENTAL REVIEW
40. Tennessee Valley Authority, Distribution and Disposition of Polychlorinated Biphenyl (PCB) Materials at TVA Facilities - Annual Report - Calendar Year 1988
41. Tennessee Valley Authority - Environmental Compliance Procedures (ECP) - Kentucky Hydro Plant
42. Tennessee Valley Authority - Environmental Compliance Audit Report - Audit No. KYH-WSO-86-06-26
43. TVA Correspondence with Regulatory Agencies
44. Letter, Marvin Runyon to The Honorable Lee M. Thomas, October 19, 1988, re: Emergency Planning and Community-Right-to-Know Act of 1986 (Title III)
45. Letter, M. Paul Schmierbach to Jack A. Wilson, June 29, 1989, re: Elimination of pH Monitoring Requirements
46. Letter, M. Paul Schmierbach to Don Harker, February 27, 1989, re: Tennessee Valley Authority, 1988 Annual Hazardous Waste Report
47. Memorandum, F. E. Adkins to Those listed, February 9, 1990, "Polychlorinated Biphenyls (PCB) Annual Reporting - 1989"
48. Memorandum, Richard D. Urban to Those listed, July 6, 1989, "Distribution and Disposition of Polychlorinated Biphenyl (PCB) Materials at TVA Facilities - Annual Report - Calendar Year 1988"

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL COMPLIANCE AUDIT REPORT
Appendix D

Audit No.:	KYH/KL-AWSO-90-04-24	Facility/Activity Audited:	
Date Conducted:	April 24-25, 1990	Kentucky Hydro Plant/Kentucky Lock	

PERSONS CONTACTED

POWER PRODUCTION

HUMAN RESOURCES

J. Ronald Barnett, Specialist
Connie J. Frizzell, Specialist, Operation and Maintenance Training

KENTUCKY HYDRO

Paul G. Campbell, Plant Manager (1,2)
Richard E. Page, Management Operations and Maintenance (1)
Donnie K. Young, Senior Operator
Robert M. Hunt, Senior Operator

ENVIRONMENTAL AFFAIRS

Gordon G. Park, Program Manager
J. Steve Cooper, Environmental Scientist (2)
E. Gregory Marcus, Environmental Engineer

POWER ENGINEERING AND CONSTRUCTION

Tommy L. McDaniel, Environmental Engineer
David Brown, Painter

RESOURCE DEVELOPMENT

RIVER BASIN OPERATIONS

George G. Conner Jr., Civil Engineer

CORPS OF ENGINEERS

Steve Honeymaker, Lockmaster

(1) Present at Entrance Meeting
(2) Present at Exit Meeting

EXHIBIT 3

PADUCAH & LOUISVILLE RAILWAY, INC.

1500 Kentucky Avenue, Paducah, KY 42001 (502) 444-4300

October 4, 1991

Mr. Joe Morrison
Nashville Corps of Engineers
P. O. Box 1070
Nashville, Tennessee 37202

Dear Mr. Morrison:

This is in reference to our recent phone conversation regarding derailments that involved chemical spills in the area that you have selected as the new site for relocating the portion of P&L trackage in vicinity of Kentucky Dam.

We have examined our records and have discussed this matter with our people - especially with those who have been around since 1955. To the best of our knowledge, no chemical spills have occurred in this area.

If you have any further questions regarding this matter, please do not hesitate to contact us.

Very truly yours,

W. H. Sandefur

W. H. Sandefur
Engineering Superintendent

EXHIBIT 4

TVA

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902

NOV 8 1991

Mr. Richard Tippit
Nashville District
Corps of Engineers
Department of the Army
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Mr. Tippit:

LOWER CUMBERLAND AND TENNESSEE RIVERS KENTUCKY LOCK ADDITION - HAZARDOUS AND TOXIC WASTE (HTW)

As requested, TVA has expanded its information search to more specifically document the potential for HTW at the subject site and to provide you information by November 8, 1991. Listed below are specific information sources, including documents, files, or interviews, as well as the TVA contact person. The information either identifies HTW sources or suspect areas for further investigation. Each of the sources of information (or appropriate excerpt) is enclosed.

Enclosure	Contact Person
A. Memorandum, L. W. Fielding to R. D. Davis, "Kentucky Reservoir - CERCLA Clearance Associated with Proposed Kentucky Lock Addition," November 6, 1991	Larry W. Fielding (901) 642-2041
B. Memorandum, G. V. Downer to M. Hines, "Lower Cumberland and Tennessee Rivers Kentucky Lock Addition - Hazardous Toxic Waste (HTW)," October 15, 1991	Curtis Taylor (615) 751-8877
C. E-Mail, G. G. Conner to D. R. Gengozian "Kentucky New Lock - HTW," October 20, 1991	George G. Conner (615) 632-7157

D. Excerpts from Technical Report No. 13, The Kentucky Project, TVA, 1951 — George G. Conner (615) 632-7157

   1. Description of the construction camp and village

   2. Figure 100, "General Lay-Out of Construction Plant and Cofferdam Arrangement"

E. Environmental Compliance Audit Report, No. KYH/KL-AWSO-90-04-24, TVA Environmental Quality Staff, May 30, 1990 — John R. Thurman (615) 632-6585

Our file search is not yet complete and is subject to additions in the next 30 days. We will inform you if new information becomes available. Please contact Greg Askew at (615) 632-6418 in Knoxville for any general questions and requests. The contact persons listed will answers specific questions regarding the information sources.

Sincerely,

M. Paul Schmierbach, Manager
Environmental Quality

Enclosures

Enclosure A

November 6, 1991

R. D. Davis
FOR 2A-N

KENTUCKY RESERVOIR - CERCLA CLEARANCE ASSOCIATED WITH PROPOSED KENTUCKY LAKE ADDITION

The files listed below have been searched for information on Hazardous Toxic Wastes at the subject site. Please note that a sanitary landfill license was in place from October 1, 1963, until August 7, 1968, affecting 13 acres as illustrated on the attached map. Our records do not indicate if the landfill was used or provide information on its contents. This search did not include Operations and Maintenance activities. Our O&M/Public Use section is performing that record search. Beyond the landfill, I found no record or information indicating the presence of Hazardous Toxic Waste.

HAZARDOUS TOXIC WASTE RECORD SEARCH

Contract File	TV- 11508A	Lease agreement with Department of Conservation campground
Contract File	1-4024(8)	License to TVA for Railroad wire crossing, ICRR
Contract File	TV-13252A	Sledd Creek area License for boat rental service
Record File		Site Improvements, 1948-19541
Contract File	TV-24770A	Reed Crushed Stone License
Contract File	TV-24702A	Kentucky Lake Disposal Sanitary Landfill

Information File		Concession agreement between Kentucky and Kentucky Dam Boat Basin Company, Inc.
Information File	772 B4 1951-1952	
Information File	772 B4 1949-1950	Restrooms at Kentucky Dam Boat Basin Company, Inc.
Information File	772 B4 1948-1949	Concessions Building at Kentucky Dam Boat Basin
Information File	772 B4 1947-1948	
Information File	772 B4 1946-1947	
Information File	771 D 1953-1954	Kentucky Dam State Park
Information File	771 B1 1947-1948	Kentucky Dam Access Road
Information File	771 D 1952-1953	Roadwork memos
Information File	771 D 1953-1954	Communication Towers
Information File	745 1970-1972	Kentucky Dam Reservoir Maintenance Plan. Various Maintenance Issues
Information File	745 1968-1969	Maintenance Issues

HAZARDOUS TOXIC WASTE RECORD SEARCH (cont.)

Information File	745 1964-1967	Maintenance Issues
Safety File	840H 1984-present	Safety Audits and Inspections
Information File	745K 1975-present	Taylor Park
Information File	745	Kentucky Dam
Information File	745 1977-present	Kentucky Dam Reservoir
Information File	741 M105 1974-present	Kentucky Dam Access Road
Contract File	1100.711 -1100.721 (1966-1991)	Agricultural licenses, downstream, right bank
Contract File	1169.11 1978-1983	City of Grand Rivers Occupancy and use license
Contract File	TV-20364A 1958-present	Kentucky Department of Conservation Camping Area
Information/Contract File	TV-6205A	Commonwealth of Kentucky Facilities
Information/Contract File	Lease TV-7685A License TV-21475A	Commonwealth of Kentucky Use of land below 381-foot contour
Contract File	Lease TV-24712A	Commonwealth of Kentucky
Correspondence	Lease TV-24712A	Commonwealth of Kentucky
Correspondence	TV-6205A	Early correspondence leading to transfer of Kentucky Dam Village

HAZARDOUS TOXIC WASTE RECORD SEARCH (cont.)

