US Army Corps of Engineers
St. Paul District

# Rice Lake
# Habitat Rehabilitation and Enhancement Project
# Project Evaluation Report

## Environmental Management Program
## for the Upper Mississippi River System

U.S. Army Corps of Engineers
St. Paul District
180 Fifth Street East, Suite 700
St. Paul, MN 55101-1638

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# 1.0 Introduction

## 1.1 UMRS EMP

The Upper Mississippi River System Environmental Management Program (UMRS-EMP) is a Federal-State partnership to manage, restore and monitor the UMRS ecosystem. The UMRS-EMP was authorized by Congress in Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) and reauthorized in 1999. Subsequent amendments have helped shape the two major components of EMP – the Habitat Rehabilitation and Enhancement Projects (HREPs) and the Long Term Resource Monitoring Program (LTRMP) (USACE, 2010). Together, HREPs and LTRMP are designed to improve the environmental health of the UMRS and increase our understanding of its natural resources (USACE, 2010).

The EMP was the first program in the Nation to combine ecosystem restoration with scientific monitoring and research efforts on a large river system (USACE, 2010). The EMP has served the Nation well for 25 years on the UMRS, completing 53 habitat projects benefiting approximately 95,000 acres of aquatic and floodplain habitat and contributing significantly to our scientific understanding of this complex system through monitoring and research (USACE, 2010). As of October 2010, five additional projects were under active construction and another 35 were in various planning and design stages. These projects range in size from small bank stabilization efforts that might cost less than a million dollars, to larger island or water level management projects that may exceed 10 million dollars. Most projects consist of several different restoration actions.

In addition to its achievements on the UMRS, the EMP has served as a model for other aquatic ecosystem efforts both nationally and internationally (USACE, 2010). The program has matured and adapted to changing conditions and new scientific insights and continues to be an efficient and effective means of ensuring that the UMRS remains both a nationally significant ecosystem and nationally significant navigation system (USACE, 2010).

## 1.2 Habitat Rehabilitation and Enhancement Projects

Habitat Rehabilitation and Enhancement Project (HREP) construction is one element of the UMRS-EMP. The projects provide site-specific ecosystem restoration, and are intended and designed to counteract the adverse ecological effects of impoundment and river regulation through a variety of modifications, including flow introductions, modification of channel training structures, dredging, island construction, and water level management. Interagency, multi-discipline teams including personnel from the Minnesota Department of Natural Resources (MDNR), the Wisconsin Department of Natural Resources (WDNR) the United States Fish and Wildlife Service (USFWS), and the United States Army Corps of Engineers (USACE) worked together to plan and design these projects, which are located on the navigable portion of the Upper Mississippi River and its navigable tributaries.

## 1.3 Purpose of Habitat Project Evaluation Reports

The purpose of this evaluation report is to summarize the project history and the effectiveness of the project in meeting stated restoration objectives. Another purpose is adaptive management, to derive lessons learned from the project experience for application to future restoration projects and river management.

This report summarizes available monitoring data, operation and maintenance information, and project observations made by the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS).

## 1.4 Project Team

Project team members, listed below in Table 1, for this evaluation report included representatives from the Corps of Engineers and the U.S. Fish and Wildlife Service. Many of these team members were also involved in the planning and construction phases of this project.

Much of the information in this report has been gathered from the project team members and others familiar with the project. This was accomplished through the use of a questionnaire (Appendix A), and subsequent review of this report by the project team.

**Table 1 - Project Team Members**

| Name | Discipline | Contribution |
|---|---|---|
| **U.S. Army Corp of Engineers** | | |
| Jessie C. Diaz | Biologist | Post-Construction Evaluation & Completion Report |
| Randall D. Devendorf | Chief, PD-P-EP | Post-Construction Evaluation |
| Jon Hendrickson | Hydraulic Engineer | Hydraulic Analyses & Post Construction Evaluation |
| Terry Jorgeson | Geologist | Groundwater and Erosion Evaluation |
| Daniel B. Wilcox | Fisheries Biologist | Post-Construction Evaluation |
| Keith LeClaire | Geographic Information Systems (GIS) Analysis | Post-Construction Evaluation |
| **U.S. Fish and Wildlife Service** | | |
| Chris Kane | Wildlife Refuge Specialist | Post-Construction Monitoring & Operation and Maintenance |
| Sharonne Baylor | Environmental Engineer | Post-Construction Monitoring & Operation and Maintenance |
| Vicki Sherry | Biologist | Post-Construction Monitoring & Operation and Maintenance |
| Jeanne Holler | Deputy Refuge Manager | Post-Construction Monitoring & Operation and Maintenance |

# 2.0 Project Background

## 2.1 Project Documents

Much of the information presented here is summarized from other documents, most of which are listed in Table 2. These documents are available from the St. Paul District on request.

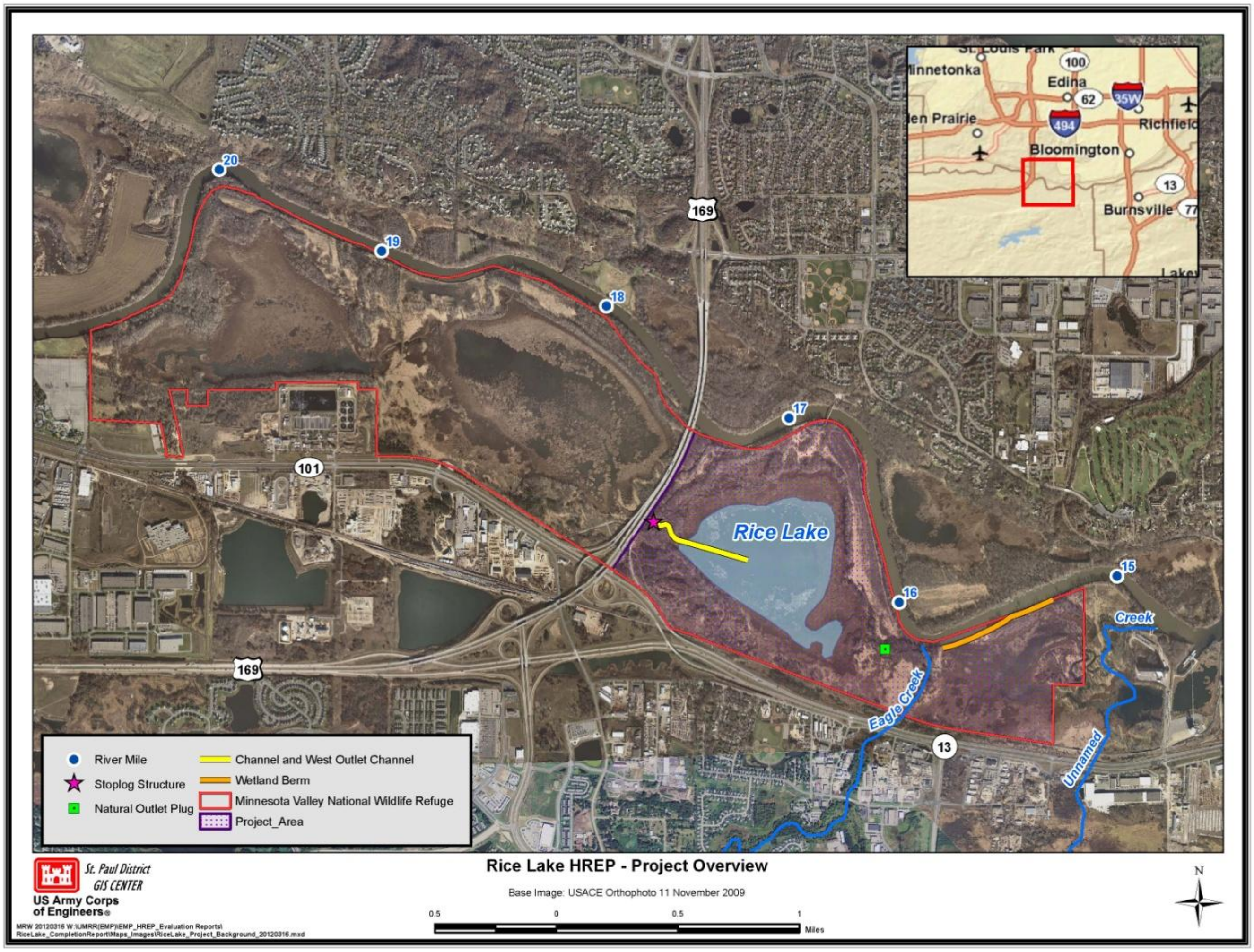
**Table 2 - Project Documents**

| | |
|---|---|
| Rice Lake<br>Definite Project Report/Environmental Assessment (SP-18) | July 1995 |
| Operation and Maintenance Manual – Rice Lake HREP, Scott County, Minnesota | September 1999 |
| Rice Lake HREP Annual Inspection Report | October 2007 |
| Rice Lake HREP Annual Inspection Report | May 2009 |
| Rice Lake HREP Annual Inspection Report | June 2010 |
| Rice Lake Shallow Lakes Survey 2010 | August 2010 |
| Memo for the Record: Rice Lake Berm Seepage and Erosion | June 2011 |
| Rice Lake Habitat Rehabilitation and Enhancement Project – Completion Report Project Objectives Analysis | August 2011 |

## 2.2 Project Area

The project area is located within the Minnesota Valley National Wildlife Refuge, which covers approximately 13,000 acres of the Minnesota River valley extending from river mile 4 to 35 on the Minnesota River (Figure 1). The footprint of the project encompasses roughly 400-acres, which includes Rice Lake and the surrounding area.

**Figure 1 – Project Overview**




## 2.3 Pre-Project Habitat Conditions and Changes

### 2.3.1 Water Resources

<u>Rice Lake</u>

Rice Lake is a floodplain lake located on the right bank of the Minnesota River at approximately river mile 16.7, and is separated from the river by higher ground. At its closest point, Rice Lake is approximately 1,000 feet from the river. Rice Lake has no defined inlet; however, outlets to the Minnesota River through an unnamed creek. Rice Lake is a 170 acre lake with maximum water depths of 18 inches to 3 feet during most growing seasons.

During a "normal" hydrologic season, Rice Lake will rise in elevation during the spring runoff period. This rise is typically caused by snowmelt and precipitation runoff, and/or high water on the Minnesota River either blocking outlet flow or backing up into Rice Lake via the unnamed outlet creek.

In the spring once high water recedes, the water surface elevation of Rice Lake continues to decline during the summer due to outlet discharges and evapotranspiration. However, groundwater inflows in the range of 4-5 acre feet per day (Sunde, 1975) help maintain the lake during the summer period.

No water quality data is available for Rice Lake. However, given its physical characteristics, it has been assumed that due to its shallow, fertile nature, the lake goes anoxic during the winter, and dissolved oxygen depletion occurs during the summer months. No water quality problems have been identified that adversely affect the quality of Rice Lake as habitat for migratory birds and aquatic mammals (USACE, 1995).

Minnesota River

The Minnesota River is a major tributary to the Mississippi River, and drains much of southwestern Minnesota; flowing northeast towards the Twin Cities metropolitan area where it enters the Mississippi River. The Minnesota River Valley in the metropolitan area is 1 to 2 miles wide and is bordered by bluffs which, in some locations, extend a few hundred feet in elevation above the river.

The river floodplain is predominately bottomland forest and marsh habitats, with limited areas of farmed floodplain. Development in the form of grain terminals, quarries, and landfills are all present, along with a number of highways and railroads crossing the area. The upland area bordering the river valley is developed or has potential for being developed in the future. These aspects have all been attributed to water quality degradation of the Minnesota River through high levels of suspended sediments, agricultural chemicals, and coliform bacteria.

Eagle Creek

Located one mile south of Rice Lake is Eagle Creek. The creek flows north-northeast to the Minnesota River, passing approximately a half mile east of Rice Lake. The unnamed creek that outlets Rice Lake, flows into Eagle Creek just before the confluence of Eagle Creek and the Minnesota River. Eagle Creek is a spring fed trout stream with good water quality conditions; higher quality trout habitat is located near its headwaters, but is greatly diminished at the confluence with the unnamed creek flowing out of Rice Lake.

### 2.3.2 Habitat Types and Distribution

The lower Minnesota River valley is dominated by a northern floodplain forest plant community located in the prairie-forest transition zone. Table 3 provides the habitat conditions present within the Refuge, along with the dominant vegetation for each habitat type.

**Table 3 – Existing Refuge Habitat**

| Habitat Present on Refuge | Type of Habitat | Dominant Species |
|---|---|---|
| 32% | Marsh and Aquatic Habitat | bulrush, softstem bulrush, cattail, bur-reed, water lily, smartweed, arrowhead, wild rice, and lotus |
| 26% | Bottomland hardwoods | elm, silver maple, cottonwood, willow, and basswood; Understory vegetation consists of willow shrubs, red-oiser dogwood, alder, sumac, little bluestem, and field thistle. |
| 12% | Wet meadow | common reed, reed canary grass, and prairie cordgrass |
| 10% | Upland | elm, oak, boxelder, aspen, cottonwood, roundleaf and grey dogwoods, sumac, hazel, chokecherry, sage, rose, prickly ash, prickly ribes, prairie bush clover, field thistle, yellow sweet clover, yarrow, common milkweed, 'little and big bluestem, Indian grass, Canada wild rye, and switchgrass |
| 20% | Human intervention | orchards, agriculture, etc. |

<u>Rice Lake</u>
Historical habitat changes of Rice Lake can be inferred from existing information; however, specific habitat changes have not been documented through time. The aquatic vegetation in Rice Lake is described as cyclic, which can contain close to 100% emergent vegetation in some years, yet completely absent in others. Table 4 presents the typical habitat breakdown prior to the HREP project.

**Table 4 – Pre-HREP Habitat**

| Habitat Type | Dominant Species |
|---|---|
| Emergent vegetation (wet areas) | River bulrush, softstem bulrush, and broad-leaved arrowhead |
| Emergent vegetation (drier areas) | Giant reed grass, reed canary grass, and jewelweed |
| Upland | Timothy, brome, various sedge species, asters, stinging nettle and milkweed |
| Forested | Green ash, silver maple, American elm, cottonwood, and willow |

<u>Farm Field</u>
The 40-acre farm field lies north of Rice Lake between the lake and the Minnesota River. Prior to cultivation, this area was dominated by cottonwood, American elm, silver maple, willow, and basswood. In approximately 1900 the 40-acre field was cultivated for production of corn and soybean. Agricultural production existed on the land through 1993, and in 1994 the field was left fallow and became overgrown with a variety of pioneer grass and forb species. The field was recently purchased by the U.S. Fish and Wildlife Service and incorporated into the Minnesota Valley National Wildlife Refuge.

<u>Minnesota River Bank</u>
Abutting the Minnesota River bank is a 40-acre farm field, in which a portion of the field abutting the river consists of a riparian strip of mature bottomland forest. The bottomland forest abutting the river is

predominately cottonwood. East of the field for approximately 900 feet, the river bank is vegetated by mature bottomland forest. Continuing downriver, the top of the river bank is vegetated by willows and tree saplings along the natural levee. Behind the natural levee lies a 70-acre perched floodplain marsh. In the lower reaches of the study area and beyond the river bank is again vegetated by mature bottomland forest.

## 2.4 Fish and Wildlife in the Project Area

The predominant wildlife present in the lower Minnesota River valley include waterfowl, wading birds {herons, egrets, and rails}, pheasant, white-tailed deer, muskrat, raptors, and songbirds. About 50% of the area is dabbling duck breeding and feeding habitat, but less than 25% is suitable nesting habitat. Wood duck nesting habitat is less than 5% but feeding habitat occurs on 40% of the area. There have been 275 species of birds recorded within the river valley during migration, 100 of which nest within the refuge. The diverse habitats within the floodplain and river valley support a large number of birds during migration.

Forty-nine species of fish were collected within the Minnesota Valley National Wildlife Refuge in a survey done in 1993 (Yess 1993). The Minnesota River contains a diverse fish assemblage, but due to water quality conditions fish consumption advisories are in place. If spring water conditions allow, Rice Lake may provide important spawning and nursery habitat to fish species. However, if spring water conditions do not overtop the banks to flood Rice Lake, it is unlikely any spawning activity would occur due to winterkill conditions.

## 2.5 Threatened and Endangered Species in the Project Area

At the time of the DPR two federally protected species could be found in the general project area: the bald eagle (Haliaetus leucocephalus), and the peregrine falcon (Falco peregrines). The peregrine falcon was noted as potentially being present in the project area at times and bald eagle nests had been documented in the project area, but were not directly located in the vicinity of the project site. Since the time of the project the bald eagle has been removed from the federal list of threatened and endangered species. However, to ensure that the bald eagle continues to thrive the U.S. Fish and Wildlife Service released a post-delisting monitoring plan on June 3, 2010 in coordination with state wildlife agencies to continue to monitor the eagles' progress. Although the bald eagle has been delisted, the eagles are still protected by the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and the Lacey Act.

## 3.0 Project Objectives

The general goals of the Rice Lake Project are to provide the Refuge a way to manage the water levels in Rice Lake to promote optimal growth of aquatic vegetation, restore a 40-acre farm field adjacent to Rice Lake into native floodplain forest, and to reconstruct a berm along a 70-acre floodplain marsh preventing interior drainage and wetland habitat loss, due to riverbank erosion.

In general the Refuge objective is to manage natural resources to enhance the natural diversity and abundance of wildlife species and ecological communities, and act as a center for wildlife-orientated recreation and education of natural systems. There were 5 areas identified in the DPR with specific project objectives. The following outlines the objectives for each of these areas.

<u>Wilkie/Rice Lake Unit</u>

Rice Lake is part of a larger management unit on the Refuge called the Wilkie/Rice Lake unit. The main objective in this unit is to restore and/or maintain the unique valuable wildlife habitats and provide for public use. Specifically:

- Managers are to focus on the protection and study of the heron rookery; the restoration and protection of oak savanna, floodplain forests and prairies; and management of water levels in the marsh complexes.
- Water control structures will be installed to allow wetland management of Blue, Fisher, and Rice Lakes. Rice Lake in particular, is heavily dominated by emergent vegetation with over 90% of the surface area covered in many years. Water level manipulation will be needed to create a desirable interspersion of open water and emergent vegetation.
- Areas of oak savanna, floodplain forest and prairie will be restored and/or maintained in native species.

<u>Rice Lake</u>

The habitat goal for Rice Lake was to maintain the lake as a shallow floodplain lake/marsh to provide high quality habitat for migratory birds and aquatic wildlife. This goal was in accordance with the overall Refuge goals and objectives, and the more specific management objectives of the Wilkie/Rice Lake management unit. The following were identified as the specific project objectives for Rice Lake:

- Provide the ability to draw down water levels in Rice Lake.
- Provide the ability to raise and maintain water levels in Rice Lake.

<u>Farm Field</u>

The general habitat goal for the farm field is to restore the site to mature bottomland forest habitat with the species variety typically found under natural conditions. The following were identified as the specific project objectives for the farm field:

- Re-vegetate 40 acres of farm field in a manner that will accelerate the vegetation succession process as much as practicable, and promote succession to a diversity of native species that provide high quality wildlife habitat.

Minnesota River Bank

The primary habitat goal for the Minnesota River bank in the study area was to prevent the loss of a 70-acre floodplain marsh due to riverbank erosion and breaching of the natural levee. In addition, maintaining the river bank would also potentially reduce the loss of mature bottomland forest and other floodplain habitats that provide fish and wildlife habitat. The following were identified as the specific project objectives for the Minnesota River Bank:

- Maintain 1,300 feet of natural levee between river miles 15.40 and 15.65.
- Maintain 1,300 feet of river bank between river miles 15.65 and 15.90.

