

Green River Locks and Dams 3, 4, 5 and 6 and Barren River Lock and Dam 1 Disposition Feasibility Study, Kentucky



**US Army Corps
of Engineers.**

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Main Report

Executive Summary

Green River Locks and Dams 3 through 6 and Barren River Lock and Dam 1 are navigation facilities that are no longer in use. The facilities and the pools are no longer maintained by the U.S. Army Corps of Engineers (USACE); however, the U.S. Army still has administrative accountability of the properties and USACE periodically inspects the facilities.

In 1991, the USACE conducted a study to determine if it would be feasible to restore navigation to the upper reaches of the Green River. This study found that the benefits from commercial navigation operations would be insufficient to support restoring navigation. Subsequently, in 2004 the USACE conducted a study to assess the impacts of—and make a recommendation to—deauthorize the Green River Locks and Dams 3 - 6 and Barren River Lock and Dam 1 and relinquish its interest in the property and facilities. No action was taken at that time to act on the study's recommendations; therefore, the USACE maintains the properties in a caretaker status.

The purpose of this study is to reexamine the evaluation and recommendations of the 2004 study and update the recommendations regarding the possible deauthorization and disposal of the facilities. The 1993 study, 2004 study and this reevaluation were accomplished under the original authority of Section 216 of the Flood Control Act of 1970 (P.L. 91-611). This is a general authority for the Secretary of the Army to review completed projects, when found advisable due to changed physical, economic or environmental conditions. This study also supports the objectives of the 10 June 2010 Presidential Memorandum 'Disposing of Unneeded Federal Real Estate'.

This study reevaluated current uses of the pools formed by these dams and the impacts if the pool were to be lost, either by demolition or failure of the lock and/or dam. The study reassessed the condition and safety of the structures. Four alternatives for disposition were reevaluated for each site. These are:

1. No action.
2. Dispose of the properties and structures without structural alterations with steps taken to lessen the risk of injuries associated with unauthorized entry.
3. Dispose of the properties after removing or breaching the dam (thereby removing the pools) and measures are taken to ensure the structural integrity and safety of the lock.
4. Dispose of the properties after measures are taken to ensure the structural integrity and safety of the lock and dam, without removing or breaching the dam (retaining the pools).

The study reexamined ecosystem restoration opportunities and the environmental and socio-economic impacts of each alternative, including impacts to water supply, recreation and transportation.

The recommended plan is to deauthorize all the projects and dispose of the properties after recommended construction is complete at each site. The recommended construction consists of demolishing the dam and filling the lock chamber at Green River Lock and Dam 6 and addressing stability at Green River Lock and Dam 3.

The estimated implementation cost of the recommended plan is \$14,464,981. The costs would be entirely federally funded.

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1 Introduction

The purpose of this report is to evaluate the existing navigation facilities located on the Green and Barren Rivers between Brownsville, Kentucky and Rochester, Kentucky on the Green River, and at Greencastle, Kentucky on the Barren River. These facilities include Locks and Dams 3, 4, 5, and 6 on the Green River and Lock and Dam 1 on the Barren River. These facilities are the focus of this study because they are no longer used for navigation. (There are two other navigation facilities on the Green River. Lock and Dam 1 near Spotsville, Kentucky and Lock and Dam 2 at Calhoun, Kentucky are still used for commercial navigation. This study does not include these two locks and dams.) This evaluation would be used to make recommendations regarding the deauthorization and disposal of the facilities. The goal of the study is to provide data necessary to make recommendations as to possible deauthorization of the facilities at the five lock and dam sites. Upon a favorable finding regarding deauthorization the facilities, the sites could then be disposed of using the provisions regarding surplus government property administered by the General Services Administration (GSA).

2 Study Authority and History

This study was authorized by Section 216 of the Flood Control Act of 1970 (P.L. 91-611), which is a general authority for the Secretary of the Army to review completed projects due to changed physical, economic or environmental conditions.

This study was initially funded as part of a congressional add to the FY 1995 Energy and Water Resource Appropriation Bill and the resulting study found that there would be insufficient benefits from commercial navigation operations to support restoration of navigation. Currently, the Corps of Engineers maintains the properties in a caretaker status.

In 1998, a Phase 1 cultural resources examination was undertaken of property associated with Locks and Dams 3, 4, 5, and 6 along the Green River and Lock and Dam 1 on the Barren River in south-central Kentucky. No evidence of either prehistoric or undisturbed historic-era remains was encountered and no further archaeological studies are recommended on these parcels. The locks and dams themselves are considered eligible for the National Register of Historic Places (NRHP) and the required level of documentation needed on these navigation facilities remains to be coordinated with the Kentucky State Historic Preservation Officer (KY-SHPO).

To date, the USACE has completed a brief historical overview of the Green and Barren Navigation System and prepared archival quality photo documentation of all existing structures. A report containing this information was completed in July 2000.

Additionally, an environmental baseline survey (EBS) was performed in February 2000 to determine the possibility that the sites have been contaminated by HTRW; or, that the potential exists for contamination by such materials. Some indications of the presence, or potential presence, of hazardous or toxic materials were noted at almost all of the properties surveyed during the EBS. However, based on the information reviewed and physical observations, there is no evidence that significant amounts of hazardous materials were ever stored, handled, transported, disposed or otherwise released at any of the locks and dams within the study area.

A feasibility study was performed in 2004 that recommended deauthorization and disposal of Green River Locks and Dams 3 - 6 and Barren River Lock and Dam 1. The recommended alternative consisted of demolishing the dam at Green River Lock and Dam 6 (which would restore the Green River to its natural conditions at Mammoth Cave) and filling the lock chambers at Green River Locks & Dams 3-5 and Barren River Lock and Dam 1.

A decision on how to proceed with the recommendations in the 2004 feasibility study was not reached until 2008 and project funding was not available until 2013. In the intervening 10 years since the study was complete, changes have taken place. Therefore, it is necessary to update the existing conditions at each lock and dam,

Table 2.a: Recent History Leading to the 2014 Disposition Study

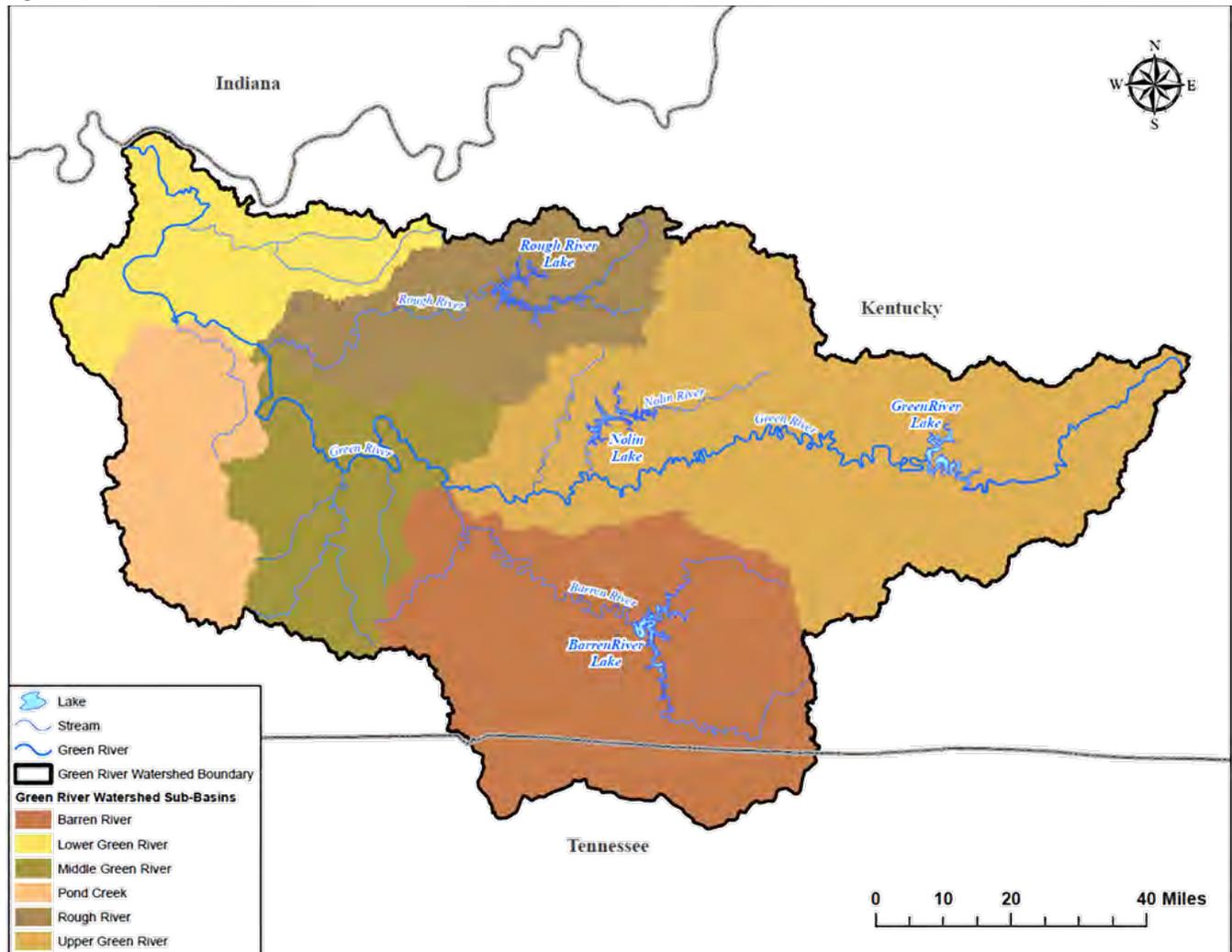
1991	Green and Barren Rivers Navigation Study (Reconnaissance) determined there were only benefits for restoring L&D 3
1993	Feasibility Study for Navigation Improvements to the Green River: Concluded that there were insufficient benefits from commercial navigation to support any improvement to the system
1998-2000	Phase 1 cultural resources examination conducted of property associated with L&Ds 3, 4, 5, and 6 along the Green River and L&D 1 on the Barren River
2000	Environmental Baseline Survey completed
2004	Submitted completed disposition study through MSC to HQ Office of Water Project Review (OWPR)
2004-2005	Disposition Study released for state and agency review
2007	HQUSACE was ready to prepare Chief's Report to submit to ASA-CW, subject to verification of completed state & agency review; no action taken
2007-2008	Local and Congressional interest in L&D 3 regarding water supply issues unrelated to navigation authorization
2008	Response from HQUSACE to Louisville District that the 2004 report requires updating
2009-2010	ARRA funding received to complete an engineering analysis at L&D 3
2013	Funding received to update the 2004 Disposition Study

recommended plan, cost estimates, National Environmental Policy Act compliance documentation, public coordination and study reviews. The Review Plan for this study was approved on 22 October 2013 and the Independent External Peer Review Exclusion Request was approved on 18 December 2013.

3 Study Area

The Green River Basin has a drainage area of 9230 square miles and stretches from west-central Kentucky into north-central Tennessee. Basin topography varies from gently rolling in the east to the moderately rugged Western Kentucky coalfields regions and then into a broad floodplain as the river enters the Ohio River just upstream of Henderson, Kentucky. Major tributaries include the Barren, Rough and Nolin rivers. See Plate 1.

Figure 3.a: Green River Watershed



4 USACE Projects in the Basin

Water resource development in the Green River Basin area consists of the navigation system as well as four multipurpose reservoirs and six local flood risk management projects. These are discussed in Sections 4.3 & 4.4.

4.1 Navigation System

The navigation system consists of six structures located on the Green and one structure each on the Barren and Rough rivers. Locks and Dams 1 to 4 on the Green River and Lock and Dam 1 on the Barren River were built by the Commonwealth of Kentucky prior to 1886 and purchased by the U. S. Government under authorization of the River and Harbor Act of 11 August 1888. Green River Lock and Dam 6 was constructed in 1906 and Lock and Dam 5 followed in 1934; Rough River Lock and Dam 1 was constructed in 1897. The system was modified and improved by the United States to provide slack water navigation from the mouth to Bowling Green at mile 30 on Barren River, mile 8 on Nolin River and Bear Creek, and to Hartford at mile 29 on Rough River.

The Lock and Dam Projects are all located in Kentucky, approximate locations (shown on Figure 4.a) are as follows:

- Green River Lock and Dam 1: Spotsville, Henderson County, Green River mile 9.1.
- Green River Lock and Dam 2: Calhoun, McLean County at Green River mile 63.1.
- Green River Lock and Dam 3: near Rochester, in Ohio and Muhlenberg Counties at Green River mile 108.5.
- Green River Lock and Dam 4: Woodbury, Butler County at Green River mile 149.0.
- Green River Lock and Dam 5: Butler and Warren Counties at Green River mile 168.1.
- Green River Lock and Dam 6: Brownsville, Edmonson County at Green River mile 181.7.
- Barren River Lock and Dam 1: near Greencastle in Warren County at Barren River mile 15.0.
- Rough River Lock and Dam 1: near Livermore in Ohio County at Rough River mile 7.0. The lock and dam were deeded to the City of Hartford, Kentucky, on 03 August 1960.

Table 4.a: Pertinent Data for the Green and Barren Rivers Locks and Dams

L&D No.	year built	mi above mouth	lock			pool	
			width	length	lift	upper	lower
Green 1	1956	9.1	84.0	600.0	11.8	349.1	337.3
Green 2	1956	63.1	84.0	600.0	14.0	363.1	349.1
Green 3	1836	108.5	35.8	137.5	17.3	380.4	363.1
Green 4	1839	149.0	35.8	138.0	16.4	396.8	380.4
Green 5	1934	168.1	56.0	360.0	15.2	412.0	396.8
Green 6	1906	181.7	36.0	145.0	9.2	421.2	4112.0
Barren 1	1934	15.0	56.0	360.0	15.2	412.0	396.8
Rough 1	1897	7.0	27.0	123.0	9.9	373.3	363.4

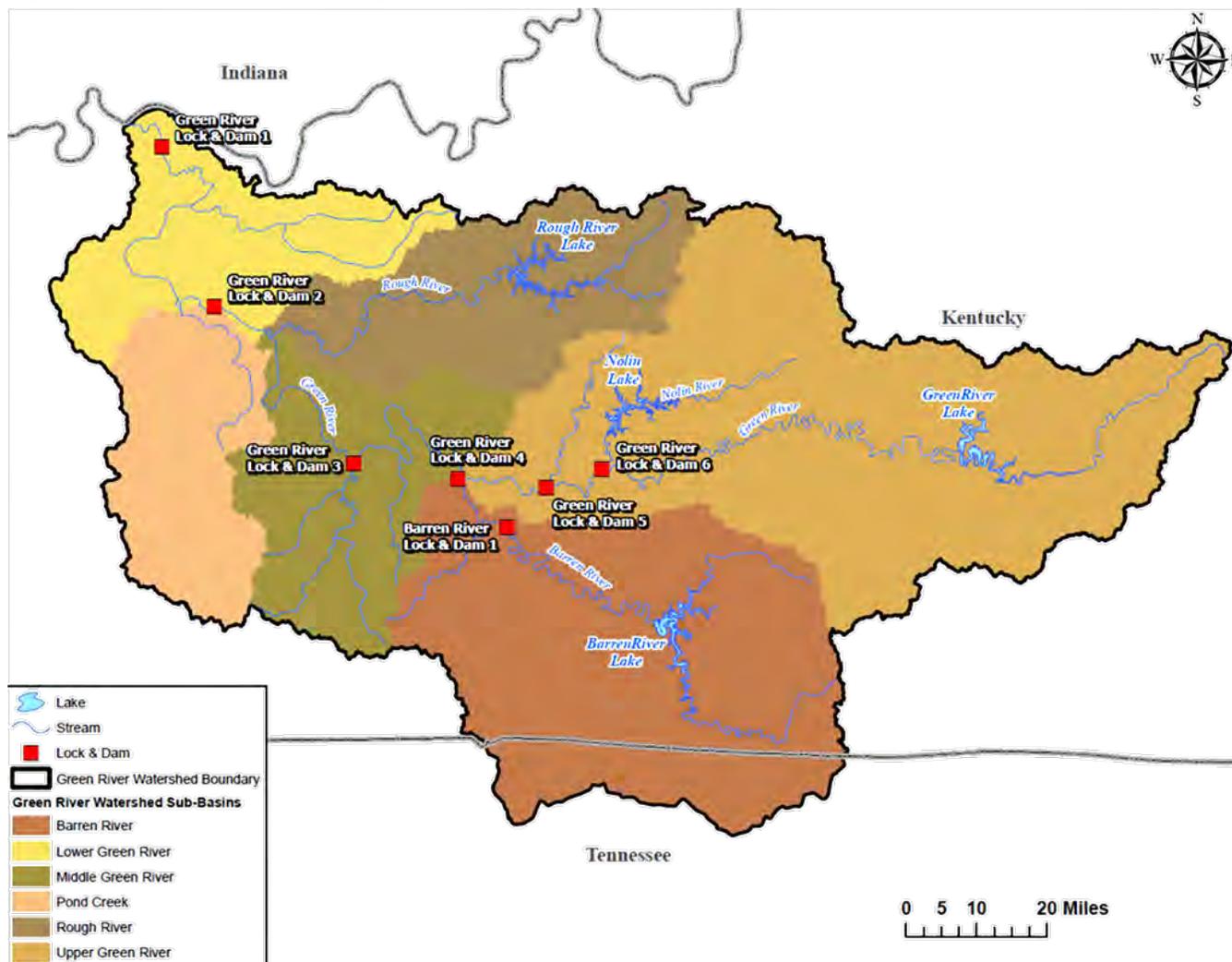
4.2 Multipurpose Reservoirs

The primary purpose of the Green River Basin reservoirs (shown on Figure 4.a) is managing flood waters; however, they are also used for recreation, water supply and managing natural resources. These multipurpose projects are integral units in the system for flood risk management for the Ohio and Mississippi rivers. Estimated damages prevented by the completed projects exceed \$200 million since their completion. Communities along the banks of the Green River are afforded significantly lower annual flood risk by the four reservoirs in the upper basin.

The multipurpose reservoir system consists of the following projects:

- Barren River Lake: Allen, Barren and Monroe Counties, Kentucky, on the Barren River.
- Green River Lake: Taylor, Adair and Casey Counties, Kentucky on the Green River.
- Nolin Lake: Edmonson, Grayson, Hardin and Hart Counties, Kentucky, on the Nolin River.
- Rough River Lake: Breckinridge, Grayson and Hardin Counties, Kentucky, on the Rough River.

Figure 4.a: Green River Watershed Navigation and Multipurpose Reservoir Locations



4.3 Flood Risk Management Projects

The Rough River and Barnett Creek Channel Improvements were authorized by the Flood Control Act of 1944. Work consisted of approximately 9 miles of clearing the channel and the banks of the lower 64 miles of the river. The project was turned over to local authorities for operation and maintenance in July 1961.

4.4 Continuing Authorities Projects

Congress has provided nine legislative authorities under which the Secretary of the Army, acting through the Chief of Engineers, is authorized to plan, design and construct certain types of water resource projects without additional and specific congressional authorization. These authorities are called the Continuing Authorities Program (CAP) when referred to as a group. The authorities are for specific purposes. Continuing Authority Projects in the study area are as listed:

- Cypress Creek Channel Clearing (§¹208). Under the authority of §208 of the Flood Control Act of 1954, the USACE may study and construct in-stream clearing and snagging projects to reduce damage caused by

¹ The § symbol is shorthand for “section”; §205 is equivalent to “section 205”.

overbank flooding. The Cypress Creek project consisted of clearing an average 120-foot minimum width from the mouth of Cypress Creek to Pond River mile 18.4. The project was completed in November 1963.

- Panther Creek Channel Clearing and Cleaning (§205). Under the authority of §205 of the Flood Control Act of 1948, the USACE may study and construct works to manage the risk posed by overbank flooding. The Panther Creek project was completed in 1968 and consisted of clearing and snagging the channel and constructing a berm on each side averaging 20 feet in width from the mouth upstream to the confluence of the two forks at mile 22.6, upstream 13 miles on the North Fork and upstream 10 miles on the South Fork.
- Green River-Calhoun-Streambank Erosion (§14): Section 14 of the Flood Control Act of 1946 provides authority to stabilize riverbank erosion where that erosion threatens public facilities. Two separate §14 projects were completed in this area. Both projects are located on the right bank of the Green River at Calhoun, just upstream of Green River Lock and Dam 2. The first involved placing riprap on the bank to protect a sewer line. The second project was upstream of the first, and consisted of placing riprap on the bank to protect the City of Calhoun's municipal water intake. The projects were completed in 1994.
- Green River Handy Riparian Restoration Project (§1135) Under the authority of §1135 (b) of WRDA 1986, USACE may plan, design and build modifications to existing USACE projects, or areas degraded by USACE projects for the purpose of restoring aquatic habitats for fish and wildlife. Green River Lake eliminated out-of-bank flooding in the project area. Prior to impoundment, the project area experienced out-of-bank flooding with each 5-year storm event. Today, out-of-bank flooding occurs only with an approximate 100-year event. In the thirty plus years of Green River Lake's existence, there has been no flooding of the bottomlands. This severely restricts natural recruitment and reforestation, as floods are the primary method of seed dispersal for many bottomland hardwood trees. Without this regeneration the riverbanks have lost natural protection against wind and wave action, runoff and other factors contributing to erosion. To restore this natural process, approximately 800 linear feet of riverbank was stabilized using a combination of plantings, rock protection and two bend way weirs. These weirs were specifically designed for this location to intercept flow from Russell Creek and redirect it toward the middle of Green River. The project was completed in 2003.