Reed Terminal Company	TV-58176A	TRACT XGIR-252R (GIR-308 Map 4D)
Reed Terminal Company	1169.16	TRACT XGIR-9041E (GIR-294 Map 4D) Dredge spoil area)
Lazy Beaver Campground	TV-41170A	TRACT XGIR-252R
Reed Crushed Stone Company	TV-19401A	Jetty
Reed Crushed Stone Company	TV-74705A TV-74200A	TRACT XGIR-913H Road row
Reed Terminal Company	TV-78287T	XGIR-914E Fleeting Area
Reed Terminal Company		9041E

Larry W. Fielding

Larry W. Fielding
Property Manager

LWF:kk
Attachment
cc: Files, WLRD, Paris
Greg Askew, WT 11E-K (Faxed copy)

(0026G)

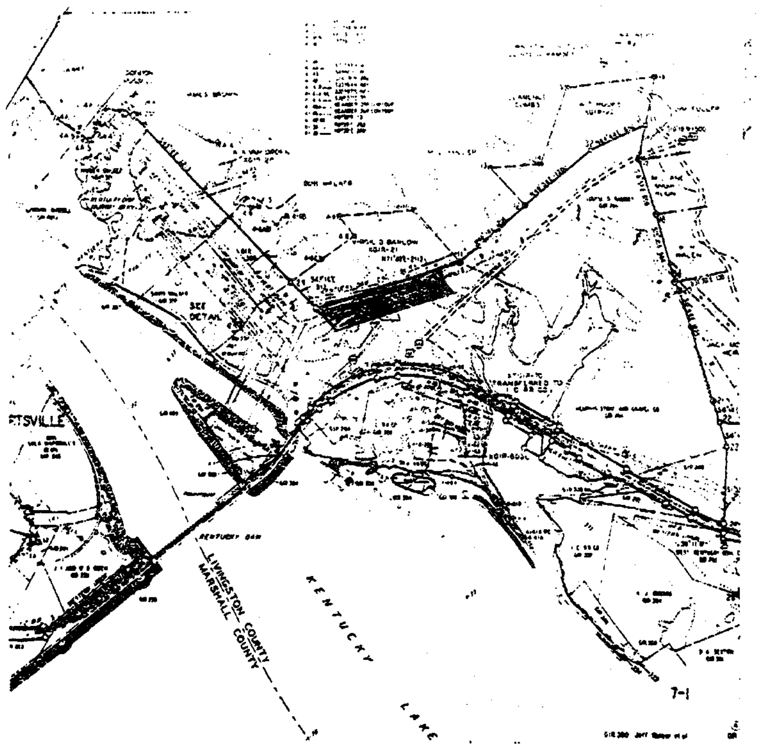


EXHIBIT A
Scale 1" = 1320'

TENNESSEE VALLEY AUTHORITY
WESTERN BRANCH

Proposed Garbage and Refuse Disposal Area

KENTUCKY LAKE DISPOSAL SERVICE

Contract No. TV-24708A Date 10-1-63

County Livingston Map LD Tract KGIR-252R

Licensed Area
13.0 Ac. above 375'

A60 911009 066 Enclosure B

October 15, 1991

M. W. Hines, WT 8B-K

LOWER CUMBERLAND AND TENNESSEE RIVERS KENTUCKY LOCK ADDITION - HAZARDOUS TOXIC WASTE (HTW)

Your October 3, 1991, memorandum to Jon M. Loney and William G. Ruffner (A60 911007 001) stated that additional information was needed to confirm that there is no HTW at the site for the lock addition. Based on our knowledge of the site and discussions with Paul Campbell, plant manager, the only two suspected problems are: (1) the asbestos in the Lock Operation Center on the electrical wire insulation and possibly the floor tile which has been carpeted, and (2) the septic lines coming from the hydro plant. The field line for this system is located east of the lock and north of the access road. The removal of the septic system will need to be evaluated before the construction of the lock. We do not suspect any unnatural material, other than wire cable and construction debris used for backfill, to be encountered during the excavation of the site. The only known reported HTW release occurred on September 24, 1990, when an extensive cleanup occurred to remove lead-containing sandblast material generated when the bridge was sandblasted and painted. The area was cleaned and the material was taken to Chemical Waste Management in Emelle, Alabama, for proper disposal.

If you have any questions, please call Curtis Taylor at extension 8877 in Chattanooga.

G. V. Downer
Manager of Hazardous Materials
and Waste Services
LP 3F-C

ECT:SRH
cc: RIMS, MR 2F-C
G. G. Conner, EB 1A-K
D. M. Hastings, ET 10H-K

6865h

OCT 17 '9
005

Enclosure C

VS OFFICE Electronic Mail   Monday   10/21/91 07:47 am

To: David R. Gengozian   K TVAKNX02 WT8
From: George G. Conner
Subject: Kentucky New Lock - HTW   Date: 10/20/91

Distribution:

Not Requested

David Gengozian:

We have reviewed Technical Report No. 13, "The Kentucky Project," and found sites of possible problem areas on Figure 100, "General lay-out of construction plant and cofferdam arrangement." The construction sites are the cement silo, mixing plant, cement shed, and oil house. A copy of Figure 100 is being mailed to you.

We also called George Palo, retired manager of the former TVA Office of Engineering Design and Construction. He participated in the construction of Kentucky Dam and remembered use of a freezing process in excavating earth but could not recall any specific details.

George Conner

EMPLOYEE HOUSING

The inadequate housing facilities in the vicinity of the Kentucky Dam site presented essentially the same problem of employee housing previously encountered at other TVA main river locations. In one respect, however, it differed in that 46 houses located in the old town of Gilbertsville and within ½ mile of the site were reconditioned and utilized for employee housing. In addition, TVA constructed a camp and village composed of separate areas for white employees and Negro employees. Employee housing facilities included 11 permanent and 72 temporary single houses, 6 temporary duplex houses, and 8 men's dormitories with a total capacity of 480. Related service facilities included permanent administration, personnel, and community buildings, a semipermanent auditorium, and 2 temporary cafeterias, a hospital, a nurses' dormitory, a visitors' building, Negro school and recreational buildings, warehouses, and garages. The area was served by a permanent utility system including a water treatment plant and storage tank, a sewage disposal plant, electric power, and telephone connections. A permanent school was constructed by Marshall County adjacent to the community center and on land deeded to the county by TVA.

Camp and village site

Preliminary studies to determine the location of the construction camp and village resulted in the selection of a gently rolling farm area approximately 1½ miles southwest of the dam site (fig. 80). A permanent hard-surface access road, 7.6 miles long, was built by TVA from U. S. Highway No. 68 north of Benton to the town of Gilbertsville and Kentucky State Highway No. 95. This access road, which connects with the roadway on top of the west embankment of the dam, runs between the camp and village area and the west shore line of the lake. From the community center and portions of the village excellent views are available of the 2-mile expanse of water.

Permanent houses

Eleven permanent houses (fig. 81) were designed and built for the supervisory construction employees, to be used by the lock and powerhouse employees when construction was completed. All houses were constructed on cinder block piers and concrete footings; with wood frame superstructures; hardwood floors sanded and varnished; electric lighting, refrigeration, water heating, and cooking provision; sanitary plumbing; automatic oil-fired heating systems; and attached garages.

One type "AA" house was built primarily to make comparative space heating experiments with electric and oil heaters. This house measures 27 feet by 53 feet 5 inches over all and contains 2 bedrooms, a living room, a kitchen and bath. The attached garage is separated from the remainder of the house by a screened porch. This experimental house differed from the later models through the use of weather-resisting fiberboard on the exterior walls and an interlocking galvanized metal roof.

The oil-fired heating system is an interesting feature of this house. Installed in a small room opposite the bathroom, an oil heater is automatically fed by a pump with fuel oil from a 250-gallon underground storage tank located near the driveway for convenient filling

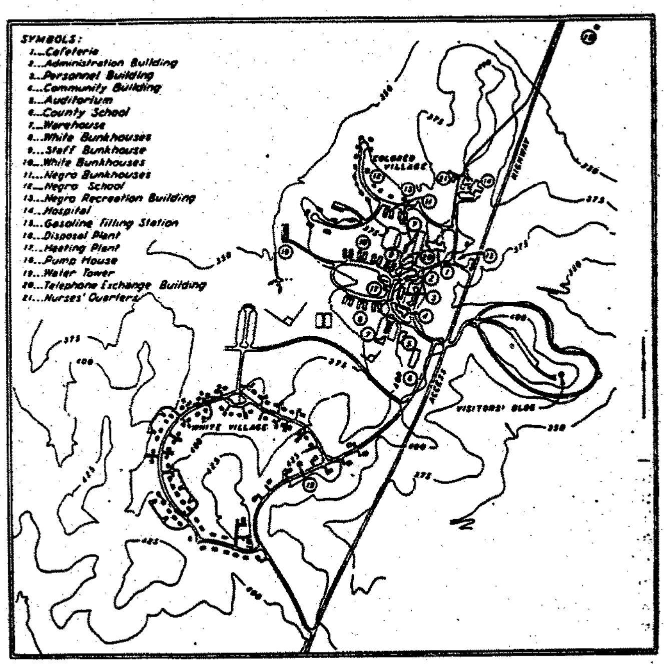


FIGURE 80.—*Construction camp and village.*

from a tank truck. Warm air is distributed to all rooms through a heat duct in the suspended ceiling and under force from a blower fan in the bottom of the heater jacket. A large return register located near the floor in the living room side of the heater room provides circulation. The system is thermostatically controlled.