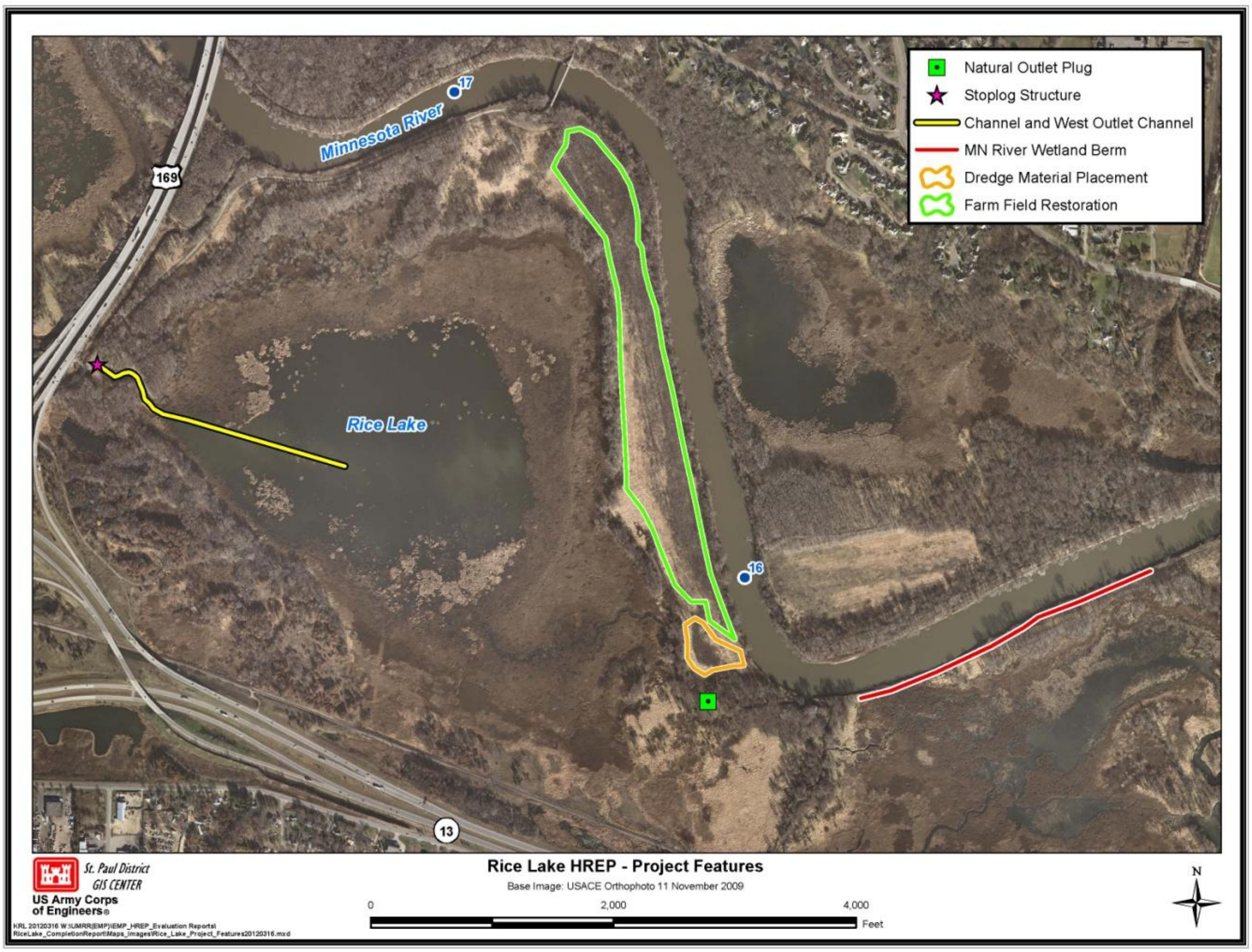
# 4.0 Project Description

## 4.1 Project Features and Implementation History

The Rice Lake project consists of three components each with specific project objectives: Rice Lake, a 40-acre Farm Field, and the Minnesota River Bank. For each of these components a number of alternatives were considered in the planning process, and identified in the DPR (USACE, 1995). Below are the descriptions of the chosen alternative for each of the three project components.

Figure 2 provides the location and the features of the three project components.

**Figure 2 – Project Features**




### 4.1.1 Rice Lake

The selected plan for Rice Lake involved the excavation of an outlet channel for the lake, plugging of the lake's natural outlet, and the installation of a culvert with stop log controls to manage lake water levels.

Outlet Channel
The outlet channel to permit the drawdown of Rice Lake extends from the low spot in the lake approximately 1, 730 feet, to the west shoreline of Rice Lake. The final 800 feet of channel extends from the shoreline to Old County Road 18. The channel has a 10 foot bottom width and was constructed to a depth of 0.6 feet below the invert elevation on the outlet culvert which is 693.1 msl (all elevations referred to in this document are based on NGVD 1929). The 800 foot reach between the lake and the road has a 10 foot wide maintenance road alongside the channel, which was constructed from materials excavated from the channel.

Outlet Plug
In order to raise the water levels in Rice Lake it was necessary to plug the existing natural outlet. The plug is located approximately midway down Eagle Creek between Rice Lake and the Minnesota River. Approximately 365 cubic yards of fill material was used to construct the plug, which was obtained through the excavation of the outlet channel between Rice Lake and County Road 18. After construction of the outlet plug, both top-soiling and seeding were administered.

Outlet Culvert/Stop Log Structure
Also constructed to raise or lower water levels in Rice Lake was a control structure on the outlet culvert under Old County Road 18. The existing oval shaped culvert was removed and replaced with a 42-inch round culvert and stop log structure, which provided the ability for the Lake levels to be managed between elevation 693.1 and 698 feet msl.

### 4.1.2 Farm Field
Restoration of the farm field to bottomland hardwood forest occurred in a series of two steps. First, seeds and acorns were collected from the Minnesota River floodplain and planted at a nursery. Second, two years after the planting, the trees were transplanted to the 40 acre farm field at a rate of 600 trees per acre over approximately 32 acres of the field at anywhere from 6 to 16 feet apart. On about 6 acres of the field, trees were planted at a rate of 400 trees per acre; additional measures to enhance tree survival were also employed in these locations. Table 5 shows the primary tree species planted and target composition.

**Table 5 – Tree planting composition of the 40-acre farm field**

| Tree Species Planted | Percent Composition |
|---|---|
| Silver maple | 46% |
| Green ash | 18% |
| American elm (native) | 16% |
| American elm (Dutch elm disease resistant) | 16% |
| Boxelder | 2% |
| Bur oak | 1% |
| Hackberry | 1% |

Prior to planting, two types of field pre-treatments were conducted in select locations: mechanical spot treatment by scraping or tilling or Rodeo chemical treatment of 4’ x 4’ areas. Some trees were also given protection in the form of either mats, wood chip mulch, tree tubes, or in some cases a combination of the three.

### 4.1.3 Minnesota River Bank

The selected plan for the Minnesota River Bank was to reconstruct the existing temporary berm behind the natural levee. The new constructed berm is located adjacent to the existing berm on its landward side. Approximately 2,300 cubic yards of fill material, obtained from a commercial source was used for the new berm construction. To prevent sheet flow erosion as floodwaters either entered or returned from the adjacent 70 acre wetland, an overflow spillway was incorporated into the design of the berm. The overflow spillway is located in the area where flows from the perched wetland to the Minnesota River had already eroded a cut in the river bank. The cut was graded and lined with 250 cubic yards of bedding and 500 cubic yards of rock. The eastern portion of the berm was topped with approximately 150 cubic yards of gravel to serve as a maintenance road to get to the overflow spillway. The rock spillway was designed with an invert elevation of 699.0 and had a bottom width of 30 feet. The sand berm was designed with a top elevation of 701.0 and a top width of 12 feet. Stabilizing the river bank with riprap was considered but deemed too expensive.

## 4.2 Project Construction Costs

The total cost of the project at the fully funded level was estimated to be $463,000, which did not include the $155,000 for general design and planning (Table 6).

**Table 6 – Summary of Estimated Total Project Costs**

| Feature | Cost |
|---|---|
| Construction | |
| - Mobilization | $45,000 |
| - channel construction | $142,000 |
| - outlet channel plug | $21,000 |
| - 42-inch culvert | $33,000 |
| - stop log control structure | $22,000 |
| - reforestation | $37,000 |
| - berm | $25,000 |
| - rock-lined spillway | $33,000 |
| Planning, Engineering and Design | $69,000(1) |
| Construction Management | $36,000 |
| **Total** | **$463,000** |
| (1) This does not include prior allocations of $155,000 for general design (planning). | |
| | Corps, 1995 |

Construction began in December 1996 and was completed in November 1998. All features of the project, except for the Rice Lake portion of the outlet channel, were completed during the 1997 construction season. Mechanical excavation of the Rice Lake portion of the outlet channel was originally scheduled for the winter of 1996-97, and then rescheduled for the winter of 1997-98. Inadequate ice conditions prevented the work from being done in either of the two seasons. In the fall of 1998 the excavation was accomplished by hydraulic dredging.

The actual construction cost for the project amounted to $386,455.31, and broken down as follows:

| | |
|---|---|
| Mobilization/Demobilization | $30,941.46 |
| Outlet Channel Excavation | $153,436.05 |
| Outlet Culvert/Control Structure | $40,750.60 |
| Outlet Plug | $24,815.97 |
| Wetland Berm/Rock Spillway | $74,890.26 |
| Tree Plantings | $54,594.88 |
| Performance Bonds | $7,026.09 |
| **Total** | **$386,455.31** |

# 5.0 Operation and Maintenance

## 5.1 Project Features Requiring Operation and Maintenance

The stop log structure on the outlet culvert is the one project feature that requires regular operation and maintenance by the USFWS. It was estimated that the stop logs in this structure would need to be changed an average of twice a year, although, the frequency in any given year could range from 0 to 4 times (USACE, 1995).

No maintenance of the Rice Lake dredged channel was anticipated as the channel was over-depth dredged to account for future sedimentation. Should inspections reveal that sedimentation in the channel reaches a point where the channel no longer serves the function for which it was designed, then re-dredging of the channel would be considered (USACE, 1999). Maintenance requirements would primarily center on cleaning the outlet channel of debris and woody vegetation, maintenance and repair of the control structure, and replacement of rock at the berm/overflow spillway (USACE, 1995).

## 5.2 Operation and Maintenance Responsibilities

Upon completion of construction, the USFWS accepted responsibility for the operation and maintenance of the Rice Lake project in accordance with Section 107(b) of the Water Resources Development Act of 1992, Public Law 102-580, and subsequent Annual Addendums (USACE, 1995). Typically the USFWS operation and maintenance responsibility for habitat projects are given to the Refuge Manager in charge of the National Wildlife Refuge. The acceptance of these responsibilities was formally recognized by an agreement signed by the U.S. Fish and Wildlife Service (USFWS) and the St. Paul District, Army Corps of Engineers. The capability of the USFWS to carry out the operation and maintenance responsibilities is contingent on the passage of sufficient appropriations by Congress (USACE, 1995).

As stated in the Memorandum of Agreement between the USFWS and the Corps, the Corps is responsible for any mutually agreed upon repair and rehabilitation of the Rice Lake project that may be needed as a result of a specific storm or flood. Should a natural disaster cause substantial damage to the project, the Corps and USFWS would meet to discuss the appropriate course of action. Any decisions would be carried forth only upon written mutual agreement of the USFWS and the Corps (USACE, 1999).

The District Engineer or his representative will be kept informed on the operation and maintenance activities through periodic inspection of the project by the Corps and through an annual report submitted by the USFWS. The Corps and the USFWS will coordinate periodic inspections which will occur in 5 year intervals. After the first 10 years of project operation, the Corps and the USFWS will jointly review the inspection plans and make any appropriate revisions. Findings of the periodic inspections are to be transmitted to the USFWS, and any remedial work considered necessary is the responsibility of the USFWS and is to be completed as soon as possible (USACE, 1999).

## 5.3 Operation and Maintenance Tasks and Schedule

The USFWS will operate the Rice Lake structure to maximize the habitat benefits for which the project was designed and constructed as described in the DPR (USACE, 1999). The Rice Lake control structure would be used in most years to drain off Minnesota River flood waters, and in some years, to dewater the lake to promote the growth of emergent wetland vegetation or to hold water levels at an artificially high level to control willow and other woody growth.

## 5.4 History of Major Disturbances and Repairs

### 5.4.1 Rice Lake

In 2003, 600-feet of the Rice Lake outlet channel were re-excavated to a 2-foot depth. Siltation of the channel had gradually built up over time, limiting the ability for complete drawdowns. Channel excavation was necessary to restore the channel to properly perform project objectives (Appendix A).

The stop log structure and the outlet channel are frequently affected by beaver habitation. Removal of beaver dams has been necessary in a number of years, and in 2006 the wood stoplogs were replaced with aluminum stoplogs due to continued beaver damage.

### 5.4.2 Minnesota River Bank

As described in section 4.1.3, in the late 1990's the berm along the Minnesota River bank was reconstructed and a rock lined spillway was constructed to prevent sheet erosion due to inflows and outflows from the perched wetland. Since the time of the project, erosion along this portion of the Minnesota River bank is still occurring. Surveyed cross sections obtained by the Corps in 1994 and 2008 indicate that the top of the river bank has eroded back 29 to 39 feet during this 14 year period. This high rate of erosion is partly due to a recent wetter climate and increase in discharge. It is the belief of the USFWS that erosion has been most severe below the overflow spillway, and this hard point is contributing to the erosion in this location. On the Minnesota River, average annual discharge increased 68% for the two decade time period 1991 to 2010 compared to the previous two decade period, 1971 to 1990 (based on USGS measurements at the Jordan gage). Associated with this increase in average annual discharge is an increase in the number and duration of bankfull flow events that occur every year. In addition, in April of 2001 the second largest flood event occurred, possibly enhancing the rate of erosion to the reconstructed berm. Spring flooding is an annual event and similar out-of-bank events have also occurred during the fall and summer. These events typically cause siltation of the spillway and Rice Lake channel. Also, gravel around the outlet structure is typically eroded to an extent during these out-of-bank events (Appendix A).

## 5.5 Operation and Maintenance History and Costs

In the Definite Project Report it was determined that the Rice Lake HREP operation and maintenance needs would primarily center on cleaning the outlet channel of debris and woody vegetation, maintenance and repair of the control structure, and replacement of rock at the berm/overflow spillway (USACE,1995).

The average annual operation and maintenance cost was calculated to be $2,876, and is broken down in Table 7 (USACE, 1995). As stated in the Memorandum of Agreement between the USFWS and the Department of Army (DOA), "the USFWS is responsible for operation, maintenance, and repair: upon completion of construction as determined by the District Engineer, St. Paul, the USFWS shall accept the project and shall operate, maintain, and repair the project as defined in the Definite Project Report" (USACE, 1999). Table 8 below summarizes operation and maintenance tasks performed by year and the costs associated with those tasks. The table is based on information provided in the 2007, 2009, & 2010 USFWS Rice Lake Annual inspection reports, and outlines the operation and maintenance history and costs for the Rice Lake Project.

**Table 7 – Estimated Average Annual Operation and Maintenance Costs**

| Item | Amount |
|---|---|
| Outlet channel (clear woody debris) | $143 |
| Outlet channel (control woody plants) | $127 |
| Control structure operation | $863 |
| Control structure maintenance | $386 |
| Bedding/rock replacement | $237 |
| Reporting | $1,120 |
| **Total** | **$2,876** |

**Table 8 – Operation and Maintenance History and Costs Associated**

| Year | Years in O&M | Cost | Activities |
|---|---|---|---|
| 1999 | 1 | $0 | None |
| 2003 | 5 | $4,805 | • Project Inspection<br>• Clean outlet channel and stop log structure<br>• Re-excavate 600-feet of the Rice Lake outlet channel to a 2-foot depth<br>• Operation of the water control structure (WCS) |
| 2004 | 6 | $1,591 | • Clean stop log structure<br>• Operation of the WCS<br>• Install gage<br>• Beaver control<br>• Project inspection |
| 2005 | 7 | $2,110 | • Operation of the WCS<br>• Clean stop log structure<br>• Project inspection |
| 2006 | 8 | $7,542 | • Operation of the WCS<br>• Project inspection<br>• Beaver dam removal<br>• Purchase and install new aluminum stoplogs |
| 2007 | 9 | $2,936 | • Operation of the WCS<br>• Beaver dam removal<br>• Project inspection |
| 2008 | 10 | $2, 748 | • Operation of the WCS<br>• Beaver dam removal<br>• Project inspection |
| 2009 | 11 | $2, 815 | • Operation of the WCS<br>• Beaver dam removal<br>• Project inspection |

# 6.0 Project Monitoring Plan

## 6.1 Monitoring Plan

As specified in the operations and maintenance manual, operation and maintenance activities are to be periodically inspected by the Corps, and an annual inspection report will be submitted by the USFWS. Inspections by the Corps are to be coordinated with the USFWS prior to the date of inspection. Inspections by the Corps are to occur in intervals of every 5 years, and after the first 10 years of the project operation, the Corps and the USFWS will jointly review the inspection plans and make any appropriate revisions (USACE, 1999).

The findings of the Corps periodic inspections are to be transmitted to the USFWS and could include recommendations for any remedial work considered necessary to maintain the habitat project in a satisfactory condition. Any agreed upon remedial work should be completed as soon as possible by the USFWS as provided in the Memorandum of Agreement between the USFWS and the Corps (USACE, 1999).

The project will be inspected by the Refuge Manager or designated representative, at a minimum frequency of once per year. A review of the frequency interval by the USFWS and the Corps can be changed only upon mutual agreement.  The timing of the inspection can be made at the discretion of the Refuge Manager. Given the high frequency of flooding in the area, no special inspections are necessary after a high water event.  Annual inspections should be sufficient to reveal any problems or damage caused by high water events (USACE, 1999).  Table 9 shows the monitoring schedule for the goals of the Rice Lake Project.

Table 9 – Rice Lake Project Monitoring Goals and Schedule

| Goal | Project Objective | Enhancement Feature | Unit of Measure | Measurement Plan | Monitoring Interval | Projected Cost/Effort |
|---|---|---|---|---|---|---|
| Enhance the value of Rice Lake for migratory waterfowl | Provide drawdown capability | Channel | Years | Monitor number of years drawdown is successfully used to manage vegetation | Annually | $200 |
| | Provide the ability to raise lake levels | Control structure outlet channel plug | Years | Monitor number of years impoundment is successfully used to manage vegetation | Annually | $200 |
| Reforest farm field to bottomland forest | Revegetate to accelerate natural succession to desired species | Plantings | Trees/acre of desired species | Count number of trees of desired species within 20 permanent circular plots | Annually for five years, and every five years thereafter | $1,000 |
| Maintain 70 acre perched wetland | Prevent breaching river levee | Berm overflow spillway | Acres | Measurements from aerial photographs | 1994 photographs for pre-construction Every 10 years post-construction | $200 |

## 6.2 Post-Construction Monitoring

As indicated in the Operation and Maintenance Manual an annual report should be submitted at the end of each calendar year to the St. Paul District's Construction-Operation Division, and should briefly summarize the condition of the project and any maintenance or repairs required during the reporting period (USACE, 1999). The following are summaries of the reports submitted to the Corps by the USFWS.

### 6.2.1 October 2007: Rice Lake HREP (Minnesota Valley NWR) Annual Inspection Report

The annual 2007 inspection took place on August 14, 2007. The inspection included observations of the stoplog closure structure and East outlet channel plug on Rice Lake, and the wetland berm and overflow spillway along the Minnesota River. Items not inspected during this time include: the Rice Lake outlet channel and Rice Lake channel, and the farm field bottomland forest restoration.