5 Prior Studies and Reports

- 1953 Survey Report - A review of prior reports titled, Review of Prior Reports on Green and Barren Rivers, Kentucky for Navigation, recommended modernization of the lower 103 miles of the Green River consisting of (a) reconstruction of Lock and Dam 2, (b) reconstruction of Dam 2, (c) partial rehabilitation of Dam 1, (d) widening the channel to 200 feet and deepening it to 9 feet, and (e) the provision of guide fenders and cells at restricted bridge openings. As a result of this favorable report, the lower river modernization was authorized and construction completed in 1956.
- 1960's Studies – USACE undertook a review of the Green River Navigation System pursuant to study authorities provided by resolution of Committee on Public Works of the United States Senate and House of Representatives. Multiple studies investigated alternatives for replacing and modernizing Green River Locks and Dams 3, 4, and 5; and Barren River 1 including the provision for a 9-foot depth channel. Constructing a multipurpose reservoir near Rochester, Kentucky was also considered. Estimated benefit/cost ratios ranged from 0.54 to 1.0 and significant opposition to the proposed Rochester Lake developed. Commodity and market studies conducted during this time frame included a coal market study by the Paul Weir Company of Chicago, Illinois with stages 1 and 2 of the study completed in 1966; and studies conducted by the Battle Memorial Institute of Columbus, Ohio, which addressed primarily commodities other than coal.
- Failure of Dam 4 - On 24 May 1965, Dam 4 on the Green River failed. In July 1965, a report on the failure was completed which concluded that insufficient economic justification existed to repair the dam.
- Rehabilitation of Dam 1 - A 1968 Report of Rehabilitation of Dam 1 on the Green River recommended that USACE construct a new concrete filled cellular sheet pile dam just downstream of the existing structure. The work was completed in 1970.
- Green and Barren River Environmental Impact Statement - Completed in December 1975, the Final Environmental Impact Statement, Continued Operation and Maintenance, Green and Barren Rivers, Kentucky was completed pursuant to the National Environmental Policy Act of 1969.
- 1978 Preliminary Feasibility Report, Green and Barren Rivers, Kentucky - This study investigated numerous alternatives for restoring navigation to the Upper Green River System, including the previously considered Rochester Lake Alternative. The alternatives in this study were found to be marginally beneficial; therefore, the study was terminated.
- 1990 Reconnaissance Study, Green and Barren Rivers Navigation – This reconnaissance study was completed in March 1990 and focused on reestablishing nine-foot draft navigation to Bowling Green, Kentucky by replacing Lock and Dam 3 at Rochester, Lock and Dam 4 at Woodbury and renovating Lock and Dam 1 on the Barren River to reach Bowling Green with four barge tows. Navigation-only and multipurpose lake projects with navigation were evaluated. The reconnaissance study concluded that replacement of Lock and Dam 3 at Rochester was the only potentially economically feasible alternative.
- 1993 Feasibility Study for Navigation Improvements to the Green River - This study focused on improvements to the existing facilities located at Lock and Dam 3 at Rochester, Kentucky. The study found that there were insufficient benefits from commercial navigation to support any type of improvement.
- 1994 Green and Barren Rivers Flood Control Reconnaissance Study - This screening level study effort was conducted to determine any possible candidate sites for further study under the Continuing Authority Program. No sites were identified.
- 1995 - Green River - McLean County Kentucky Reconnaissance Study - This study evaluated flooding within McLean County, Kentucky and its county seat located at Calhoun. No structural improvements were identified, but the study did produce additional flood and stream data and new floodplain mapping. The

referenced data was provided to the local sponsor (Office of the McLean County Judge Executive) in the form of a Geographical Information System (GIS) database.

- 2000 Green River Lake Reoperation (MOU between The Nature Conservancy (TNC) and USACE) - Green River Lake Reoperation became the first USACE project to receive approval for permanent operation for ecological benefits downstream of a USACE reservoir as part of the Sustainable Rivers Project (SRP), a joint effort of USACE and TNC. The SRP is executed under a Memorandum of Understanding (MOU) between USACE and TNC signed in 2000, and was sparked by an initial collaboration to restore native biodiversity of the Green River by changing the water release schedule for Green River Dam. In 2002, USACE began a three-year trial period of reoperating the Dam to mimic natural conditions; the reoperation was made permanent in 2005.
- 2004 Green River Locks and Dams 3, 4, 5 and 6 and Barren River Lock and Dam 1 Navigation Disposition Study - The study evaluated current uses of the pools formed by these dams and the impacts on those uses if the pool were to be lost, either through demolition or failure of the lock and/or dam. The study assessed the condition and safety of the structures. The recommended plan was to deauthorize all the projects and dispose of the properties after recommended construction is completed at each sites. The recommended construction consisted of demolishing the dam at Green River Lock and Dam 6 and filling the lock chambers at Green River Lock and Dams 3 - 6 and Barren Lock and Dam 1 with engineered stone.
- 2011 Green River Lock and Dam 3 (Rochester Dam) - Rochester Dam was found in several previous studies to no longer fulfill the authorized purpose of commercial navigation on the Green River. However, pool three above the dam is the primary water supply for several communities in the area. This study developed three dam stabilization options for local governments to consider. Other work for the study included an in-depth environmental analysis of the river habitat as well as a mussel survey that included a search for any endangered species that could potentially be impacted by any future construction. The study was prepared under the authority provided by §22 of the Water Resources Development Act (WRDA) of 1974, known as the Planning Assistance to States program.
- 2011 Green River Section 729 Initial Watershed Assessment (IWA) - The Green River IWA identified existing conditions within the watershed, highlighted the major water resource problems of the watershed and discussed the potential scope and objective of a Final Watershed Assessment based on a shared vision for the watershed. Throughout the planning process, water quality and enhanced community engagement were identified as immediate needs in the watershed. Sedimentation, agricultural inputs, incompatible land use and water supply are some of the predominant water quality concerns in the watershed. The conclusion of the IWA recommended drafting a watershed assessment management plan to define the objectives of the Final Watershed Assessment.

6 Existing Conditions

6.1 Green River Lock and Dam 3

Green River Lock and Dam 3 is located at Green River mile 108.5 near Rochester, Kentucky. Locally, the facility is also known as the Rochester Dam. The normal pool elevation is 379.9. The pool formed by this dam either borders or lies within Ohio and Butler Counties. Towns located near the river in Pool 3 are Rochester, Cromwell, Aberdeen, Morgantown and part of Woodbury. Plate 2 shows the area around the pool formed by Lock and Dam 3.

Built in the period from 1833 to 1838 to enhance commercial navigation, the facility consists of a 353 foot long fixed-crest overflow dam (rock-filled timber crib structure covered with derrick stone) and a 35.8 foot by 137.5 foot stone masonry navigation lock. The dam abuts a shallow rock outcrop that also serves as part of the fixed-crest overflow control for the upper pool. In 1848, a mill was constructed on the rock bluff at the left abutment, and a portion of the rock outcrop was excavated to create a “mill race” that channeled water to power the mill. The facilities were acquired by the federal government in 1895.

In 1981, USACE closed the lock to navigation and placed the facility in “caretaker” status. Since the 1960s, USACE has undertaken studies to evaluate the feasibility of a replacement lock and dam near the existing site, as well as studies to address the condition of the existing structures. However, no documented repairs have been performed on the lock since 1977 (replacement of the lower gates and installation of new operating mechanisms) and no documented repairs have been performed on the dam since 1966 (derrick stone placed on the timber face of the dam).

The esplanade, although cracked, can still adequately support light cars and trucks. The lock walls, constructed of cut stone masonry, are in good condition. Their alignments are straight and there are no signs of settlement. There are some root intrusions under the first layer of limestone blocks on the riverside. The riverside lock wall is losing some of its limestone blocks on the downstream end of the wall. This loss is far enough away from the downstream miter gates that it should not have an affect on the gates’ structural integrity. The portions of the miter gates that are visible appear to be in good condition. The gates are not mitered completely due to some debris stuck between them but the pool has not been compromised due to heavy siltation and woody vegetation growth in front of the upstream and especially the downstream gates. All structural members look sound, and all connections and welds appear to be intact. There are some visible signs of the metal rusting and pitting, but their condition is good overall. The upstream guide wall is made of timber cribbing and appears to be in good condition. The downstream guide wall is made of timber cribbing and is leaning at approximately 20 degrees. It appears that this wall would collapse if it were not for the roots of some adjacent trees holding it up. If the wall were to collapse, it would not have an impact on the rest of the project. The dam appeared intact and stone fill was observed for the entire length of the dam.

Photo 6.a: Green River Lock 3 (2013)



The property at Green Lock and Dam 3 is adjacent to residential and agricultural areas, and as such, has good accessibility. At this site, the lockmaster’s house and a maintenance shed are still standing. The roof systems and walls are intact and the buildings are not in any danger of imminent collapse. On several occasions, transients have taken up residence in these structures. Fishermen have been observed out on the lock walls fishing in the tailwater of the dam. Since routine maintenance is no longer

performed on the project, significant siltation occurs around the miter gates and in the lock approaches. Considerable debris has accumulated in the area downstream of the lower miter gates, and the upstream approach has heavy siltation.

A Phase I cultural resources reconnaissance undertaken on this facility encountered no evidence of either prehistoric or undisturbed historic archaeological remains. Through documentation of the history and architecture of the facility the lock and dam components are considered by the USACE to be eligible for listing on the NRHP as part of a navigation system. These two reports (Appendix A) were coordinated with the KY-SHPO, who concurred in the findings of the reports and that the lock and dam components are considered eligible for the NRHP.



Photo 6.b: Green River Dam 3 (2013)

6.2 Green River Lock and Dam 4

The Green River Lock and Dam 4 is located at Woodbury in Butler County, Kentucky at Mile 149.0 on the Green River. Plate 4 shows the area of the lock and dam and the area up to Lock and Dam 5. The normal pool prior to 1965 was 396.1. This pool either borders or lies in Butler and Warren Counties. Part of Woodbury and the community of Glenmore are located near the river in Pool 4.

The facilities were constructed by the Commonwealth of Kentucky in the 1830s and acquired by the federal government in 1886. The navigation structure consists of a 35.8 foot by 137.5 foot lock; and timber cribbing and rock fill dam approximately 409 feet long. The dam failed in May of 1965 and the lock was closed to traffic at that time. The property and all buildings were deeded to the City of Woodbury, which now operates the Green River Museum in one of the former lockmaster's dwellings. The plan and cross-sections of the lock and dam are shown on Plate 5.

In the 48 years since the breach occurred, the upstream approach to the lock has silted in completely and has significant tree growth. From a stability standpoint, the majority of the project is in satisfactory condition. The exception to this observation is a portion of the upstream guard wall, which is in a condition of failure. This wall has settled and rotated landward significantly, and is in a state of total failure. The walls of the lock, constructed of cut stone masonry, show signs of significant surficial weathering with weeds and brush growing through the walls in several places. However, the walls do not show evidence of settlement or movement that would cause



Photo 6.c:
Green River
Lock and
Dam 4
(2013)

concern from a stability standpoint. The miter gates appear to be in good condition. The majority of the dam is gone due to the breach. Significant siltation has occurred downstream of the right bank abutment of the dam which has stabilized the remaining portion of the dam.

As with Green River Lock and Dam 3, the site is readily accessible and there is ample evidence of unauthorized activity at the site. Fishermen venture across the lock gates to the riverward lock wall to fish.

A Phase I cultural resources reconnaissance undertaken on this facility encountered no evidence of either prehistoric or undisturbed historic archaeological remains. Through documentation of the history and architecture of the facility the lock and dam components are considered by the USACE to be eligible for listing on the NRHP as part of a navigation system. These two reports (Appendix A) were coordinated with the KY-SHPO, who concurred in the findings of the reports and that the lock and dam components are considered eligible for the NRHP.

6.3 Green River Lock and Dam 5

The Green River Lock and Dam 5 is located at Mile 168.1 in Warren and Butler Counties, Kentucky. The pool is 13.6 miles long, and the normal pool elevation is 411.0. This pool either borders or lies within Butler, Warren, and Edmonson Counties. The City of Brownsville is located along the river in Pool 5. Plate 6 shows the Pool 5 area.

The first navigation lock at the site was constructed in 1900. A new lock and dam were built in 1933-1934, and the new lock was put in operation in 1934. The old lock and dam, slightly downstream of the present lock and dam, were removed in 1934. The locks were deactivated in August 1951. The lock is 56 feet wide by 360 feet long. The dam is 301.2 feet long. Plate 7 shows a plan and cross sections of the lock and dam.

The lock walls and dam, which are concrete, appeared to be stable and in good condition. There is some minor weathering and spalling of surficial concrete, but the lock walls do not show evidence of settlement or movement that would cause concern from a stability standpoint. This lock system also used two sheet pile cells as part of the riverside upstream guide walls. These cells, which are linked together by walkway planks, appear to be in very good condition. The miter gates are also in good condition. The miter gates are holding back a significant amount of silt and tree growth. At least $\frac{3}{4}$ of the upper gates and over half of the lower gates are covered by silt. There is a two-story concrete operations building immediately adjacent to the locks. It is also in good condition. This is one of the two projects in this study that are relatively modern and were operated hydraulically rather than manually.

Photo 6.d: Green River Lock and Dam 5 (2013)



This site is relatively remote, not being located near any population centers. However, there is evidence that the site is visited regularly, despite its remoteness. Fishing from the riverside lock wall appears to be a regular activity, since remnants of campfires, trash, and discarded fishing tackle have been observed at the site.

A Phase I cultural resources reconnaissance undertaken on this facility encountered no evidence of either prehistoric or undisturbed historic archaeological remains. Through documentation of the history and architecture of the facility the lock and dam components are considered by the USACE

to be eligible for listing on the NRHP as part of a navigation system. These two reports (Appendix A) were coordinated with the KY-SHPO, who concurred in the findings of the reports and that the lock and dam components are considered eligible for the NRHP.

6.4 Green River Lock and Dam 6

The Green River Lock and Dam 6 and its pool are located entirely in Edmonson County at Brownsville, Kentucky at Green River Mile 181.7. The normal pool elevation is 420.9. There are no urban areas in Pool 6, most of which lies within the Mammoth Cave National Park. Plate 8 shows the Pool 6 area.

The lock and dam were built in 1904-1905 and put into operation in 1906. USACE ceased operation of the lock in 1951. The lock chamber is 36 feet wide by 145 feet long and the dam is 220 feet wide. The lock and dam are constructed of concrete on timber piles. In 1989, a z-pile cutoff wall was constructed upstream and across the upper miter gate to reduce seepage around the gates. This wall was braced with a strut to the miter gates, and the gates were encased in concrete up to elevation 421. This work was performed to stop major seepage through the lock chamber, and end-around seepage occurring through the right bank. Plate 9 shows a plan view and cross sections of the lock and dam.

From a stability standpoint, there are some items of concern related to this lock and dam. The most notable concern is the seepage through and around the upstream land-side lock wall and sheet pile cutoff located upstream of the upstream miter gates. Low areas/sinkholes are still evident in the right bank directly behind the lock wall, indicating seepage is still occurring. Also, water was observed seeping under the land wall into the lock chamber. However, the seepage observed in the lock chamber adjacent to the land wall has been noted as clear for the last several inspections. Previous inspections have noted seepage through the wall at monolith joints just above the water surface (the lock chamber is always at lower pool as the lower miter gates are no longer in place); however this was not as obvious during the December 2013 inspection due to high water.

Drought in the summer of 2001 led to the unusual condition of having the upper pool actually slightly below the top of the dam, meaning that no water was flowing over the dam. This was the only time in recent history when direct observations of the dam were possible. Observations made at that time revealed that seepage was occurring through the structure at the dam/abutment interface on the left bank and at the dam/river wall interface. Seepage was also observed through a horizontal crack approximately 30 feet in length in the weir about 1.5 feet below the crest. Seepage was occurring through the z-pile wall, which appears to be in a partial state of failure.

At the end of the lower approach wall, where the wall runs into the bank, the wall appears to have settled and rotated outward at the top. Upstream, the upper approach wall directly above the sheet pile cutoff wall is in a state of failure. The downstream miter gates have been cut off and are lying in the chamber. The upper gates were encased in concrete to a height equal to the dam.

The USACE had an interest in maintaining the pool behind Lock and Dam 6 during the early operational years of the Nolin Lake and Dam Project. Lock and Dam 6 backed a pool up to the tailwater levels of the Nolin Lake and Dam. In a worst-case scenario, the pooled water would serve to dissipate the energy associated with maximum discharges released through the Nolin Lake and Dam facility. In the 1980's, a design study and reconstruction of the tailwater areas of Nolin Lake were completed, making the interface with the Lock and Dam 6 pool no longer an operational consideration at the upstream end.

The pool from Lock and Dam 6 backs up into the Department of the Interior's Mammoth Cave National Park. The water from the navigation pool has arrested natural cave development for nearly 100 years. See Section 11.7 for further description of the pool's effect on cave development.

A Phase I cultural resources reconnaissance undertaken on this facility encountered no evidence of either prehistoric or undisturbed historic archaeological remains. Through documentation of the history and architecture of the facility the lock and dam components are considered by the USACE to be eligible for listing on the NRHP as part of a navigation system. These two reports (Appendix A) were coordinated with the KY-SHPO, who concurred in the findings of the reports and that the lock and dam components are considered eligible for the NRHP.

Photo 6.e:
Green River
Lock and Dam
6. Bottom-
left: the
downstream
miter gates
are lying at
the foot of the
lock chamber.
(2013)



6.5 Barren Lock and Dam 1

The Barren River Lock and Dam 1 is located in Warren County, Kentucky at Barren River Mile 15. The normal pool elevation is 412.0. The pool extends upstream to approximately River Mile 30, in Bowling Green. This pool is located entirely within Warren County. Bowling Green is the only community on the Barren River in Pool 1. Plate 10 shows the Pool 1 area.

The Commonwealth of Kentucky built the original lock and dam in 1841. The federal government acquired the facility in February 1886. A new lock was built in 1933-1934 at the same site, and was put into operation in September 1934. The locks are constructed of concrete, the newer lock being founded on timber piles. The dam is timber crib construction founded on timber piles with a concrete cap. The old lock is 35.6 feet wide by 143 feet long. The newer lock is 56 feet wide by 360 feet long. The dam is approximately 276 feet long. The lock closed to traffic after the failure of the dam at Green River Lock and Dam 4, in May 1965, since navigation beyond that point was not possible. Plate 11 shows a plan view and cross sections of the lock and dam.

The lock walls, which are concrete, are in good condition, with the exception of minor weathering. The downstream side of the dam has some surficial damage, as indicated by zones of turbulent water flow. The lock walls do not show evidence of settlement or movement that would cause concern from a stability standpoint. The miter gates are in good condition. The two-story control tower is missing windowpanes and has evidence of bullet holes, but there is no exposed reinforcing and the overall condition of the concrete is good. The lock and guide walls are in good condition. The old lock chamber was put out of service by placing a concrete cutoff wall across the upstream sill, and putting rock fill in the rest of the chamber. This concrete cutoff wall appears to be in good condition. There is not much evidence of the rock fill in the chamber.

The downstream concrete apron of the dam has been undermined. Some sections of the apron have shifted and settled due to loss of the underlying fill. The void under the downstream apron of the dam has been there for quite some time. During the recent inspection (December 2013) the lower pool was up on the downstream apron and significant water was flowing over the dam so signs of under-seepage could not be observed. The dam is constructed from timber cribbing and rock fill with a concrete cap founded on timber piling. From the observations made during the recent inspection (December 2013) it was concluded that the dam is not likely to fail in the foreseeable future.

A Phase I cultural resources reconnaissance undertaken on this facility encountered no evidence of either prehistoric or undisturbed historic archaeological remains. Through documentation of the history and architecture of the facility the lock and dam components are considered by the USACE to be eligible for listing on the NRHP as part of a navigation system. These two reports (Appendix A) were coordinated with the KY-SHPO, who concurred in the findings of the reports and that the lock and dam components are considered eligible for the NRHP.

Photo 6.f: Barren River Lock and Dam 1 (2013)



7 Real Estate Interests at the Sites

Appendix F contains a complete description of the real estate holdings and the history of the sites. Table 7.a summarizes the real estate holdings at each site.

Table 7.a: Real Estate Interests at Each Lock and Dam Site

L&D No.	Right Bank	Left Bank	Comments
Green 3	6.72 ac, Ohio Co.	4.99 ac, Muhlenberg Co.	5.01 ac on left bank transferred to US Dept. of Interior in 1980.
Green 4	none	0.01 ac, Butler Co. (gauging station)	26.74 ac have been disposed of
Green 5	27.07 ac, Butler Co.	5.21 ac, Warren Co.	2.45 ac on the left bank and 10.49 on the right bank have been disposed of.
Green 6	18.0 ac, Edmonson Co.	4.19 ac, Edmonson Co.	6.22 ac on left bank have been disposed of.
Barren 1	16.63 ac, Warren Co.	none	11.47 ac previously disposed of.

8 Disposal of United States Real Property

In order to dispose of all of the land at the projects listed in Table 7.a on page 16 to include the lock and dam structures, legislation would have to be enacted to deauthorize the project. If deauthorization legislation does not set out specific guidelines for conveyance, the property will be disposed of in accordance with the Federal Property and Administrative Services Act of 1949 and Army regulations. The disposal process begins with an estimate of the current fair market value. The Department of Defense has a delegation of authority from the U.S. General Services Administration (GSA) that allows the USACE to dispose of excess real property whose estimated fair market value is less than \$50,000. This delegation does not preclude the GSA from disposing of property on behalf of the USACE.

8.1 Disposal by GSA

A Report and Recommendation of Excess (RROE) is prepared and submitted, along with environmental and cultural resources clearances, through the Great Lakes and Ohio River Division to USACE headquarters for approval. When approval of the RROE is received, the USACE would screen the property with the Department of Defense for interests. If there is no Department of Defense interest, a SF 118 - Report of Excess Real and Related Personal Property would then be prepared and forwarded to the appropriate GSA regional office. GSA would perform the disposal including screening with the Department of Housing and Urban Development, and Federal, state and local governments.

Early coordination with GSA's Real Property Utilization and Disposal Division indicates the properties will most likely be accepted for disposal "as is", subject to physical inspections by GSA staff. The USACE would remain the responsible landholding agency during the disposal process.