Seven type "B" two-bedroom houses were built. Measuring 30 feet 2 inches by 73 feet 4 inches over all, these houses contain a living room, a dining room, and a kitchen in addition to the bedrooms and bath; also a screened living porch at one end, and the garage at the other, connected to the house by an enclosed service porch.

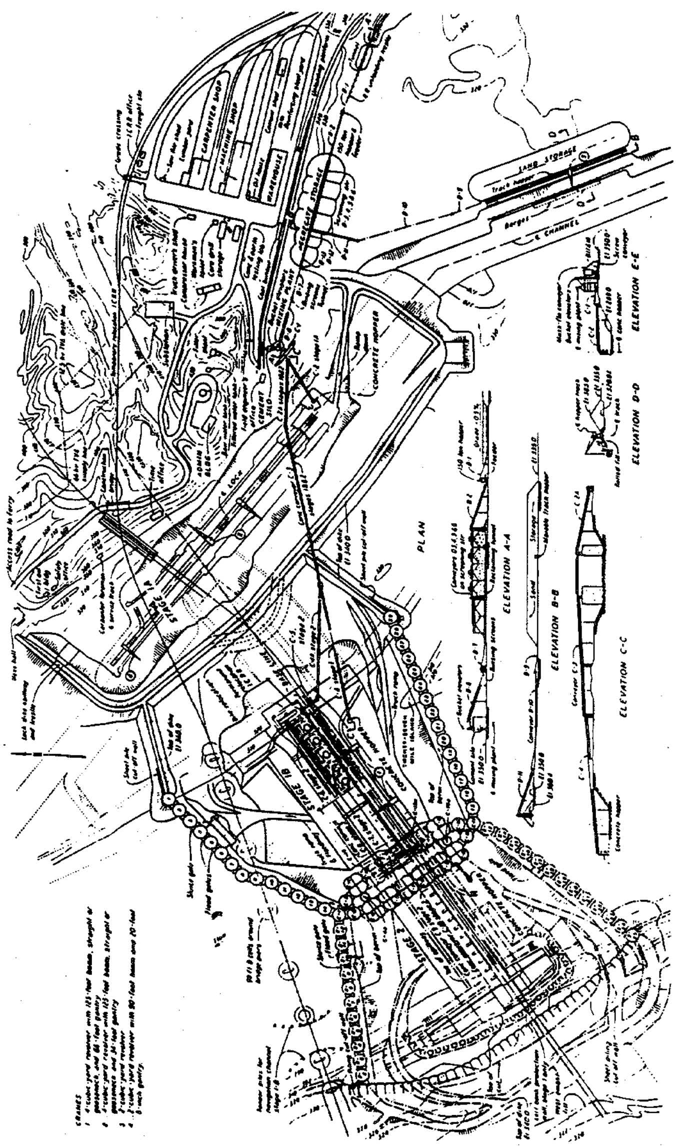


FIGURE 100.—General lay-out of construction plant and cofferdam arrangement.

100041 O - 50 (Face p. 388)

Enclosure E

TENNESSEE VALLEY AUTHORITY
ENVIRONMENTAL QUALITY STAFF

Environmental Compliance Audit Report

Power Production, Hydro Operations
Kentucky Hydro Plant/Kentucky Lock

April 24-25, 1990

Audit No. KYH/KL-AWSO-90-04-24

(Refer to EXHIBIT 2 of Phase 1 Preliminary HTRW Assessment, for a complete copy of this report).

Released MAY 3 0 1990

APPENDIX E (a)

PHASE 1 PRELIMINARY HTRW ASSESSMENT ENDORSEMENT

CE

MEMORANDUM FOR CEORN-EP-E (210-1c)

SUBJECT: Review of Kentucky Lock Addition Phase I Preliminary HTRW Assessment.

1. Comments on specific portions of the subject document are presented below. Based on information gathered to date, a Phase II HTRW assessment is not judged to be necessary for this project.

2. Exhibit 1 - Response Letter from TVA to CEORN letter dated 5 December 1990.

   a. The Asbestos Containing Material (ACM) located in the Lock Operations Center will need to be disposed of in accordance with the applicable state and federal regulations. The ACM includes the pipe and electrical wire insulation and the floor tile. Although the floor tile was not tested for the presence of asbestos, in order to avoid the costs for analysis, it would be prudent to dispose of it as ACM.

   b. The old clay tile leading to the abandoned sanitary field and the wire cable are not considered HTRW material. However, these items should be disposed of in a sanitary landfill, along with any other construction debris, whenever they are uncovered and removed during the excavation.

3. Exhibit 2 - TVA Environmental Compliance Audit Report, April 1990.

   a. The Lock facility maintains a hazardous waste storage area which contains drums of paint and solvent wastes. Lock personnel should ensure that all wastes are contained, properly labeled, secured and removed prior to construction. In addition, environmental samples will need to be collected from the area in order to determine the presence or absence of HTRW contaminants.

   b. The Lock facility is known to generate PCB wastes and maintains a PCB waste storage area. Lock personnel should ensure that all wastes are contained, properly labeled, secured and removed prior to construction. Environmental samples will need to be collected from the area in order to determine the presence or absence of PCB contamination.

c. Plant records indicate that there are nine (9) PCB-contaminated items in the Switchyard which drains to the river through an underground drain field. Environmental samples will need to be collected from the Switchyard drainage area to determine the presence or absence as well as the extent of PCB-contaminated soils.

d. The Powerhouse is serviced by an on-site sewage treatment system which includes a 2000 gallon septic tank, a lift station, and an absorption field. Although these items are not considered to be HTRW material, this material should be disposed of in a sanitary landfill, along with any other construction debris, whenever it is uncovered and removed during the excavation.

4. Exhibit 3 - Response Letter from Paducah and Louisville (P&L) Railway dated 4 October 1991.

No comment; no information regarding HTRW contamination discussed.

5. Exhibit 4 - Enclosure A, Memorandum from L.W. Fielding to R.D. Davis, "Kentucky Reservoir - CERCLA Clearance Associated with Proposed Kentucky Lock Addition", dated 6 November 1991.

A sanitary landfill license was in place from October 1963 until August 1968 for a 13 acre site shown on Exhibit A. Recent information has been obtained which indicates that the landfill was never utilized; therefore, no further assessment is judged necessary at this site.

6. Exhibit 4 - Enclosure B, Memorandum from G.V. Downer to M. Hines, "Lower Cumberland and Tennessee Rivers Kentucky Lock Addition - Hazardous and Toxic Waste", dated 15 October 1991.

a. ACM and septic lines addressed in paragraph 2.

b. Further investigation of the HTRW incident which occurred on 24 September 1990, is not recommended. The lead-containing sandblast material was removed and disposed of at a facility in Emelle, Alabama.

7. Exhibit 4 - Enclosure C, E-Mail from G.G. Conner to D.R. Gengozian, "Kentucky New Lock - HTW", dated 20 October 1991.

a. The construction site includes a cement silo, a mixing plant, a cement shed, and an oil house. Although there is no information regarding the contents of the cement silo, mixing plant or cement shed, we assume that the material is construction-type debris and would not be considered as HTRW material.

b. The "oil house" assuming Mr. Conner is referring to House "AA" described in the excerpts from Technical Report 13, is an area of concern. This house has an oil-fired heating system which includes an oil heater an underground storage tank (UST). The UST along with its contents and associated distribution lines will need to be removed and disposed of. The UST appears to be an unregulated tank and no closure report will be required.

8. Exhibit 4 - Enclosure D, "Excerpts from Technical Report 13, The Kentucky Project", TVA, 1951.

Document used to formulate and support assumption and recommendation listed in paragraph 7.

9. Exhibit 4 - Enclosure E, Environmental Compliance Audit Report, TVA, 30 May 1990.

This Enclosure refers to Exhibit 2; therefore, comments listed in paragraph 3.

10. Borrow/Disposal Site - Reed Crushed Stone Property.

In order to complete a comprehensive review of all properties cited in the Phase I Assessment Report, we need to review all documents and reports concerning environmental assessment. Therefore, it is recommended that an additional effort be made to obtain a copy of the Environmental Assessment Study conducted by Reed personnel in order to provide a recommendation to acquire the property or seek other available property.

11. If there are any questions regarding the above information, the point of contact (POC) for this report is Paul Muraca. He can be contacted at extensions 7140 and 5966.

John W. Hall
JOHN W. HALL
Chief, HTW/Engineering Support Branch

EXHIBIT 1

SCOPING LETTER

DEPARTMENT OF THE ARMY
NASHVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 1070
NASHVILLE, TENNESSEE 37202

24 May 1984

IN REPLY REFER TO

ORNED-P

To Whom It May Concern:

The Corps of Engineers, Nashville District, has begun a study to identify solutions to navigation problems on the Cumberland and Tennessee Rivers downstream of the Barkley Canal. As part of this effort and as required by the National Environmental Policy Act (NEPA), Nashville District will be preparing an Environmental Impact Statement (EIS) covering alternative solutions to navigation problems in this area.