During the inspection, it was reported that the stop log closure structure has been frequently damaged by beavers and blocked by beaver dams. The East outlet channel plug was heavily vegetated, but appeared to be in okay condition. The wetland berm along the Minnesota River bank had significant erosion, and the access road along the top of the berm was no longer drivable. The overflow spillway was heavily vegetated and had some erosion behind the rock on the river bank.

Actions recommended by the USFWS to be taken care of immediately included:

1. Removal of willows and other woody vegetation from the East outlet channel plug and overflow spill ways.
2. Work with the Corps of Engineers to rehabilitate the Minnesota River bank erosion problem along the wetland berm and overflow spillway.

Actions recommended by the USFWS to prolong the life of the project included:

1. Repairing the erosion between the stop log structure inlet riprap and blacktop trail.
2. Replacing the missing stop log channel and lock.
3. Remove beavers from the project area if they affect the project function.
4. Continue to monitor the project.

#### 6.2.2 May 2009: Rice Lake HREP (Minnesota Valley NWR) Annual Inspection Report

The annual 2009 inspection report took place on May 7, 2009. The inspection included observations of the stop log closure structure on Rice Lake and the wetland berm and overflow spill way along the Minnesota River bank. The inspection did not include observations of the outlet channel, Rice Lake channel, or east outlet channel on Rice Lake. The inspection also did not document the progress of the farm field bottomland forest restoration.

During the inspection it was reported that new aluminum stoplogs were installed at the stoplog closure structure on Rice Lake to prevent further beaver damage. There was also minor erosion between the inlet riprap and blacktop trail. The wetland berm along the Minnesota River was documented as being severely eroded and nearly gone in one location. The vegetation was removed from the overflow spillway and it was discovered that the rock at the bottom of the spillway had eroded away.

Actions recommended by the USFWS to be taken care of immediately included:

1. Work with the Corps of Engineers to repair the Minnesota River bank erosion problem along the wetland berm and overflow spillway.

Actions recommended by the USFWS to prolong the life of the project included:

1. Replace riprap on the lower end of the overflow spillway
2. Continue to keep spillways clear of woody vegetation.
3. Repair erosion between the stoplog structure inlet riprap and blacktop trail.
4. Continue to monitor project.

#### 6.2.3 June 2010: Rice Lake HREP (Minnesota Valley NWR) Annual Inspection Report

The annual 2010 inspection took place on May 10, 2010. The inspection included observations of the stop log closure structure on Rice Lake and the wetland berm and overflow spill way along the Minnesota River bank. The inspection did not include observations of the outlet channel, Rice Lake channel, or east outlet channel on Rice Lake. The inspection also did not document the progress of the farm field bottomland forest restoration.

During the inspection it was reported that the stoplog closure structure was in good condition, and that no damage had been done to the new aluminum stoplogs. It was also noted that the structure was overtopped with water during the spring flow. The wetland berm along the Minnesota River bank had not changed much since the previous year's inspection. The berm was documented as being severely eroded and almost gone in one location. During the spring, flood waters from the Minnesota River overtopped the berm, leaving fresh sediment over most of the area. The overflow spillway had new woody vegetation filling in, and the spillway was full of sediment from the spring flood.

Actions recommended by the USFWS to be taken care of immediately included:

1. Work with the Corps of Engineers to repair the Minnesota River bank erosion along the wetland berm and overflow spillway.
2. Repair erosion between the stoplog structure inlet riprap and the blacktop trail.

Actions recommended by the USFWS to prolong the life of the project included:

1. Replace the riprap on the lower end of the overflow spillway along the Minnesota River.
2. Keep the spillways clear of woody vegetation.
3. Continue to monitor the project.

#### 6.2.4 USACE Subsurface Investigation

A preliminary analysis of shoreline bank migration patterns along this reach of the Minnesota River was completed by using aerial photographs from 1991 and 2004 to digitize approximate shoreline locations from river mile 14 to river mile 19.3 (

Figure 3). The general pattern showed active shoreline erosion/deposition occurring in the immediate vicinity of bend areas and relatively stable shoreline locations in long straight areas (Figure 4). The analysis only showed that the pattern is relatively consistent throughout the reach and was not meant to quantify erosion/deposition rates or to identify factors contributing of the amount of migration/deposition in any given area.

**Figure 3 – Area overview for shoreline location analysis**

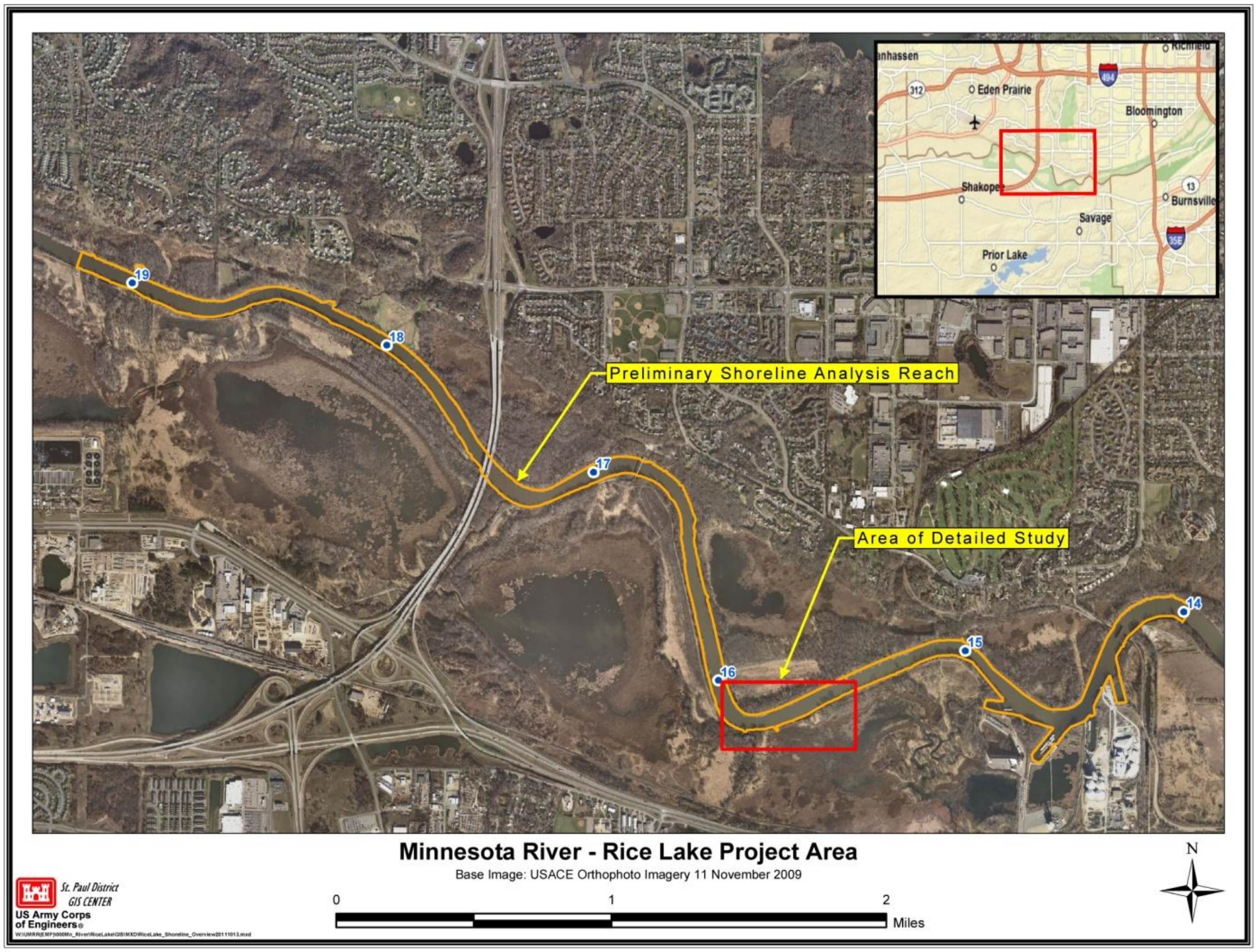
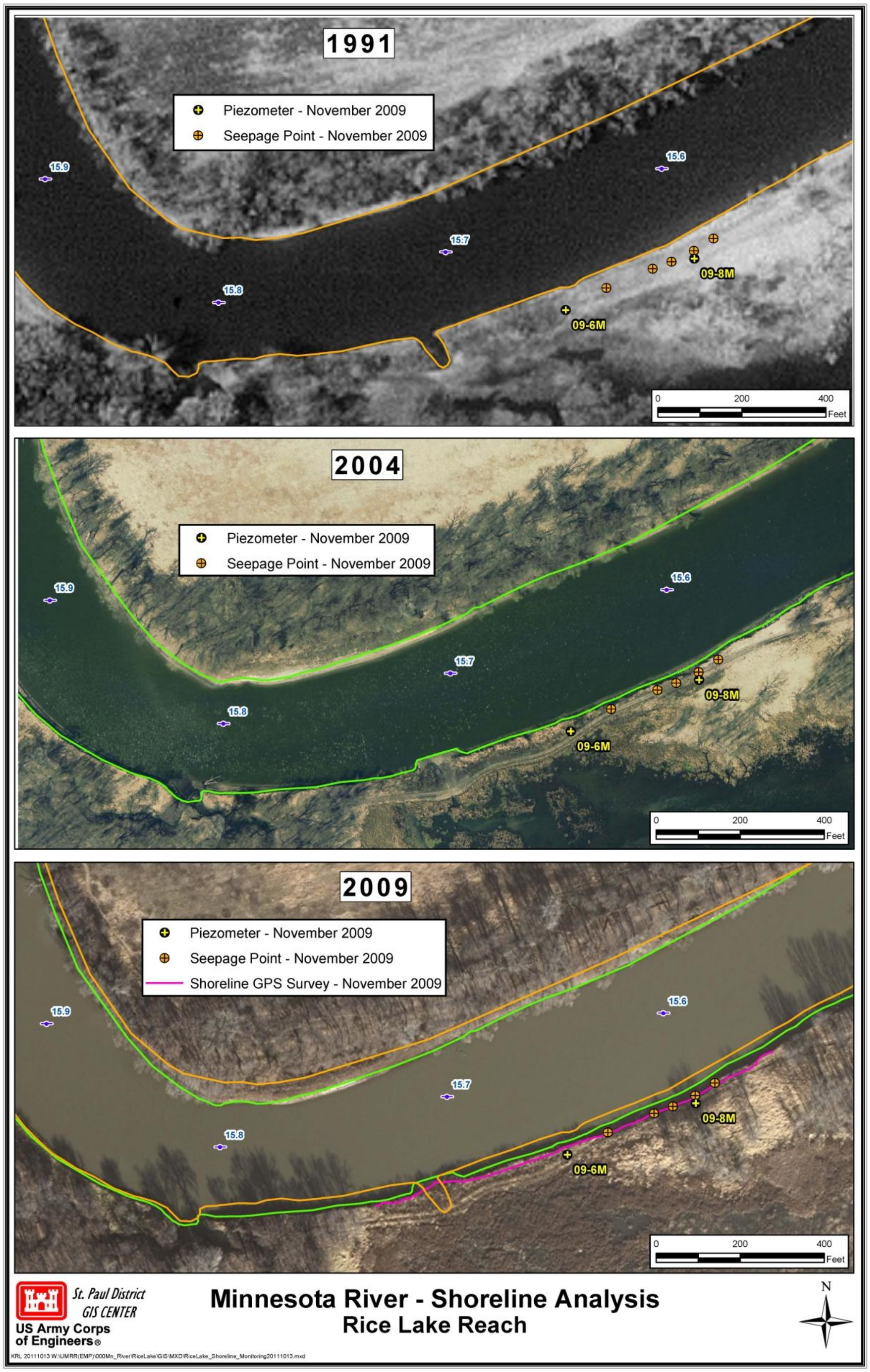


**Figure 4 – Analysis of shoreline locations through time**

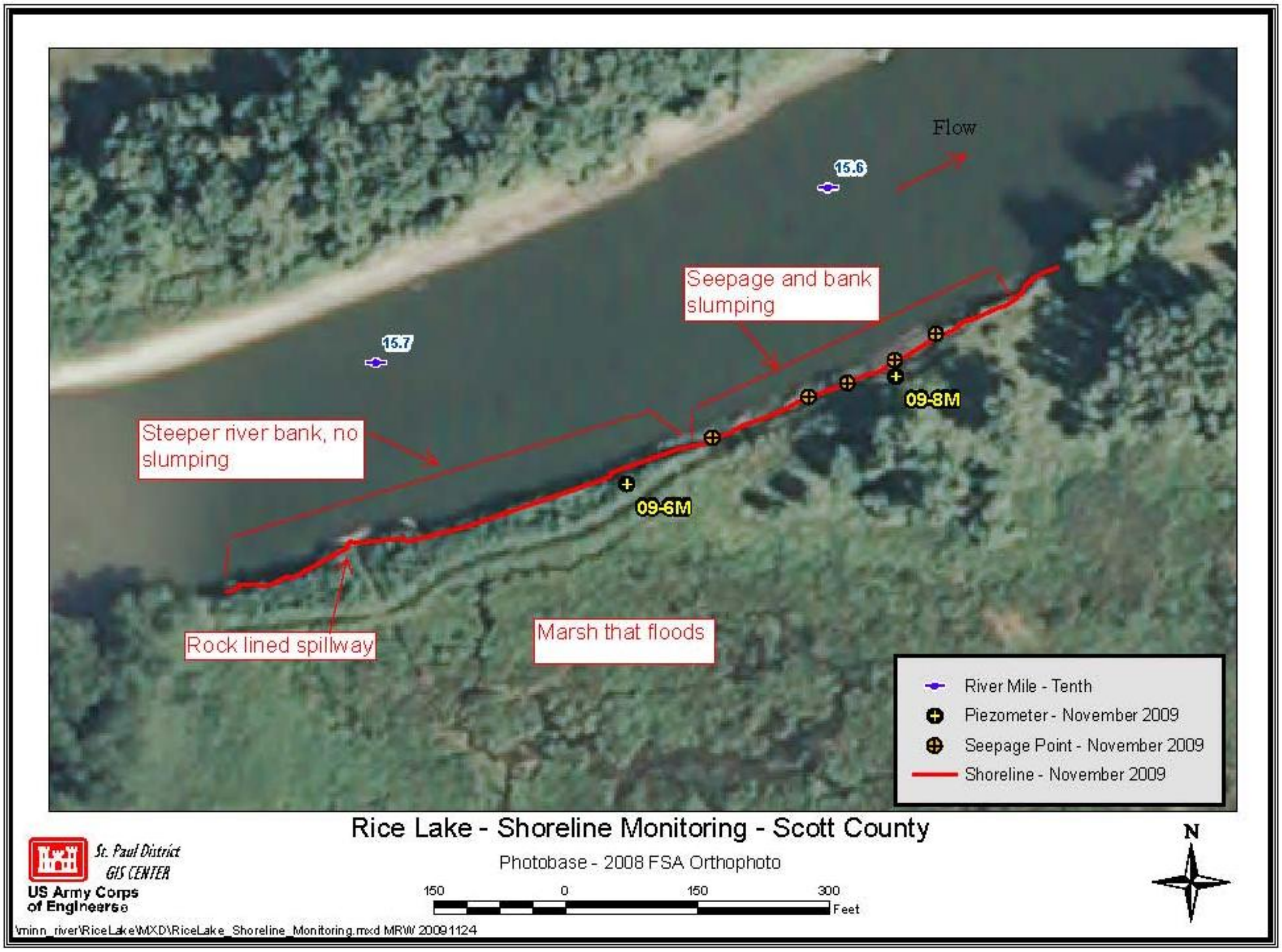


From November of 2009 to June 2011 the Corp monitored groundwater levels, and conducted a subsurface investigation along the project area to investigate seepage and the progressive erosion rates along the Minnesota River bank. River bank cross section surveys were taken in 2008 along the same alignment as the original surveys that were done in 1994 during project design. The ten cross sections that were surveyed along this river bank are shown in Appendix B. These surveys indicate that the top of river bank has eroded 29 to 39 feet except at the rock lined spillway which appeared to be relatively stable, though USFWS observations indicate some rock displacement at the toe of the spillway. The following are the two areas investigated along the river bank:

1. Upstream area – 600-feet long with steeper banks including scattered seeps close to the water line with approximately 30-feet of erosion.
2. Downstream area – 350-feet long showing approximately 39-feet of erosion and dominated by seeps and slumping soil units.

Four borings, labeled 09-5M through 09-08M, were drilled along the river bank; two 40-foot deep borings in the downstream area adjacent to the slumping bank and a 20 and 40-foot boring adjacent to the more stable steeper riverbank area. Borings, labeled 09-6M and 09-8M, were conducted along the project location: an upstream area and a downstream area, respectively. Figure 5 shows the seepage points and the locations of the piezometers. A pair of vibrating wire transducer piezometers were nested in each borehole and installed at 10-feet and 35-feet below ground surface (6P shallow(sh) and deep (dp)) and 8P sh and dp). Piezometers 6P sh and dp were installed in the berm foundation in the upstream area near the project overflow spillway where the river bank maintains a more vertical slope, and seepage is less pronounced. Piezometers 8P sh and dp were installed in the downstream area where the river bank has significant seepage, bank slumping, and a higher erosion rate. The borings showed very similar soils dominated by soft silty clay and organic clay. In the upstream area of the project, boring 6M, P had two sandy seams in the upper 5-feet of the soil profile. The downstream location, boring 8M, P had three thin silty sandy seams interbedded in a very soft silty clay layer within the upper 10-feet of the soil profile. Both Dataloggers and manual readings were employed to collect the data. Due to frequent flooding the monitoring period was extended beyond one year to account for lost data during times of flooding (Jorgenson, 2011; Appendix B).

Figure 5 – MN River Bank Seepage Points and Locations

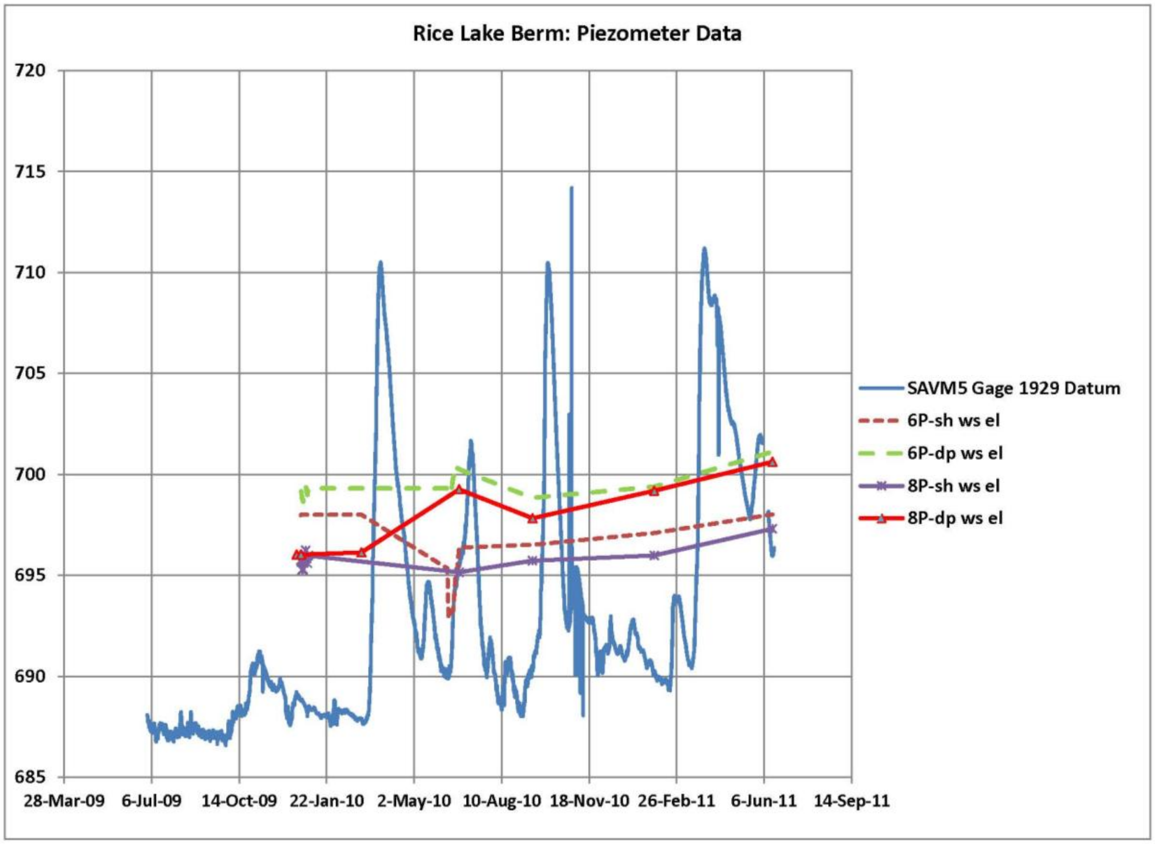



**Piezometer Results**

Interpreting piezometer data can be subjective and needs to be conducted with timely field observations; not all piezometer responses can be readily explained in a short period of time. Figure 6 shows the piezometer data for the upstream and downstream area locations, along with the Minnesota River levels recorded at the Savage gage, which is just downstream of the project location.