8.2 Disposal by the USACE

A Report and Recommendation of Excess (RROE) is prepared and submitted, along with environmental and cultural resources clearances, through the Great Lakes and Ohio River Division to USACE headquarters for approval. After approval of the RROE is received, environmental and cultural resources requirements are completed and the property is screened with nondefense federal agencies, the Department of Defense, Department of Housing and Urban Development, Federal, state, and local governments for any interest. If no interest is expressed, the property would be disposed of by negotiated or competitive sale to the public.

Any conveyance of the property would be by quitclaim deed. Conveyance would be made subject to existing easements for public roads and highways, public utilities, railroads and pipelines; and to reservations, exceptions and any other outstanding rights contained in or referred to in patents issued by the United States of America. The United States would not retain any liability for the property disposed of.

The Louisville District real estate administrative costs for processing a disposal action are estimated at \$10,000.

9 Non-Navigation Facilities in the Pools

9.1 Water Intakes in the Green River Pools

Kentucky Revised Statute 151.120 defines public water as: "Water occurring in any stream, lake, groundwater, subterranean water or other body of water in the Commonwealth which may be applied to any useful and beneficial purpose is hereby declared to be a natural resource and public water of the Commonwealth and subject to control or regulation for the public welfare." Therefore, the Commonwealth of Kentucky regulates all water withdrawals, diversions or transfers of any surface, ground or spring water averaging more than 10,000 gallons per day.

These withdrawals must be permitted, with the exception of water used in the generation of electricity and single domestic users. This requirement applies even if the land surrounding the water source is privately owned (including underground reservoirs, irrigation, storage or sediment impoundments). In addition to the traditional uses of drinking water and industrial process water, this includes such diverse uses as deep mine and quarry dewatering operations, golf course withdrawals for irrigation, trout farms, artificial waterfalls, coal prep plant recycling ponds, etc.

Water intakes on the Green River that are located within the project study area are shown in Table 9.a. The depth of intake is given as the approximate depth below the water surface at normal summer levels.

The Butler County Water District provides water service for about 10,000 people out of the total population of 12,000. The Butler County Judge Executive was interviewed about the water intakes. He reported that the water district had investigated using wells for their water supply, but had found that they would not be a viable option.

During public meetings and coordination with local authorities, it was discovered that there are a number of individuals with agricultural irrigation intakes in these pools. No agricultural intakes have been permitted by the state. So while these intakes may exist, there is no data on their locations or the quantity of water withdrawn.

The USACE's authority over the waters of the Green and Barren Rivers extends to navigational servitude and regulatory authority under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Under this authority, the USACE has granted permits for all of the water intake structures that the state has also permitted. Until the 1960's the primary purpose of the regulatory program was to protect navigation. Since then, as a result of laws and court decisions, the program has been broadened so that it now considers the full public interest for both the protection and utilization of water resources.

The locks and dams were built for the sole purpose of facilitating navigation, and providing water for water supply is not an authorized purpose of these projects. Therefore, the USACE has no obligation at all to maintain these pools to enable users to withdraw water. During discussions with local communities about alternative plans, they were reminded that the USACE had no authority or obligation to maintain the pools for water supply.

Table 9.a: Water Intakes in the Green and Barren Pools

intake owner	river mile	max withdrawal	water supplier	# intakes @ depth
Bowling Green Country Club	Barren 30.2	0.3 MGD	No	Unknown
Bowling Green Municipal Utilities	Barren 37.8	20.0 MGD	Yes	Unknown
Ohio County Water District	Green 130.6	1.9 MGD	Yes	1 @ 10 ft 1 @ 15 ft
Perdue Farms Inc.	Green 130.5	3.0 MGD	Yes*	1 @ 8 ft
Butler County Water System	Green 142.2	0.5 MGD	Yes	1 @ 3 ft
Morgantown Utilities	Green 143.3	0.972 MGD	Yes	1 @ +8 ft ** 1 @ 6 ft
Edmonson County Water District	Green 181.3	1.0 MGD	Yes	1 @ 5 ft 1 @ 8 ft 1 @ 12 ft

*Provides water to Ohio County Water District.

**This is the high water intake. At normal low water it is approximately 8 feet above the water surface.

9.2 Ferries in the Green River Pools

There are four ferries operating in the navigation pools of the Green River. Table 9.b summarizes them.

The ferries' approaches at all of these locations are also used for boat ramps by recreational boaters.

Table 9.b: Ferries in the Green River Pools

Location	River Mile	Road Served	Operation	Pool
Rochester	108.9	Hwy 369	Private	Green L&D 3
Reeds Ferry	123.2	Hwy 269	Public (county)	Green L&D 3
Houchins Ferry	185.1	Houchins Ferry Rd	Public (National Park Service)	Green L&D 6
Green River Ferry	197.2	North Entrance Rd/ Green River Ferry Rd	Public (National Park Service)	Green L&D 6

9.3 Boat Ramps in the Green & Barren Pools

The Green and Barren Rivers are used by recreational boaters as well as by commercial fishermen fishing for mussels, catfish, and buffalo fish. Table 9.c lists the boat ramps in the study area.

Table 9.c: Boat Ramps in the Green & Barren Pools

river mile	bank	location/nearest feature	pool	comments
Green River Mile 134.5	right	1.4 miles upstream from Cromwell	Green River L&D 3	
Green River Mile 149.6	both	just upstream from Woodbury	Green River L&D 4	At the confluence of the Green and Barren Rivers; was once a ferry crossing.
Green River Mile 166.9	left	just upstream of State Hwy 185	Green River L&D 4	This is the Arrue Young boat ramp.
Barren River Mile 14.5	right	Greencastle	Green River L&D 4	
Green River Mile 168.4	both	Glenmore	Green River L&D 5	Was once a ferry crossing.
Green River Mile 175.6	left	37° 9'7.52"N, 86°18'19.71"W	Green River L&D 5	Private boat ramp
Green River Mile 180.3	left	Brownsville City Park	Green River L&D 5	
Barren River Mile 30.1	left	Bowling Green	Barren River L&D 1	

9.4 Canoeing on the Green & Barren Rivers

Canoeing may be found anywhere on the Green and Barren Rivers, but it occurs most frequently in Mammoth Cave National Park. According to National Park Service officials, boat and canoe use in the National Park was 7,762 in 1995, 9,589 in 1996 and 9,092 in 1997. Canoe and boat use data for 2013 – 2004 is available in Table 9.e. Table 9.d lists the canoe liveries operating in the study area.

Table 9.d: Canoe Liveries in the Study Area

Big Buffalo Crossing 100 River Rd. Munfordville
Cave Country Canoe 856 Old Mammoth Cave Rd. Cave City
Green River Canoeing Inc. 1145 S. Main Brownsville

Table 9.e: Observed Boat and Canoe Use on the Green River

calendar year	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
vessels	11,157*	12,689	10,969	11,955	9,545	11,877	12,275	7,976	11,854	10,033

*Estimated the data for Dec-13 was not available; usage was projected based on the December average from 2012 - 2004.

These numbers are approximate and were counted by the river ferry operators in Mammoth Cave National Park.

10 Plan Formulation

The period from 2004 to 2014 has brought about many changes in the Green and Barren navigation system and within the US Army Corps of Engineers. Firstly, when the 2004 disposition study was completed, the 2003 reoperation study and modifications to the operations of the Green River Multipurpose Reservoir project had just been implemented. The purpose of the reoperation was to release water from the reservoir in a manner that would mimic seasonal flooding that would have occurred prior to impoundment of the Green River.

A probable side effect of this seasonal flooding has been faster accumulation of sediment in the lock chambers and around the lock and dam facilities. This accumulation of sediment would aid in establishing herbaceous and woody vegetation from the latent seed bank, which would stabilize the freshly accumulated sediment. This process would work in an annual cycle of flooding, sediment deposition, vegetation establishment and sediment stabilization. It is anticipated that this cycle would continue until equilibrium is reached, meaning that the sediment had accumulated until it is equal to or higher than the flood stage, providing little further opportunity for accumulation. More sediment accumulating more rapidly is expected to obviate the need for much of the riprap that was recommended in the 2004 study.

USACE treats risk as the composite of probability and consequences. In the case of the 2004 study, the recommended plan sought to minimize the consequences to the maximum extent possible - to change the physical conditions to prevent a specific type of accident - a fall off a lock wall. In the 2014 reevaluation, USACE acknowledges that risk is inherent to life, especially in and around bodies of water. Therefore, the recommendations for this reevaluation sought to minimize the probability of an accident to persons who enter upon a lock and dam site without legal authority (e.g. fan fencing barricades to prevent access to miter gates) – while understanding that all risks at these sites cannot be fully and completely mitigated.

10.1 Problems and Opportunities

The problems that this study seeks to address are as follows:

- Five locks and dams on the Green and Barren Rivers are no longer used for navigation. The USACE remains responsible for them despite their being no federal interest in repairing, operating or maintaining them.
- The facilities have fallen into disrepair.
- Use of the pools formed by the dams has expanded beyond the original authorized purpose of navigation.

The opportunities that this study seeks to take advantage of are:

- Altering structures to lessen the risk of injuries associated with unauthorized entry upon the sites.
- Restoring natural river flow wherever practical to provide ecosystem restoration opportunities.
- Identifying potential interested parties to facilitate disposal if the facilities are deauthorized.

10.2 Alternatives

The following alternatives are largely the same as reported in the 2004 Green and Barren Disposition study. However, the recommendations regarding how safety is considered at the lock chambers does deviate from the 2004 study. Specifically, Alternative 4 in the 2004 study recommended that at all of the locks would be filled with riprap in order to stabilize the gates and to lessen the risk of injuries associated with unauthorized entry.

Additionally, stone would be placed around the outside of the lock chamber in order to mitigate the risk posed by the vertical condition of the lock structures. For comparison purposes, the cost of the original recommendation was updated and is presented in Table 10.a.

During the course of the report update and site visits to each lock and dam the Project Delivery Team explored measures other than filling the lock chambers to address safety at the lock and dam sites. While this measure does reduce some risk associated with the vertical condition of the sites, injuries associated with unauthorized entry upon the properties could be possible. The PDT feels that other actions can be implemented at the lock chambers, such as providing egress from the chambers or installing barricades on the land side miter gates, are expected to lessen the risk of injuries associated with unauthorized entry at a reduced cost. Fan fences were used as the basis for estimating cost throughout this report; however, during design and construction another barricade may prove more effective or cost efficient.

The various studies conducted beginning in 1965 and running through 1993 established that there would be insufficient benefits from commercial navigation to support any type of navigation improvements to these facilities. Therefore, no alternatives that involved the restoration of commercial navigation to the study area were considered. Further, since the authorized purpose of the projects is commercial navigation, it was concluded that these facilities are no longer serving their authorized purpose and that it would be in the federal interest to deauthorize the projects and dispose of the properties. Therefore, the alternatives considered included no action and various options for disposal.

To facilitate the formulation of alternative plans, the 2004 technical investigations were reevaluated in the course of this study. Reports on these investigations are contained in the appendices. The investigations and analyses in these appendices contain information on the following:

- A. An investigation of the cultural resources

Table 10.a: Updated Costs of the 2004 Recommended Plan

	Item	Cost
Green L&D 3	Fill Lock Chamber with Rip-Rap	\$ 1,218,285.00
	Traffic Control	\$ 29,658.00
	Road Improvements	\$ 194,278.00
	Subtotal	\$ 1,442,221.00
Green L&D 4	Fill Lock Chamber with Rip-Rap	\$ 1,141,082.00
	Traffic Control	\$ 29,658.00
	Road Improvements	\$ 102,490.00
	Subtotal	\$ 1,273,230.00
Green L&D 5	Fill Lock Chamber with Rip-Rap	\$ 4,889,608.00
	Traffic Control	\$ 29,658.00
	Road Improvements	\$ 553,196.00
	Subtotal	\$ 5,472,462.00
Green L&D 6	Chamber and along Approach Wall	\$ 1,240,722.00
	Demo Dam	\$ 7,962,612.00
	Road Improvements	\$ 121,520.00
	Subtotal	\$ 9,324,854.00
Barren L&D 1	Fill Lock Chamber with Rip-Rap	\$ 5,255,691.00
	Traffic Control	\$ 29,658.00
	Road Improvements	\$ 1,088,560.00
	Subtotal	\$ 6,373,909.00
Houchins Ferry	Traffic Control	\$ 11,913.00
	Erosion Control	\$ 5,425.00
	Extend Southeast Ferry Ramp	\$ 373,946.00
	Extend Northwest Ferry Ramp	\$ 370,261.00
	Subtotal	\$ 761,545.00
Green River Ferry	Traffic Control	\$ 11,913.00
	Erosion Control	\$ 5,425.00
	Dredge Ferry Canal	\$ 215,240.00
	Subtotal	\$ 232,578.00
	Real Estate	\$ 80,185.00
	Planning, Engineering, and Design	\$ 4,209,076.00
	Construction Management	\$ 1,737,755.00
	Total	\$ 30,907,815.00

- B. Detailed data on the structures' condition, and measures necessary to maintain structural integrity
- C. Hydrologic and hydraulic analyses for the Green and Barren Rivers in their existing condition and with the dams removed, either by demolition or failure
- D. An environmental assessment of all of the alternatives considered, including no action
- E. An environmental baseline survey investigating the possible presence of hazardous, toxic, and radiological waste
- F. A complete investigation of the real estate interests at each site
- G. Coordination with the U.S. Fish and Wildlife Service
- H. Detailed cost estimates for the 2014 recommended plan and updated costs for the 2004 recommended plan

Each alternative was considered for every site. A more detailed description of each alternative follows.

10.2.1 Alternative 1

With this alternative, the locks and dams would remain in federal ownership in caretaker status. The USACE would remain responsible for the facilities. At present, the USACE spends approximately \$10,000 per year for all of the sites to inspect the properties and maintain "No Trespassing" signage. While trespassing is prohibited, there is ample evidence that the sites are frequently used, even those that are relatively remote. With a "no action" alternative, this would likely continue. A "no action" alternative would mean that the federal government would not make any alterations to the facilities.

10.2.2 Alternative 2

With this alternative, the properties would be disposed of without any structural alterations to the locks and dams. However, to impede access to the river side lock wall, the land side miter gates would be gated. The USACE would remain responsible for the properties until ownership is transferred. Any action necessary to complete the real estate transfer would be included, but no construction is included in this alternative (other than installing the barricades). After hazard mitigation is complete, the property would be disposed of through normal GSA and USACE procedures.

10.2.3 Alternative 3

With this alternative, the dams would be removed and the lock chambers would be filled with materials from the demolition of the dam. Excess dam materials would be disposed of onsite along the lock approaches or in an approved offsite location. After dam removal is complete, the property would be disposed of through normal GSA and USACE procedures.

10.2.4 Alternative 4

With this alternative, the locks would be modified to ensure stability and pool retention before disposal. To impede access to the river side lock wall, the land side miter gates would be gated. After construction is complete, the property would be disposed of through normal GSA and USACE procedures.

10.3 Green River Lock and Dam 3

The Green River Lock and Dam 3 (known locally as Rochester Dam) site is one of the most accessible sites in the study area. There are improved roads right up to the lock chamber, and the lock is located very near Rochester, assuring that visitation to the site would be high. In spite of the "No Trespassing" signage, the site is very popular with local residents. The primary safety concern with Lock and Dam 3 is access to the dam side of the lock wall by traversing the closed miter gates. Accumulated sediment and vegetation in the chamber is substantial enough to act as a means of egress and it is expected for sedimentation to continue in the lock chamber provided the upstream and downstream miter gates remain closed/mitered.

Because of the public use of this site, alternative 1, the no action plan would not lessen the risk of injuries associated with unauthorized entry. Consequently, this alternative was dismissed.

Alternative 2 addresses the safety concerns by installing barricades on both the upstream and downstream miter gates, as well as updating signage at the site. Taken alone, this alternative does not fully address the long-term stability of the upstream miter gates and consequently the pool impounded by Lock and Dam 3.

If alternative 3 were implemented, it would reduce the public safety concern, since filling the lock chambers would lessen the risk of injuries associated with unauthorized entry. However, removing the dam at this site would have serious effects on the public water supply. Five water intakes for potable water are located in the Green Lock and Dam 3 pool. These intakes serve three water districts providing water for the residents of Ohio County, Butler County, Muhlenberg County and the City of Morgantown. Additionally, the Perdue Farms processing facility also has a water intake at river mile 130.4 in Cromwell for their poultry processing facility. Appendix C contains a profile showing the effects of removing the dam on the pool level. These intakes would not function if the dam were removed. Replacing these intakes with wells is not a viable alternative, as there is not an aquifer capable of meeting the demand.

Water supply is not an authorized purpose of this project; however, over the years, the local communities have come to depend on the pool impounded by this dam for their water supply. Therefore, the project has become a vital public resource. Because of this, removal of the dam would not be recommended.

For this site, alternatives 2 and 4 are recommended. This would consist of constructing a concrete plug against the upstream face of the upstream miter gates in order to maintain the pool in the long-term. Also, to block access to the dam side lock wall, the upstream and downstream miter gates would be gated with barricades on the land side miter gates.

In 2004, the county judge executives of Muhlenberg, Ohio, and Butler Counties were contacted about the study and interviewed about possible ownership of the properties. All of the officials agreed that the interests of the water supply of their communities were of such prime importance that they could not allow the ownership of this dam to fall into private hands. They indicated that the communities involved have a strong interest in ownership of the properties.

In further support of these entities assuming ownership of the site, the City of Morgantown, Butler County Water System, Inc. and the Ohio County Water District created the Rochester Dam Regional Water Commission (RDRWC) in June 2013. These three public utilities, in collaboration with local county governments, created the RDRWC pursuant to KRS 74.420 to 74.520. for the purpose of ensuring and providing an adequate and dependable supply of water. Specifically, these groups are focused on maintaining the pool formed by Green River Lock and Dam 3. In a letter dated 2 November 2012 the RDRWC expressed their interest in exploring the possibility of taking ownership of the property from the United States Government, if and when the USACE disposes of it. Prior to disposition, the RDRWC also communicated that they are interested in obtaining a lease or easement on the property in order to make repairs to the dam as recommended in Stantec's "Engineering Documentation Report" dated 18 May 2011. After construction is complete, it is recommended that the property be disposed of through the normal USACE and GSA property disposal procedures; however, local entities should be contacted to inquire about their interest in acquiring the properties.

10.4 Green River Lock and Dam 4

The Green River Lock and Dam 4 site is also very accessible to the public. The lock is located in the town of Woodbury and there are improved roads right up to the lock chamber. Also, there is a Green River museum open to the public in one of the former lockmaster's quarters on the site.

Because of the public use of this site, alternative 1, the no action plan would not lessen the risk of injuries associated with unauthorized entry. Consequently, this alternative was dismissed.

Alternative 2 addresses the safety concerns by installing barricades on both the upstream and downstream miter gates, as well as updating signage at the site. In addition, the accumulated sediment and vegetation in the chamber is substantial enough to act as a means of egress along with the deterioration of the lower downstream miter gates. Sedimentation is expected to continue in the lock chamber provided the upstream and downstream miter gates remain closed/mitered.

The dam at Green River Lock and Dam 4 failed in May 1965; therefore, alternative 3, which includes removal of the dam, is not considered a viable alternative. While remnants of the dam still exist at the site, they do not have a significant effect on the pool level. Additionally, the dam remnants are not considered a safety hazard.

For this site, alternative 2 is recommended. After installing the barricades, the property would be disposed through normal GSA and USACE property disposal procedures. The original lockmaster's quarters, as well as ancillary structures would remain at the site, which provides the opportunity for additional historical interpretation.

10.5 Green River Lock and Dam 5

The site of Green River Lock and Dam 5 is much more remote than the others locks and dams; however, that does not appear to preclude visitation to the area.

Because of the public use of this site, alternative 1, the no action plan presents concerns for public safety as people would still be able to access the dam side lock wall via the upstream and downstream miter gates. Consequently, this alternative was screened out.

Alternative 2 addresses the safety concerns by installing barricades on both the upstream and downstream miter gates, as well as updating signage at the site. In addition, accumulated silt and vegetation in the lock chamber is substantial enough to provide a means of egress along with the deterioration of the lower downstream miter gates. Sedimentation in the lock chamber is expected to continue provided the upstream and downstream miter gates remain closed/mitered.

If alternative 3 were implemented at this site, it would reduce the public safety concern, since the lock chamber would be filled; which would lessen the risk of injuries associated with unauthorized entry. However, removing the dam at this site would affect the public water supply. Three intakes for potable water are located in the Green Lock and Dam 5 pool. These intakes are all located at river mile 181.4, Brownsville, Kentucky. Edmonson County Water District operates these three intakes. As with the water supply facilities in the Green River Lock and Dam 3 pool, wells are not a viable alternative.

Water supply is not an authorized purpose of this project, yet over the years nearby communities have come to depend on the pool impounded by this dam for their water supply. Local residents also use this pool for recreation. Because the pool is serving as a vital public resource for water supply, this alternative would not be recommended.

For this site, alternative 2 is recommended. After the installation of barricades is complete, the property would be disposed through normal GSA and USACE property disposal procedures. The primary reason for leaving the dam in place is to preserve the pool formed by the dam in order to ensure continued operation of the water supply intakes for the Edmonson County Water District in that pool. Officials from the communities using the pool for water supply have indicated that there is strong local interest in assuming ownership of the property and structures.

Once the minimal work to lessen the risk of injuries associated with unauthorized entry at the site is complete and the project is deauthorized, no additional work or continued maintenance is recommended.

10.6 Green River Lock and Dam 6

The site of Green River Lock and Dam 6 is fairly accessible to the public. There is a public road that leads directly to the site. As with the other sites, there is evidence of trespassing. At a public meeting in Brownsville in March 2000, the majority of attending members spoke of visiting the site often to fish, even walking across the gates to fish from the riverward lock wall. Other people spoke of visiting the site to sit and watch the water go over the dam. All of these people knew that they were visiting government property where trespassing was not allowed, yet they were not deterred.