Structural plans being considered include the construction of additional locking capacity at Kentucky Lock, modifications to bendways on the Cumberland River downstream of Barkley Dam, while nonstructural plans include traffic routing, and no action. The purpose of this letter is to solicit any comments you might provide regarding the environmental effects of the action, particularly those you consider most significant. Your response will be very valuable in our NEPA scoping effort, which ultimately will surface the real issues early in the planning process. Identifying the significant issues early will enable Nashville District to devote our resources to those significant issues and thus prepare an EIS that will assist decision makers in selecting the most appropriate solution to this problem.

The EIS will identify, describe, and evaluate the existing environmental, cultural, and recreational resources; explain the navigation problems of the Cumberland and Tennessee Rivers downstream of Barkley Canal and possible solutions to the navigation problems; and evaluate the impacts associated with the alternatives under consideration. Additional information on the alternatives will be specified in the EIS. This will include details on variations of the bendway modifications and possible uses of excavated materials.

The study area includes the Corps of Engineers Barkley Lock and Dam at Cumberland River Mile 30.6 downstream to the Cumberland River's confluence with the Ohio River at Mile 920.5 (Smithland, Kentucky); the Tennessee Valley Authority's Kentucky Lock and Dam adjacent to the Barkley Project at Mile 22.4 on the Tennessee River which enters the Ohio River at Mile 932.5 near

Puducah, Kentucky; and the 1.75-mile-long open navigation canal which joins Barkley and Kentucky Lakes approximately 2.2 miles upstream from Barkley Dam. This area is depicted on the enclosed map.

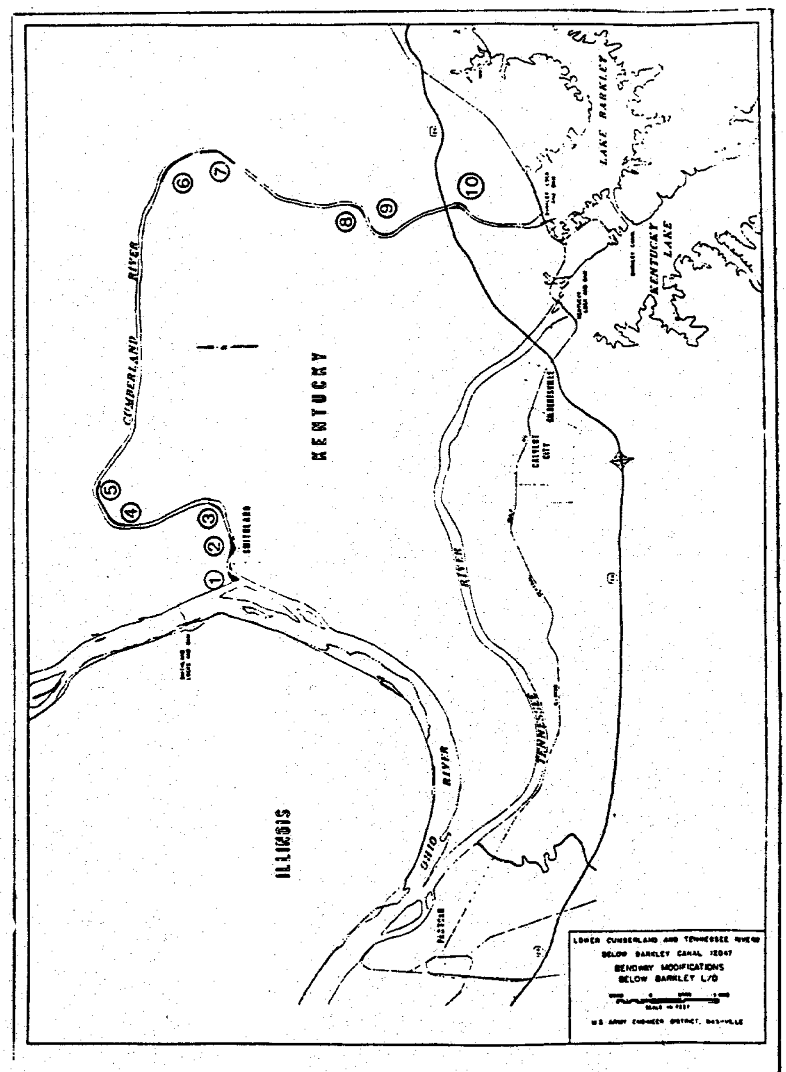
Thank you for your cooperation on this project. We would appreciate receiving comments by 09 July 1984.

Sincerely,

William T. Kirkpatrick

1 Encl
Map

William T. Kirkpatrick
Colonel, Corps of Engineers
District Engineer


ILLINOIS
KENTUCKY
CUMBERLAND RIVER
OHIO RIVER
TENNESSEE RIVER
LAKE BARKLEY
KENTUCKY LAKE
SMITHLAND
PADUCAH
CALVERT CITY
GILBERTSVILLE
1
2
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10
LOWER CUMBERLAND AND TENNESSEE RIVERS
BENDWAY MODIFICATIONS
BELOW BARKLEY L/D
U.S. ARMY ENGINEER DISTRICT, NASHVILLE

EXHIBIT 2

NOTICE OF INTENT TO PREPARE AN EIS
(FR 49 NO 170, Page 34392)

The subgroup is tasked with a comprehensive review of BMD requirements, technology, and specific critical issues impacting on program development. This meeting will be closed to the public in accordance with section 552b(c) of Title 5, U.S.C., specifically subparagraph (1) thereof, and Title 5, U.S.C., Appendix 1, subsection 10(d). The classified and nonclassified matters to be discussed are so inextricably intertwined so as to preclude opening any portion of the meeting.

The Army Science Board Administrative Officer, Sally Warner, may be contacted for further information at (202) 695-3039 or 695-7046.

Sally A. Warner,

Administrative Officer, Army Science Board.

[FR Doc. 84-23084 Filed 8-29-84; 8:45 am]

BILLING CODE 3710-08-M

Department of the Army; Corps of Engineers

Intent To Prepare a Draft Environmental Impact Statement; Cumberland and Tennessee Rivers Below Barkley Canal

AGENCY: U.S. Army Corps of Engineers, Nashille District.

ACTION: Notice of Intent To Prepare a Draft Environmental Impact Statement (DEIS) for the Cumberland and Tennessee Rivers Below Barkley Canal Navigation Study.

I. Summary

The navigation study of the Cumberland and Tennessee Rivers below Barkley Canal was authorized by Senate Committee on Public Works Resolution, dated 2 October 1972, as amended on 9 September 1982, by resolution of the Senate Committee on Environment and Public Works. The U.S. Army Corps of Engineers is preparing a feasibility report/EIS as required by the National Environmental Policy Act (NEPA) for navigation improvement alternatives within the study area. The report will identify and evaluate beneficial and adverse effects of alternatives on the resources of the study area.

The study area includes the Corps of Engineers' Barkley Lock and Dam at Cumberland River (Mile 30.6) downstream to the Cumberland River's confluence with the Ohio River at Mile 920.5 (Smithland, Kentucky); the Tennessee Valley Authority's Kentucky Lock and Dam at Mile 22.4 on the Tennessee River, which enters the Ohio River at Mile 932.5 near Paducah, Kentucky; and the 1.75-mile-long open navigation canal which joins Barkley and Kentucky Lakes approximately 2.2 miles upstream from Barkley Dam.

A. Structural plans being studied, alone or in combination, include the construction of additional locking capacity at Kentucky Lock and modifications to ten bendways on the Cumberland River downstream of Barkley Dam. Variations for providing additional locking capacity at Kentucky Lock are a 600' x 110' lock or a 1,200' x 110' lock, both located adjacent to the existing lock. An additional structural alternative would consist of modification of ten bendways coupled with traffic regulation.

B. Nonstructural alternatives include regulating traffic, congestion fees, and no action.

II. Scoping Process

The public is invited to submit written comments within 30 days of this notice, to aid in determining the issues to be covered in the DEIS. Comments have also been solicited by letter of 24 May 1984.

The EIS will identify, describe, and evaluate the existing environmental, cultural, and recreational resources; explain the navigation problems of the Cumberland and Tennessee Rivers downstream of Barkley Canal and possible solutions to the navigation problems; and evaluate the impacts associated with the alternatives under consideration. The following is a preliminary list of significant issues which would be analyzed and addressed in the DEIS:

A. Effects on fish and wildlife.
B. Effects on terrestrial habitat.
C. Effects on endangered species.
D. Effects on prime and unique farmlands.
E. Effects on aquatic habitats.
F. Effects on cultural resources.
G. Effects on water quality.
H. Effects of discharge of fill material below ordinary high water under section 404 of the Clean Water Act of 1977.