The shallow piezometers (6P-sh ws el and 8P-sh ws el) seem to be influenced by the marsh water levels, showing little change when piezometric levels are 2-5 feet below the berm ground surface when there is no flooding (Jorgenson, 2011; Appendix B). The sandy seeps in the river bank are 3-6 feet below the top of the berm in the slumping area, and 5-8 feet below the top of the berm in the area showing a less pronounced rate of slumping and erosion (Jorgenson, 2011; Appendix B).

**Figure 6 – Piezometer Data**




The following is a summary of the field observations by the Corps including soil data, which were monitored during the course of the piezometer study (Jorgenson, 2011; Appendix B). Once again, piezometer data rarely provides a direct result and can be used to supplement field observations over periods of change.

- The deep (dp) piezometers showed higher levels than the shallow (sh) piezometers
- Both pairs of piezometers, in the slumping and non-slumping areas showed similar responses to fluctuations in the river level
- Shallow or meteoric groundwater is likely due to the lack of iron staining in the seeps and soils that were sampled
- Additional piezometric data during times when the river level is low is needed and may offer additional insight on the slumping and erosion occurring
- Boring 8M had 3 saturated sandy seams interbedded in a soft clay near 5, 7 and 9-feet below the ground surface, contributing to the seeps and slumping
- In addition to groundwater discharge, overland flow and erosion from the marsh may be contributing to the slumping soils in the downstream area
- During times of flooding (above el 700) all piezometer levels were assumed to be at the river level
- Frequent flooding and ponding due to a large beaver dam maintain a steady source of water for the marsh

## 6.3 Project-Induced Habitat Changes

### 6.3.1 Rice Lake

Since construction of the project, Rice Lake's habitat quality has significantly increased. Through observation by the USFWS and the implementation of a Shallow Lake Survey (MN DNR Protocol) on Rice Lake in 2010, it was determined that plant abundance and species diversity significantly increased from pre-project conditions (USFWS, 2010). One successful drawdown, numerous partial draw-downs, and the ability to manage the water levels within the lake are attributed to the increase in habitat diversity. Dominate species reported in the 1995 DPR for Rice Lake were river bulrush (Scirpus fluviatilis), softstem bulrush (Scirpus validus), broad-leaved arrowhead (Sagittaria latifolia), giant reed-grass (Arundo donax), reed canary grass (Phalaris arundinacea), and jewelweed (Impatiens spp.). In 2010, 50 locations were surveyed in Rice Lake for vegetation.

Table 10 shows the species found, and the number of locations it was found with in Rice Lake.

**Table 10 – Aquatic plants present at Rice Lake, 2012, listed in order of plant frequency[1].**

| Shallow Lake Survey, August 2010 USFWS (MNDNR Protocol) (50 Points Surveyed) | | | | |
|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Plant Type** | **Number of Sites Present** | **% of Sites Present** |
| *Lemna sp.* | lemna species (not including star) | free floating | 50 | 100% |
| *Ceratophyllum demersum* | coontail | submerged | 36 | 72% |
| *Nymphaea odorata* | white waterlily | surface | 29 | 58% |
| *Lemna trisulca* | star duckweed | free floating | 21 | 42% |
| | algae | free floating | 16 | 32% |
| *Utricularia vulgaris* | greater bladderwort | submerged | 15 | 30% |
| *Carex sp.* | sedge sp. | emergent | 15 | 30% |
| *Wolffia sp.* | wolffia | free floating | 14 | 28% |
| *Stuckenia pectinata* | sago pondweed | submerged | 13 | 26% |
| *Scirpus fluviatilis* | river bullrush | emergent | 12 | 24% |
| *Typha sp.* | cattail | emergent | 8 | 16% |
| *Elodea canadensis* | Canada waterweed | submerged | 7 | 14% |
| *Typha latifolia* | broadleaf cattail | emergent | 7 | 14% |
| *Sagittaria latifolia* | common arrowhead | emergent | 5 | 10% |
| *Sagittaria graminea* | grass-leaved arrowhead | emergent | 5 | 10% |
| *Scirpus validus* | softstem bulrush | emergent | 4 | 8% |
| *Scirpus acutus* | hardstem bulrush | emergent | 2 | 4% |
| *Lythrum salicaria* | purple loosestrife | emergent | 2 | 4% |
| *Chara sp.* | chara | submerged | 1 | 2% |
| *Nitella sp.* | nitella | submerged | 1 | 2% |
| *Potamogeton natans* | floating-leaf pondweed | submerged | 1 | 2% |
| *Nelumbo lutea* | water lotus | surface | 1 | 2% |
| *Nuphar variegata* | yellow waterlily | surface | 1 | 2% |
| *Sagittaria cuneata* | arum-leaved arrowhead | emergent | 1 | 2% |
| *Typha angustifolia/glauca* | narrowleaf cattail group | emergent | 1 | 2% |
| *Zizania palustris* | wild rice | emergent | 1 | 2% |
| [1] The data contained in this table is courtesy of the USFWS. | | | | |

In addition the USFWS noted a corresponding increase for both waterfowl and furbearer species (Appendix A). Although there is no documented survey for these increases, random bag checks, waterfowl survey, and observational analysis at the refuge by the USFWS validate these increases (USFWS, 2010).

### 6.3.2 Farm Field

At this time there has been no documented survey or inspection of the farm field reforestation since the time of the project. Only qualitative observations of the tree planting area have been conducted. As observed by the USFWS, since the time of the project most reforestation of the farm field occurred naturally, although the plantings have helped to add diversity to what would have otherwise been primarily silver-maple (Acer saccharinum), cottonwood (Populus spp.), and boxelder (Acer negundo) (Appendix A).

### 6.3.3 Minnesota River Bank

Prior to construction of the project, a comparison of aerial photographs indicated that the Minnesota River bank within the project area had eroded back approximately 45 feet during the timeframe of 1937-1994 (USACE, 1995). Since completion of the project, the reconstructed berm and natural levee have continued to erode. Ten surveyed cross sections taken in 2008 show an additional 25-39 feet of recession of the upper bank since the 1994 cross sections (Jorgenson, 2011; Appendix B).

Since project completion, the following changes in the marsh characteristics have been noted by the USFWS:

- The marsh began to drain into Eagle Creek, a trout stream located on the west side
- Erosion has been occurring through the forested floodplain into Eagle Creek
- Portions of the marsh have become dry
- Water in portions of the marsh cannot be manipulated; the water control structure on the east side is ineffective
- The diversity of vegetation has noticeably decreased
- The abundance of wildlife has noticeably decreased

# 7.0 Project Evaluation

## 7.1 Construction

The contract for the Rice Lake project was awarded in September 1996 to Abe Construction Company of Golden Valley, Minnesota. Project construction began in December of 1996 and was completed in November of 1998. During the 1997 construction season, all project features were constructed, with the exception of the Rice Lake outlet channel. Mechanical excavation of the Rice Lake outlet channel was originally scheduled for the winter of 1996-97, and then rescheduled for the winter of 1997-98, but could not be completed during either timeframe due to inadequate ice conditions. In the fall of 1998, the excavation was completed by hydraulic dredging.

## 7.2 Engineering Design Considerations

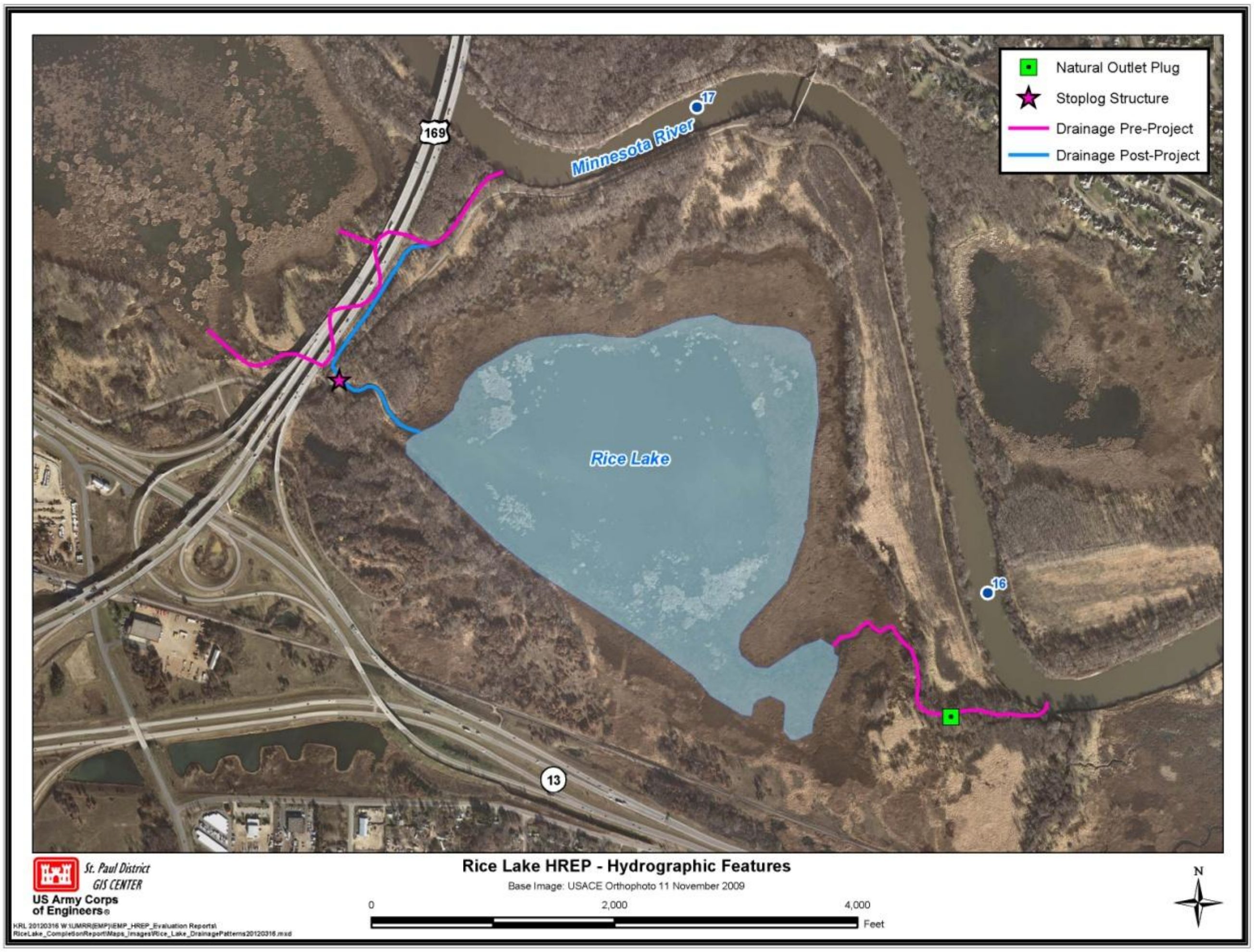
### 7.2.1 Rice Lake Outlet Channel and Structure

The natural outlet for Rice Lake is through an unnamed channel eastward to Eagle Creek and then into the Minnesota River. It was decided to reroute the natural outlet to the west in order to avoid significant environmental disturbances during the excavation of the channel and construction of the control structure.

Figure 7 shows pre and post project drainage paths. An earthen plug was used to cut off flow from Rice Lake's natural outlet. Since the plug is higher than the natural levee, no additional rock protection was needed. However, topsoil and seeding were conducted to promote vegetation growth. Construction of the outlet channel to the west allowed for passage under an existing road (Old County Road 18), which provided a convenient location for the construction, operation and maintenance of a control structure. The channel has a 10-foot bottom width and a channel invert at elevation 692.5. The channel invert which is 0.6-feet below the invert of the outlet culvert will provide some capacity to accommodate future sedimentation (USACE, 1999).

The control structure was designed to provide the Refuge with the capability to control water levels in Rice Lake when the Minnesota River discharges are below bankfull conditions. The control structure would typically be operated to convey +30 cfs to -30 cfs and to maintain a range of water surface elevations from 693.1 to 698 depending on the stoplog settings and the elevation of the Minnesota River relative to Rice Lake. Preformed scour holes were also included in the design of the control structure with the capability of handling a discharge of up to 65 cfs. The scour holes were necessary on both sides of the structure due to bi-directional flow (USACE, 1999). The existing culvert under County Road 18 was replaced with a 42-inch round corrugated metal pipe (CMP). Although a 30-inch culvert was determined to be sufficient, the 42-inch culvert was decided on to provide for a margin of error and additional management flexibility.

**Figure 7 – Pre and Post Project Drainage**




### 7.2.2 Wetland Berm/Spillway

The wetland berm was constructed to an elevation matching the topography of the natural levee along the Minnesota River, which provides protection up to a 1.5-year flood event of 11,000 cfs. The rock lined overflow spillway was designed to be constructed within the natural swales that connect the river to the floodplain. The spillway acts as an outlet for water flow from the wetland to the Minnesota River after a bankfull event (USACE, 1999).

## 7.3 Cost

In the Definite Project Report cost estimate at the fully funded level were estimated at $463,000 (USACE, 1995). The official reported cost after construction was $386,455.31(USACE 1999). As reported in the USFWS 2010 Annual Inspection Report, the USFWS has spent an additional $24,574 on the operation and maintenance of the project since the completion of the project.

## 7.4 Ecological Effectiveness

### 7.4.1 Rice Lake

The general habitat goal for Rice Lake was to maintain the lake as a shallow floodplain lake/marsh to provide high quality habitat for migratory birds and aquatic life. Specifically, the idea was to be able to raise or lower the lake level to induce habitat changes of higher quality. Summer drawdowns would induce settling and compaction of the muck layer and enhance the oxidation and decay of organic material, thus potentially increasing the diversity of vegetation. The ability to raise and maintain water levels within Rice Lake would benefit submergent aquatic vegetation, improve the open water to emergent ratio and help control the encroachment of woody vegetation and exotic species.

In a recent project objective analysis by the USFWS, the USFWS identified that the general habitat goal for the Rice Lake project successfully provided an adequate solution for maintaining the lake as a shallow/floodplain lake/marsh (Appendix A). The project design successfully allowed the manipulation of water levels necessary to maintain this condition, despite frequent drawdown challenges due to Minnesota River flooding (Appendix A).

Furthermore, the results of a 2010 Shallow Lake Survey on Rice Lake showed that 62% of the plants found within the lake provide fair to good waterfowl food value (

Table 10). Waterfowl surveys, random bag checks, and observational information have shown that the number and diversity of migratory birds including ducks, geese, swans, and other non-game wading birds have increased since completion of the project (Appendix A). In addition, muskrat and beaver lodge numbers have increased as well as success rates for trappers on Rice Lake.

### 7.4.2 Farm Field

The habitat goal for the farm field was to restore the site to mature bottomland forest habitat with the species variety typical of natural conditions. The intent was to accelerate the vegetation succession process and to provide a diverse array or native species that would provide high quality wildlife habitat.

Since completion of the project the farm field has re-vegetated very well. There have been no documented surveys or inspections since the completion of the project; only qualitative observations have been conducted. Most of the re-vegetation occurred through natural succession, though the plantings added to the diversity of the species (Appendix A). Observations made by the USFWS indicate that the planted tree species appear to be doing well, particularly the swamp white oak (Quercus alba).

### 7.4.3 Minnesota River Bank

The primary project goal for the Minnesota River bank was to prevent the loss of a 70-acre floodplain marsh due to riverbank erosion and breaching of a natural levee. The objective would also prevent the loss of riparian bottomland forest and the habitat values it provides.

Since completion of the project in November of 1998, annual inspections conducted by the USFWS have shown a continued high rate of riverbank erosion at the project location. Surveyed cross sections indicate that the top of the river bank has eroded back 29 to 39 feet from 1994 to 2008 (Jorgenson, 2011; Appendix B). As previously mentioned in section 5.4.2, the Corp conducted a subsurface investigation and groundwater level monitoring at the subject site from November 2009 to June 2011. The river bank investigation consisted of two different areas:

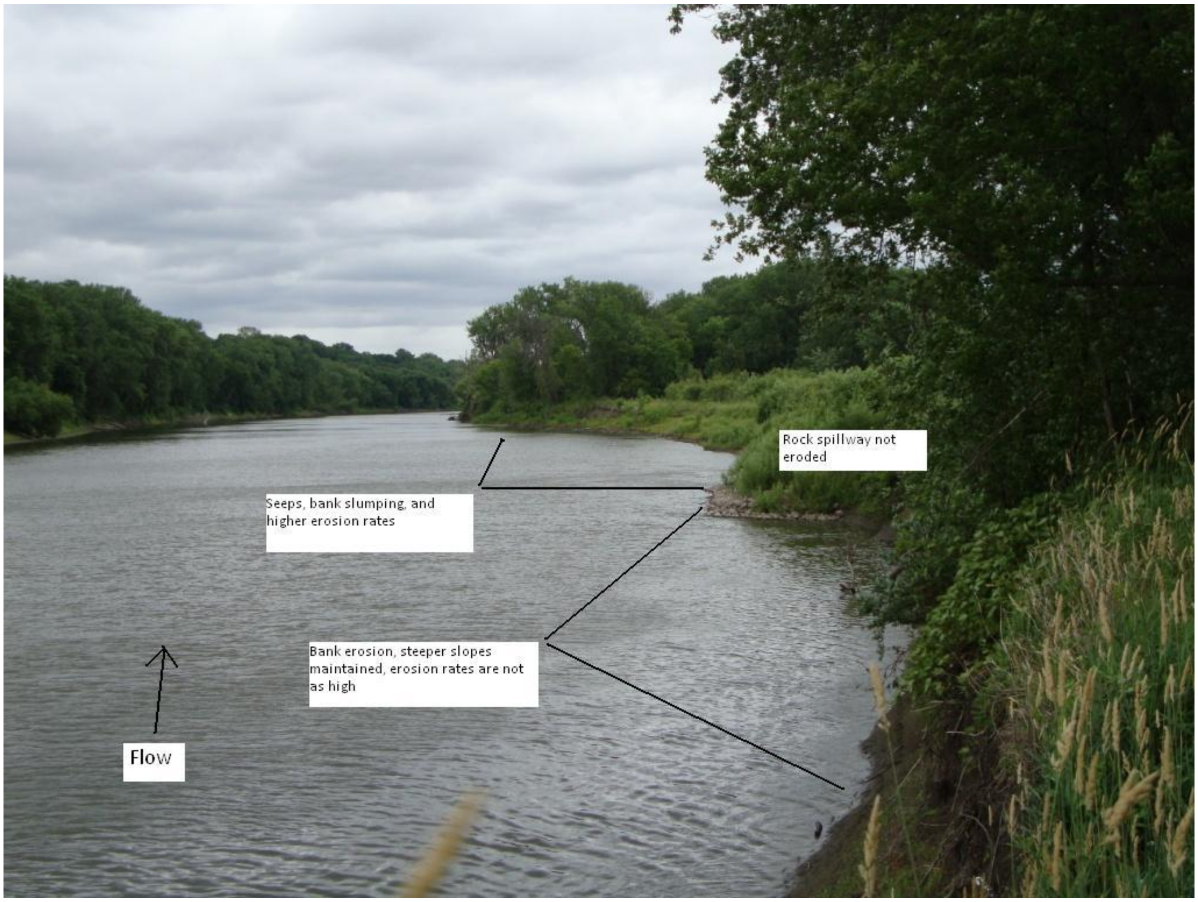
1. Upstream area – 600-feet long with steeper banks including scattered seeps close to the water line with approximately 30-feet of erosion
2. Downstream area – 350-feet long showing approximately 39-feet of erosion and dominated by seeps and slumping soil units

Common to the Minnesota River Valley, are artesian conditions exhibited as seeps, springs, and boils. The project area is just downstream of the confluence of Eagle Creek, one of the few trout streams (spring fed) in the metro area, and within a ½ mile of Savage Fen; both standing out as significant point sources of groundwater discharge in the area (Jorgenson, 2011; Appendix B). The project itself consists of a natural river bank with a berm constructed on top of a natural levee and a rock lined spillway located in the upstream portion of the project (Jorgenson, 2011; Appendix B). The source of water for the marsh protected by the berm and natural levee includes: flooding of the Minnesota River, precipitation, and groundwater discharge (USACE, 2011). Both flooding and groundwater discharge, which are typical of the Minnesota River Valley, are significant contributing sources of water for the marsh.