An additional concern regarding public safety involves the proximity to Mammoth Cave National Park. Several canoe liveries operate on the Green River in the park. Recreational canoeists in the park are most often not local residents, and have no prior knowledge of the location or mere existence of the dam. The dam poses a very real danger for canoeists who get misdirected in the park. Anyone going over the dam in a canoe or kayak could suffer a serious or even fatal injury. In 1998, the USACE received a letter from a family who narrowly avoided going over the dam. They just managed to get their canoe to shore before becoming caught in the current of the water flowing over the dam.

Of all the projects examined in this study, Green River Lock and Dam 6 is in the worst condition by far. From a stability standpoint, there are some items of concern. Most notable are the seepage conditions through and around the upstream land lock wall and sheet pile cutoff located upstream of the upstream miter gates. Low areas/sinkholes are evident in the right bank directly behind the lock wall, indicating seepage is occurring. Also, water was observed seeping under the land wall into the lock chamber. However, the seepage observed in the lock chamber adjacent to the land wall has been noted as clear for the last several inspections. Previous inspections have noted seepage through the wall at monolith joints just above the water surface (the lock chamber is always at lower pool as the lower miter gates are no longer functional); however this was not as obvious during the December 2013 inspection due to high water.

Seepage is also occurring under the dam. If seepage is occurring through the stone fill and timber cribbing underlying the weir, it could dislodge and remove the stone fill. If piping of the foundation material accompanies the seepage, a substantial loss of material may lead the dam to collapse, or to progressive widening of an open seepage path eventually causing a portion of the dam to wash out. These types of dam failure could occur either progressively or catastrophically.

While problematic, seepage through the structure is considered a lesser concern, but may be an indicator of a larger problem. Seepage paths through the concrete portions of the structure open paths for corrosive agents to attack structural elements. As the structure corrodes, new areas are continually exposed to corrosion and the structure is progressively deteriorated. Ice could form from water perched in cracks at low pool levels, which promotes cracking and spalling. Further, open seepage paths facilitate scour, which would result in breaching the dam. These failure scenarios are expected to occur progressively over a long period. Continual widening of seepage paths may also indicate relative displacement between the dam and its abutments.

If the lock wall fails, flow would be diverted toward the abutment, significantly widening the existing channel or even creating a new channel. Bank erosion would be severe as the river is redirected and flows increase. The water supply intake for the Edmonson County Water District is 1500 feet downstream of the dam on the right bank. The intake could be affected in several ways, depending on the water level and flooding conditions present at the time of failure. If the river flow returns to the center of the existing channel shortly downstream from the failed abutment, then large amounts of sediment could be deposited over the intake. This is likely as

the flowing water meets the stiller water impounded by Lock and Dam 5. On the other hand, if the water is still flowing swiftly at the edge of the bank, as it could be in a flood situation, the water intake could be undermined by erosion caused by the swiftly flowing water.

In addition to the damage that could occur at the water intakes, failure of the lock and/or dam would have serious consequences for the ferries. The loss of the Lock and Dam 6 pool would likely render the ferries unusable except during high water. These two ferries are vital transportation links in the region, and their loss would have substantial impacts to the community.

The National Park Service established Mammoth Cave National Park in 1941. At the time the land in Edmonson County was acquired, the NPS began operating the ferries to preserve the transportation links in the county. The NPS has been operating and maintaining these ferries continuously since that time. Table 10.b shows the use of the ferries in recent history.

To calculate the economic impact that loss of the ferries (either through demolition or failure of the dam) would have, the costs of the additional time and operating expenses due to the necessity of using alternate routes were calculated. For each of the ferries, the mileage between common origins and destinations was calculated for the route using the ferry and for the most likely route one would use without the ferry. Average values of mileage with and without the ferries were calculated, and the additional time required to travel the detour was calculated. Using this value of additional time and the annual median family income for Edmonson County, Kentucky, the annual value of the extra time needed to traverse common routes without the ferry was calculated. Additionally, the annual costs of operating vehicles for the increase in mileage for the “without ferries” condition were calculated. The annual costs of using alternate routes are summarized in Table 10.c.

Because of the significant public safety concerns at this site and the consequences of failure of the structures, alternatives 1 and 2, no action and disposal without modification, are not considered viable alternatives.

If alternative 3 were implemented, it would nearly eliminate public safety concerns at the site. Removing the dam would eliminate the possibility of failure of the abutment, since it is the differential head of water being maintained by the dam that is driving the seepage through the abutment and under the lock chamber. Additionally, removing the dam would eliminate the possibility of recreational canoeists and kayakers going over the dam. Filling it with a combination of riprap, rock and concrete removed from the dam would eliminate the possibility of accidental falls into the lock chamber. Filling around the lock chamber and into the river from the riverward lock wall would lessen the risk of injuries associated with unauthorized entry.

If alternative 3 were implemented, the ferry crossings in Mammoth Cave National Park would be affected. Modifications would be necessary to allow the ferries to continue operations after dam removal. The two ferries affected, Green River Ferry and Houchins Ferry, would require different types of modifications. The Houchins Ferry would require extending the launching ramps on each end farther into the river. The Green River Ferry would require that a channel be dredged across the river to allow the ferryboat adequate draft to operate.

Public support for removing the dam is questionable unless provisions are made to keep the ferries operational. Views opposing the cessation of the ferry operation have been expressed in public meetings, in coordination with Edmonson County officials and in the media.

The study team examined several options for each ferry before selecting a preferred option for the ferry alterations. For the Houchins Ferry, a bridge was eliminated

Table 10.b: Average Annual Ferry Traffic

	2012	2011	2010	2009	2008
Green River	86760	78590	88676	89394	79772
Houchins	8254	9733	7732	9062	8077
TOTAL	95014	88323	96408	98456	87849

from consideration early because of the cost of construction. Additionally, it was not felt that the traffic counts at this

Table 10.c: Estimated Annual Costs of “Without Ferries” Condition

	FY99	FY14 (Rounded)
Value of additional time required to drive alternate route	\$56,000	\$93,000
Increased operating costs to drive alternate route	\$107,000	\$177,000
Total annual costs	\$163,000	\$270,000

site would justify constructing a bridge. The team looked at alterations to the ferryboat to allow it to operate with a shallower draft in addition to altering the approach ramps. It was determined that extending the length of ramps on the boat itself was not structurally feasible. The boat could not support the additional weight of a longer ramp or additional stress placed on it by having a weighted ramp farther from the center of the boat. Therefore, that option was eliminated. The team determined that the best way to accommodate the lower pool was to extend the concrete aprons of the approach ramps farther into the river.

For the Green River Ferry, the team examined a number of options for maintaining the depth necessary for operation. This ferry is located at a relatively high spot in the river. Therefore, the same options examined for Houchins Ferry would not work. Extending the approach ramps was not feasible, as there still was not adequate draft to float the boat. As with the Houchins Ferry, extending the ramps on the boat itself was not structurally feasible. Because of the high usage of this ferry, the team also considered a bridge over the Green River at the site. The team contacted the National Park Service to discuss a possible bridge. In 1988, the Federal Highway Administration, at the request of the NPS, investigated the feasibility of a bridge to replace the Green River Ferry. Their study examined 5 alternatives. The lowest cost alternative was to replace the ferry with a bridge at the same location. This alternative required the least amount of construction of new roads. The cost of this alternative, in 1988 dollars, was \$20,000,000. Because of the cost, a bridge was eliminated from consideration. Another option considered was a low-head dam that would maintain a pool at the ferry crossing. The cost of this option was \$725,000. However, the National Park Service did not want to have the continuing responsibility of maintaining a small dam for the sole purpose of providing adequate depth for the ferry. They also felt that the dam could back water into the cave, and returning the cave to its natural hydrologic conditions is of paramount importance to the NPS. Since the NPS would have the responsibility to maintain any structure installed to facilitate ferry operation, their objections led to the elimination of this option. The final option examined was dredging a channel in the river bottom sediments at the ferry location to accommodate the draft of the ferryboat. This channel would require maintenance dredging yearly. This alternative was also the least costly.

The NPS fully supports removing the dam for a variety of reasons. Running 27 miles through the park, the Green River is one of North America’s most biologically diverse rivers. Additionally, the cave itself holds the world’s most diverse cave ecosystem. Removing the dam would enhance the cave ecosystem by restoring the river’s natural condition in the cave; would enhance the ecosystem of the river by returning it to its former free-flowing state; and would enhance recreational opportunities available through canoeing, kayaking and camping. It is expected that both Edmondson County and the City of Brownsville will see a positive economic benefit from the removal of Dam 6. Habitat for Threatened and Endangered Species would be restored as well. During public review of the 2004 report, the USACE received a letter of support from the National Park Service. A portion of that letter follows:

The position of the National Park Service since 1951 has been and continues to be that the LD6 pool should be eliminated. The continued presence of this structure is the single greatest unresolved ecosystem management issue at Mammoth Cave National Park. The current situation has tremendous direct adverse effects on resources and resource values within Mammoth Cave National Park....

Elimination of the LD6 pool would provide a number of benefits. The suitable habitat for a number of Federal threatened and endangered species and a large number of state list species would be

increased.... Elimination of the pool would provide for restoration of the ecosystem and improve its long-term sustainability. Removal of the pool would also result in benefits for research and understanding of the longest and most renowned cave system in the world.

Any negative environmental effects related to removal of LD6 and modification of ferries within the park appear to be only the minor and short-lived impacts related to construction activities. Conversely, the benefits are expected to be vast and long lasting. Therefore, we concur with the recommendation to remove LD6 and modify the ferry landings within the park and with the proposed Finding of No Significant Impact (FONSI).

If alternative 4 for disposition were implemented, it would partially address the safety concerns at this site. Filling in and around the lock chamber would lessen the risk of injuries associated with unauthorized entry.

Additionally, leaving the dam in place does not address the stability concerns caused by the seepage around and under the locks. Therefore, efforts would have to be undertaken to stabilize the lock and abutment. Seepage control would be best achieved by installing a positive means of cutoff upstream of the dam and into the right bank. The best way to achieve cutoff would be to install a driven sheet pile wall. For the dam, the sheet piling would need to be driven upstream of the concrete berm, which would be about 40 feet upstream of the crest. By terminating the sheets at elevation 421 (the crest of the dam), much of the seepage through the structure would also be controlled. The area between the sheet pile wall and the face of the crest could be filled with stone and capped with a thick concrete cap. This type of repair has been used successfully to combat seepage on similar structures on the Kentucky River. Extending a sheet pile wall into the right bank would cut off any open seepage paths and make the length of the new seepage path sufficiently long that the exit gradient at the end of the seepage path does not allow for piping. The estimated cost of this construction is \$3,308,300.

Because alternative 3 addresses the public safety concerns most completely, it is the recommended plan for Green River Lock and Dam 6. After the construction is complete, the property would be disposed through normal GSA and USACE property disposal procedures. Edmonson County has expressed an interest in the 18 acres of property on the right bank, which they would like to acquire for recreational development. The National Park Service already owns the property on three sides of the United States property on the left bank. Also, the National Park Service may have interest in the existing road on the left bank, as it abuts their property.

10.7 Barren Lock and Dam 1

The site of Barren River Lock and Dam 1 is rural, making it somewhat more remote than the other locks and dams in this study, except for Green River Lock and Dam 5. Having to walk through farm fields to get to the right abutment of the lock and dam does not seem to discourage visitation to the area.

There is also some canoeing in this pool. However, most of the canoeing is done by local residents rather than by tourists, and most of the canoeing is done in the upper reaches of the pool, nearer to the City of Bowling Green. Local officials are planning development of the riverfront in Bowling Green, and that could lead to an increase in canoeing; however, local officials estimate that such increases would be minor. Additionally, the sites of the riverfront development project and the lock and dam are at least 22 miles apart. Therefore, the threat of canoeing accidents was considered to be significantly less for Barren River Lock and Dam 1 than for Green River Lock and Dam 6.

Because of the public use of this site, alternative 1, the no action plan presents concerns for public safety as people would still be able to access the dam side lock wall via the upstream and downstream miter gates. Consequently, this alternative was screened out.

Alternative 2 addresses the safety concerns by installing barricades on both the upstream and downstream miter gates, as well as updating signage at the site. In addition, accumulated silt and vegetation in the lock chamber is substantial enough to provide a means of egress along with the deterioration of the lower downstream miter gates. Sedimentation in the lock chamber is expected to continue provided the upstream and downstream miter gates remain closed/mitered.

Alternative 3, removing the dam and filling the lock chamber, was considered. This alternative fully satisfies the public safety concerns at this site. However, a cost estimate was prepared in the 2004 report for this alternative, and the cost, \$5.2 million, appeared to be quite high, relative to the costs of this alternative at the other sites. Part of this is due to the remoteness of the site, and part is due to the fact that the dam at this site is wider than at the other sites in this study. For this reason, a variation of this alternative was developed for this site only. This variation, which is called Alternative 3a, consists of the construction of a breach in the dam. This breach would allow the passage of recreational canoe and kayak traffic and greatly reduce the chance of injury associated with going over the dam. Two different breach widths were investigated, 75 feet and 135 feet. Velocity profiles were developed for varying flows for both opening sizes. The velocities produced by flow through both size openings were acceptable for canoeing. However, the 135-foot opening was favored over the 75-foot opening for two reasons. First, the smaller size opening increases the chances of debris and logjams collecting in the notch. This would pose a danger to canoeists passing through the notch. Second, the smaller notch increases the chances that eddies would form at the upper and lower ends where fast flowing water joins flat water. Therefore, the 135-foot notch was considered to be the best option for breaching.

There are no water intakes located in this pool, except for the City of Bowling Green. This intake has its own low-head dam constructed near the intake to keep it submerged, and it is not subject to influence from Lock and Dam 1. Therefore, the public water supply would not be threatened by lowering the pool.

Operation P.R.I.D.E. (Plant, Repair, Improve, Develop, Enjoy) the city organization initially responsible for the development of the waterfront, originally supported the removal of the dam, and expressed that view to Congressional interests. However, subsequent contact with city and county officials revealed that most local officials opposed removing or breaching the dam.

If alternative 4 for disposition were implemented, it would only partially address the safety concerns at this site. While filling in and around the lock chambers are expected to lessen the risk of injuries associated with unauthorized entry, this alternative does not address the danger of canoeists and kayakers rowing across the dam. However, there is not a great deal of canoe traffic on this stretch of the river, and local officials do not expect an increase in the immediate future.

Several local officials and agencies contacted the USACE about the possibility of removing or breaching the dam. All of the officials were opposed to the alternative for various reasons. During the development of the 2004 study, the Warren County Judge/Executive informed the USACE that while the City of Bowling Green does not have a water intake in the pool formed by the dam at Barren River Lock and Dam No. 1, Bowling Green and Warren County regard the pool as a potential source of water. They believe that future growth and development of the city and county would require that additional sources of water be found. In fact, Warren County is interested in assuming ownership of the property upon a disposal action by the USACE as long as the dam is not removed or breached. The City and County have recently engaged the services of an architect/engineer firm to investigate the possible use of this pool as a source of drinking water.

There are also a number of individuals who have intakes in the pool for private irrigation systems. The decision by the county to advise the USACE that it is willing to assume the property stems also from a desire to keep these individuals' farming operations from being affected by any change in pool.

County officials are also concerned about the recreational use of the pool. Larger motorboats often use the pool. County officials fear that the loss of the pool would force the boaters to other areas. There are many opportunities for this type of water recreation in the area, with Barren River Lake and Nolin River Lake. Local officials fear that the local economy would suffer if boaters were forced to use different venues for their recreational boating. This concern also contributes to the county's desire to acquire the lock and dam property.

The USACE also had contact with Bowling Green Municipal Utilities during the 2004 study. Their concern is that the loss of the pool would adversely affect the city's ability to meet pollution control requirements. While breaching the pool would improve the aeration of the pool and subsequently its Biochemical Oxygen Demand, officials feel that the pool is necessary to meet standards for other pollutants. Again, local officials are willing for the county to assume acquire the property in order to prevent loss of the pool.

For this site, alternative 2 is recommended. This would consist of installing barricades on both the upstream and downstream miter gates, as well as updating signage at the site. After this construction is complete, it is recommended that the property be disposed of through standard real estate disposal procedures. However, it should be noted that Warren County has an interest in the property.

Once the recommended work at the site is complete and the project is deauthorized, no additional work or continued maintenance is recommended.

10.8 Summary & Comparison of Alternatives

A summation and comparison of the four alternatives considered for each lock and dam is presented in Table 10.d. Each alternative was evaluated for its impact on unauthorized entry, water supply, boat ramps, ferries, other facilities, environmental effects, maintenance and disposal. In addition to cost, these variables were considered to be significant factors in identifying the recommended alternative for each site. Additional discussion on these variables, specific to each site, is contained Sections 10.3, 10.4, 10.5, 10.6 and 10.7 of this report. The recommended plan for each site is in bold text.

Table 10.d: Comparison of Alternatives

site	alternative	Unauthorized Entry	water supply	boat ramps	ferries	other facilities	environmental effects	maintenance	disposal	recommendation	
Green River L&D 3	1 - No action	Injuries associated with unauthorized entry upon the property could be possible	No effect	No effect	No effect	None	No effect	Continued maintenance of "No trespassing" signage	N/A	Not recommended	
	2- Disposal without altering structures	Fan fencing barricades and updated signage will be installed to deter unauthorized entry upon the property	No effect	No effect	No effect	None	No effect	None	Party acquiring ownership will be responsible for maintenance	Recommended	
	3 - Remove dam and fill lock	Rock fill is not expected to be appreciably safer than sediment in the lock chamber	Would adversely affect six intakes for potable and process water	Could adversely affect one boat ramp at Cromwell	May require alteration of ferries	None	Minor increase in turbidity during construction Pool removal would benefit threatened and endangered species	None	Party acquiring ownership will be responsible for maintenance	Not recommended	
	4 - Modify lock	Rock fill is not expected to be appreciably safer than sediment in the lock chamber	A bulkhead on the upstream miter gate would maintain pool	No effect	No effect	None	Minor increase in turbidity during construction	None	The RDRVC has expressed an interest in acquiring the property; party acquiring ownership will be responsible for maintenance	Recommended	
Green River L&D 4	1 - No action	Injuries associated with unauthorized entry upon the property could be possible	No effect	No effect	N/A	None	No effect	Continued maintenance of "No trespassing" signage	N/A	Not recommended	
	2- Disposal without altering structures	Fan fencing barricades and updated signage will be installed to deter unauthorized entry upon the property.	No effect	No effect	N/A	None	No effect	None	Party acquiring ownership will be responsible for maintenance	Recommended	
	3 - Remove dam and fill lock	<i>This alternative was not considered because the dam has long since breached and is no longer retaining pool.</i>									
	4 - Modify lock	Rock fill is not expected to be appreciably safer than sediment in the lock chamber	No effect	No effect	N/A	None	Minor increase in turbidity during construction	None	Party acquiring ownership will be responsible for maintenance	Not recommended	
Green River L&D 5	1 - No action	Injuries associated with unauthorized entry upon the property could be possible	No effect	No effect	N/A	None	No effect	Continued maintenance of "No trespassing" signage	N/A	Not recommended	
	2- Disposal without altering structures	Fan fencing barricades and updated signage will be installed to deter unauthorized entry upon the property.	No effect	No effect	N/A	None	No effect	None	Party acquiring ownership will be responsible for maintenance	Recommended	
	3 - Remove dam and fill lock	Rock fill is not expected to be appreciably safer than sediment in the lock chamber	Would require relocation of intakes for potable water supply for Brownsville, Ky	Four ramps could be affected by lowering pool	N/A	None	Minor increase in turbidity during construction Pool removal would benefit threatened and endangered species	None	Party assuming ownership will be responsible for maintenance	Not recommended	
	4 - Modify lock		No effect	No effect						Not recommended	

site	alternative	Unauthorized Entry	water supply	boat ramps	ferries	other facilities	environmental effects	maintenance	disposal	recommendation
Green River L&D 6	1- No action	Injuries associated with unauthorized entry upon property Could be possible	Failure of lock and dam could endanger water intake structures downstream	N/A	Lock/dam failure could leave ferries with insufficient pool in which to operate, severing vital transportation	No effect	No effect	Continued maintenance of "No trespassing" signage	N/A	Not recommended
	2- Disposal without altering structures	Fan fencing barricades and updated signage will be installed to deter unauthorized entry upon the property.						None		Party acquiring ownership will be responsible for maintenance
	3 - Remove dam, fill lock, and stabilize abutment	Rock fill is not expected to be appreciably safer than sediment in the lock chamber; seepage problem will be eliminated, reducing the chance of failure; hazards associated with canoeing over dam will be eliminated	No effect	N/A	Will require alteration of two ferry services in Mammoth Cave National Park	No effect	Minor increase in turbidity during construction; pool removal would benefit threatened and endangered species; cave development will return to pre-impoundment conditions	Continued maintenance of "No trespassing" signage	Edmonson County has expressed interest in acquiring the property on the right bank; party acquiring ownership will be responsible for maintenance	Recommended
	4 - Modify lock	Rock fill is not expected to be appreciably safer than sediment in lock chamber	No effect	N/A	No effect	No effect	Minor increase in turbidity during construction	None	Party acquiring ownership will be responsible for maintenance	Not recommended
Barren River L&D 1	1- No action	Injuries associated with unauthorized entry upon the property could be possible	No effect	No effect	N/A	None	No effect	Continued maintenance of "No trespassing" signage	N/A	Not recommended
	2- Disposal without altering structures	Fan fencing barricades and updated signage will be installed to deter unauthorized entry upon the property.	No effect	No effect	N/A	None	No effect	None	Party acquiring ownership will be responsible for maintenance	Recommended
	3 - Remove dam and fill lock	Rock fill is not expected to be appreciably safer than sediment in the lock chamber	No effect	One ramp may be affected by lowering pool	N/A	Some private irrigation intakes may be affected	Minor increase in turbidity during construction Removal of pool would benefit threatened and endangered species	None	Party acquiring ownership will be responsible for maintenance	Not recommended
	3a - Breach dam and fill lock			Not recommended						
	4 - Modify lock	Rock fill is not expected to be appreciably safer than sediment in the lock chamber	No effect	No effect	N/A	None	Minor increase in turbidity during construction	None	Warren County has expressed interest in acquiring the property, provided the dam is still intact; party acquiring ownership will be responsible for maintenance	Not recommended

Table 11.a: Green L&D 3 Recommended Plan Cost Estimate

Item	Cost	
Warning Signs	\$	2,524.00
Fan Gates	\$	5,416.00
Reinforced Concrete Plug	\$	338,662.00
Subtotal	\$	346,602.00

11 Recommended Plans

11.1 Green River Lock and Dam 3

11.1.1 Description of Plan

Structurally, the lock and dam system looks sound and, except for the downstream guide wall, does not appear to be in any danger of imminent failure. The site investigation did not reveal any conditions at this structure which would result in the loss of pool in the foreseeable future. Therefore, no repair actions are considered necessary prior to disposition.