Coordination will be conducted with the US Fish and Wildlife Service (FWS) to insure compliance with section 7 of the Endangered Species Act of 1973, as amended in 1978, as well as the FWS and Kentucky Department of Fish and Wildlife under the Fish and Wildlife Coordination Act (48 Stat. 401 as amended; 16 U.S.C. 661 et seq.). The cultural resources reconnaissance for the project area has been coordinated with Kentucky Historic Preservation Officer and the State Archeologist.

Copies of the draft and final EIS will be transmitted to state and Federal agencies for comments and filed with the Environmental Protection Agency in accordance with ER 200-2-2 and 40 CFR Parts 1500-1508.

III. Scoping Meeting

No scoping meeting will be conducted unless comments indicate that one is needed to obtain adequate input from the public and from other agencies. Scoping has been undertaken by mail.

IV. Estimated Completion

The DEIS should be made available to the public in August 1985.

Questions. The District point of contact for questions concerning this project DEIS is Ms. Liz Rhodes, (615) 251-5028 or FTS 852-5028. All correspondence should be sent to the following address: U.S. Army Engineer District, Nashville, Planning Branch, Environmental Analysis Section, PO Box 1070, Nashville, Tennessee 37202.

Dated: August 21, 1984.

William T. Kirkpatrick,

Colonel, Corps of Engineers, Commanding.

[FR Doc. 84-23086 Filed 8-29-84; 8:45 am]

BILLING CODE 3710-GP-M

Intent To Prepare a Draft Environmental Impact Statement (DEIS) for a Department of the Army (DA) Permit for a 6-Mile Long Public Access Road Causeway Connecting Ebeye Island to the Islands North of Ebeye, Kwajalein Atoll, Republic of the Marshall Islands

August 21, 1984

AGENCY: U.S. Army Corps of Engineers, Honolulu District, Pacific Ocean Division, Fort Shafter, Hawaii.

ACTION: Notice of Intent to prepare a Draft Environmental Impact Statement (DEIS).

SUMMARY: 1. Description of the proposed action: The applicant, Kwajalein Development Authority (KADA), proposes to construct approximately 1.7 miles of causeway and 3.8 miles of roadway linking the island of Ebeye with the six small islands to the north. The purpose of the causeway/roadway is to provide more land area for the people of Ebeye to relieve the existing overcrowding and substandard living conditions. The proposed project requires a Department of the Army (DA) permit under section 404 of the Clean Water Act (33 U.S.C. 1344).

2. Description of reasonable alternatives: Because of the preliminary nature of the project, details on reasonable alternatives have not been finalized. The applicant is in the process of determining various alternatives, which will include:

EXHIBIT 3

SECTION 404(b)(1) EVALUATION

FINAL
SECTION 404(b)(1) EVALUATION
PROPOSED KENTUCKY LOCK ADDITION
LIVINGSTON AND MARSHALL COUNTIES, KY

1. PROJECT DESCRIPTION.

A. Location. The project area is located at Kentucky Lock and Dam at Tennessee River Mile 22.4 in Livingston and Marshall Counties, Kentucky. Kentucky Lock and Dam is located near Gilbertsville in northwestern Kentucky, 20 miles southeast of Paducah. The distance from Kentucky Lock to the confluence of the Ohio River and Mississippi River is less than 66 river miles. Barkley Lock and Dam is only 1 mile east and the Tennessee River is connected with the Cumberland River via the Barkley Canal three miles upstream of Kentucky Lock. These factors make Kentucky Lock and Dam a vital link in the inland navigation system.

B. General Description. Current plans call for construction of a 1200-ft. long by 110-ft. wide lock landward of the existing chamber. Guidewalls would extend 1200 feet downstream and 1500 feet upstream. A proposed 3200-ft. training dike in the downstream approach would extend from the downstream end of the powerhouse switchyard island parallel to the existing left margin of the navigation channel. The five mooring cells upstream of the dam would be removed and replaced with two new cells. Two new mooring cells would also be constructed downstream of the dam between the new lock and the I-24 bridge adjacent the right channel margin. Cofferdams would have to be constructed around the work site, both in Kentucky Lake and the tailwater. The Paducah and Louisville Railroad would have to be relocated on a new bridge to be constructed .3 miles downstream of the dam, and a portion of US 62/641 would have to be elevated. Relocating the highway eliminates the existing access to the powerhouse and switchyard, therefore a new access road and high level bridge would be built just upstream of the relocated railroad bridge. Four buildings are necessary to replace existing facilities in the path of the proposed lock. Material excavated from the proposed lock area and proposed railroad relocation would be used for the east side bridge approaches and for fill between locks. Excess material would be disposed in a 45 acre site located one mile north of Kentucky Lock and Dam adjacent Kentucky Highway 453 in Livingston County.

The project has many components. Only those activities which are covered by Section 404 of the Clean Water Act will be addressed in this document. Ordinary High Water (OHW) elevation above the dam is 359 feet above mean sea level and OHW below the dam is 302 feet above mean sea level.

C. Authority and Purpose. Authority for this activity comes from two resolutions. The first was adopted on October 2, 1972 by the US Senate Committee on Public Works, and the other resolution was adopted on September 9, 1982 by the US Senate Committee on the Environment and Public Works. The primary goals in designing the project are to:

a. Reduce the lockage delays (costs) to navigation traffic currently using the Kentucky-Barkley navigation system.
b. Facilitate the safe and efficient movement of traffic on the Cumberland and Tennessee Rivers through Barkley and Kentucky Locks to the level of demand projected during the economic life of potential replacement projects.
c. Minimize the adverse effects to the navigation industry of maintenance closures at Kentucky and Barkley Locks.
d. Maintain navigation traffic to the maximum extent possible during the implementation of improvements.
e. Minimize the adverse effects on Cumberland and Tennessee River recreational boating due to implementation of improvements.

D. General Description of the Dredged or Fill Material. Approximately 2 million cubic yards (CY) of material would be excavated for the new lock and about 145,000 CY would be removed from the approaches to the lock. Approximately 73,500 CY would be dredged downstream. Of this material, about 59,400 CY would be placed at Tennessee River Mile 19.7 to create replacement gravel bar habitat. The other 14,100 CY would be disposed in the upland disposal site. Should a bottom longitudinal filling system be chosen, 63,000 CY of dredging will be necessary upstream of the lock. All of this material would be disposed at the upland site. The dredged material is primarily composed of sandy clay and chert gravel. The total excavated material for the guidewall, lock pit, and approach channel inside the cofferdams is estimated to be 1,475,000 CY of common dry, 145,000 CY of common wet, and 620,000 CY of Fort Payne and Warsaw Formation rock.

A temporary cofferdam would be constructed of approximately 11,000 tons of sheet pile, and 320,000 CY of gravel fill. The lock structure would require about 450,000 CY of concrete and 3,000 tons of steel below OHW. The 1,500-ft. upper guide wall has an estimated 2,000 tons of sheet pile, 17,000 CY of gravel, and 4,000 CY of concrete, while the lower 1,200-ft. guide wall would need about 110,000 CY of concrete. It would take nearly 170,000 CY of blasted rock to build the 3,200-ft. training dike. Almost 45,000 square yards of filter fabric, 102,000 CY of riprap, and 28,000 CY of grout-subsurface treatment would used in the proposed project beneath OHW. A total of four mooring cells requiring approximately 417 tons of sheet pile and 6700 CY of gravel fill would be placed near the new lock. The relocation embankments would need about 300,000 CY of fill. About 12,000 CY of concrete and 2,000 tons of sheet pile would be used below OHW for bridge piers.

E. Description of the Proposed Discharge Site. There are four disposal sites. One is a 45 acre upland site on private lands one mile north of Kentucky Lock and Dam. This area has been highly disturbed by cutting and filling activities associated with quarrying. The second is an open water disposal site at Tennessee River Mile 19.7 near the right bank. The material would be configured in this area to create gravel bar habitat. The third sites are located on the right and left descending banks of the Tennessee River between miles 21.6 - 21.1. These sites are currently high banks eroding into the Tennessee River. The banks in these locations would be plated with stone to halt further erosion.

F. Description of Disposal Method. Sound engineering practices will be followed during all phases of project construction. The dredge material will be removed and placed mechanically.

2. FACTUAL DETERMINATIONS

"Factual Determinations" as required by Section 230.11 of the EPA Final Guidelines of 24 December 1980 include the following:

A. Physical Substrate Determinations. As stated earlier, the ordinary high water water elevation at the Kentucky Lock and Dam project is 359 MSL at the headwater and 302 MSL in the tailwater. The river channel bottom grade in the lower Tennessee River is 288 MSL. The upland site is above OHW and does not have any wetlands. This area would be revegetated in species similar to those presently there. The bottom elevation of the open water site ranges from 288 MSL to 295 MSL. The material would be placed to create a site conducive to mussel colonization.