As of July 2009, the rock lined overflow spillway appeared to be intact and in good condition; although, vegetation clearing and sedimentation maintenance was needed (Jorgenson, 2011; Appendix B). Water levels within the marsh were found to be managed at a high level by a large beaver damn; typically within 2-3 feet of the top of the berm. As previously discussed in section 5.4.2, the soils along the Minnesota River bank in the project area are composed of a silty clay soil with fine sandy seams (less than 0.1' thick). These sandy seams located in various depths within the soil profile seem to be the source of the visible bank seepage in the slumping soils (Jorgenson, 2011; Appendix B). The slumping tends to be progressive and likely occurs when the river erodes the toe of the slumping soil. The 350-foot downstream portion of the project showed significantly more seepage than the 600-foot upstream area (

Figure 8). The areas along the river bank where seepage is greatest are also the locations with the greatest erosion. In most locations seepage was found to occur approximately 5 to 6 feet below the top of the berm (elevation 700), causing benching and downward soil mass movement/slumping (Jorgenson, 2011; Appendix B). The project area is just downstream of a sharp outside bend, so erosion is not unexpected; however, erosion has been occurring at a higher than expected rate. Typical erosion rates in this reach of the Minnesota River, based on the Design Memorandum and another private report (Wenck Associates, Inc., 2010) appear to be along the lines of 1-foot or less per year vs. the 2-feet or more that have been occurring at this site. Banks showing slope stability problems due to seepage tend to be prone to higher erosion rates, and can be further influenced by site specific field conditions that may alter averages (e.g. river level fluctuations, flooding frequency, hydraulic conditions, and soil conditions, etc.). The piezometric levels shown in the collected data (section 5.4.2) are typical of this environment; however, in combination of the seeps, saturated clay soils, and the velocity of the Minnesota River, these components all work together accelerating the slumping and erosion of the riverbank (Jorgenson, 2011; Appendix B). In addition, the ponded water seeping from the marsh and regional groundwater flowing toward the river provide a persistent source of groundwater for the seeps along the riverbank (Jorgenson, 2011; Appendix B).

**Figure 8 – Minnesota River Upstream and Downstream Areas**




## 7.5 Public Acceptance

The draft Definite Project Report/Environmental Assessment was sent to Congressional interests; Federal, State, and local agencies; special interest groups; and other interested citizens. Comments were received on the draft Definite Project Report/Environmental Assessment from the U.S Fish and Wildlife Service, the National Park Service, the Natural Resource Conservation Service, the Minnesota Department of Natural Resources, and the Minnesota Pollution Control Agency (USACE, 1995).

The U.S. Fish and Wildlife Service supported the project and provided their agencies Finding of No Significant Impact. The National Park Service (NPS) supported the proposed project, especially the decision to protect the Minnesota River bank with a berm instead of riprap. The NPS indicated that the project may affect the "Minnesota Valley Trail." Subsequent coordination with the Minnesota Department of Natural Resources led to the conclusion that the trail would not be impacted by the project (USACE, 1995).

As identified in the DPR, there were no Natural Resource Conservation Service programs affected by the project. The Farmland Policy Protection Act site assessment was not required since no land acquisition was conducted. Concerns of the Minnesota Department of Natural Resources were addressed during project planning and coordination. The Minnesota Pollution Control Agency waived the Section 401 water quality 63 certification subject to compliance with certain conditions. These conditions were met as no wetlands were filled or drained by the project, and an erosion control plan was incorporated into the final project design (USACE, 1995).

# 8.0 Lessons Learned

## 8.1 Rice Lake

Prior to the Rice Lake project, Rice Lake was characterized by a ring of emergent vegetation with an open water basin in the center (Appendix A). The project provided the refuge with the ability to manipulate water levels within the basin, and successfully influence the species composition and abundance of emergent, free floating, surface, and submerged aquatic vegetation, while limiting the amount of exotic species and woody species encroachment. The Shallow Lake Survey performed in 2010 showed 26 plant species present; based on qualitative observations over the last 15 years this is a significant diversity improvement (Appendix A). The goal of greater interspersion has been accomplished for this part of the basin. However, areas are present where river bulrush has taken hold and even with water level manipulation, little has changed. Additional drawdowns may allow other management options for this vegetation in the future (Appendix A).

The increase in Rice Lake's habitat diversity has subsequently shown an increase in the number and diversity of waterfowl and furbearer species that use the lake; this is based on observational data and random hunter bag checks by the USFWS. The initial project design called for a wooden stoplog structure to be used, however, after continual destruction of the wooden stoplog structure by beavers, an aluminum stoplog structure was installed.

The overall improvements of the lake have added to the value of Rice Lake as a source for wildlife orientated recreation and education for hunters, trappers, and birders (Appendix A). Since beaver activity has significantly increased on Rice Lake, weekly maintenance checks are necessary to ensure the project components are not being affected. In addition, shallow Lake Surveys have proved to provide adequate information, but need to be conducted on a more frequent basis.

## 8.2 Farm Field

There have only been qualitative observations of the reforestation efforts to the farm field since the completion of the project. Most of the revegetation occurred naturally, but as indicated by the USFWS, the tree plantings did help add to the diversity. After the project was completed it was discovered that swamp white oak, a planted species, may not have been an appropriate choice, as no historical account of this species has been documented. The succession rate for the swamp white oak has taken to the area well, and now inhabits the farm field frequently (Appendix A). During the first flood event after completion of the project it was discovered that the use of tubing and matting in the flood prone area is not practical. Most of these materials were washed away during the flooding event (Appendix A). Currently reforestation efforts at the Minnesota Valley National Wildlife Refuge have been discontinued. Although the Rice Lake farm field is less prone to flooding and the tree plantings were successful at creating diversity, most floodplain planting have been unsuccessful due to flooding. At this time natural succession seems to be the best and most economical option for these areas. Studies are being conducted to define alternative ways to influence natural regeneration of a more diverse floodplain forested system (Appendix A).

## 8.3 Minnesota River Bank

The initial project design was intended to prevent the loss of a 70-acre floodplain marsh due to riverbank erosion and breaching of the natural levee. Because of the high cost of stabilizing the river bank with riprap, an alternative involving reconstruction of the berm separating the wetland from the river and construction of a rock-lined spillway to reduce erosion due to water entering and returning from the wetland during flood events was selected. Since completion of the project, erosion along the

Minnesota River at the project location ranges from 29 to 39 feet, which occurred in the timeframe of 1994 to 2008 (Jorgenson, 2011; Appendix B). After several site visits and a piezometer study conducted by the USACE, it was discovered that seeps occurring along the Minnesota River bank at the project location were likely contributing to the progressive erosion rates. Other additional contributing factors, ponding of the marsh by a beaver damn, river velocity and other possible artesian conditions in the area, all work together to enhance the rate of erosion.

The following recommendations and analysis are based on the 2010 USACE piezometer study findings. Riverbank erosion along the outside bend of the project location will continue to occur unless erosion protection is added or river flows are diverted from the river bank. An erosion protection design should include recent river cross sections and a slope stability review to account for the seepage and to assure adequate safety can be met. Although a "top of berm" survey was conducted in 2008, given all the high water events that have occurred in the last 2-3 years it is recommended that a new "top of berm" survey be conducted along the length of the natural levee/berm to verify the existing conditions prior to any remedial work. The top of the berm at the downstream area may now be lower than the rock berm spillway. Recent field observation from the last high water event has shown erosion to occur both parallel and perpendicular to the river bank. Overland flow from the marsh is likely enhancing the rate of erosion already occurring along the riverbank. Repairs to only manage the seepage would be incomplete due to the ongoing erosion along the riverbank; the sandy seams could be discontinuous and complex. Based on field observations it appears that portions of the natural levee (sand and silt deposits forming parallel to the river) may be starting to form landward of the existing eroding bank. Methods to increase the rate of formation of the new natural levee could be used or possibly adding material to the berm could prolong the life of this project (Jorgenson, 2011; Appendix B).

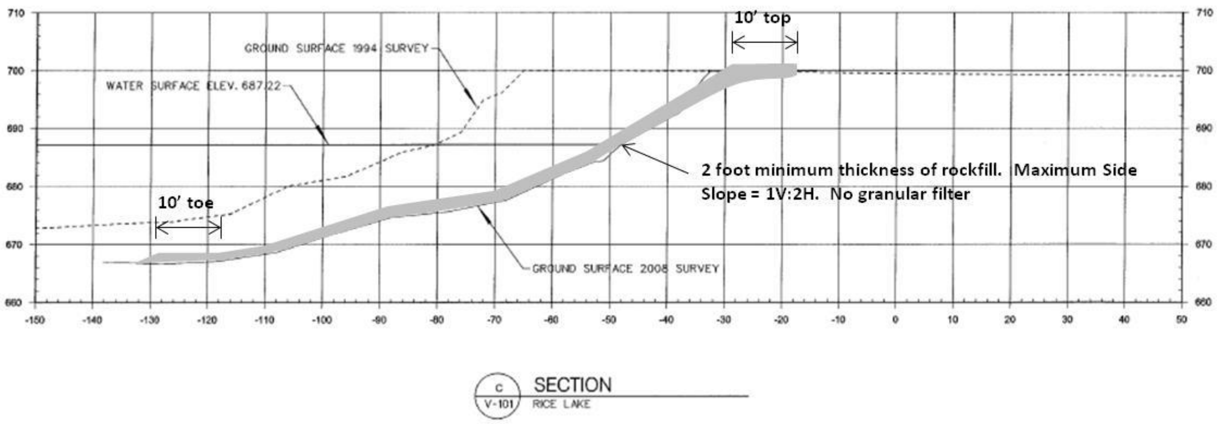
Two alternative methods of stabilizing the river bank were briefly looked at, a 2 foot layer of rock fill without a granular filter, and rock vanes. The rock fill layer (

Figure 9), extends from the toe of the bank (elevation 665 to 670) to the top of the bank (elevation 700). Additional rock is included at the toe and top of the bank. Over 12,000 tons of rock would be needed to stabilize a 1000 foot section of shoreline using this design.

The preliminary design for rock vanes included vanes with an elevation of 700 feet where they tie into the river bank and an elevation of 688 at their water-ward end. It was assumed they would be about 100' long and angled upstream at a 30 degree angle to the bank. Each vane would require approximately 850 tons of rock, and with 10 vanes being required to stabilize the same 1000 foot length of shoreline as discussed above, around 8,500 tons of rock would be required. This is about 30-percent less rock. There is less certainty with rock vanes and given the USFWS belief that the wetland is in peril of draining, this may not be a desirable stabilization technique.

As identified in the DPR and the Operation and Maintenance manual, all operation and maintenance of the project, after project completion, are the responsibilities of the USFWS (USACE, 1995, 1999). With either of these two stabilization techniques or any other techniques that are looked at, additional engineering and design will be needed before investing these large sums of money. An in depth project longevity, benefits, and cost analysis should be conducted prior to the design of the project to determine whether the project longevity may overrule the cost of the project (Appendix A).

Figure 9 – Preliminary design for a two foot layer of rock fill at the Minnesota River Bank, Cross Section C



## 9.0 Conclusion

The Rice Lake Rehabilitation & Enhancement Project was constructed with the intent to maintain and improve habitat for migratory birds, aquatic mammals and other wildlife within the Minnesota River Valley. The project focused on correcting existing habitat problems and providing improved wildlife management capabilities. Valuable lessons were learned throughout the post-construction monitoring period that can lead as an example for projects similar in nature.

The ability for Refuge Managers to control water levels within Rice Lake has proven effective for both vegetation management and habitat value enhancement to wildlife. During monitoring, minor changes to the outlet structure were needed, and additional maintenance was required to prevent wildlife from obstructing the proper function of the project. The restoration of an old farm field to floodplain forest, adjacent to the Minnesota River, was also successful. Although, post-construction observations found that natural succession may have been just as effective as tree planting in restoring the forest. However, the plantings provided a more diverse variety of trees.

Post-construction monitoring at the Minnesota River Bank site indicates that a number of factors have had an effect on the rate of bank erosion and the conditions in the 70 acre floodplain marsh including: groundwater seepage, beaver activity causing ponding in the marsh, and increased river flows. Construction of the berm and spillway was a reasonable action and the only economically feasible action to take at this site; however, it appears that these other factors will ultimately influence the future conditions of this marsh.

While the institutional Fish and Wildlife Management Goals for the Minnesota River Bank portion of the project were not met, overall the Rice Lake Rehabilitation & Enhancement Project has been successful. Although the project has proven to be very challenging in some respects, the project has successfully achieved the projects main intent of maintaining and improving habitat for migratory birds, aquatic mammals and other wildlife within the Minnesota River Valley. Although, future challenges persist for the Rice Lake area of the Minnesota River Valley, valuable lessons can be drawn on, and lead as an example for future projects as a result of this project.

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# Appendix A

**Rice Lake Habitat Rehabilitation and Enhancement Project (HREP) Completion Report Project Objectives Analysis**

# Rice Lake Habitat Rehabilitation and Enhancement Project (HREP) Completion Report Project Objectives Analysis

US Army Corps of Engineers St. Paul District

Sent: 07/14/2011
Received: 08/08/2011

Below are the main objectives of the Rice Lake Project. Each objective is followed by a series of questions for analysis of the project. Please answer each question with as much detail as you feel is necessary to explain the successes or shortcomings of each project objective.

## Institutional Fish and Wildlife Management Goals

**A.** General Objective: The general Refuge objective is to manage the natural resources in order to perpetuate wildlife species and ecological communities' natural diversity and abundance, as well as provide opportunities for wildlife orientated recreation and educational center for the study of natural systems.

***1. Do you feel that the Rice Lake Project is in line with the general objective of the Institutional Fish and Wildlife Management Goals? Please explain your response.[1]***

The Rice Lake project has successfully achieved the Institutional Fish and Wildlife Management Goals for Rice Lake. Through observational information and the implementation of a Shallow Lake Survey (MNDNR protocol) on Rice Lake in 2010, it was determined that plant species diversity and abundance significantly increased from pre-project conditions. This was a result of one successful full drawdown, numerous partial drawdowns, and the general ability to manage water levels. Waterfowl surveys, random hunter bag checks and observational information showed a corresponding increase in the number and diversity of waterfowl species. Trapping success for aquatic furbearers has also increased since the project. The overall improvements have added to the value of Rice Lake as a source for wildlife oriented recreation and education for hunters, trappers, and birders.

Conditions on the Continental Grain Marsh have deteriorated significantly since the project. Erosion of the natural levee where the riprap spillway was built has progressed to the point where the levee has almost breached through to the marsh. In addition, the marsh began to drain into Eagle Creek, a valuable trout stream on the west side, since the project was completed. The result has been an inability to manage water levels effectively, potential degradation of a trout stream, loss of most of a natural levee, and significant erosion through the floodplain forest to Eagle Creek. While data on vegetation and wildlife is only observational, portions of the marsh have become dry while other areas of the marsh have water that cannot be manipulated due to an ineffective water control structure on the east side. Diversity of vegetation and the diversity and abundance of wildlife has been negatively impacted. It is unknown how the project influenced these items, however, these are conditions that manifested after the project completion. The Institutional Fish and Wildlife Management Goals were not met on the Continental Grain Marsh portion of the Rice Lake Project.[2]



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

**B.** Wilkie/Rice Lake Unit Objective: Managers will focus on the protection and study of the heron rookery; the restoration and protection of oak savanna, floodplain forests and prairies; and management of water levels in the marsh complexes.

***1. Do you feel the Rice Lake Project has allowed or enhanced the Refuge Managers' abilities to reach their unit objective? Please explain your response.*** [1]

The unit objectives with regard to management of the heron rookery and management of water levels in Rice Lake has been achieved. Despite the frequent flooding of Rice Lake from the Minnesota River, repeated attempts to manipulate water levels have been successful and allowed managers to achieve unit objectives. Rice Lake has become on attractive feeding area for rookery species as a result of the ability to manipulate water levels for optimum feeding conditions. The design of the project has allowed successful drawdowns (full and partial) and this has had a positive impact on wetland communities.

Continental Grain Marsh, however, given the conditions already identified, is not manageable and unit objectives have not been met. [2]

## Project Goals and Objectives

### A. Rice Lake

General Habitat Goal: The habitat goal for Rice Lake is to maintain the lake as a shallow floodplain lake/marsh to provide high quality habitat for migratory birds and aquatic wildlife.

1. ***Do you feel the Rice Lake Project has provided an adequate solution for maintaining the lake as a shallow floodplain lake/marsh? Please explain your response.*** [1]

The Rice Lake Project has successfully provided an adequate solution for maintaining it as a shallow/floodplain lake. The project design has successfully allowed the manipulation of water levels necessary to maintain this condition. Frequent Minnesota River flooding has made it a challenge to employ water level manipulation, however, enough successful drawdowns have been completed to achieve the goal. [2]

***2. Did the Rice Lake Project enhance the habitat quality for migratory birds? Please explain your response.*** [1]

Results of a 2010 Shallow Lake Survey on Rice Lake showed that 62% of the plants found provide fair to good waterfowl food value. Very few invasive plants were found. Waterfowl surveys and random



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

hunter bag checks have shown an increase in the number and diversity of waterfowl using Rice Lake. We believe that this is a result of the ability to manipulate water levels and vegetation response.