However, to maintain pool over the long term, a concrete plug would be placed against the upstream face of the upstream miter gates. This would require some sediment and vegetation removal and sheet piles driven upstream of the miter gates. These would serve as the upstream formwork for the concrete plug. The miter gates themselves could be used as the downstream forms. The height of the concrete plug would be equal to that of the dam. This is similar to the fix proposed by an Engineering Documentation Report, Remedial Suite No. 2 provided by Stantec Consulting Services dated 13 April 2011.

In addition, to lessen the risk of injuries associated with unauthorized entry, the upstream and downstream miter gates would be gated with barricades on the land side miter gates. The accumulated silt and vegetation within the chamber is substantial enough to act as a means of egress. It is expected for the sediment to continue to collect in the lock chamber, provided the upstream and downstream miter gates remain closed/mitered.

11.1.2 Environmental Effects

It is expected that impacts to water quality in the river would be minimal from construction of the concrete plug. Some minor temporary increases in turbidity may result from construction activities. However, the increased turbidity is expected to be of a short-term nature and is not anticipated to significantly degrade water quality in the Green River. Stream water levels would not be significantly affected; therefore no impacts on groundwater are anticipated. Implementation of barricades on the miter gates would have no adverse environmental effects.

11.1.3 Socio-Economic Effects

The construction expenditures associated with this plan would result in beneficial short-term economic impacts to the region during the actual period of construction. Because of the rural nature of the study area, the impacts may be limited due to contract award; the availability of skilled and unskilled labor in the region; and the availability of regional materials and equipment. It is assumed that, at a minimum, a portion of the direct labor and materials budgets would be expended in the study area or the region surrounding the study area. This assumption is based on the belief that some of the labor would be hired from the local work force and the materials would come from local sources. Expending these resources within the regional economy could result in a temporary increase in employment, personal income and business activity.

11.1.4 Cultural Resources Effects

As a result of archaeological investigations, no prehistoric or undisturbed historic archaeological remains were documented. Therefore under the described plan no prehistoric or undisturbed historic archaeological remains would be affected. Documentation of the history and architecture of this facility has determined that the lock and dam are considered eligible for listing on the NRHP. Under the described plan the transfer of the facility from Federal ownership, placement of a concrete plug against the upstream miter gate and placement of barricades on the land side miter gates would have an effect to the lock and dam. The KY-SHPO has commented that the proposed disposition of Green River Locks and Dams 3, 4, 5 and 6 and Barren River Lock and Dam 1

would have an adverse effect on these NRHP eligible properties. Transfer from Federal ownership is considered an adverse effect. Further consultation with the KY-SHPO and other interested parties would be undertaken to determine appropriate mitigation measures for inclusion in a Memorandum of Agreement to address project effects. Development of a Memorandum of Agreement would be completed prior to implementing this plan.

11.2 Green River Lock and Dam 4

11.2.1 Description of Plan

Structurally, the lock and downstream guide wall do not appear to be in any danger of failure. No conditions were observed at the site that would further impair the stability of this structure.

To lessen the risk of injuries associated with unauthorized entry, the upstream and downstream miter gates would be gated with barricades on the land side miter gates. Accumulated silt and vegetation in the chamber is substantial enough to acts as a means of egress along with the deterioration of the lower downstream miter gates. Sediment is expected to continue to collect in the lock chamber provided the upstream and downstream miter gates remain closed/mitered.

11.2.2 Environmental Effects

No actions are recommended for the section of the upstream guard wall which has failed. Implementation of barricades on the miter gates would have no adverse environmental effects. Stream water levels would not be affected; therefore, no impacts on groundwater are anticipated.

11.2.3 Socio-Economic Effects

Construction activities associated with the implementing the barricades would likely provide positive short-term (albeit negligible) economic impacts to the local communities.

Table 11.b: Green L&D 4 Recommended Plan Cost Estimate

Warning Signs	\$	2,524.00
Fan Gates	\$	5,416.00
Subtotal	\$	7,940.00

11.2.4 Cultural Resources Effects

As a result of archaeological investigations no prehistoric or undisturbed historic archaeological remains were documented. Therefore under the described plan no prehistoric or undisturbed historic archaeological remains would be affected. Documentation of the history and architecture of this facility however has determined that the lock and dam are considered eligible for listing on the National Register of Historic Places (NRHP). Under the described plan the transfer of the facility from Federal ownership and placement of barricades on the land side miter gates would have an effect to the lock and dam. The KY-SHPO has commented that the proposed disposition of Green River Locks and Dams 3, 4, 5 and 6 and Barren River Lock and Dam 1 would have an adverse effect on these NRHP eligible properties. Transfer from Federal ownership is considered an adverse effect. Further consultation with the KY-SHPO and other interested parties would be undertaken to determine appropriate mitigation measures for inclusion in a Memorandum of Agreement to address project effects. Development of a Memorandum of Agreement would be completed prior to implementing this plan.

11.3 Green River Lock and Dam 5

11.3.1 Description of Plan

No conditions were observed at this site which would result in the loss of pool in the foreseeable future. The condition of the miter gates appears to be satisfactory. If the upper set of miter gates were to fail, the lower set would provide the redundancy needed to maintain the pool until a fix (rock plug, sheet pile cut off, etc.) could be effected on the upstream end of the lock.

To lessen the risk of injuries associated with unauthorized entry, the upstream and downstream miter gates would be gated with barricades on the land side and the land side valve pits and bulkhead slots grates would be bolted securely. Accumulated silt and vegetation in the chamber is substantial enough to acts as a means of egress (Figures GR5-2 & GR5-3). Sediment is expected to continue to collect in the lock chamber provided the upstream and downstream miter gates remain closed / mitered.

Table 11.c: Green L&D 5 Recommended Plan Cost Estimate

Warning Signs	\$	2,524.00
Fan Gates	\$	5,416.00
Subtotal	\$	7,940.00

11.3.2 Environmental Effects

No significant actions are recommended for this lock and dam. Implementation of barricades on the miter gates would have no adverse environmental effects.

11.3.3 Socio-Economic Effects

Construction activities associated with the implementing the barricades would likely provide positive short-term (albeit negligible) economic impacts to the local communities.

11.3.4 Cultural Resources Effects

As a result of archaeological investigations no prehistoric or undisturbed historic archaeological remains were documented. Therefore, under the described plan no prehistoric or undisturbed historic archaeological remains would be affected. Documentation of the history and architecture of this facility however has determined that the lock and dam are considered eligible for listing on the NRHP. Under the described plan the transfer of the facility from Federal ownership and placement of barricades on the land side miter gates would have an effect to the lock and dam. The KY-SHPO has commented that the proposed disposition of Green River Locks and Dams 3, 4, 5 and 6 and Barren River Lock and Dam 1 would have an adverse effect on these NRHP eligible properties. Transfer from Federal ownership is considered an adverse effect. Further consultation with the KY-SHPO and other interested parties would be undertaken to determine appropriate mitigation measures for inclusion in a Memorandum of Agreement to address project effects. Development of a Memorandum of Agreement would be completed prior to implementing this plan.

11.4 Green River Lock and Dam 6

11.4.1 Description of Plan

No work would be done to the miter gates, as they would not be needed to help maintain pool. The dam would be demolished and removed from across the river channel. This would be accomplished by constructing a road to enable equipment to gain access to the dam from the lock side to breach the dam. The material would be removed from the dam gradually and placed in the lock chamber and along the lower approach wall and the associated steps to help minimize disposal costs and environmental impacts and mitigate any safety issues. As the dam is breached, the access road would be removed. The stone used to construct the access road would also be placed in and around the lock chamber and lower approach. Stone would be placed against the river lock wall in such a way that there there would not be an unbalanced pressure against the river wall. Egress for this structure is not an issue since the downstream gates have been removed. In addition to work at the site of the lock and dam, modifications would also be made at the sites of the two ferry operations in the Lock and Dam 6 pool. At the Green River Ferry site, material would be dredged from the river at the site of the ferry crossing and the concrete approach ramps would be extended. At Houchins Ferry, the concrete approach ramps would also be extended. Plate 12 shows a rendering of the recommended plan.

11.4.2 Environmental Effects

When filling the lock chambers and removing the dam, minor impacts to water quality can be expected. During the dam removal, temporary increases in turbidity would likely create short-term degradation of water quality downstream from the work sites. Following dam removal, increased water flow in the former pool area would likely re-suspend sediment from that area and for some period of time, which would result in increased turbidity and total suspended solids downstream. Over time, this process would result in redistributing the sediment, as fine sediment would be picked up by the increased current and carried the farthest before settling out. Increased water velocity in the former pool area would also likely result in increased aeration and higher dissolved oxygen levels. Eventually, all sediment available for re-suspension would be picked up from the former pool area above the dam and redistributed downstream, creating a more natural bed elevation throughout the channel. Upon reaching this state of equilibrium, stream water quality should stabilize at conditions close to or somewhat better than the existing levels.

Table 11.d: Green L&D 6 Recommended Plan Cost Estimate

Green L&D 6	Warning Signs	\$ 2,524.00
	Fan Gates	\$ 2,708.00
	Temporary Access Road	\$ 121,729.00
	Demo Dam	\$ 7,921,810.00
	Place Dam Demo Spoils in Lock Chamber and along Approach	\$ 1,247,087.00
	Subtotal	\$ 9,295,858.00
Houchins Ferry	Traffic Control	\$ 9,244.00
	Erosion Control	\$ 5,444.00
	Extend Southeast Ferry Ramp	\$ 380,458.00
	Extend Northwest Ferry Ramp	\$ 376,738.00
	Subtotal	\$ 771,884.00
Green River Ferry	Traffic Control	\$ 12,035.00
	Erosion Control	\$ 5,444.00
	Dredge Ferry Canal	\$ 194,516.00
	Subtotal	\$ 211,995.00

Local groundwater levels are not expected to be significantly impacted. Increased velocities of groundwater flow toward the river as well as changes in the hydrologic patterns of underground streams in the Mammoth Cave system may result. A decrease in groundwater elevation in the Mammoth Cave system is anticipated to be beneficial, as this would expose previously documented, and possibly some undocumented, passages for exploration and study. Lowering Green River Pool 6 is expected to allow the River Styx (a subterranean stream that runs through Mammoth Cave) to once again flow out of Mammoth Cave into the Green River. This effect would greatly reduce the period of flow into the cave from the river, consequently reducing flooding and sedimentation within cave passages.

Construction activities may temporarily disrupt wildlife patterns in the immediate vicinity, but no significant effects on terrestrial wildlife are expected. Dam removal would change river characteristics from lentic (still waters such as lakes and ponds) to lotic (actively moving water). Short-term impacts associated with dam removal would be an increase in turbidity and sediment load during construction. Some stream bank erosion may occur with the lowering of the water levels. However, once vegetation becomes established along the exposed portions of the bank, erosion would be minimized.

Long-term impacts would be beneficial to the natural aquatic community. Removing the dam would return 17 miles of river habitat to pre-impoundment flow conditions. Species composition would change to more closely resemble the unimpounded community present above Pool 6 on the Green River. Smallmouth bass numbers would likely increase as largemouth bass numbers would likely decrease. Kentucky bass populations would not likely be significantly affected. As recolonization by pre-impoundment fish species occurs, those fish species that serve as hosts for glochidia of freshwater mussels would increase the potential for recolonization of restored riverine habitats by mussels. There would likely be long-term beneficial impacts to threatened and endangered mussels and their habitat. Although some federally endangered mussels appear to have adapted to the pooling conditions, this habitat is not considered preferred. The endangered aquatic species present in the project area appear to prefer the habitat of free flowing streams to that of impounded streams. Removing the dam and

flushing accumulated sediments would re-expose gravel bars within the channel, which could then be colonized by mussels.

The Kentucky cave shrimp and its habitat would also benefit from removing Dam 6, which would restore free flow out of Mammoth Cave. Restoring this area to near pre-impoundment conditions could reduce the potential for sediment accumulation in the subterranean waters of Mammoth Cave; restore habitat diversity; and enhance habitat for the Kentucky cave shrimp, the northern cavefish, southern cavefish and crayfish. The endangered Indiana bat and gray bat would also gain potential hibernacula and maternity sites, as normal water elevations drop and expose additional cave openings near Mammoth Cave National Park.

Water surface elevations on Nolin will be affected by the removal of Dam 6. However, Nolin Lake Dam, like all Green River Basin Projects, has a minimum required outflow of 50 cfs. This minimum outflow was established to promote biodiversity and protect the ecosystems; there should be no effect on aquatic life on the Nolin River as a result of removing the Dam 6.

11.4.3 Socio-Economic Effects

With dam removal it is expected that water levels would recede and allow access to additional cave passages. Presently, the National Park Service has no plans to establish additional tours. No additional tourism revenue from increased cave access for the public would be realized under this alternative. It is likely that some increased revenues would result from an increase in cave exploration and mapping activities by more avid spelunkers (those who study or explore caves) and members of organizations such as the Cave Research Foundation.

Canoeing in the study area is concentrated upriver from Dam 6 because of Mammoth Cave National Park. The park provides several landings for launch and removal of canoes and has islands that are used for picnicking and camping. Dam 6 presents a major obstacle to canoeing, as there is no portage around the dam. Also, canoeing near the dam is extremely hazardous. On both sides of Mammoth Cave National Park, the Green River flows through private property that canoeists cannot use without permission from property owners. This lack of public access to the river discourages two-day canoe trips that would bring tourists from urban centers outside the study area. Both Louisville and Nashville are within 100 miles of Mammoth Cave National Park, and canoeing is popular on similar rivers in the region. Presently, the canoe liveries serve canoeists wanting primarily half-day trips. This is a different clientele than canoeists who would be interested in multi-day trips. Removing the dam would increase interest in multi-day canoe trips, which would lead to an increase in canoe rentals and other businesses serving area visitors. While multi-day canoeing activity would never approach that of existing day-trips on the river and the number of canoe liveries would likely not increase, there could be an increase in rental activity. If the canoe liveries were able to market multi-day trips, these liveries could experience an increase in rental activity to the point that multi-day trips would account for 15 to 30 percent of their business. This extrapolates into a total of 2,350 to 2,850 canoe trips a year, including 350 to 850 multi-day canoe rentals and 2,000 day-trips. Based on an increase of 350 to 850 additional canoe rentals a year and an impact of \$84 per multi-day canoe rental (based on the 1999 rental activity impact of \$42 per day-trip canoe rental) there could be a potential increase of approximately \$30,000 to \$70,000 in canoe rentals in the area.

Removing Dam 6 is not expected to markedly affect boating businesses in the study area because there are two nearby large lakes that are used for boating and fishing. Marinas and boating supply stores are located at Nolin River Lake and Barren River Lake. The slack water near Dam 6 is used for power boating primarily by local residents.

Construction activities associated with filling the lock and removing the dam are expected to create short-term impacts within the regional economy. The construction expenditures would likely result in beneficial short-term

economic impacts to the region during the actual period of construction. Because of the rural nature of the study area, the impacts may be limited due to contract award; the availability of skilled and unskilled labor in the region; and the availability of regional materials and equipment. At a minimum, a portion of the direct labor and materials budgets would be expended in the study area or the region surrounding the study area. This is based on the expectation that some of the labor would be hired from the local workforce and the materials would come from local sources. Expending these resources within the regional economy could result in a temporary increase in employment, personal income and business activity.

11.4.4 Cultural Resources Effects

As a result of archaeological investigations no prehistoric or undisturbed historic archaeological remains were documented. Therefore, under the described plan no prehistoric or undisturbed historic archaeological remains would be affected. Documentation of the history and architecture of this facility however has determined that the lock and dam are considered eligible for listing on the NRHP. Under the described plan the demolition of the dam; transfer of the facility from Federal ownership; placement of the dam material in the lock chamber and along the lower approach wall; and placement of barricades on the land side miter gate would have an effect to the lock and dam. The KY-SHPO has commented that the proposed disposition of Green River Locks and Dams 3, 4, 5 and 6 and Barren River Lock and Dam 1 would have an adverse effect on these NRHP eligible properties. Demolition of the dam and transfer from Federal ownership are considered adverse effects. Further consultation with the KY-SHPO and other interested parties would be undertaken to determine appropriate mitigation measures for inclusion in a Memorandum of Agreement to address project effects. Development of a Memorandum of Agreement would be completed prior to implementing this plan.

11.5 Barren River Lock and Dam 1

11.5.1 Description of Plan

No conditions were observed at this site that would result in the loss of pool in the foreseeable future. The condition of the miter gates appears to be satisfactory. If the upper set of miter gates were to fail, the lower set would provide the redundancy needed to maintain the pool until a fix (rock plug, sheet pile cut off, etc.) could be effected on the upstream end of the lock.

To lessen the risk of injuries associated with unauthorized entry, the upstream and downstream miter gates would be gated with barricades on the land side miter gates. Additionally, the land side valve pits and bulkhead slots grates would be inspected to ensure that they are bolted securely. Egress from the lock chamber is available by the following means: ladders located on the lock walls; vegetation and concrete berm just downstream of upstream miter gates; and accumulated sediment located near the miter gates.

11.5.2 Environmental Effects

No significant actions are recommended for this lock and dam. Implementation of barricades on the miter gates would have no adverse environmental effects.

Table 11.e: Barren L&D 1 Recommended Plan Cost Estimate

Warning Signs	\$	2,524.00
Fan Gates	\$	5,416.00
Subtotal	\$	7,940.00

11.5.3 Socio-Economic Effects

Construction activities associated with implementing the barricades would likely provide positive short-term (albeit negligible) economic impacts to the local communities.

11.5.4 Cultural Resources Effects

As a result of archaeological investigations no prehistoric or undisturbed historic archaeological remains were documented. Therefore, under the described plan no prehistoric or undisturbed historic archaeological remains would be affected. Documentation of the history and architecture of this facility however has determined that

the lock and dam are considered eligible for listing on the NRHP. Under the described plan the transfer of the facility from Federal ownership and placement of barricades on the land side miter gates would have an effect to the lock and dam. The KY-SHPO has commented that the proposed disposition of Green River Locks and Dams 3, 4, 5 and 6 and Barren River Lock and Dam 1 would have an adverse effect on these NRHP eligible properties. Transfer from Federal ownership is considered an adverse effect. Further consultation with the KY-SHPO and other interested parties would be undertaken to determine appropriate mitigation measures for inclusion in a Memorandum of Agreement to address project effects. Development of a Memorandum of Agreement would be completed prior to implementing this plan.

11.6 2004 vs. 2014 Recommended Plans

The recommended plans for both the 2004 and 2014 studies are intended to achieve the same results for the safety of those persons who enter upon Government property without permission or authority, pool retention, dam removal, structural stability and ecosystem restoration as applicable at each site per the formulation constraints.

As previously discussed, the 2004 report recommended extensive placement of engineered stone at every site to fill the lock chambers and grade out the approach walls. The stone was intended for the safety of those persons who enter upon Government property without permission or authority from falling off the lock wall into a chamber or to the ground below an approach wall. Before and since the 2004 study, sediment has accumulated in and around the locks, lessening the hazard posed by a fall and mitigating the drowning hazard by providing landmass within and around the chambers to reach a ladder or escape an open lock chamber. The 2014 recommended plan includes barricades across the miter gates to block access to the river-side lock walls.

Specific differences between the 2004 and 2014 recommended plans for each site are outlined in Table 11.f on page 40. For more information on the cost estimates for this project, refer to Appendix H.

Table 11.f: Comparison of 2004 and 2014 Recommended Plans

	2004 Recommended Plan and Costs		2014 Recommended Plan and Costs	
	Measure	2004 Cost ¹	Measure	2014 Cost
Green L&D 3	Fill Lock Chamber with Rip-Rap	\$ 1,218,285.00	Warning Signs	\$ 2,524.00
	Traffic Control	\$ 29,658.00	Fan Gates	\$ 5,416.00
	Road Improvements	\$ 194,278.00	Reinforced Concrete Plug	\$ 338,662.00
	Subtotal	\$ 1,442,221.00	Subtotal	\$ 346,602.00
Green L&D 4	Fill Lock Chamber with Rip-Rap	\$ 1,141,082.00	Warning Signs	\$ 2,524.00
	Traffic Control	\$ 29,658.00	Fan Gates	\$ 5,416.00
	Road Improvements	\$ 102,490.00		
	Subtotal	\$ 1,273,230.00	Subtotal	\$ 7,940.00
Green L&D 5	Fill Lock Chamber with Rip-Rap	\$ 4,889,608.00	Warning Signs	\$ 2,524.00
	Traffic Control	\$ 29,658.00	Fan Gates	\$ 5,416.00
	Road Improvements	\$ 553,196.00		
	Subtotal	\$ 5,472,462.00	Subtotal	\$ 7,940.00
Barren L&D 1	Fill Lock Chamber with Rip-Rap	\$ 5,255,691.00	Warning Signs	\$ 2,524.00
	Traffic Control	\$ 29,658.00	Fan Gates	\$ 5,416.00
	Road Improvements	\$ 1,088,560.00		
	Subtotal	\$ 6,373,909.00	Subtotal	\$ 7,940.00
Green L&D 6	Place Dam Demo Spoils in Lock Chamber and along Approach	\$ 1,240,722.00	Warning Signs	\$ 2,524.00
			Fan Gates	\$ 2,708.00
	Demo Dam	\$ 7,962,612.00	Demo Dam	\$ 7,921,810.00
	Road Improvements	\$ 121,520.00	Place Dam Demo Spoils in Lock Chamber and along Approach	\$ 1,247,087.00
	Subtotal	\$ 9,324,854.00	Temporary Access Road	\$ 121,729.00
		Subtotal	\$ 9,295,858.00	
Houchins Ferry	Traffic Control	\$ 11,913.00	Traffic Control	\$ 9,244.00
	Erosion Control	\$ 5,425.00	Erosion Control	\$ 5,444.00
	Extend Southeast Ferry Ramp	\$ 373,946.00	Extend Southeast Ferry Ramp	\$ 380,458.00
	Extend Northwest Ferry Ramp	\$ 370,261.00	Extend Northwest Ferry Ramp	\$ 376,738.00
	Subtotal	\$ 761,545.00	Subtotal	\$ 771,884.00
Green River Ferry	Traffic Control	\$ 11,913.00	Traffic Control	\$ 12,035.00
	Erosion Control	\$ 5,425.00	Erosion Control	\$ 5,444.00
	Dredge Ferry Canal	\$ 215,240.00	Dredge Ferry Canal	\$ 194,516.00
	Subtotal	\$ 232,578.00	Subtotal	\$ 211,995.00
	Real Estate	\$ 80,185.00	Real Estate	\$ 80,185.00
	Planning, Engineering, and Design	\$ 4,209,076.00	Planning, Engineering, and Design	\$ 2,667,292.00
	Construction Management	\$ 1,737,755.00	Construction Management	\$ 1,067,345.00
	Total	\$30,907,815.00	Total	\$14,464,981.00

¹The 2004 costs presented in this table have been indexed to 2013 price levels.