B. Water Circulation, Fluctuation and Salinity Determinations. Water chemistry, odor, taste, dissolved oxygen levels, nutrients, and eutrophication will be affected by the dredging and fill operation. These effects will stabilize in preconstruction ranges fairly quickly in the new channel. Current patterns, river flow, and velocity and hydrologic regime will only locally be affected. There will be no discernable fluctuation of pool level and no significant project induced effects during high water periods. Salinity is not a consideration.

C. Suspended Particulate and Turbidity Determinations.

Turbidity levels will be significantly elevated locally during dredging and lock construction activities. Following construction activities, turbidity levels should return to preconstruction levels. The fill materials will be obtained from adjacent site sources. Dredged material placed in the upland site will be spread and compacted then capped and seeded to prevent sediment from returning to the river. The material placed in the open water site is large grain, inert matter. The effect on the chemical and physical properties of the Tennessee River will be insignificant. Primary production in the channel should not be significantly affected since light penetration will be modified only locally for short periods of time. The channel construction will not significantly affect filter and sight feeding organisms. The effect of fill material for construction of the lock will have no significant effect on post-construction fisheries.

D. Contaminant Determination. Construction activities for the lock will be contained within the cofferdams, therefore, no water column contaminant problems are expected. The channel modifications are in high energy areas associated with the hydropower operations of Kentucky Dam with little sediment to bond contaminants. Most of the material is large, chert gravel. Elutriate tests were not deemed necessary for this reason. No toxic spills are known to have occured in the area. According to the Preliminary HTRW Assessment (Appendix E, FEIS), there is little likelihood of any borrow areas, or backfill sites containing hazardous or toxic wastes.

E. Aquatic Ecosystem and Organism Determination. The preferred alternative will disturb a portion of the natural river bed, however, it would create replacement habitat for mussels. The Tennessee River between Miles 17.8 and 22.4 is designated by the Commonwealth of Kentucky as a mussel sanctuary. During three extensive studies, 23, 27, and 34 species of mussels have been recovered alive in the area. During the two most recent and intensive surveys, only one individual of a federally endangered mussel species has been found out of almost 16,000 animals collected. A full discussion of endangered species may be found in the Environmental Impact Statement for the Lower Cumberland and Tennessee Rivers, Navigation Feasibility Report, Kentucky Lock Addition.

F. Proposed Disposal Site Determinations. Economic, engineering, and environmental concerns resulted in the selection of the preferred sites evaluated here. Placement of the dredged and fill materials will not violate Kentucky water quality standards. There will be no effect on municipal water supplies; impacts on the recreation fishery will not be long term.

G. Determination of Cumulative Effects on the Aquatic

Ecosystem. No cummulative effects to the aquatic ecosystem of the Tennessee River could be attributed to the disposal of dredged and fill materials associated with the construction of the proposed project.

H. Determination of Secondary Effects on the Aquatic Ecosystem. No significant adverse secondary effects to the aquatic ecosystem can be identified from the proposed placement of dredged and fill materials.

3. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE.

The Environmental Protection Agency's "Guidelines for Specification of Disposal Sites for Dredged or Fill Material", published in the 24 December 1980 Federal Register were applied to the various discharges associated with construction of the Kentucky Lock Addition. No adaptations of the guidelines were applied to this project.

Because the materials to be discharged are standard in the construction industry, are non-toxic, and are primarily composed of riprap (limestone rock), concrete, gravels, and earth, there will be no significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, shellfish, wildlife, and endangered species. Life stages of aquatic and terrestrial species will not be adversely affected. No significant adverse effects on aquatic ecosystem diversity, productivity, and stability will occur. Recreational, aesthetic, and economic values will not be adversely affected. Water quality parameters will not be violated nor will the State's assigned uses of aquatic life, wildlife, and agriculture be jeopardized. The disposal operation will not violate the toxic effluent standards of Section 307 of the Clean Water Act, or harm any species protected by the Endangered Species Act.

Appropriate steps to minimize potential adverse impacts of the discharge on the aquatic ecosystem of the Tennessee River include sound engineering design. In addition, the Contractor(s) placing the fill material and the dredged material will be governed by detailed contract specifications to prevent pollution and damage to the aquatic system, as a result of construction operation and fill placement. Any losses of aquatic habitat would be offset by proper placement of riprap and creation of replacement gravel bar habitat.

On the basis of the guidelines, the proposed disposal sites for the discharge of dredged material is specified as complying with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects to the aquatic ecosystem.

Date: 12 December 1991

STEPHEN M. SHEPPARD
LTC, Corps of Engineers
District Engineer

EXHIBIT 4

U.S. FISH AND WILDLIFE SERVICE
HABITAT EVALUATION PROCEDURE LETTER

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Post Office Box 845
Cookeville, TN 38503

March 26, 1991

MAR 28 1991

Colonel James P. King
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1070
Nashville, Tennessee 37202-1070

Dear Colonel King:

This is in regard to the ongoing coordination between our respective agencies for the Lower Cumberland River Navigation Study in Livingston and Marshall Counties, Kentucky. On February 7, 1991, Messrs. Richard Tippit, Joe Cathey, and Tom Swor from the Nashville District met with Messrs. Bob Bay and Jim Widlak of my staff to discuss the present status of the study, and the information and transfer funding needs of the Service for preparation of the draft and final Coordination Act reports this fiscal year.

One issue that was raised at the meeting was whether or not the project required an incremental quantitative analysis, such as the Habitat Evaluation Procedure, of impacts to fish and wildlife resources for purposes of developing appropriate recommendations for mitigation of unavoidable losses of resources. The Service believes that the proposed construction and operation of a new lock at Kentucky Dam will result in loss of, or disturbance to, both aquatic and terrestrial habitats and could have adverse impacts on fish and wildlife populations, including Federally endangered species. Although the Service still has concerns about potential impacts to endangered mussels and wetland resources, we believe that the Corps of Engineers has selected the least environmentally damaging of the alternatives that were considered, and that, through adequate environmental planning and good coordination with Federal and State resource agencies, has addressed significant impacts to fish and wildlife resources that might occur as a result of the project and reduced the level of impacts to a point below which a Habitat Evaluation Procedure analysis would be necessary. Therefore, the Fish and Wildlife Service does not believe that a complex, expensive quantitative impact analysis is needed for the Lower Cumberland Navigation Study.

Recommendations for the protection of fish and wildlife resources and endangered species, and for mitigation for unavoidable losses of resources, will be made in our draft Fish and Wildlife Coordination Act Report and biological opinion. These recommendations will be based on Best Professional Judgement and will be supported by the best information available to our respective agencies.

We appreciate the cooperation given us by your staff throughout the planning stages of this project, and we look forward to continued close coordination.

Sincerely,

Lee A. Barclay, Ph.D.
Field Supervisor

xc:
Joe Cathey, U.S. Army Corps of Engineers, Nashville, TN

EXHIBIT 5

CULTURAL RESOURCES CORRESPONDENCE

KENTUCKY HERITAGE COUNCIL
The State Historic Preservation Office

October 5, 1990

Mr. R. J. Conner, P.E.
Chief, Engineering Division
U.S. Army Corps of Engineers,
Nashville District
P.O. Box 1070
Nashville, Kentucky 37202-1070

Re: **Preliminary Draft Report and Draft Environmental Impact Statement for the Lower Cumberland and Tennessee Rivers: Interim Feasibility Study: Kentucky Lock Addition**

Dear Mr. Conner:

Thank you for the opportunity to review the above referenced documents. In my opinion the Kentucky River Lock is eligible for listing in the National Register (see enclosed consensus determination of eligibility statement). I concur with your evaluation that the implementation of the proposed project will have an adverse effect on this property, and that the project has the potential to impact archaeological sites eligible for listing in the National Register.

My staff and I look forward to working with the Corps of Engineers on this project. If you have any questions please feel free to contact David Pollack of my staff at 502-564-7005.

Sincerely,

David L. Morgan, Director
Kentucky Heritage Council and
State Historic Preservation Officer

enclosure

KENTUCKY HERITAGE COUNCIL
The State Historic Preservation Office

CONCENSUS DETERMINATION OF ELIGIBILITY

Pursuant to the Regulations of the Advisory Council on Historic Preservation governing the Section 106 Review Process and the Identification of Historic Properties, 36 CFR Part 800.4(c)(2), the

Tennessee Valley Authority ________ and the Kentucky State
(Agency)
Historic Preservation Officer have consulted and are in agreement that

________________________ meets the criteria for
(Name and location of historic property)
inclusion in the National Register of Historic Places and shall be considered eligible for the Register for Section 106 purposes.

Statement of Significance

Kentucky Dam is significant under Criterion A & C during the period 1938-1944 under the themes of Conservation, Engineering, Transportation and Politics/Government. Kentucky Dam is the largest hydroelectric dam facility in the Tennessee Valley Authority system. The last to be completed on the main body of the Tennessee, Kentucky Dam symbolizes the achievement of an era. A product of the New Deal most visible social engineering experiment, Kentucky Dam and the TVA had a major impact on the history of a region. By harnessing a flood prone river and making electric power available in an area that lagged behind the rest of the country, T.V.A. showed that Federal government investments in a regional infrastructure could lead the way in encouraging regional redevelopment. Kentucky Dam, because of its monumentality and elegant art deco design, represents the climax of the T.V.A. era. It has natural significance under Criterion A in the area of politics/government and under Criterion C for the quality of the engineering. Under Criterion A it also has regional significance in the areas of transportation and conservation.