Although there is no quantitative data for Continental Grain Marsh, observational information has shown a decrease in the number of waterfowl using the marsh due to a decline in the diversity of vegetation and the inability to effectively manipulate water levels. [2]

2. ***Did the Rice Lake Project enhance the habitat quality for aquatic wildlife? Please explain your response.*** [1]

Due to the successful drawdowns on Rice Lake, the increase in vegetation abundance and diversity had a positive impact on the number of muskrat and beaver. This is based on trapper success and other observational data. [2]

There is no data for Continental Grain Marsh, however, the inability to manipulate water levels due to an eroded dike and spillage into Eagle Creek has not allowed any manipulation of the vegetation in order to improve the habitat quality for aquatic wildlife. [2]

3. ***Has there been a noticeable increase in the use of Rice Lake by migratory birds? Please explain your response.*** [1]

Waterfowl surveys, random hunter bag checks and observational information for Rice Lake indicate that the number and variety of migratory birds including ducks, geese, swans, and other non-game wading birds has increased since the project. Water level manipulation has allowed for the management of vegetation and different water levels at different times of the year to benefit a variety of migratory birds. [2]

4. ***Has there been a noticeable increase in the use of Rice Lake by aquatic wildlife? Please explain your response.*** [1]

Muskrat and beaver lodge numbers have increased as well as success rates for trappers on Rice Lake. No information is available for Continental Grain Marsh other than the observation that areas that no longer receive water and the lack of vegetation management would presumably have a negative impact on aquatic wildlife. [2]

Objective 1: Provide the ability to draw down water levels in Rice Lake

Objective 2: Provide the ability to raise and maintain water levels in Rice Lake

1. ***Did the installation of the water control structure in Rice Lake provide an adequate solution to manage water levels within the lake? Please explain your response.*** [1]



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

The installation of the water control structure, excavation of a channel, and the installation of a ditch plug in the northwest corner did provide an adequate solution to manage water levels within the lake. We have been able to successfully do partial and complete drawdowns. Minnesota River flooding has prevented many of these attempts, but this is not controllable.

Continental Grain Marsh had some degree of water level manipulation available before the project, though it was limited and the project did not address the limitations that were present with the existing structure and channel. The new spillway and levee fill, however, may have had an influence on what we see now as extreme levee erosion and the drainage of the marsh into Eagle Creek. No attempts have been made to manipulate water levels since the project. [2]

2. ***Do you feel the water control structure has provided the capability to increase vegetative diversity? Please explain your response.*** [1]

Shallow lake surveys performed on Rice Lake in 2010 showed 26 plant species present, a low presence of invasive aquatic plants, and a high abundance of submerged, surface, free floating, and emergent plants. There is no baseline data, however, qualitative observations for the past 15 years has shown that this is a significant improvement. The manipulation of water levels with the control structure is thought to be the main reason for this improvement. [2]

3. ***Do you feel the water control structure has provided refuge managers the ability to improve the open water to emergent vegetation ratio within Rice Lake? How has that ratio changed? Please explain your response.*** [1]

Before the project, Rice Lake was characterized by a ring of emergent vegetation with open water in the middle of the basin. Historically, wild rice was a major component basin-wide, even as recent as 20 years ago, but it had disappeared and left most of the basin devoid of vegetation except for species typical of deeper water marshes that have not gone through a drying cycle. With the ability to manipulate water levels has come the ability to influence species composition and abundance in the interior of the basin. All of the plots surveyed in 2010 showed high diversity and abundance of emergent, free floating, surface, and submerged plants. The goal of greater interspersion has been accomplished for this part of the basin. Unfortunately, there are areas where river bulrush have taken hold and, even with water level manipulation, little has changed. However, drawdowns may allow other management options for this vegetation in the future. [2]

4. ***Do you feel that being able to raise the water levels in Rice Lake has provided additional protection against the encroachment of woody vegetation and exotic species?*** [1]

Having the ability to keep levels at maximum pool has kept woody species from encroaching. Exotic species have also been kept to a minimum. [2]



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

## B. Farm Field

General Habitat Goal: The general habitat goal for the farm field is to restore the site to mature bottomland forest habitat with the species variety typically found under natural conditions.

Farm Field Objective: Re-vegetate 40 acres of farm field in a manner that will accelerate the vegetation succession process as much as practicable, and promote succession to a diversity of native species that provide high quality wildlife habitat.

1. ***Overall do you feel that the farm field has been adequately re-vegetated using the appropriate species varieties?*** [1]

The farm fields have re-vegetated very well since the project. Most of the re-vegetation occurred naturally, though the plantings added diversity to what would have otherwise been just silver maple, cottonwood, and box elder. After the project is was discovered that swamp white oak, a planted species, may not have been appropriate as no historical account of this species has been documented. [2]

2. ***Have there been tree counts done since the time of the project? Are the species present of a desirable type? What is the overall status of the reforestation?*** [1]

There have only been qualitative observations on the tree planting area. Survival of the planted species appeared to be very good, particularly swamp white oak. Much of the reforestation occurred naturally and, as a matter of fact, was occurring rapidly between the time this project was proposed and its completion; thus the scaling-back of mowing activity during the project. [2]

3. ***Do you feel that the "accelerated" methods (as identified in the DPR) used were appropriate and successful? Please explain your response.*** [1]

Reforestation efforts at Minnesota Valley have been discontinued. Most of the floodplain plantings that have been done have been unsuccessful due to flooding. In these areas, natural succession is allowed to take place. Diversity is low, however. Studies are under way to determine alternative ways to influence natural regeneration. The Rice Lake field is less prone to flooding and therefore the planting of additional species to increase the diversity was successful. [2]

4. ***Do you feel anything could have been done differently? Please explain your response.*** [1]

The use of tubing and matting in flood prone areas is not practical. A lot of these material s wash away after one flood. [2]



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

## C. Minnesota River Bank

General Habitat Goals: To prevent the loss of a 70-acre floodplain marsh due to breaching of the natural levee, and reduce the loss of mature bottomland forest and other floodplain habitats that provide fish and wildlife habitat.

Objective 1: Maintain 1,300 feet of natural levee between river miles 15.40 and 15.65 to prevent the loss of the perched wetland created by the natural river levee along this reach of the river bank.

Objective 2: Maintain 1,300 feet of river bank between river miles 15.65 and 15.90 to prevent the loss of riparian bottomland forest and the habitat value it provides.

1. ***Do you feel reconstruction of the berm and rocked spillway has done an adequate job at preventing loss of the perched wetland? Please explain your response.*** [1]

The condition of the natural levee is very poor at this time. There are parts of the levee that are only 1-2 feet wide on top. It is no longer passable except on foot. The spillway is still intact, though silted over. In addition, since the reconstruction, water began to re-route itself out of the wetland to the west and into Eagle Creek, a trout stream. The water leaving the Marsh has created a ditch several feet wide and several feet deep. It also has drained a significant portion of Continental Grain Marsh. It is unknown what the influence of this project has been on these conditions, but these were conditions not present before the project. We speculate that the rock spillway has influenced the dynamics of the current below the spillway as the levee is intact upstream of the new spillway. In addition, the elevation of the spillway may have influenced the drainage to the west. [2]

2. ***Do you feel reconstruction of the berm and rocked spillway has done an adequate job at preventing the loss of the bottomland forest? Please explain your response.*** [1]

If the levee breaches there may be a negative influence on bottomland forest behind the levee as it will be more susceptible to river currents and increased flooding. [2]

3. ***Do you feel the solution employed and the design of the project for the Minnesota River bank was the best option under the given circumstances? Please explain your response.*** [1]

The solution employed was not the best option. It was recommended by the Refuge during the design period that the berm be riprapped. This point in the river is very susceptible to erosion as it is on a bend. In addition, the level set for the spillway may not have been appropriate as water is being lost on the west side. [2]



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

4. ***Do you feel anything could have been done differently? Please explain your response.*** [1]

Though it would have significantly added to the cost, the berm should have been riprapped. In addition, more detailed information should have been gathered in order to set the spillway at an appropriate level. [2]

**Additional Questions**

1.) ***In April 2001, it was documented in the annual inspection reports that the 2nd largest flood occurred. Do you feel this flooding event had an effect on the reconstructed berm and rocked spillway along the Minnesota River? Did the flooding event have any other effects on the project?*** [1]

It is unknown what this particular flooding event had on the berm and spillway. Spring flooding is an annual event and out-of-bank events have occurred here during the summer and fall. These events typically add silt to the spillway and Rice Lake channel, as well as erode gravel from around the structure. The erosion of the berm has progressed each year since the project. [2]

2.) ***In 2003, 600-feet of the Rice Lake outlet channel was re-excavated. What led to this need?*** [1]

Siltation in the channel was beginning to limit the ability for complete drawdowns. While the intra-lake channel remains intact, it too has had silt deposited in it and at some point will need to be re-excavated. [2]

3.) ***How could the appearance of the Rice Lake project be improved?*** [1]

There is nothing about the project that is negative in appearance. [2]

4.) ***Is the amount of O&M appropriate? Do you feel it needs to be reduced/increased?*** [1]

Operation and maintenance for this project includes woody species control on dikes, replacement of riprap and gravel from erosion, beaver control, and water control structure maintenance. Limited Refuge resources keeps it operational, but more O&M would be appropriate. [2]

5.) ***What monitoring is appropriate to assess project effectiveness?*** [1]

Shallow lake surveys have provided adequate information. They need to be conducted on a more frequent basis. Weekly maintenance checks are necessary to keep up with beaver activity. [2]

6.) ***What needs to be done to further improve habitat conditions in the Rice Lake project area?*** [1]



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

More water manipulation on Rice Lake is needed, however, this is dictated now by Minnesota River flooding. Additional techniques for vegetation manipulation needs to be employed to manage homogenous stands of river bulrush.

The natural levee on Continental Grain Marsh needs to be rebuilt and armored. A new spillway level needs to be set. A new water control structure and channel needs to be installed to adequately manage water levels. [2]

**7.) *What were the "lessons learned" from this project? Please provide any recommendations you may have for future projects similar to the Rice Lake Project.* [1]**

a) A heavy equipment pad for excavation of debris from control structure.
b) Metal stop logs for control structure to prevent beaver damage.
c) Tree planting may not be practical. Assess on a case by case basis.
d) Better evaluation of wetland dynamics and the water cycle when placing infrastructure, and a better evaluation of the effects of placing new infrastructure against the river current.
e) Armoring dikes may have an initial high cost, but may be more cost-effective than having to replace the entire dike at a later date.[2]



[1] Project objective analysis questions – conducted by Diaz, Jessie C. – USACE – Saint Paul District
[2] Project objective analysis responses – given by Baylor, Sharonne, Kane, Chris, and Sherry, Vicki – USFWS

# Appendix B

**Memo for the Record: Rice Lake Berm Seepage and Erosion**

Memo for the Record 17 June, 2011
Subject: Rice Lake Berm Seepage and Erosion tljorgenson

1. **PROJECT SUMMARY**: This memo summarizes the Corps subsurface investigation and groundwater level monitoring at the subject site from November 2009 to June of 2011. This work was done to look into the high rate of riverbank erosion. The Corps of Engineers agreed to investigate the seepage and erosion occurring along the Minnesota River downstream of Rice Lake and the confluence of Eagle Creek, near river miles 15.8 to 15.6 (Figures 1 & 2). The site is the downstream portion of a COE/FWS project completed in the late 1990's. The project site consists of a wetland berm and a rock lined overflow spillway built along the natural levee located on the right descending bank of a sharp outside bend on the Minnesota River. Surveyed cross sections indicate that the top of the river bank has eroded back 29 to 39 feet from 1994 to 2008, although the rock lined spillway feature has resisted erosion. The river bank consists of two different areas; an upstream area about 600 feet long with steeper banks (typical of the MN River) and scattered seeps close to the water line showing about 30 feet of erosion, and a downstream area about 350 feet long showing about 39-feet of erosion dominated by seeps and slumping soil units. In November of 2009 four borings 09-5M through 09-08M were drilled to define the subsurface and install piezometer to better understand the seepage and erosion. Four borings were drilled along the river bank; two 40-feet deep borings in the downstream area adjacent to the slumping bank and a 20 and 40-feet deep boring adjacent to the more stable steeper river bank area. The borings showed very similar soils dominated by soft silty clay and organic clay. Boring 6M,P had two sandy thin seams in the upper 5 feet (on the river bank maintaining a steeper slope). The boring in the heart of the seep and slumping area (8M,P) had three thin silty sandy seams (less than 0.1' thick) interbedded in the upper 10-feet in a very soft silty clay layer; the sandy seams appear to be the source of the visible bank seepage in the slumping bank. The slumping tends to be progressive and likely occurs when the river erodes the toe of the slumping soil. As the river level fluctuates additional slumping and erosion occur. In the borings labeled 09-6M and 09-8M a pair of vibrating wire transducer piezometers were nested in each borehole and installed at 10- feet and 35-feet below ground surface (6P shallow(sh) and deep (dp)) and 8P sh and dp). Piezometers 6P sh and dp are installed in the berm foundation downstream of the project rock overflow spillway in an area that maintains a more vertical slope, and seepage is less pronounced. Piezometers 8P sh and dp were installed further downstream along the river bank that has significant seepage, bank slumping and a higher erosion rate. Dataloggers were used for collecting the water level information; although the area flooded at least six times, resulting in much of the data to be unrecoverable from the flooded electronic dataloggers. Manual readings were conducted during field visits to fill in lost data. The field visits during high water, low water and during the winter offer much of the relevant observations noted in this memo. The period of monitoring was extended beyond one year to accommodate for lost data due to frequent flooding.

2. **PIEZOMETERS:** Figure 3 shows plots of the two pairs of piezometers with the Minnesota River levels at the Savage gage, located downstream of the site. Interpreting piezometer data is subjective and should be done with timely field observations; not all

piezometer responses can be readily explained in a short period of record. The following comments and discussions are offered that include the soil data and field observations:

- deep piezometers show higher levels than the shallow piezometers (to be expected in a discharge zone)
- both pairs of piezometers show alike responses to river level changes (slumping and non-slumping areas)
- most seeps and sampled soil lack iron staining indicating shallow or meteoric (younger) groundwater
- obtaining more piezometric data during low river levels may offer additional insight on slumping
- boring 8M had 3 saturated sandy seams interbedded in soft clay near 5, 7 and 9-feet below ground surface, contributing to the seeps and slumping
- overland flow (and erosion) from the marsh may be occurring in the area with significant slumping
- during flooding (river level above el 700) all the piezometer levels are assumed to be at the river level
- the frequent flooding and the beaver dam ponding maintain a steady source of water for the marsh.
- maintaining a permanent pool in the marsh results in more seepage at the river bank

The shallow piezometers seem to be influenced by the marsh water levels, showing little change and piezometric levels 2-5 feet below the berm ground surface when there is no flooding. The river bank seeps are 3-6 feet below the top of berm in the slumping area and 5-8 feet below the top of the berm in the river bank area not showing the progressive slumping. Additional seeps below the river level are likely. During the flooding (above the berm elevation of approximately 700) all the piezometers are assumed to be at the river level. Since the dataloggers were either pulled or flooded during the flooding, there are no water levels recorded above the flooding elevation. The marsh had water levels near elevation 697-698 (within 2-3 feet of the top of berm) most of the time. An active beaver dam system appeared intact through most, if not all the entire monitoring period with the beaver pond overflow discharging into Eagle Creek just north of the marsh. The Fish and Wildlife staff indicated there is artesian flow in the marsh between the berm site and highway 101 located 1200 feet to the south. Although there are persistent bank seeps along the Minnesota River bank there is no visual or piezometric evidence at the berm site of unique spring activity. Piezometric levels shown in the collected data are typical for this environment but the combination of the seeps, the erodible saturated and soft clayey slumping soil mass and the erosive river energy along the outside bend all work together to further the river bank recession. The river bank seeps at the berm site are active year round (see attached photos) and appear to be fed by thin sandy seams that daylight at the river bank mid-slope or along one of the intersection slump blocks. The ponded water seeping from the marsh and regional groundwater flowing toward the river provide the persistent source of groundwater for the seeps noted along the berm river bank.

3. **RECOMMENDATIONS**: River bank recession along this outside bend will continue unless erosion protection is added or river flows are diverted from the river bank. An erosion protection design should include recent river cross sections and a slope stability review to account for the seepage and assure an adequate factor of safety can be met. A “top of berm” survey is recommended to verify the elevation along the entire length of the natural levee/berm. The top of the berm on the downstream end may already be lower than the rock berm spillway. Field observations from the recent high water events show erosion both parallel and perpendicular to the river bank. This overland flow from the marsh is expediting the erosion and bank slumping in the area already experiencing faster erosion rates. Repairs to only manage the seepage would be incomplete due to the

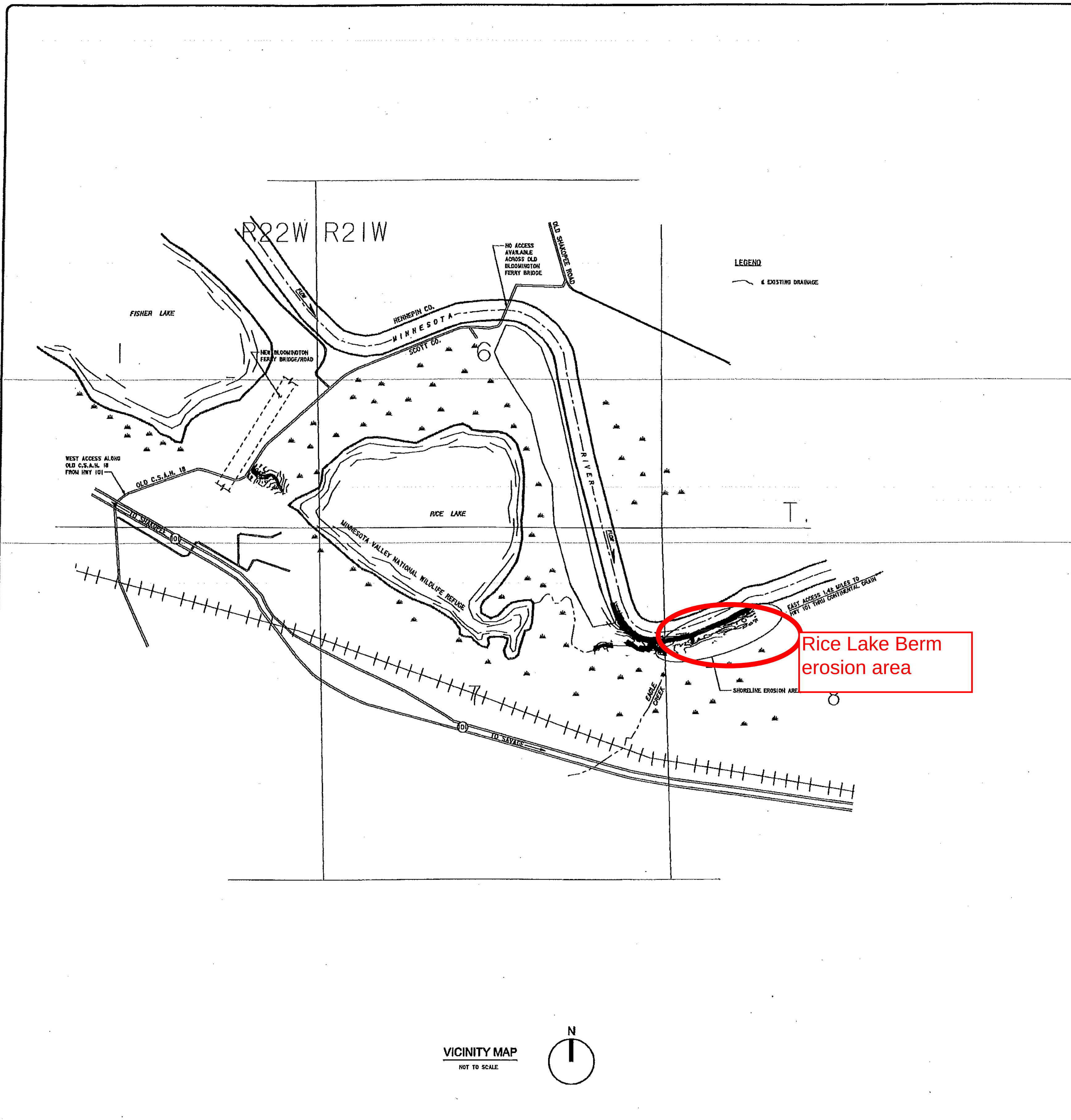
ongoing erosion; the thin sandy seams could be discontinuous and complex. Based on field observations it appears that portions of a natural levee (sand and silt deposits forming parallel to the river) may be starting to form landward of the existing eroding bank; methods to increase the rate of formation of the new natural levee or adding to material to the berm may be another method to prolong the life of this project.