11.7 Consideration of Recommended Plan

While each site was considered separately and alternatives were formulated for each individually, the final recommended plan also considered the Green and Barren system as a whole. By far the most important stretch of the river ecologically is the reach that runs through Mammoth Cave National Park. By removing Dam 6, natural flow would be restored to the most sensitive reach in the river. The most environmental benefits could be gained in that location, considering impacts to threatened and endangered species, the restoration of natural river conditions in the cave, the ability for bats to fly in and out of the cave in locations they had not been able to use for over 100 years, and the fact that this area has been designated as an International Biosphere Reserve. A biosphere reserve is a unique category of safeguarded, natural environments combining conservation and sustained economic use of natural resources.

The Green River, which meanders through the park, supports an unusual diversity of fish, including five species that have not been found anywhere else in the world and three species of cavefish. Another group of aquatic animals, freshwater mussels, survive in the sand and gravel of the Green River. Over 50 species of mussels, including at least three on the endangered species list, live in the park. About 94% of the Green River Lock and Dam 6 pool is in the National Park. Restoration of the river to its pre-impoundment state would not only benefit the species in the river, but would restore natural hydrologic conditions to Mammoth Cave. Since the development of cave passages is dependent on the movement of water, cave development has been arrested to a degree by the transformation of the free-flowing river to a static pool.

By leaving Dams 3, 5 and 1, social impacts would be minimized, there would be no negative environmental impacts and the properties would be much easier to dispose of. As a whole, the plan minimizes adverse social impacts, provides positive environmental impacts at the location where they would be the greatest, causes no negative environmental impacts and facilitates the disposal of the properties in the most efficient manner.

The study goal was to try and determine all impacts, social as well as environmental, that removal or failure of a dam might cause. In the case of removing dams where water supply is being withdrawn, there would be significant social impacts. All of these communities are rural, with little or no industry. In the case of Edmonson County, whose water supply would be affected if Dam 5 were removed, most of the county lies within the Mammoth Cave National Park. This means they have a very small tax base. Any change in their water supply has large impacts on the community. Any expense related to their water supply means that some other community need would go unaddressed. While water supply does produce revenue, any increase in rates to cover unexpected expenses would present a hardship to the users. Butler County is in a slightly better position than Edmonson, in that there is a larger community, Morgantown, located within the county, but the water intakes are closer to the dam and have a much higher chance of being left dry in lower water levels. The intakes at Butler County would require significant alteration and it could not be guaranteed that they would remain submerged in drought conditions, short of building another dam. In both of these cases, the social impacts of dam removal could be quite significant.

While there would be beneficial impacts to threatened and endangered species if these dams are removed, leaving them in place would not produce any negative impacts, given that the status quo would be unchanged. And the ease of disposal for all of these facilities was given a lot of weight during plan formulation. Given that the communities were only likely to want the properties if the dams were left in place, leaving the dams in place became the preferred alternative.

No additional real estate would be needed for construction activities. All construction can be completed using real estate already owned by the United States (i.e. the subject lock and dam sites and the ferry landing sites located within the Mammoth Cave National Park).

11.8 Value Engineering

The purpose of value engineering is to analyze the functions of systems, equipment, facilities, services and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with required performance, reliability, quality and safety.

A value engineering evaluation is currently required by Engineering Circular EC 11-1-114, “Value Management/Value Engineering” during the feasibility phase of a project as part of the plan formulation process prior to the selection of final alternatives. However, this requirement was not in effect until February 2003, while this feasibility study has been in progress since Fiscal Year 1996. A value engineering evaluation was not included in the funding for this Feasibility Study.

It has been determined that a detailed value engineering evaluation of the plan recommended in this Feasibility Study would be conducted during the Preconstruction Engineering and Design (PED) phase.

12 Mitigation Requirements

The only expected mitigation requirements result from the need to modify the ferries in the Mammoth Cave National Park to ensure their continued operations. These modifications would consist of lengthening the ramps at the Houchins Ferry and dredging at the Green River Ferry to maintain the water depth necessary to keep the ferry operational.

Although some coordination on possible mitigation alternatives for cultural resource impacts was completed under the 2004 study, further coordination with the Kentucky State Historic Preservation Officer (KY-SHPO) and other interested parties would be required if the properties are disposed of and/or altered. As the scope of cultural resource and mitigation alternatives is unknown at this time, estimated costs were calculated at 1% of total project cost for cultural resource mitigation.

Table 12.a: Cost Estimates for Mitigation of Ferry Impacts

Houchins Ferry	Traffic Control	\$ 9,244.00
	Erosion Control	\$ 5,444.00
	Extend Southeast Ferry Ramp	\$ 380,458.00
	Extend Northwest Ferry Ramp	\$ 376,738.00
Subtotal		\$ 771,884.00
Green River Ferry	Traffic Control	\$ 12,035.00
	Erosion Control	\$ 5,444.00
	Dredge Ferry Canal	\$ 194,516.00
	Subtotal	

13 Conclusions

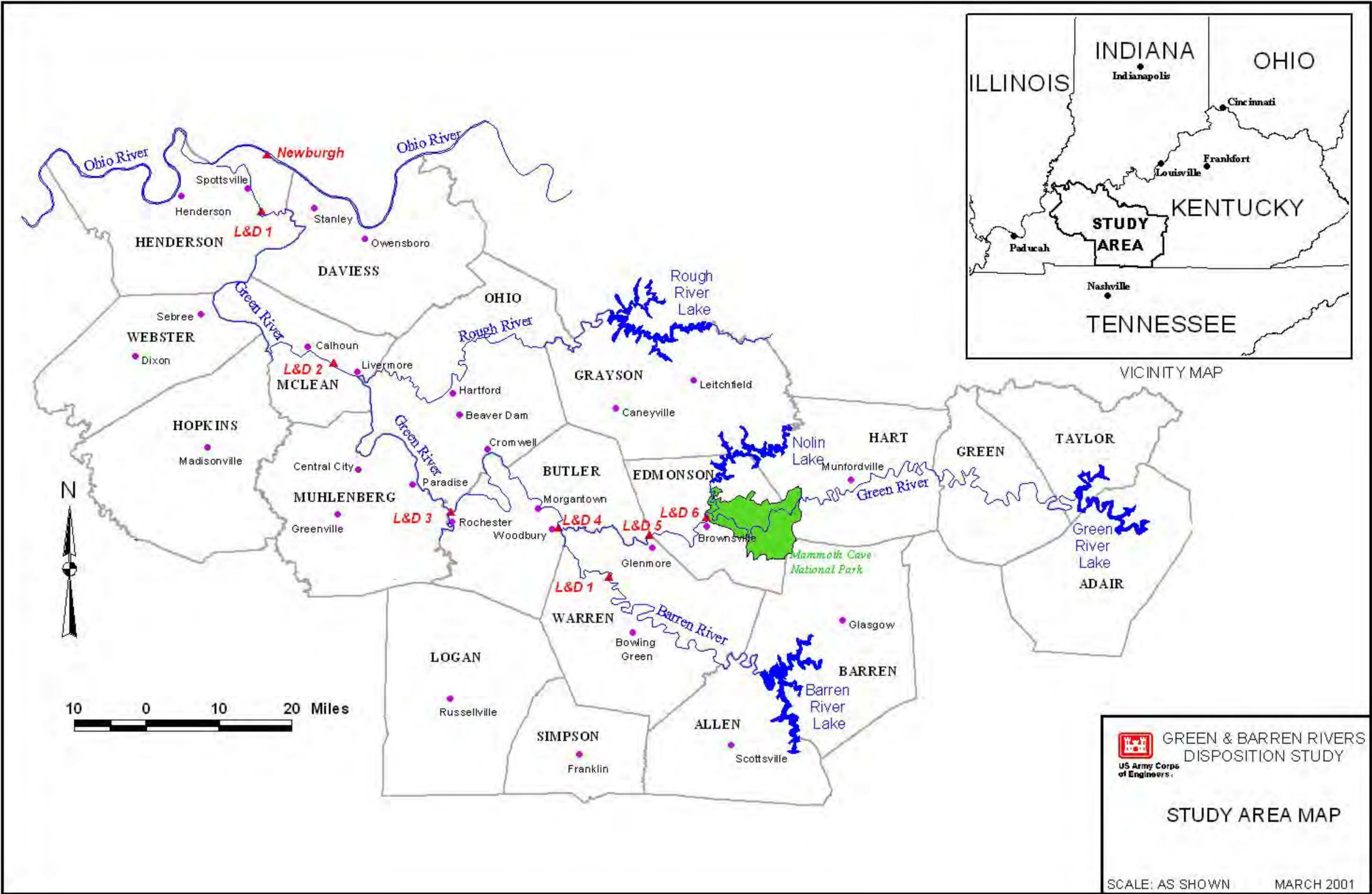
Based on the foregoing, the following conclusions are made:

- The existing navigation facilities at Green River Locks and Dams 3 through 6 and at Barren River Lock and Dam 1 are not serving the federal authorized purpose of commercial navigation and cannot reasonably be expected to do so in the foreseeable future.
- Green River Locks and Dams 3 and 5 are serving incidental purposes, including water supply, and while there is significant nonfederal interest in maintaining these pools for that purpose, there is no federal interest or authority to maintain them for that purpose.
- Officials from the local communities using the Green River Locks and Dams 3 and 5 pools as water supply have indicated that there is strong local interest in acquiring the properties.
- Officials from Warren County have informed the USACE that they wish to acquire the properties at Barren River Lock and Dam 1.

14 Recommendations

In view of the conclusions set forth above, and after considering the expected social, economic, and environmental impacts, the following recommendations are made regarding the disposition of the formerly used navigation facilities on the Green and Barren Rivers:

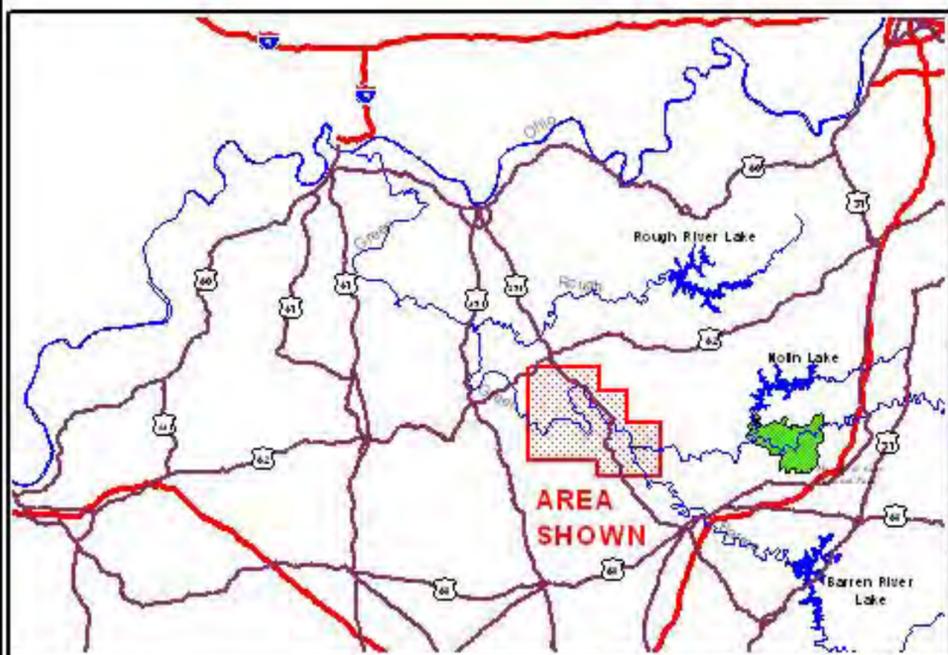
- Green River Lock and Dam 3, 4, 5, and 6 and Barren River Lock and Dam 1 should be deauthorized, as they are no longer serving their authorized purpose.
- The repairs and alterations recommended herein should be accomplished to provide for orderly disposal of the properties. This construction should be accomplished at full federal expense.
- After the recommended construction is complete, all of the properties should be disposed of through the normal Corps of Engineers and GSA property disposal procedures.
- Rochester Dam Regional Water Commission (RDWC) has expressed interest in the property at Green River Lock and Dam 3. During property disposal, RDWC should be contacted.
- Edmonson County has expressed interest in the land on the right bank of the Green River at Lock and Dam 6. During property disposal, the county should be contacted.
- Warren County has expressed interest in the property at Barren River Lock and Dam 1. During property disposal, the county should be contacted.
- If property disposal is unsuccessful after the projects are deauthorized, the properties should be maintained in caretaker status by USACE.





MAP - GREEN RIVER
LOCK AND DAM #3

SCALE: AS SHOWN MARCH 2001



Vicinity Map



Rochester Boat Ramp



Reed's Ferry



Highway 403 Boat Ramp



Guy Cook Boat Ramp



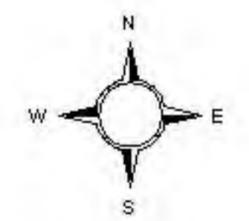
Rochester Ferry

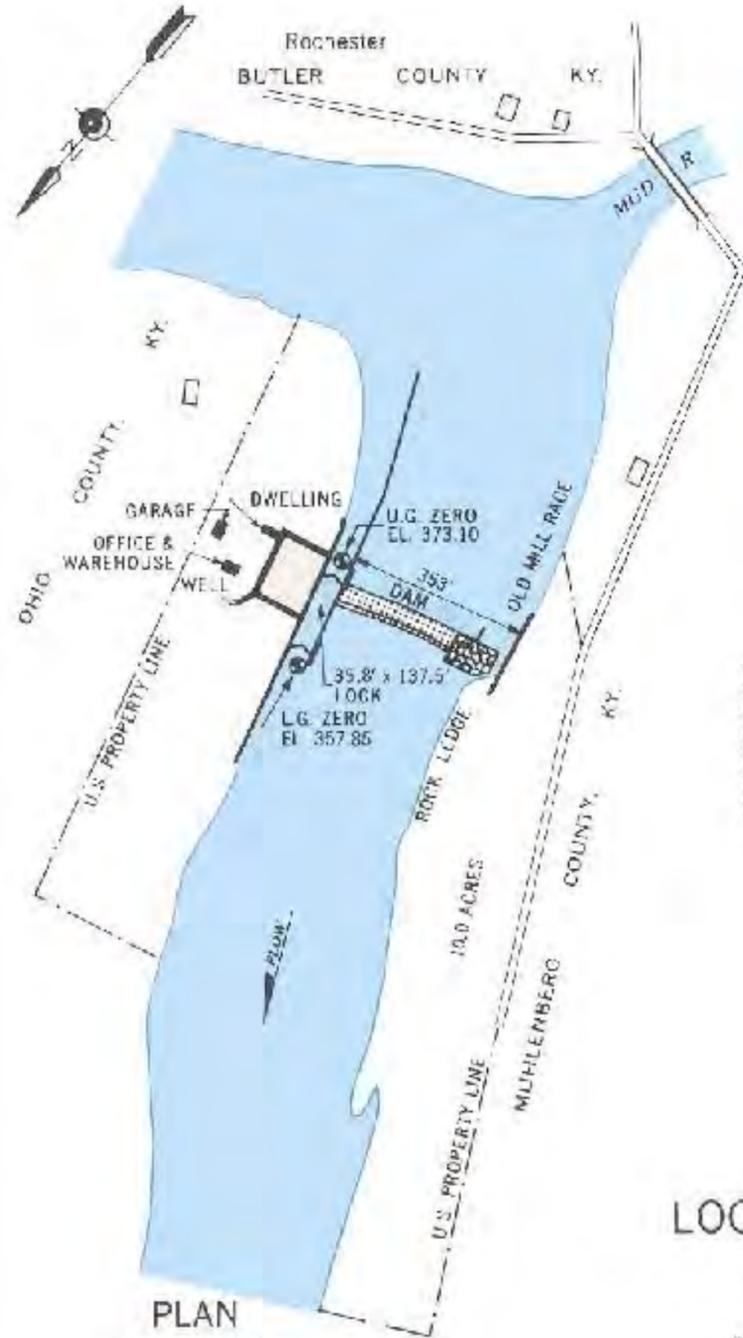


Lock and Dam #3 - View from Downstream



- ★ Boat Ramps
- Green River Locks
- ▲ Green River Water Intakes
- Ferries
- Green River



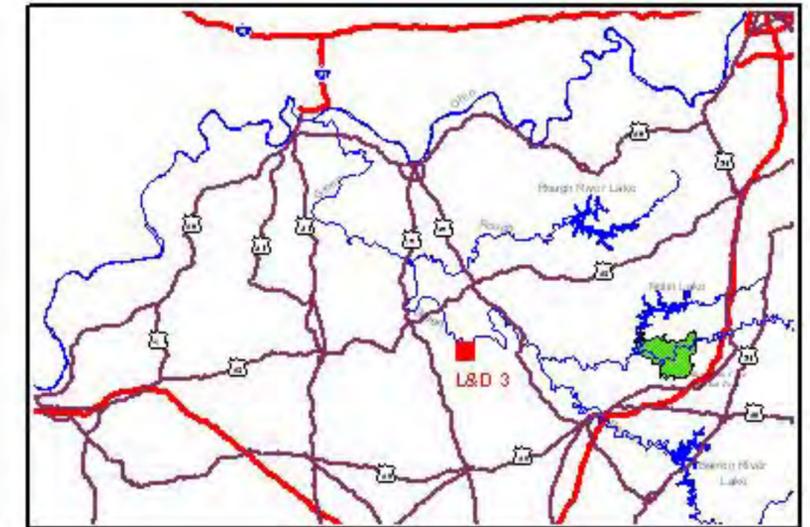
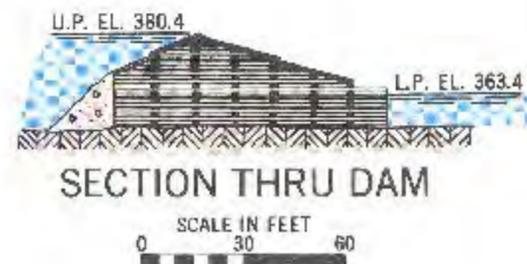
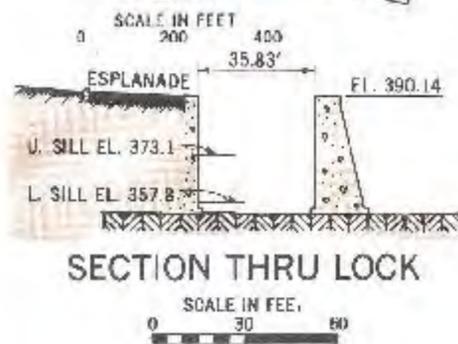


MILE 108.5
 H.W. 414.2 (1937)
 U.P. 380.4
 L.P. 363.4
 HFT 17.0'

BUILT 1833 1836
 ACQUIRED BY U.S. GOV. FEB 4, 1895
 DEPTH ON UPPER MILLER SILL 7.5'
 DEPTH ON LOWER MILLER SILL 5.8'
 U.S. PROPERTY 11.71 ACRES FEE
 5.01 ACRES PERV. T FOR FLOWAGE EASEMENT
 LOCKING OPERATIONS WERE DISCONTINUED
 IN SEPTEMBER 1981