(Signed) David L. Morgan Date 8-15-85
(State Historic Preservation Officer)

________________ Date ________
(Agency Official)

KENTUCKY HERITAGE COUNCIL
The State Historic Preservation Office

December 5, 1990

Mr. Paul D. Robinson
Acting Chief, Engineering Division
U.S. Army Corps of Engineers,
Nashville District
P.O. Box 1070
Nashville, Kentucky 37202-1070

Re: **Proposed Lock Addition Kentucky Lock and Dam, Marshall County**

Dear Mr. Robinson:

It is the Kentucky Heritage Council's position that prehistoric and historic cemeteries should, whenever possible, be preserved in place. When this is not possible all applicable state and federal laws should be complied with. Before relocating the graves the National Register eligibility of all cemeteries must be evaluated with particular attention paid to criterion D, that is for their scientific data content. Those cemeteries determined to be eligible for listing in the National Register for their scientific data content must be removed by a professional archaeologist under the supervision of a physical anthropologist. Disinterment should be done carefully, respectfully, and completely, in accordance with proper archaeological methods. For prehistoric remains, an attempt should be made to identify the tribal affiliation of the remains. If they can be assigned a tribal affiliation then the leaders of the identified tribe should be consulted concerning how the human remains should be treated (i.e. curated in a museum or reinterred in an appropriate burying ground). Otherwise, the remains and all associated cultural materials should be curated in a museum in Kentucky.

With regards to 36CFR, Part 800.1 and 800.2, Kentucky has no resident Indian tribes living within its borders. We therefore must rely on consulting with Indian tribes outside the state on a case-by-case basis depending on the tribal affiliation of the identified human remains or archaeological site.

If you have any questions, please feel free to contact David Pollack of my staff at 502-564-7005.

Sincerely,

David L. Morgan, Director
Kentucky Heritage Council and
State Historic Preservation Officer

KENTUCKY HERITAGE COUNCIL
The State Historic Preservation Office

April 10, 1991

Mr. Paul D. Robinson, P.E.
Chief, Engineering Division
U.S. Army Corps of Engineers,
Nashville District
P.O. Box 1070
Nashville, Kentucky 37202-1070

Re: "Preliminary Field Report Kentucky Lock Expansion Area, Livingston County" By Patricia K. Anderson and Glyn D. DuVall

Dear Mr. Robinson:

Thank you for the opportunity to review the above referenced draft archaeological report. During the course of their investigation of archaeological site 15Lv204, the authors documented the presence of intact subsurface Early and Late Woodland remains. Based on the results of their study, I concur with the Corps determination that archaeological site 15Lv204 is eligible for listing in the National Register of Historic Places.

I also agree with the Corps that we are at the point where it would be appropriate to develop a Memorandum of Agreement that addresses potential adverse impacts to archaeological resources as well as the existing Lock and Dam. To this end I have enclosed a draft MOA for your review and comment. If you have any questions concerning the MOA, please feel free to contact David Pollack of my staff at 502-564-7005.

Sincerely,

David L. Morgan, Director
Kentucky Heritage Council and
State Historic Preservation Officer

enclosure

MEMORANDUM OF AGREEMENT

KENTUCKY LOCK ADDITION

SUBMITTED TO THE
ADVISORY COUNCIL ON HISTORIC PRESERVATION
PURSUANT TO 36 CFR 800.6(a)

WHEREAS, the US Army Corps of Engineers, Nashville District, (Corps) has determined that construction of a new lock at the Tennessee Valley Authority's Kentucky Lake in Livingston and Marshall Counties, Kentucky will have an effect upon the Kentucky Lock and Dam, a property eligible for inclusion in the National Register of Historic Places, and may have an effect upon other previously identified and as yet unidentified properties eligible for inclusion in the National Register of Historic Places, and has consulted with the Kentucky State Historic Preservation Officer (SHPO) pursuant to 36 CFR Part 800, regulations implementing Section 106 of the National Historic Preservation Act (16 U.S.C. 470f); **and**

NOW, THEREFORE, the Corps, the Tennessee Valley Authority, and the Kentucky SHPO agree that the undertaking shall be implemented in accordance with the following stipulations in order to take into account the effect of the undertaking on historic properties.

Stipulations

The Corps will ensure that the following measures are carried out:

Survey and Evaluation

1. Archaeological survey will be conducted of all previously undisturbed areas that will be impacted by the proposed project. Archaeological survey of these areas will be conducted in accordance with the Secretary of the Interior's **Standards and Guidelines for Archaeology and Historic Preservation Projects (Standards)** and the Kentucky Heritage Council's **Specifications for Archaeological Fieldwork and Assessment Reports (Specifications)**.

2. All sites located during the survey or previously recorded archaeological sites that are considered, by concensus opinion of the SHPO and the Corps, to have potential for listing in the National Register of Historic Places will be evaluated by archaeological testing. The testing strategy will be developed by the Corps in consultation with the SHPO, and will be submitted to the SHPO for review. The SHPO will respond to the Corps within fifteen (15) days of receipt of the testing strategy. Objections to Corps' developed testing stategies will be resolved in accordance with paragraph 9 of this Agreement.

3. A testing strategy for collecting additional information on archaeological site 15Lv204, which has been determined eligible for listing in the National Register, will be developed by the Corps in consultation with the SHPO, and will be submitted to the SHPO for review. The SHPO will respond to the Corps within (15) fifteen days of receipt of the testing strategy.

4. The testing at 15Lv204, as well as at all other archaeological sites that cannot be avoided, will be of sufficient scope to (1) make a determination of eligibility of those sites for which a determination has not been previously made, and (2) develop a research design and data recovery plan for all eligible sites that cannot be avoided. A testing report documenting the results of this work and conforming to the Secretary of the Interior's **Standards** and the SHPO's **Specifications** will be submitted by the Corps to the SHPO for review and comment. The SHPO will respond to the Corps within thirty (30) days of receipt of the testing report.

5. Should the Corps and the SHPO not concur in their opinion of the National Register eligibility of a located site, the Corps will request a determination of eligibility from the Secretary of the Interior in accordance with 36 CFR Section 63.2.

Treatment

6. Affected portions of the Kentucky Lock and Dam will be treated in accordance with the aforementioned **Standards**. Prior to any alteration of the existing lock and dam, the Corps will consult with the SHPO and the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) office of the National Park Service in the development of an appropriate documentation approach. The Corps will ensure that copies of completed documentation are made available to the SHPO and appropriate local archives. Objections to Corps' proposed treatment will be resolved in accordance with paragraph 9 of this Agreement.

7. All archaeological sites considered eligible, by concensus opinion of the Corps and the SHPO, or the

Secretary of the Interior, for listing in the National Register of Historic Places will be avoided and preserved in place whenever feasible. When preservation in place is not feasible, an archaeological data recovery plan will be implemented by the Corps.

8. The archaeological data recovery plan should identify the research questions that will be addressed by the data recovery effort, and field and laboratory methodologies that will be used to address the identified research questions. The plan, which must be consistent with the Council's Handbook, **Treatment of Archaeological Properties** and the Secretary of the Interior's **Standards** will be submitted to the SHPO for review, comment, and concurrence. Unless the SHPO objects within fifteen 15) days after receipt of the plan, the Corps shall ensure that the plan is implemented.

Dispute Resolution

9. Should the SHPO object within fifteen (15) days to any plans, specifications, or research strategies, or within thirty (30) days to any reports submitted pursuant to this Memorandum of Agreement, the Corps shall consult with the SHPO to resolve the objection. If the Corps determines that the objection cannot be resolved, the Corps shall request the further comments of the Council pursuant to 36 CFR 800.6(b). Any Council comment provided in response to such a request will be taken into account by the Corps in accordance with 36 CFR 800.6(c)(2) with reference only to the subject of the dispute; the Corp's responsibility to carry out all actions under this Memorandum of Agreement that are not the subject of the dispute will remain unchanged.

Execution of this Memorandum of Agreement by the Corps, the Tennessee Valley Authority, and the Kentucky State Historic Preservation Officer, its subsequent acceptance by the Advisory Council on Historic Preservation, and implementation of its stipulations, evidence that the Corps has afforded the Council an opportunity to comment on construction of the lock addition at Kentucky Lake and its effects on historic properties, and that the Corps has taken into account the effects of the undertaking on historic properties.