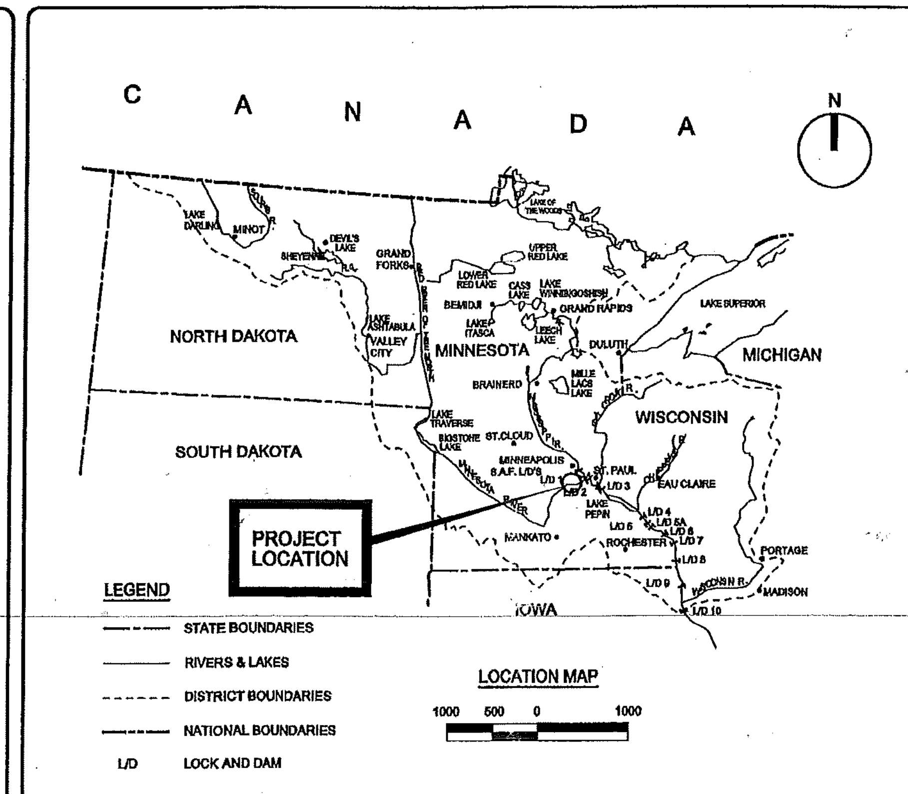
4. **BACKGROUND:** The Minnesota River Valley is a large groundwater discharge corridor; the groundwater in the uplands is flowing toward the down gradient aquifers, and ultimately to the river valleys. The surface and groundwater recharged at a higher elevation is striving to discharge at a lower elevation. This is more defined in an incised river in an oversized glacial river valley, such as the Minnesota River valley. The uplands consist of glacial sands and clayey till overlying the dolomite sandstone and siltstone bedrock. The floodplain deposits in the valley are commonly silty, clayey, and often less pervious. Geologic literature indicates alluvial soils up to 200 feet thick at the project, but less than 50-feet thick just 1200 feet to the south. Over time the major discharge areas make adjustment, striving for the easiest discharge point. This may be in a more pervious soil, through natural cracks/fissures, or "pipes" in the soil or bedrock. Artesian conditions that are exhibited as seeps, springs, boils are common in the MN river valley; our project area is just downstream of the confluence of Eagle Creek, one of the few trout streams (spring fed) in the metro area, and within a ½ mile of the Savage Fen. These are noted only because they stand out as significant point sources of groundwater discharge nearby. The seepage and erosion at this project is more common. The portion of the project showing significant erosion consists of a natural the river bank founding a minimal berm on top of a natural levee along the Minnesota River. The natural levee/berm retains the water in the marsh for times when the Minnesota River is not flooding. At the upstream end of the berm a rock overflow feature was constructed to serve as an armored discharge channel to direct how the excess water in from the flooded marsh exists to the river. Rather than flow out and erode channels through the natural levee, the excess water is directed out the overflow structure. The rock lined overflow channel appears to be intact and is in good condition, albeit it is becoming overgrown with willow brush and sediment. Prior to the FWS/COE project the excess water exited other natural and FWS features downstream through a system of ditches and small control structures and to the upstream end toward Eagle Creek, a small spring-fed trout stream that flows to the Minnesota River. The source of the water for the marsh includes: the flooding Minnesota River, precipitation, and groundwater discharge. The flooding is very frequent, and the groundwater discharge in the Minnesota River Valley can be significant. The marsh was full in the initial July, 2009 visit despite the dry period. During my subsequent site visits the marsh water levels appear to be managed on the high end (within 2-3 feet of the top of berm) by a significant beaver dam. Ten surveyed cross sections taken in 2008 show 25-39 feet of recession of the upper bank since the 1994 cross sections. The most downstream 350-feet shows significantly more seepage than the areas closer to the rock overflow spillway, the recession is also the greatest at the seepage area. The seepage is occurring approximately 5 to 6 feet below the top of the berm (elevation 700), causing benching and downward soil mass movement or slumping. The project area is just downstream of a sharp outside bend, so erosion is not unexpected; it is more of a question of why the erosion has been so rapid. Typical erosion rates based

on the Design Memorandum and another private report appear to be along the lines of 1-foot or less per year vs. the 2-feet or more that has occurred. Banks showing slope stability problems due to seepage are more prone to higher erosion rates but also are influenced by site specific field conditions (river level fluctuations, flooding frequency, hydraulic conditions, and soil conditions, etc.) that can skew averages. Just upstream of this site on another outside bend in the river the city of Eden Prairie conducted a 2008 erosion stability study on a failing river bank involving seepage and erosion, although the riverbank was over 40-feet high and primarily sandy; their repair included flattening the slopes, and adding a filter, bedding and rock protection.

Attachments
Figures 1-3
    Location maps
    Piezometer plot
Pictures of site

Terrance Jorgenson
Geologist, USACE

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RICE LAKE
MINNESOTA RIVER
RICE LAKE

VICINITY AND LOCATION MAPS
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

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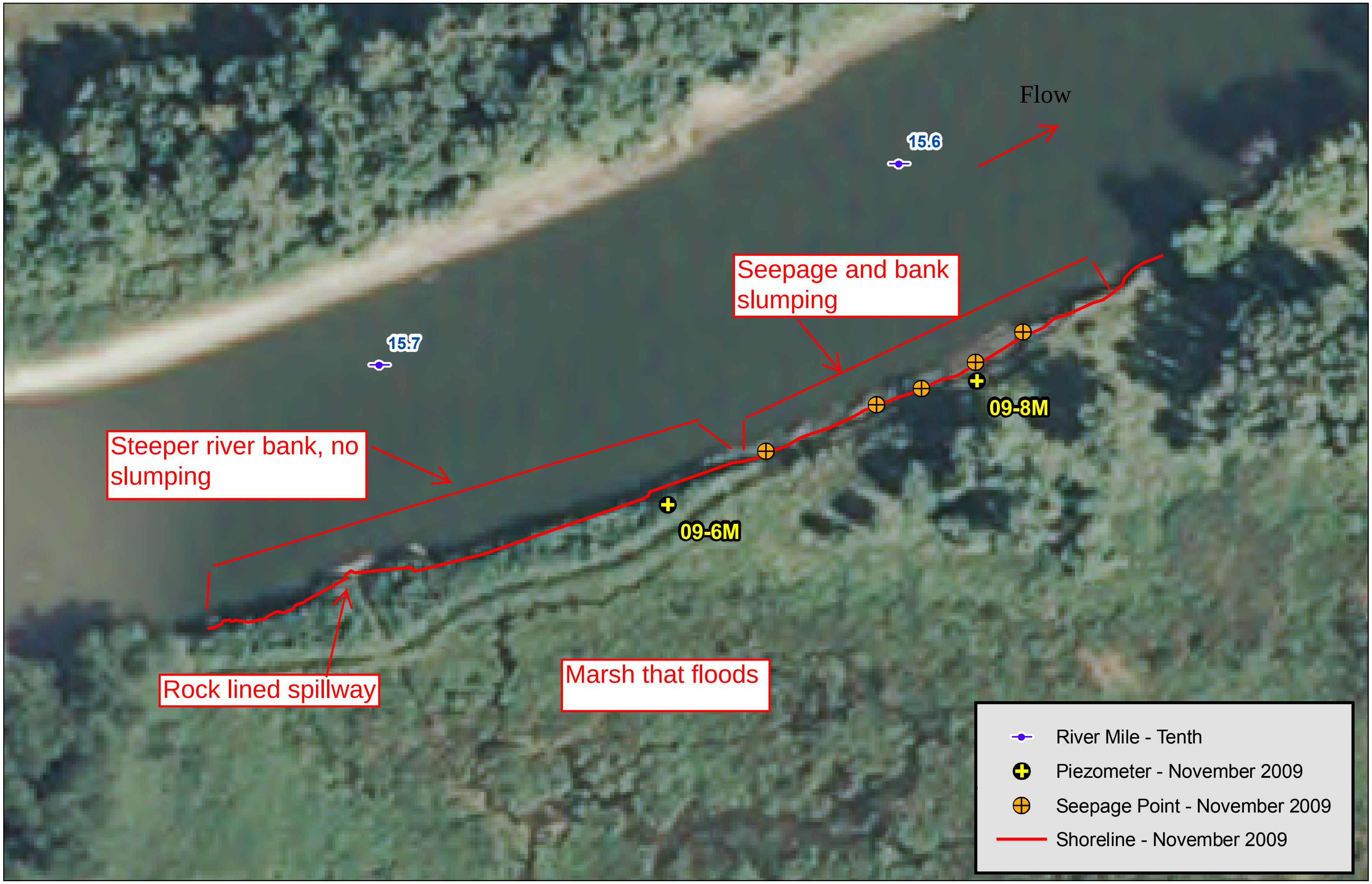
SHEET IDENTIFICATION
G-002

USACE-MVP-0000120582

FIGURE 1

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# Rice Lake - Shoreline Monitoring - Scott County

Photobase - 2008 FSA Orthophoto

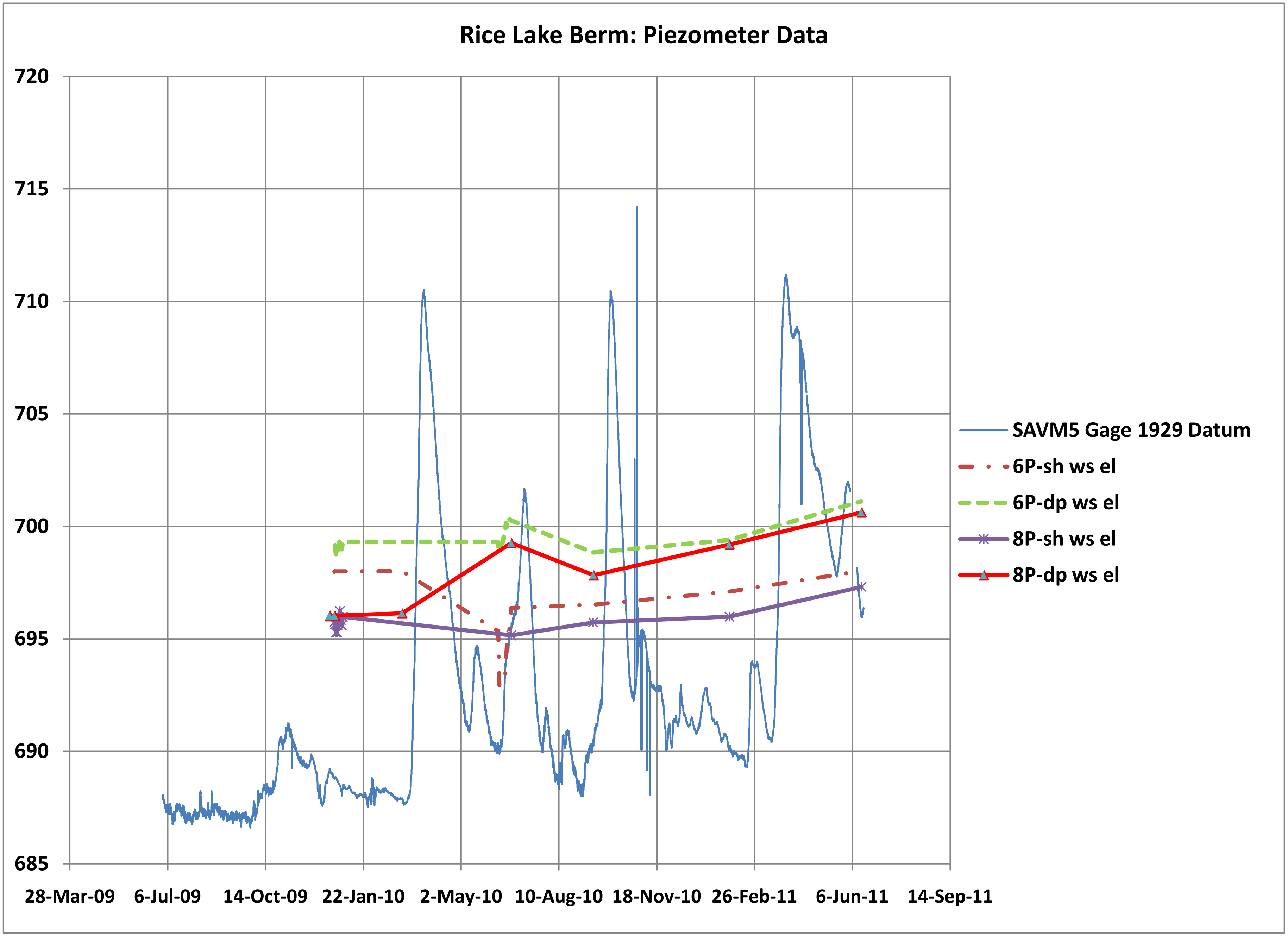
150 0 150 300 Feet

N

\minn_river\RiceLake\MXD\RiceLake_Shoreline_Monitoring.mxd MRW 20091124

USACE-MVP-0000120582

FIGURE 2



Rice Lake Berm: Piezometer Data
720
715
710
705
700
695
690
685
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
26-Feb-11
6-Jun-11
14-Sep-11
SAVM5 Gage 1929 Datum
6P-sh ws el
6P-dp ws el
8P-sh ws el
8P-dp ws el


FIGURE 3


Seeps, bank slumping,
higher erosion rates
Rock spillway
not eroded
Bank erosion, steeper
slopes maintained
FLOW

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St. Paul District

# SHORELINE EROSION SURVEY
# MINNESOTA RIVER AT RICE LAKE
# MN VALLEY NAT'L WILDLIFE REFUGE
# SAVAGE, MINNESOTA

Solicitation: W912EE-XX-X-XXXX
Contract: W912EE-XX-X-XXXX
MAY 2009

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| SIZE: ANSI D | FILE NAME: RLBS01G001___G-001xxx.dgn | |

RICE LAKE
MINNESOTA RIVER
RICE LAKE

COVER SHEET
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

SHEET IDENTIFICATION
G-001

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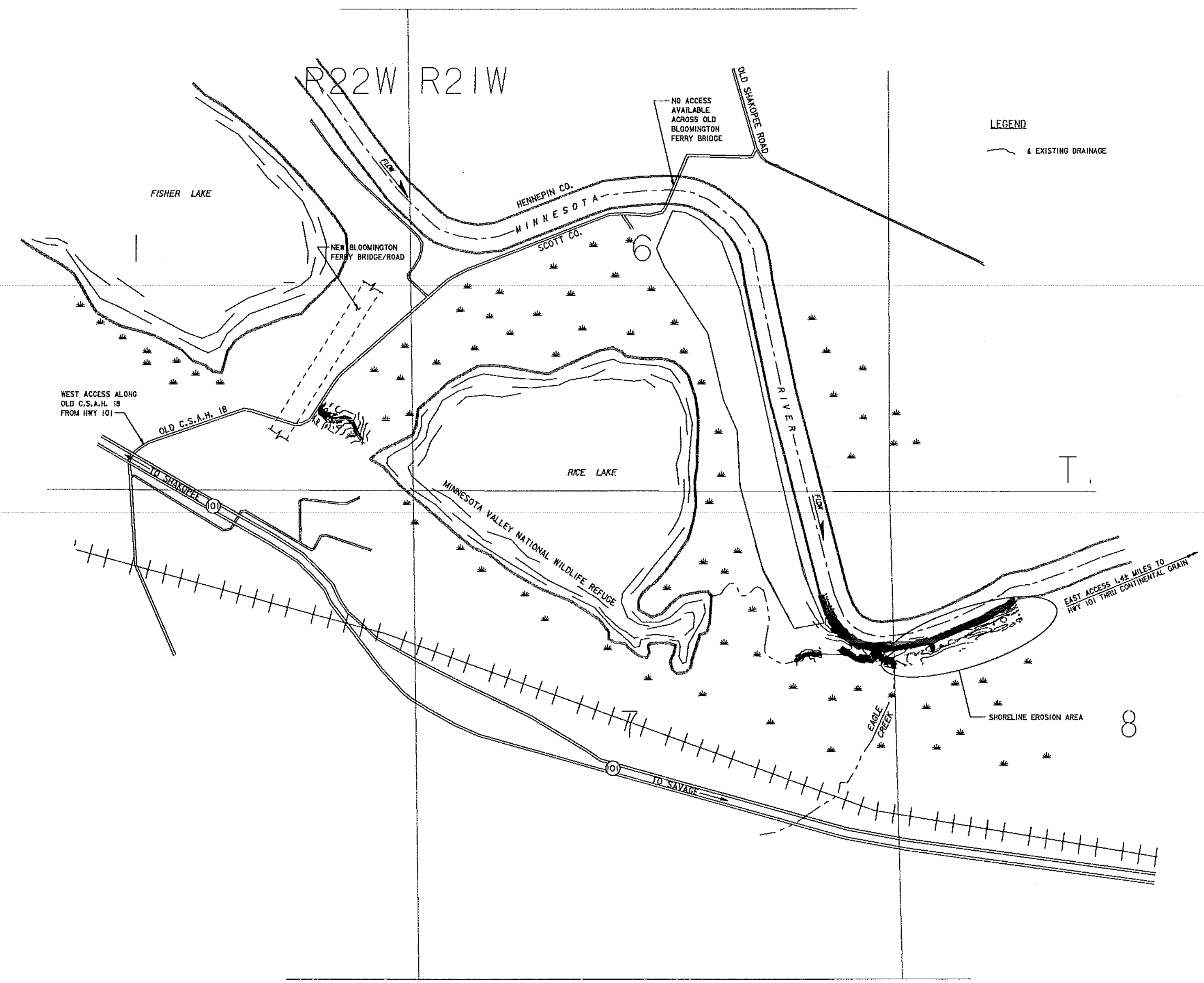