GREEN RIVER
 LOCK & DAM NO. 3

LOUISVILLE, KY. DISTRICT
 SCALES AS SHOWN
 REVISED 30 SEPTEMBER 1995

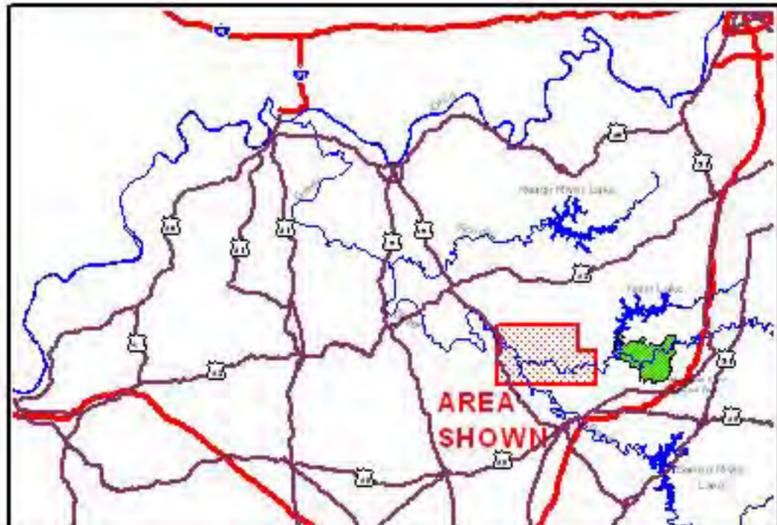
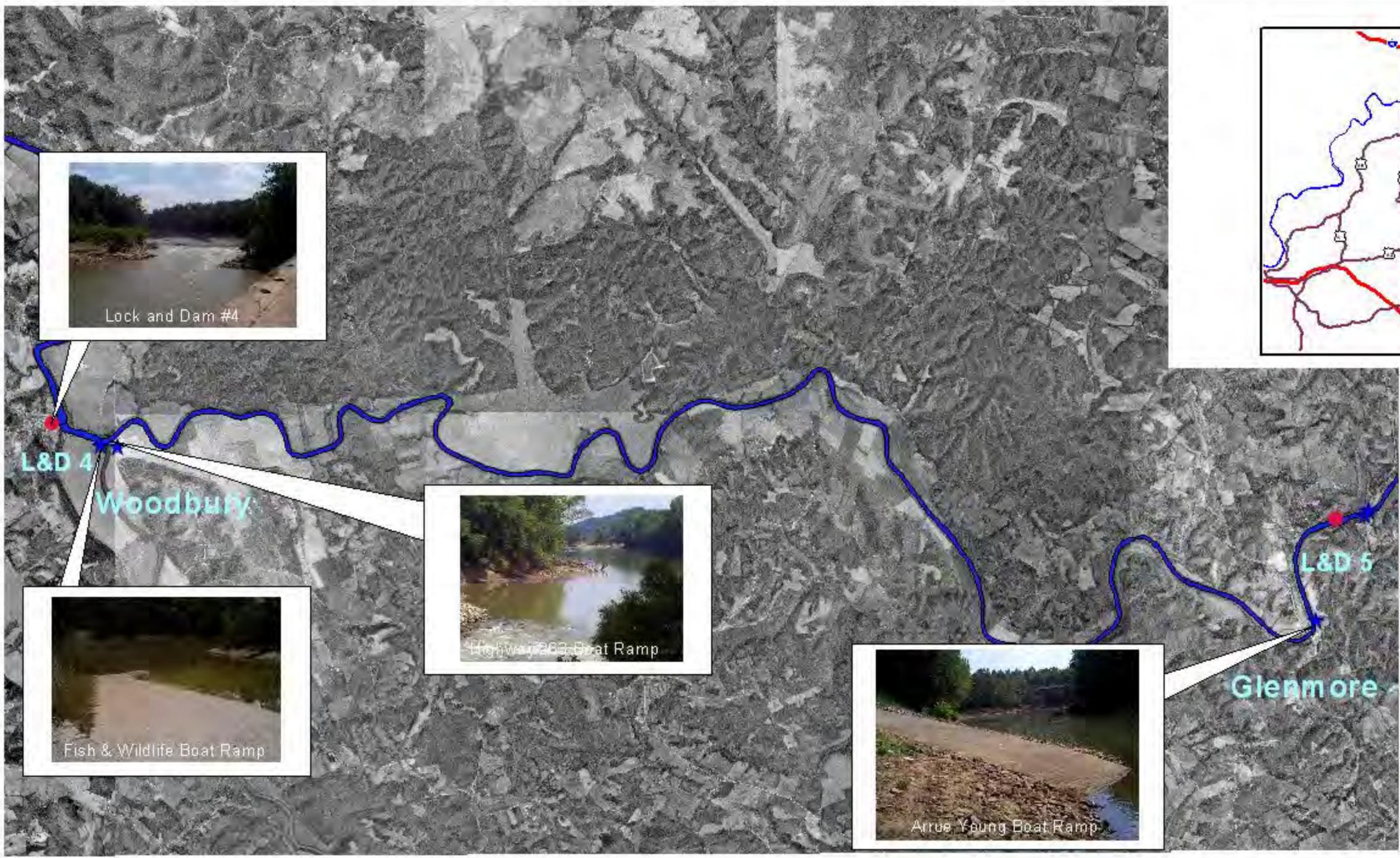


 GREEN & BARREN RIVERS
 DISPOSITION STUDY
 US Army Corps
 of Engineers

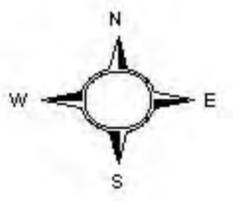
MAP - GREEN RIVER
 LOCK AND DAM #3

SCALE: AS SHOWN

MARCH 2001



Vicinity Map



- ★ Ld4ramps.shp
- Green River Locks
- Ferries
- Green River



 GREEN & BARREN RIVERS
DISPOSITION STUDY
US Army Corps
of Engineers.

**MAP - GREEN RIVER
LOCK AND DAM #4**

SCALE: AS SHOWN MARCH 2001



MILE 149.0
H.W. 432.7 (1957)
U.P. 396.8
L.P. 380.4
LIFT 16.4'

BUILT 1834-1839
ACQUIRED BY U.S. GOV'T FEB 20, 1886
DEPTH ON UPPER MILL SILL 7.1'
DEPTH ON LOWER WATER SILL 6.5'
U.S. PROPERTY 0.01 ACRES (FEET)
6.77 ACRES (FLOWAGE EASEMENT)
6.62 ACRES (BASEMENT OTHER)
DAM WAS BREACHED 24 MAY 1965
LOCK CLOSED TO TRAFFIC
POOL NOT MAINTAINED
PROPERTY HAS BEEN DEEDED TO CITY OF WOODBURY WITH ALL BUILDINGS.
(LOCK AND LOCKWALLS REMAIN U.S. PROPERTY)

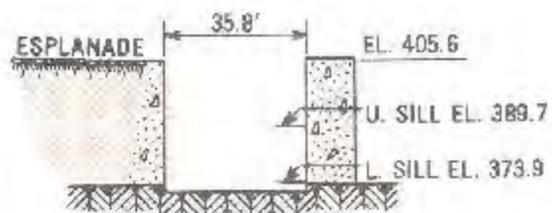
GREEN RIVER LOCK & DAM NO. 4

LOUISVILLE, KY. DISTRICT
SCALE AS SHOWN
REVISED 30 SEPTEMBER 1995



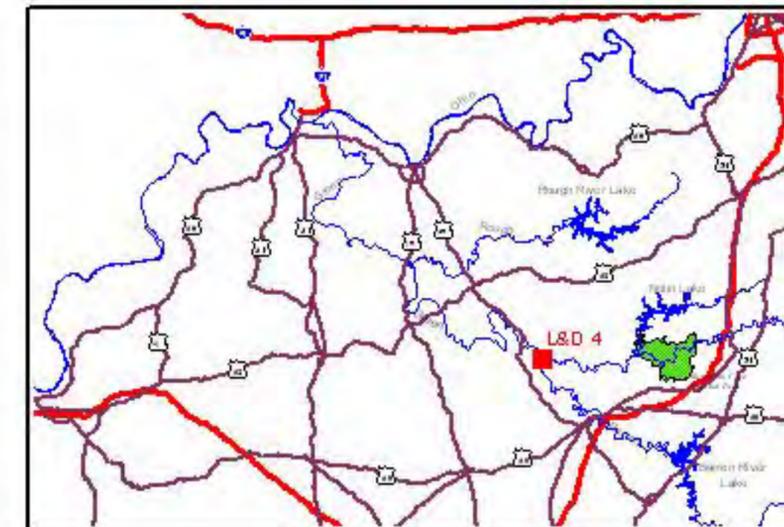
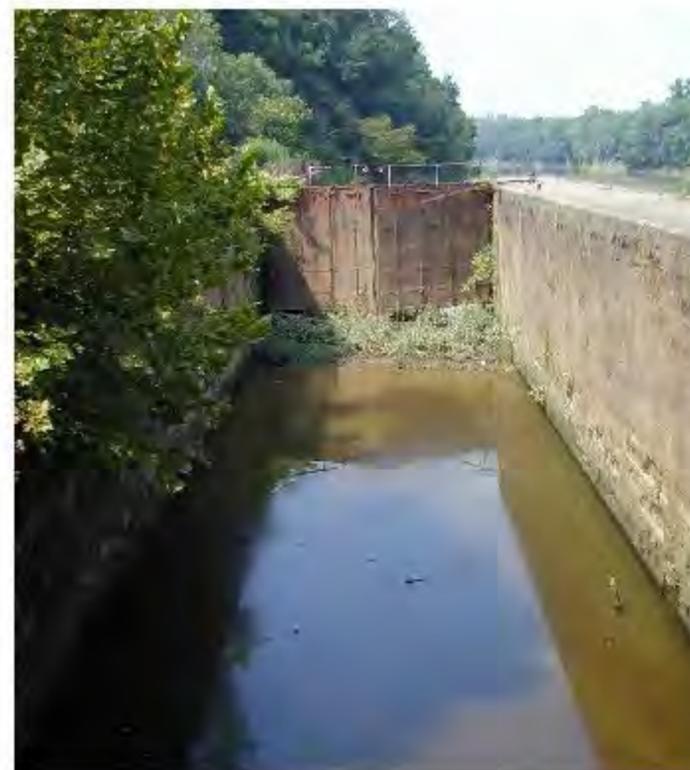
SECTION THRU DAM

SCALE IN FEET
0 30 60



SECTION THRU LOCK

SCALE IN FEET
0 30 60



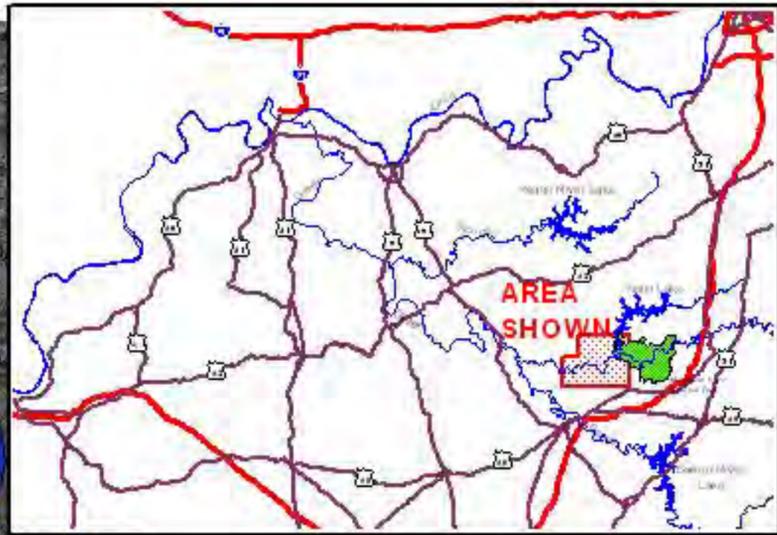
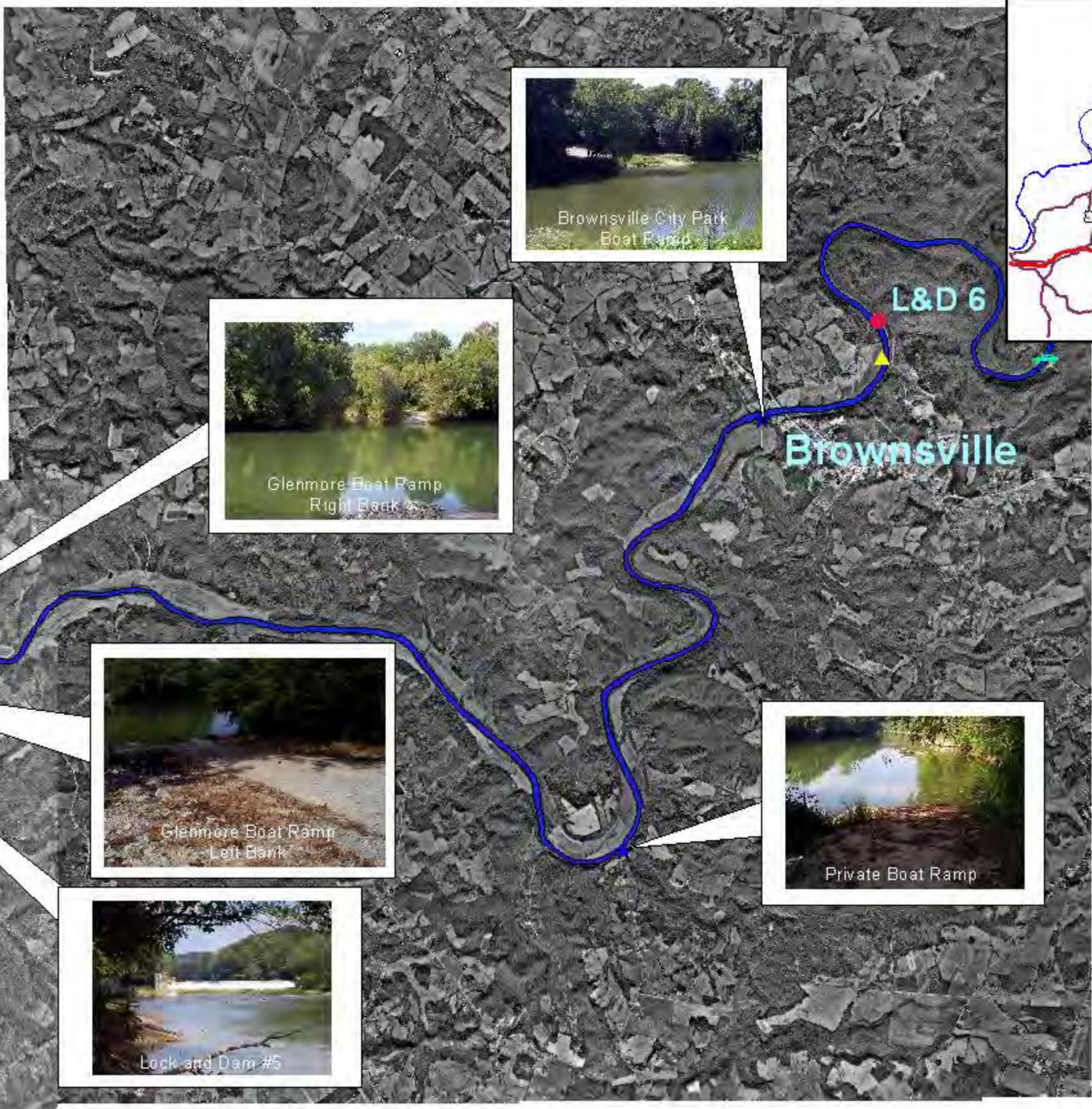
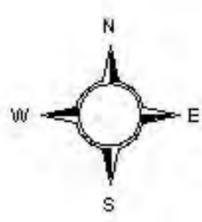
US Army Corps of Engineers

GREEN & BARREN RIVERS DISPOSITION STUDY

MAP - GREEN RIVER LOCK AND DAM #4

SCALE: AS SHOWN

MARCH 2001



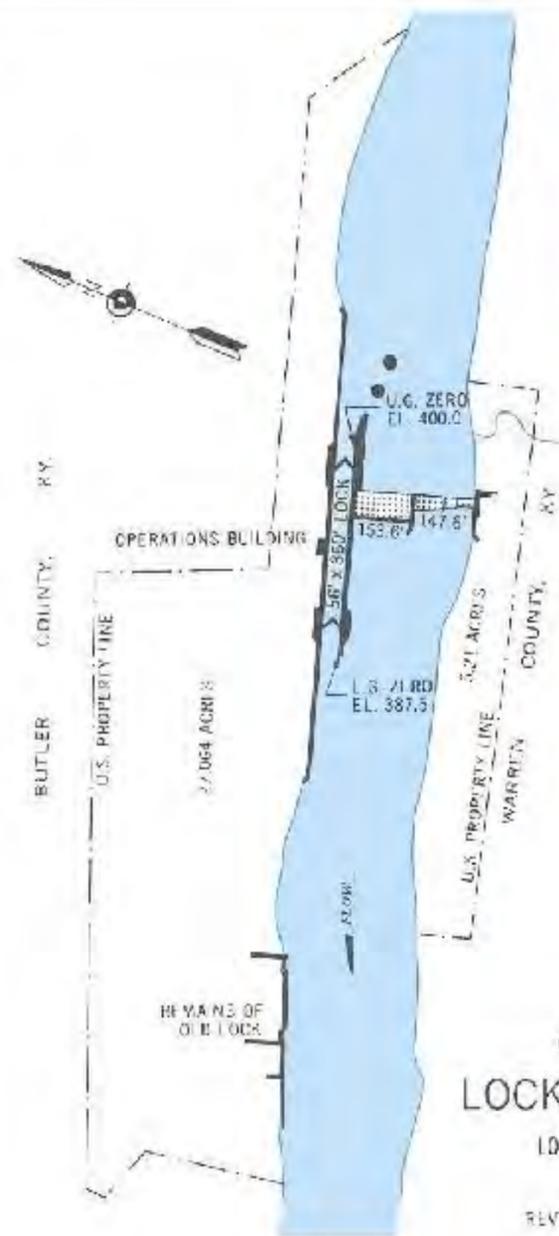
Vicinity Map

- Boat Ramps
- Green River Locks
- Green River Water Intakes
- Ferries
- Green River



GREEN & BARREN RIVERS
DISPOSITION STUDY
US Army Corps
of Engineers.

MAP - GREEN RIVER
LOCK AND DAM #5



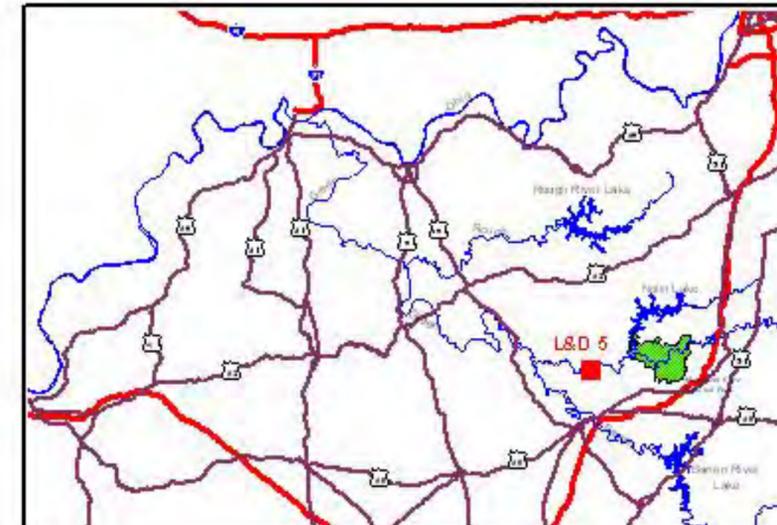
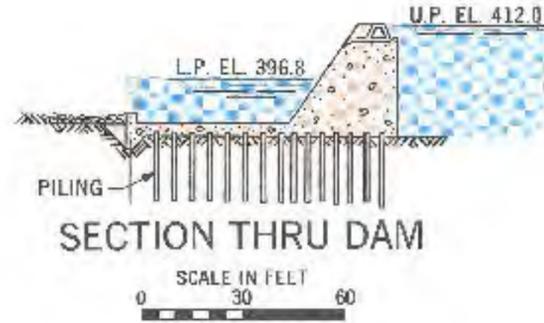
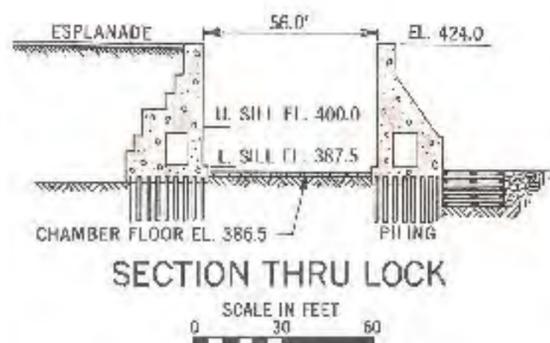
OLD LOCK PUT IN OPERATION JAN. 17, 1900
 NEW LOCK AND DAM BUILT 1933-1934
 OLD LOCK AND DAM REMOVED 1934
 NEW LOCK PUT IN OPERATION DEC. 20, 1934
 DEPTH ON UPPER MITER SILL 12.0'
 DEPTH ON LOWER MITER SILL 9.3'
 U.S. PROPERTY 32.27 ACRES (FEE)
 12.94 ACRES (FLOWAGE TARIFF IN)
 DEACTIVATED 31 AUG. 1951