BY:________________________________Date:________________
US Army Corps of Engineers, Nashville District
District Engineer

BY:________________________________Date:________________
Tennessee Valley Authority

BY:________________________________Date:________________
David L. Morgan, Director
Kentucky Heritage Council and
State Historic Preservation Officer

ACCEPTED for the Advisory Council on Historic Preservation

BY:__________________________________Date:______________
Robert D. Bush, Executive Director

EXHIBIT 6

STATEMENT RECIPIENTS

Mailing List for Kentucky Lock Addition Public Draft

NAME	TITLE	COMPANY	ADDRESS	CITYSTATE
W. N. Whitlock	President	American Barge Line Company	P.O. Box 610	Jeffersonville, IN 47130
Jim Sweeney		Cherokee Marine Terminal	P.O. Box 8128	Nashville, TN 37207
Dave Kreutzer	General Manager, Marine Division	Consolidation Coal Company	P.O. Box 3087	Elizabeth, PA 15037-3087
Robert Brewer		Crounce Corporation	P.O. Box 6109	Paducah, KY 42001
Jack B. Herbert	President	Herbert Sand & Gravel Co., Inc.	P.O. Drawer 279	New Johnsonville, TN 37134
Ron Hunter	President	Hunter Marine Transport, Inc.	P.O. Box 90025	Nashville, TN 37209
Dan Brock		Ingram Barge Company	P.O. Box 23049	Nashville, TN 37202
Peter Kopecek	President and CEO	Ingram Materials	10 Fatherland Street	Nashville, TN 37213
Jack Lordo	Vice President	Merchants Transportation, Inc.	Suite 2800	St. Louis, MO 63101-0137
William Morelli	Assoc. Gen Counsel, Dir Gov Affairs	Midland Enterprises, Inc.	P.O. Box 1460	Cincinnati, OH 45202
Don Salsbury	Vice President and General Manager	Mid-South Towing	P.O. Drawer 790	Metropolis, IL 62960
Don Sill	Assist Vice President & Gen Manager	Paducah & Louisville Railway	1500 Kentucky Avenue	Paducah, KY 42003
Kenneth A. Wheeler	President	R & W Marine, Inc.	P.O. Box 1400	Paducah, KY 42002
Charles Coombs		Reed Crushed Stone Company, Inc.	P.O. Box 35	Gilbertsville, KY 42044
William H. Dyer	President	Tennessee Valley Towing, Inc.	3594 Lone Oak Road	Paducah, KY 42001
Richard Hommrich	President	Volunteer Barge & Transport. Inc.	P.O. Box 8241	Nashville, TN 37207
Jan Casey Jones	Executive Director	TRVA/TCWC	P.O. Box 1745, City Hall Tower	Decatur, AL 35602-1745
Don Waldon	Administrator, Tennessee-Tombigbee	Waterway Development Authority	P.O. Drawer 671	Columbus, MS 39703
Barry Palmer	Executive Director	DINAMO	Three Gateway Center	Pittsburgh, PA 15222
LCDR Pat Ryan	U.S. Coast Guard	Marine Safety Office	P.O. Box 7509	Paducah, KY 42002
Wayne Davis	Kentucky Department of	Fish and Wildlife Service	1 Game Farm Road	Frankfort, KY 40601
David Morgan	State Historic Preservation Officer	Kentucky Heritage Council	12th Floor, Capital Plaza Tower	Frankfort, KY 40601
Bill McLemore	Western Fisheries Biologist	KY Dept Fish & Wildlife Resources	Rt 4, Box 785	Murray, KY 42071
Richard R. Hannan		KY Nature Preserves Commission	407 Broadway	Frankfort, KY 40601
	Lake Barkley Resource Manager	U.S. Army Corps of Engineers	P.O. Box 218	Grand Rivers, KY 42045-4236
		Kentucky Dam Village State Park	P.O. Box 69	Gilbertsville, KY
Dr. Jim Sickel	Department of Biological Sciences	Murray State University		Murray, KY 42071
Jack Wilson	Director, Division of Water	Dept for Environmental Protection	18 Reilly Road	Frankfort, KY 40601
Dr. Gerald Miller	Environmental Assessment Branch	U.S. EPA, Region IV	345 Courtland Street NE	Atlanta, GA 30365
Ron Riberich	Economic & Community Development	Tennessee Valley Authority	Evans Building	Knoxville, TN 37902
Jack Davis	Navigation & System Modific Section	Tennessee Valley Authority	Evans Building, Room 4E 440A	Knoxville, TN 37902
George Conner	Navigation Operations	Tennessee Valley Authority	Evans Building	Knoxville, TN 37902
James Niznik		Tennessee Valley Authority	101 Market Street, 3E Signal Place	Chattanooga, TN 37402-2801
David Gengorzian	Environmental Quality Branch	Tennessee Valley Authority	Evans Building	Knoxville, TN 37902
Lynwood Smelser	Land Between the Lakes NRA	Tennessee Valley Authority		Golden Pond, KY 42231
John J. Jenkinson	Aquatic Biology Department	Tennessee Valley Authority	311 Broad Street	Chattanooga, TN 37402
Lee Barclay	Field Supervisor	U.S. Fish and Wildlife Service	P.O. Box 845	Cookeville, TN 38501
Richard Biggins		U.S. Fish and Wildlife Service	100 Otis Street, Room 224	Asheville, NC 28801
Ian Young	District Conservationist	USDA-Soil Conservation Service	P.O. Box 185	Smithland, KY 42081
Rodney Bozarth	Agent	USDA-Soil Conservation Service	301 East 12th Street, Suite B	Benton, KY 42025
Samuel C. Welch		The Ohio River Company	P.O. Box 1460	Cincinnati, OH 45201
John Puryear	District Engineer	KY Transport. Cabinet, Dist #1	PO Box 3010	Paducah, KY 42001
Loyd W. Ford	Editor/Publisher	THE LAKE NEWS	P.O. Box 498	Calvert City, KY 42029
	State Highway Engineers Office	Kentucky Dept of Transportation	State Office Building	Frankfort, KY 40622
Steve Thomas		Coal Week Newsletter	901 East Summit Hill Dr, Room 225	Knoxville, TN 37915
Dick Cirre	Executive Director	KY Port & River Development Comm	Capital Plaza Tower, 23rd Floor	Frankfort, KY 40601
Sen Wendell H. Ford			173A SROB	Washington D.C. 20510-1701
Sen Mitch McConnell			120 SROB	Washington D.C. 20510-1702
Sen Mitch McConnell		Irvin Cobb Building	602 Broadway	Paducah, KY 42001
Rep Carroll Hubbard			2267 RHOB	Washington D.C. 20515-1701
Rep Carroll Hubbard			P.O. Box 2450	Paducah, KY 42002-2450
Sen Howell Heflin			728 SHOB	Washington D.C. 20510-0101
Sen Richard Shelby			313 SHOB	Washington D.C. 20510-0103
Sen Richard Shelby			P.O. Box 6026	Huntsville, AL 35806
Rep Tom Bevill			2302 RHOB	Washington D.C. 20515-0104
Rep Tom Bevill		Room 107, Federal Building	600 Broad Street	Gadsden, AL 35901-3745
Rep Ronnie G. Flippo			2334 RHOB	Washington D.C. 20515-0105
Rep Ronnie G. Flippo			301 N. Seminary Street	Florence, AL 35630-4738
Senator Jim Sasser			363 SROB	Washington D.C. 20510-4201
Senator Al Gore, Jr.			393 SROB	Washington D.C. 20510-4202
Rep James Quillen			102 CHOB	Washington D.C. 20515-4201
Rep John J. Duncan			508 CHOB	Washington D.C. 20515-4202
Rep Marilyn LLoyd			2266 RHOB	Washington D.C. 20515-4203
Rep Marilyn LLoyd	Jay Solomon Federal Builing	Room 253	900 Georgia Avenue	Chattanooga, TN 37401
Rep Jim Cooper			125 CHOB	Washington D.C. 20515-4204
Rep Bob Clement			325 CHOB	Washington D.C. 20515-4205
Rep Bob Clement			522 U.S. Courthouse	Nashville, TN 37203
Rep Don Sunquist			230 CHOB	Washington D.C. 20515-4207
Rep John S. Tanner			512 CHOB	Washington D.C. 20525-4208
Rep John S. Tanner			345 Harrison Street	Union City, TN 38261
Wallace Wilkinson	Governor of Kentucky		State Capitol	Frankfort, KY 40601
W.R. Stewart			118 Lenoak Drive	Louisville, KY 40214

Mailing List for Kentucky Lock Addition Public Draft

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Evansville, IN 47716

Mike Jones
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Huntsville, AL 35811

Kentucky Department of
Environmental Protection
Attn: Valerie Hudson
18 Reilly Road
Frankfort, KY 40601

Bill Marett
United States Coast Guard Aux
State Liaison Officer
211 Third Ave. North
Nashville, TN 37201

United States Coast Guard
Officer in Charge
Ft. of Old Harrison Pike
Chattanooga, TN 37416-2825

Mark D. Bartlett
U.S. Dept. of Transportation
Federal Highway Admin.
P.O. Box 536
Frankfort, KY 40602-0536

Todd Inman
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Calvert City, KY 42029

Kevin Murphy
Murphy's Farms/Tiline, Ky
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Mark Shaver
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Second Coast Guard District
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