NOTE:
 32.27 ACRES INCLUDES 1.899 ACRES
 IN ROAD AREA NOT SHOWN ON THIS MAP

MEAN
 H.W. 412.7 (1937)
 U.P. 412.0
 L.P. 396.8
 TIDE 15.2

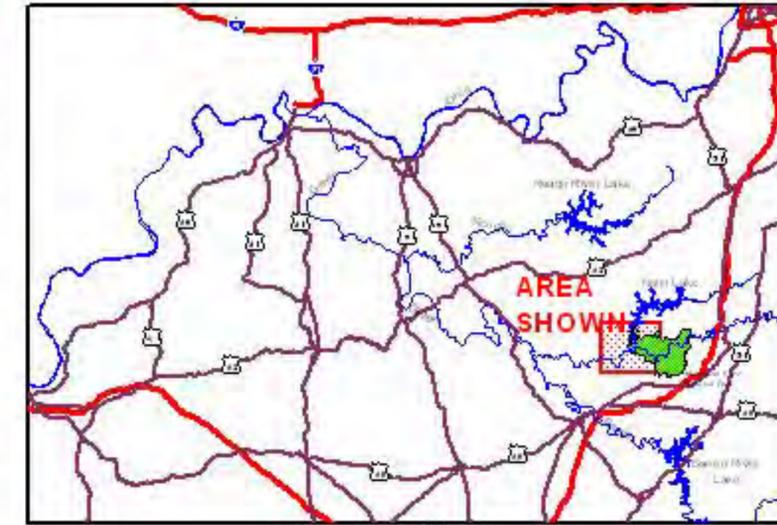
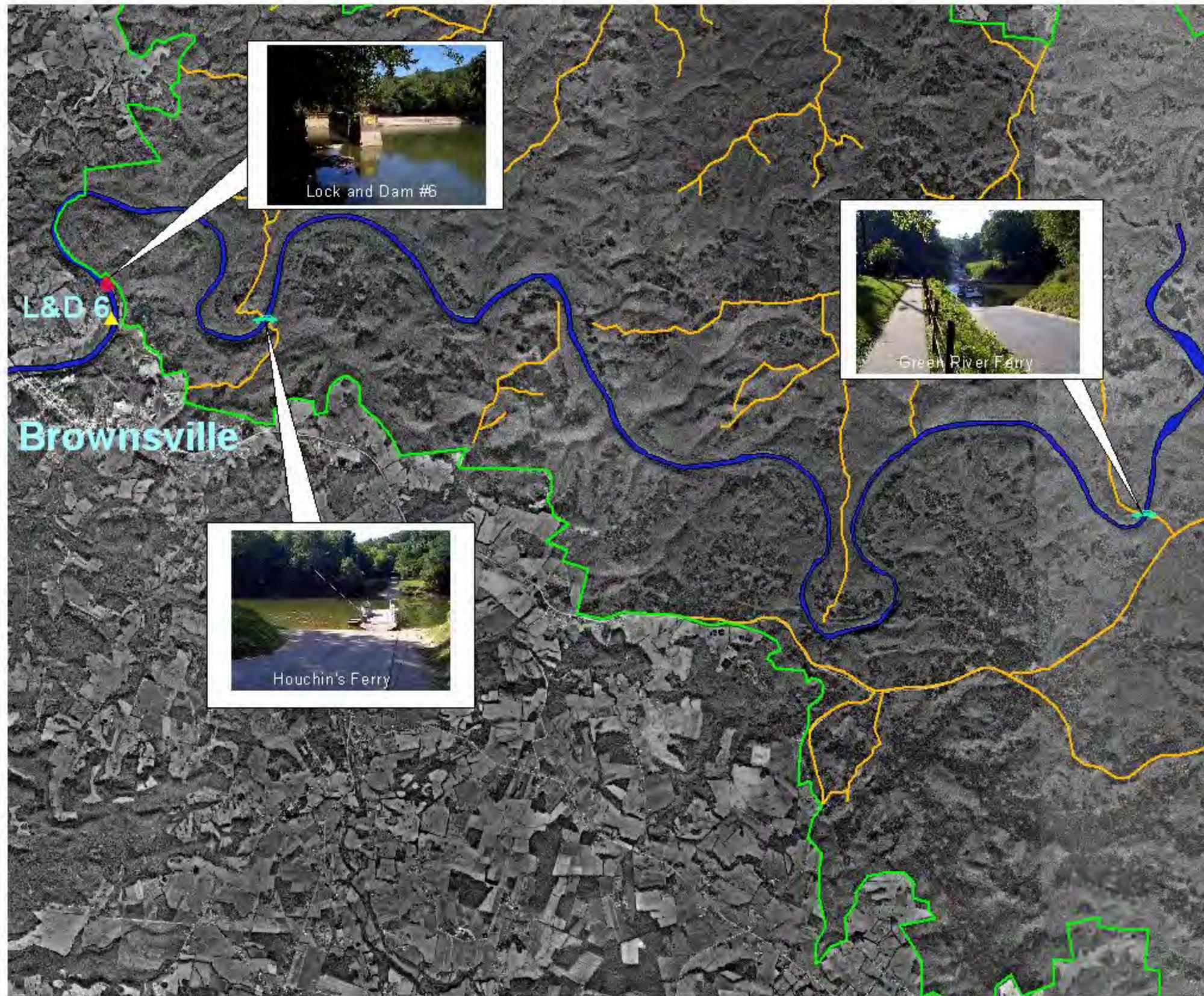
GREEN RIVER
 LOCK & DAM NO. 5

LOUISVILLE, KY. DISTRICT
 SCALES AS SHOWN
 REVISED 30 SEPTEMBER 1930

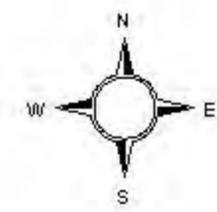


US Army Corps of Engineers
 GREEN & BARREN RIVERS
 DISPOSITION STUDY

MAP - GREEN RIVER
 LOCK AND DAM #5



Vicinity Map



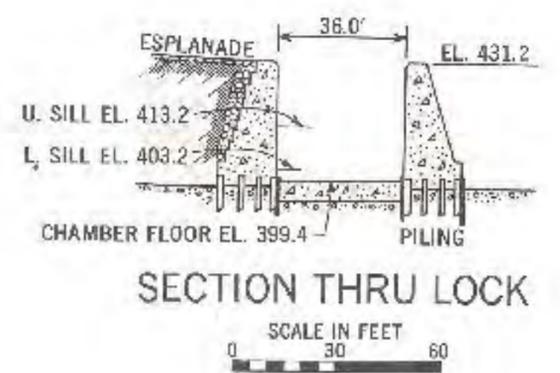
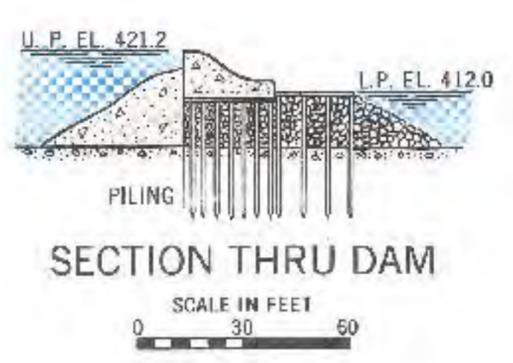
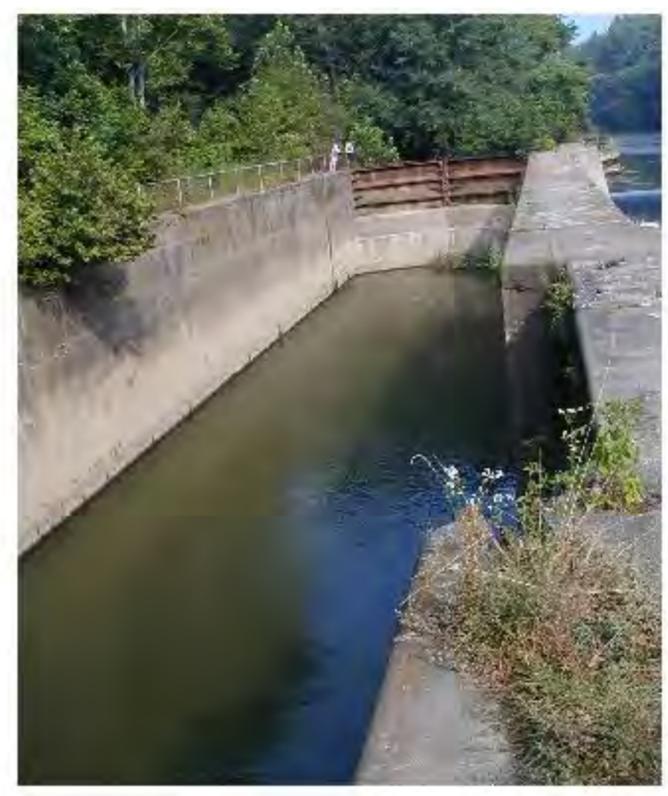
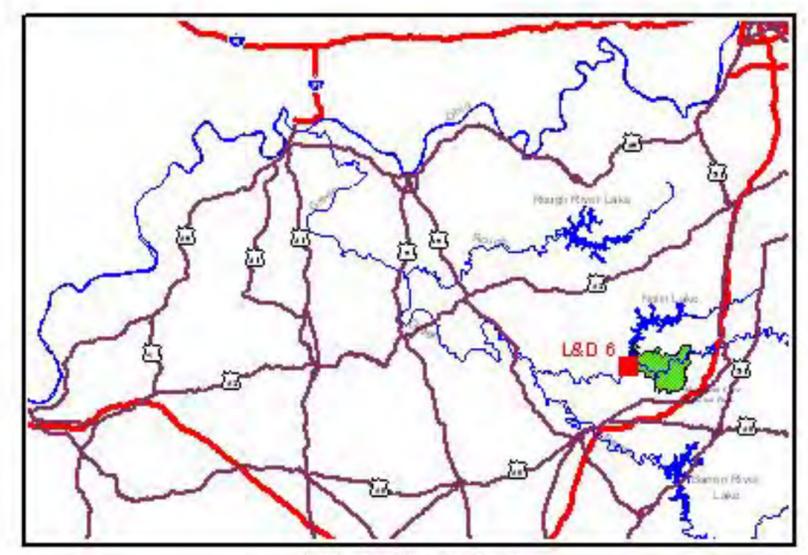
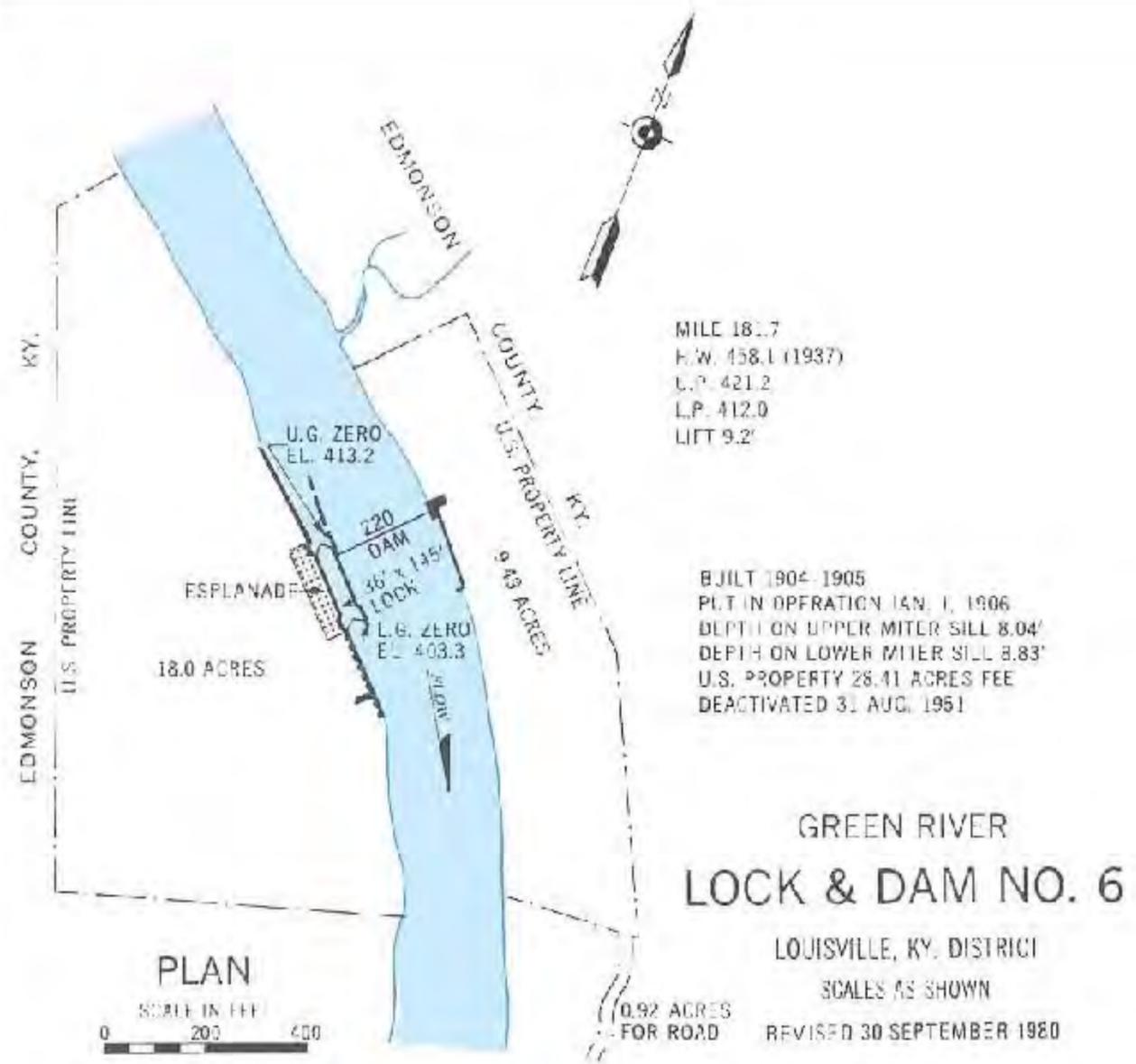
- ★ Boat Ramps
- Mammoth Cave National Park Boundary
- Green River Locks
- ▲ Green River Water Intakes
- Ferries
- Green River
- Road in Mammoth Cave National Park



 **GREEN & BARREN RIVERS
DISPOSITION STUDY**
US Army Corps
of Engineers.

**MAP - GREEN RIVER
LOCK AND DAM #6**

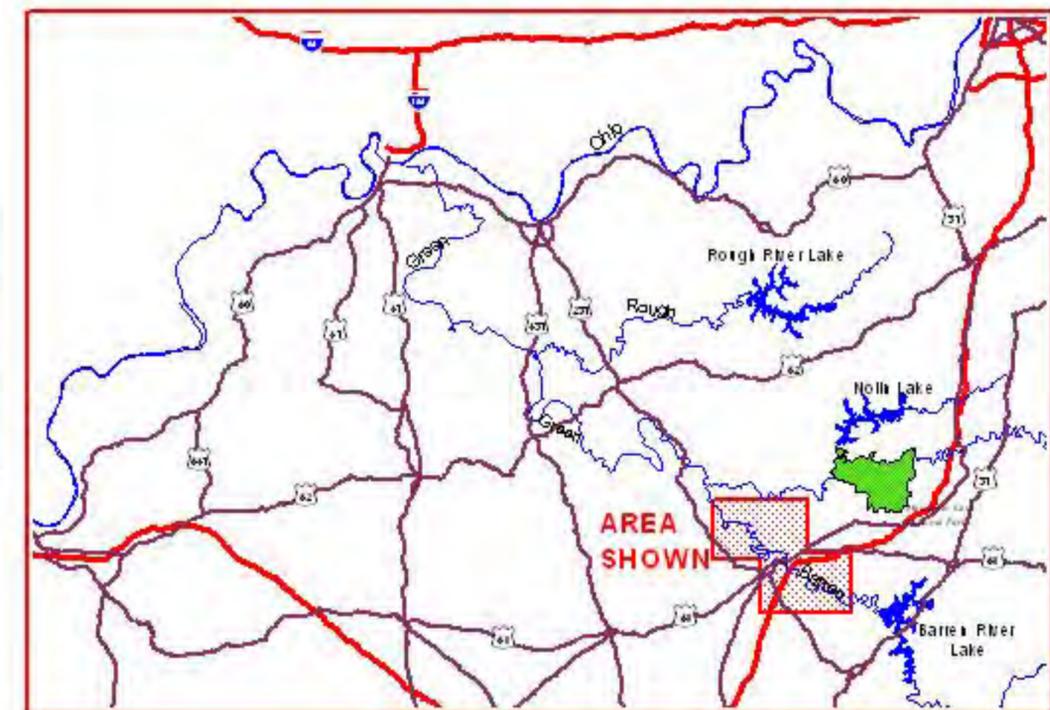
SCALE: AS SHOWN MARCH 2001



 **GREEN & BARREN RIVERS
DISPOSITION STUDY**
US Army Corps
of Engineers.

**MAP - GREEN RIVER
LOCK AND DAM #6**

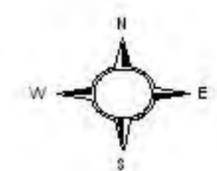
SCALE: AS SHOWN MARCH 2001



Vicinity Map



Bowling Green



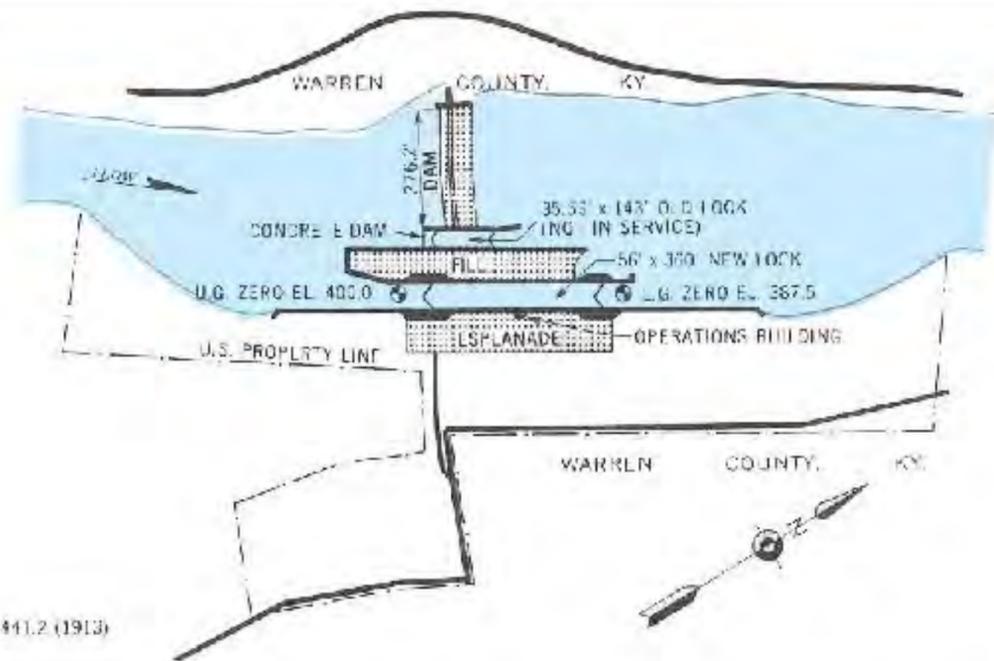
- Barren River Lock & Dam #1
- ★ Boat Ramps
- Town Boundaries
- Barren River



GREEN & BARREN RIVERS DISPOSITION STUDY
 US Army Corps of Engineers

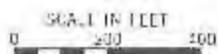
MAP - BARREN RIVER LOCK AND DAM #1

SCALE: AS SHOWN MARCH 2001



MILL 15
 MAX. H.W. 411.2 (1913)
 U.P. 412.0
 L.P. 396.8
 LIFT 15.2

PLAN

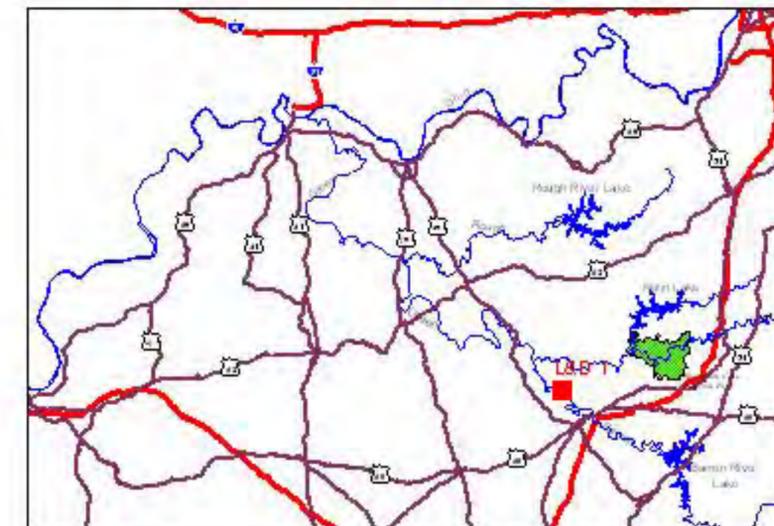
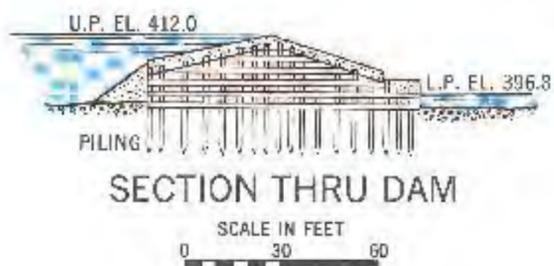
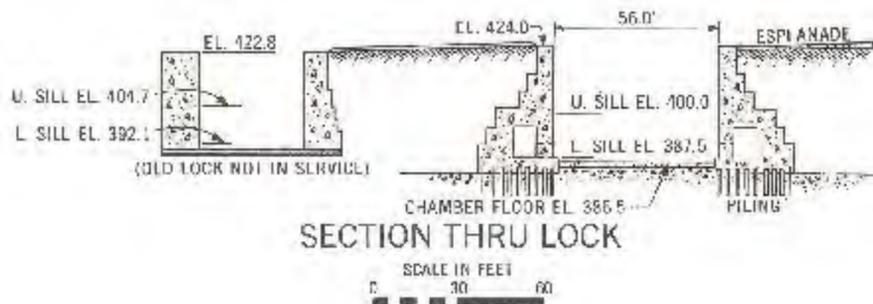


OLD LOCK AND DAM BUILT 1845
 ACQUIRED BY U.S. GOV'T. FEB. 20, 1886
 NEW LOCK BUILT 1923-1934
 PUT IN OPERATION SEPT. 17, 1934
 DEPTH ON UPPER MITER SILL 12.0'
 DEPTH ON LOWER MITER SILL 9.5'
 U.S. PROPERTY 20.1 ACRES (FEE)
 8.0 ACRES (FLOWAGE EASEMENT)

NOTE: LOCK CLOSED TO NAVIGATION
 DUE TO LOSS OF POOL AT GREEN
 RIVER DAM NO. 4.

BARREN RIVER
 LOCK & DAM NO. 1

LOUISVILLE, KY DISTRICT
 SCALES AS SHOWN
 REVISED 30 SEPTEMBER 1978



Vicinity Map



Aerial Photograph (ca. 1978)



GREEN & BARREN RIVERS
 DISPOSITION STUDY

MAP - BARREN RIVER
 LOCK AND DAM #1

SCALE: AS SHOWN

MARCH 2001

Green River Lock & Dam #6

(Digital Rendering of Proposed Project)