VICINITY MAP

NOT TO SCALE

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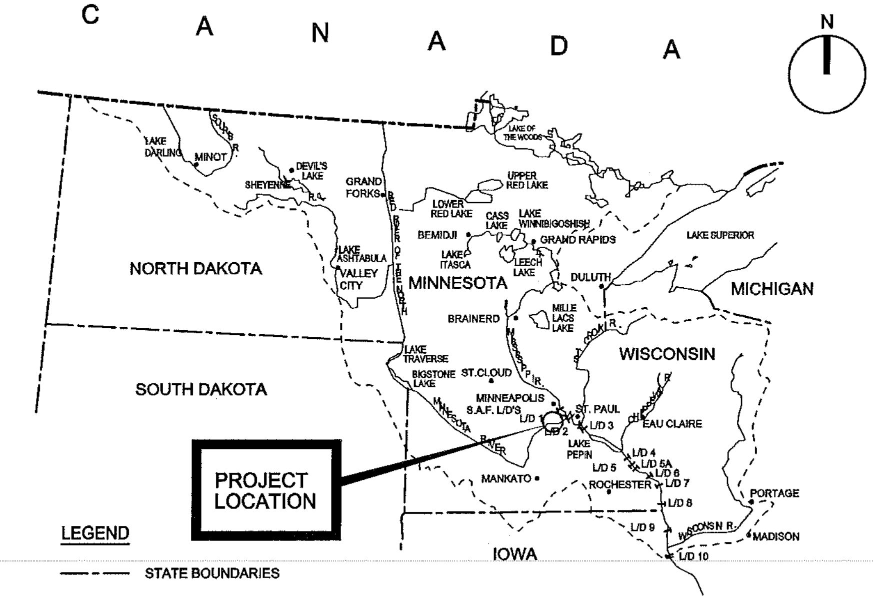


LEGEND

- STATE BOUNDARIES
- RIVERS & LAKES
- DISTRICT BOUNDARIES
- NATIONAL BOUNDARIES
- L/D LOCK AND DAM

LOCATION MAP

1000 500 0 1000

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RICE LAKE
MINNESOTA RIVER
RICE LAKE

VICINITY AND LOCATION MAPS
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

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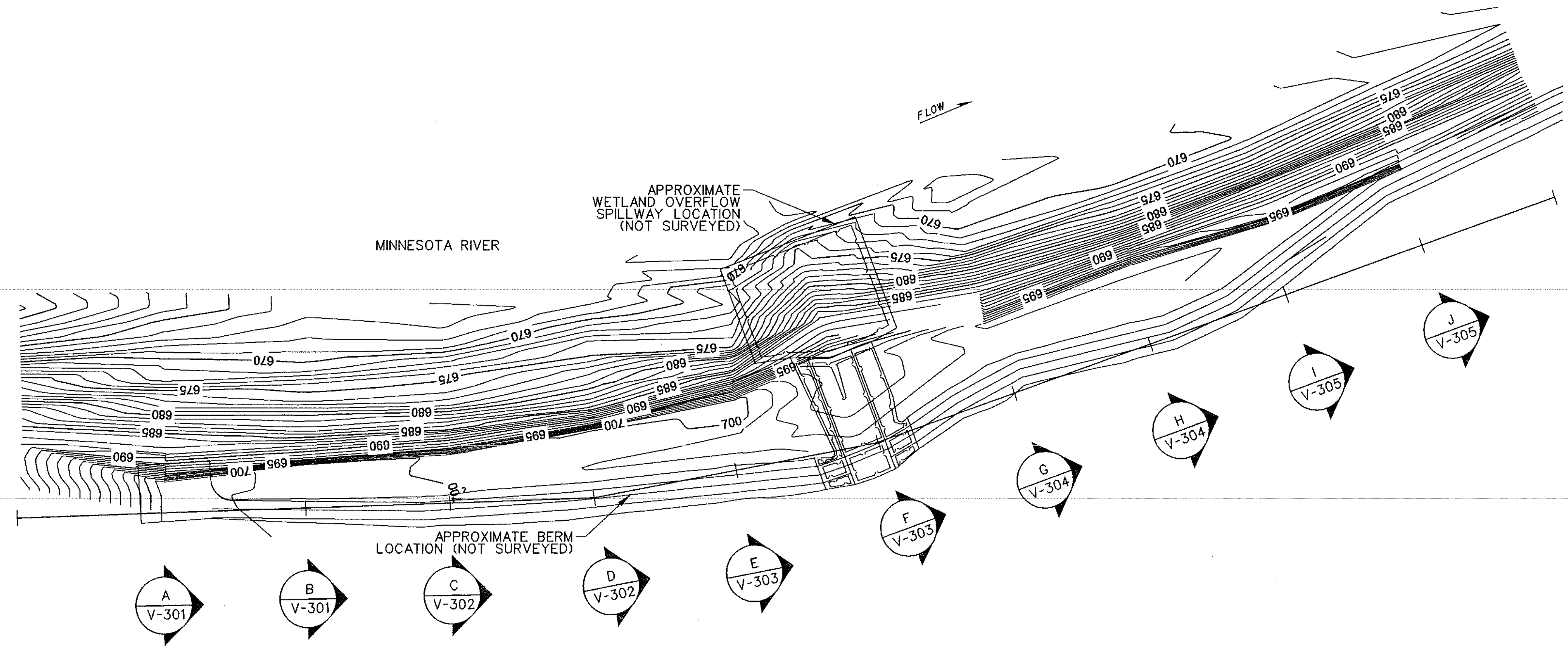
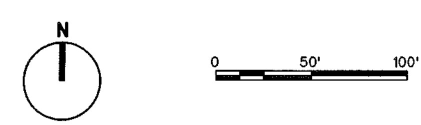



## SURVEY AND MAPPING PLAN

RICE LAKE 2008 SURVEY




1. VERTICAL IS REFERENCED TO THE ADJUSTMENT OF NGVD 1929, US SURVEY FEET.

2. HORIZONTAL IS REFERENCED TO THE ADJUSTMENT OF NAD83, MN SOUTH, US SURVEY FEET.

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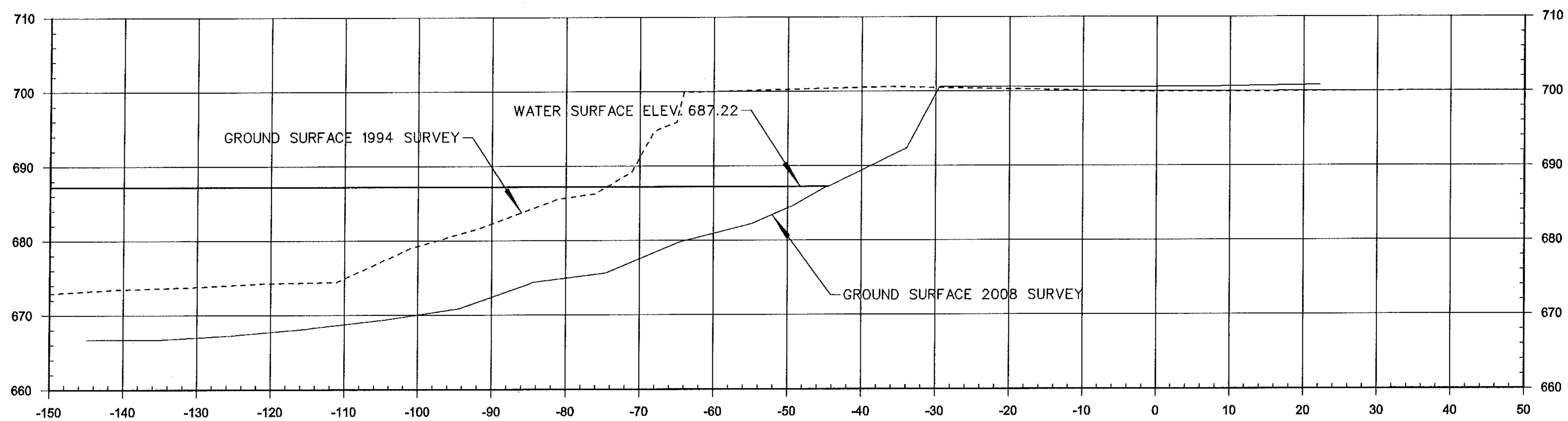
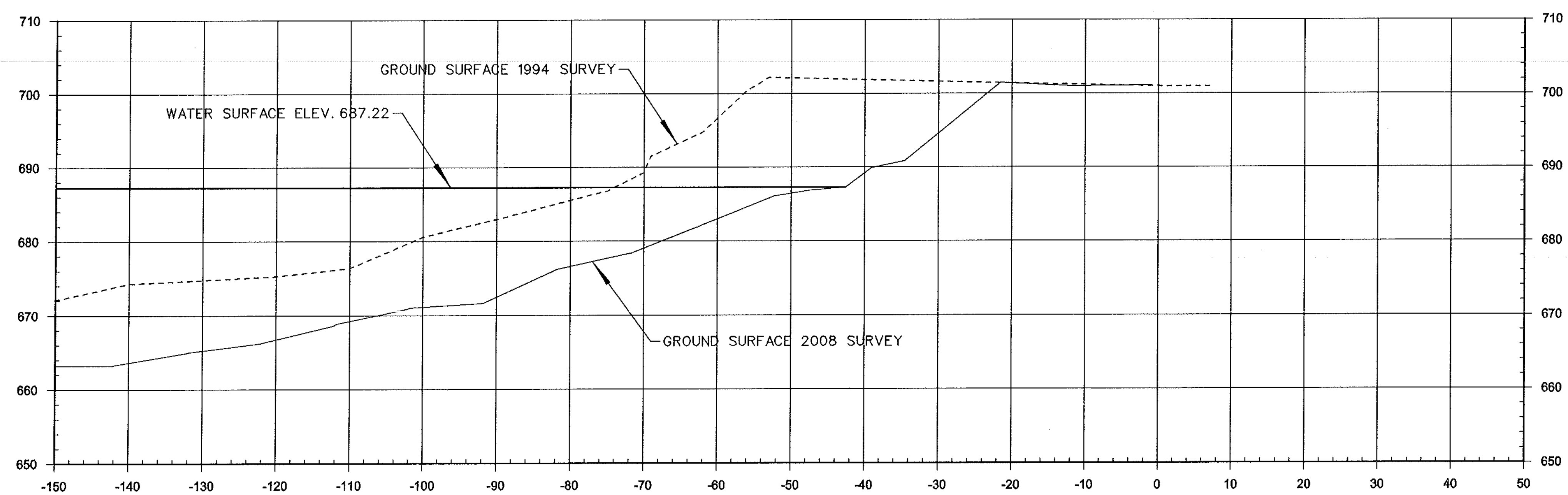
RICE LAKE
MINNESOTA RIVER
RICE LAKE
SAVAGE, MN
PLAN VIEW
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

SHEET IDENTIFICATION
V-101




B / V-101 SECTION
RICE LAKE




A / V-101 SECTION
RICE LAKE

0 10' 20'

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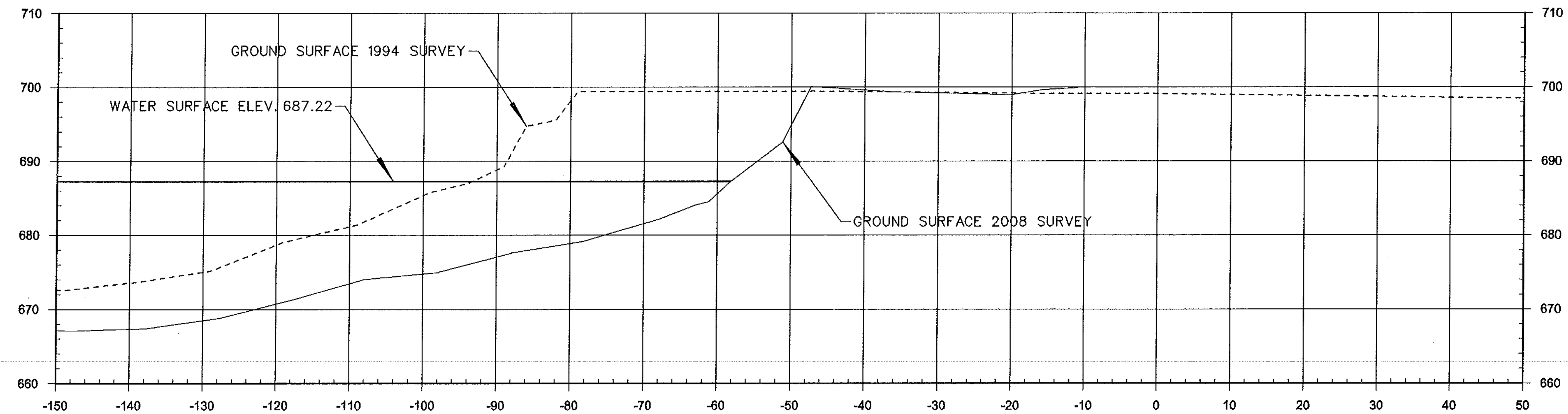
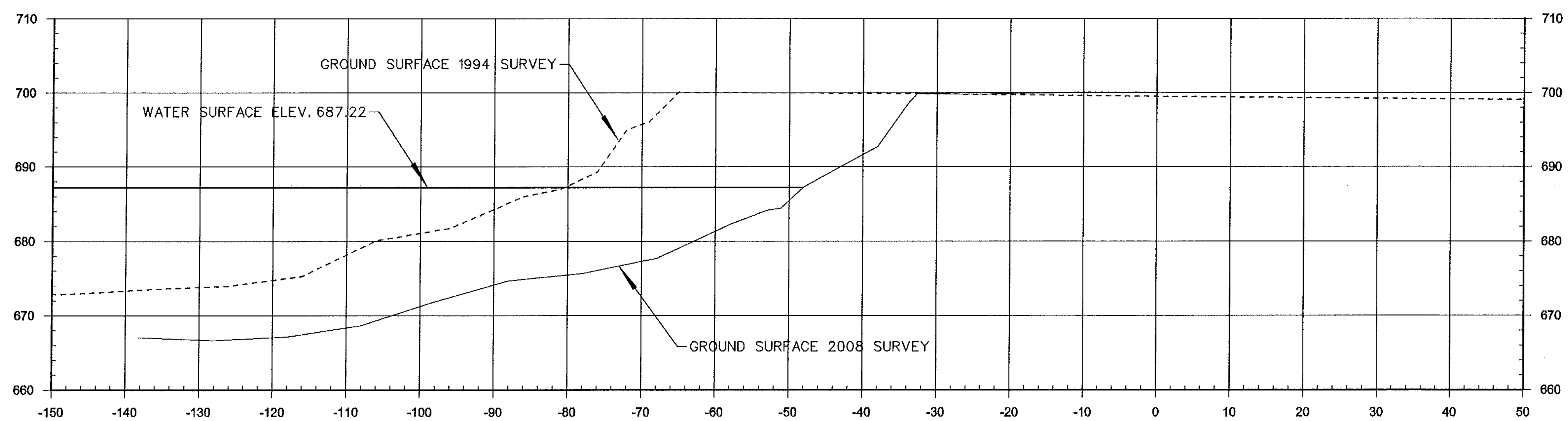
RICE LAKE
MINNESOTA RIVER
RICE LAKE

SECTIONS
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

SHEET IDENTIFICATION
V-301




D V-101 SECTION
RICE LAKE




C V-101 SECTION
RICE LAKE

0 10' 20'

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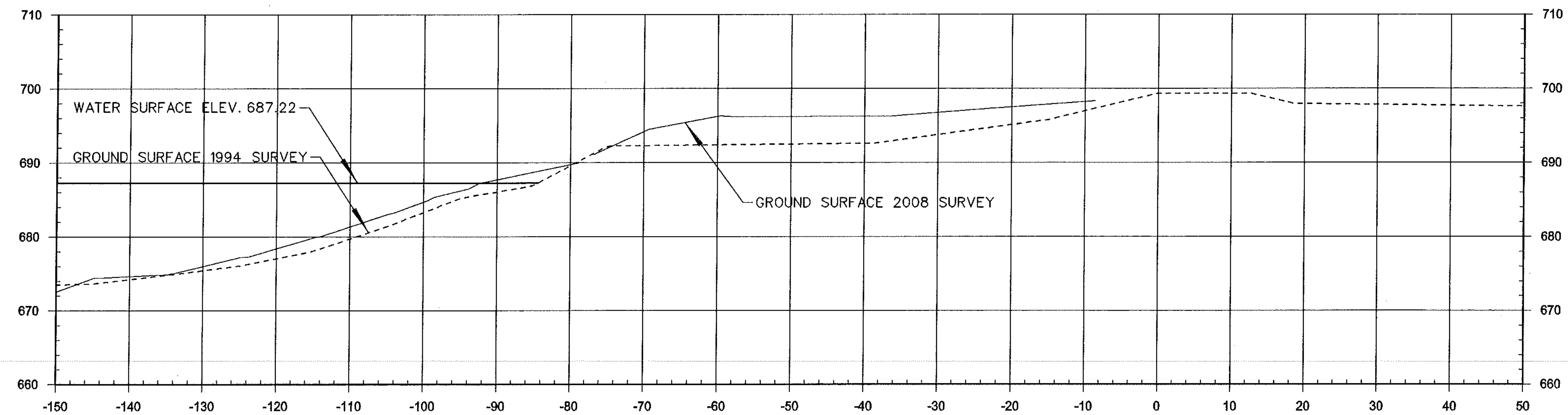
SIZE: | FILE NAME:

RICE LAKE
MINNESOTA RIVER
RICE LAKE

SECTIONS
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

SHEET IDENTIFICATION
V-302

USACE-MVP-0000120582

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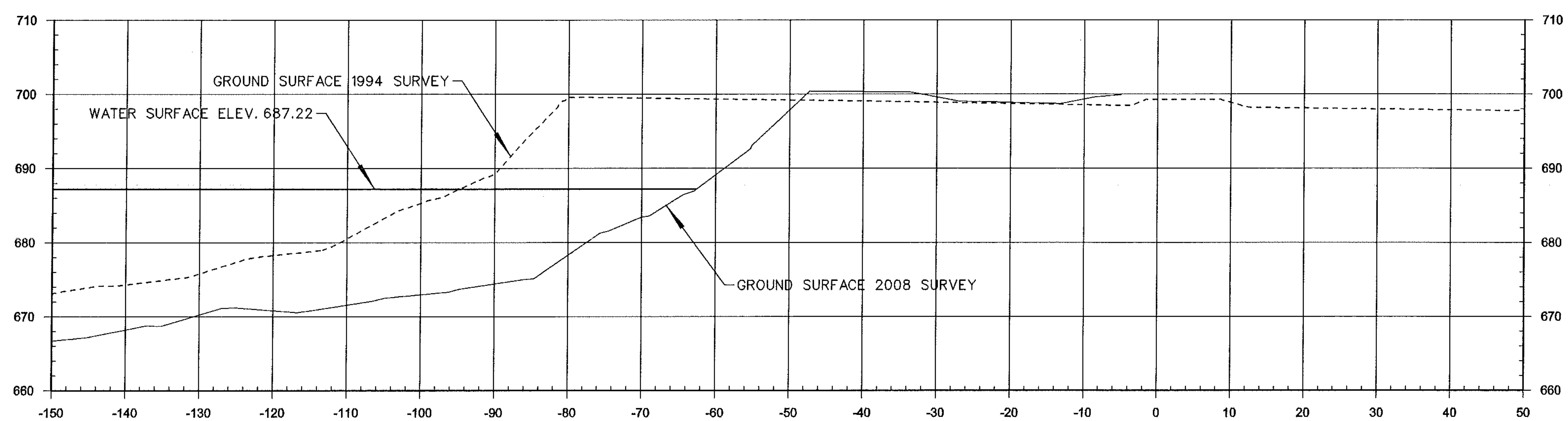
V-101
SECTION
RICE LAKE

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RICE LAKE

0 10' 20'

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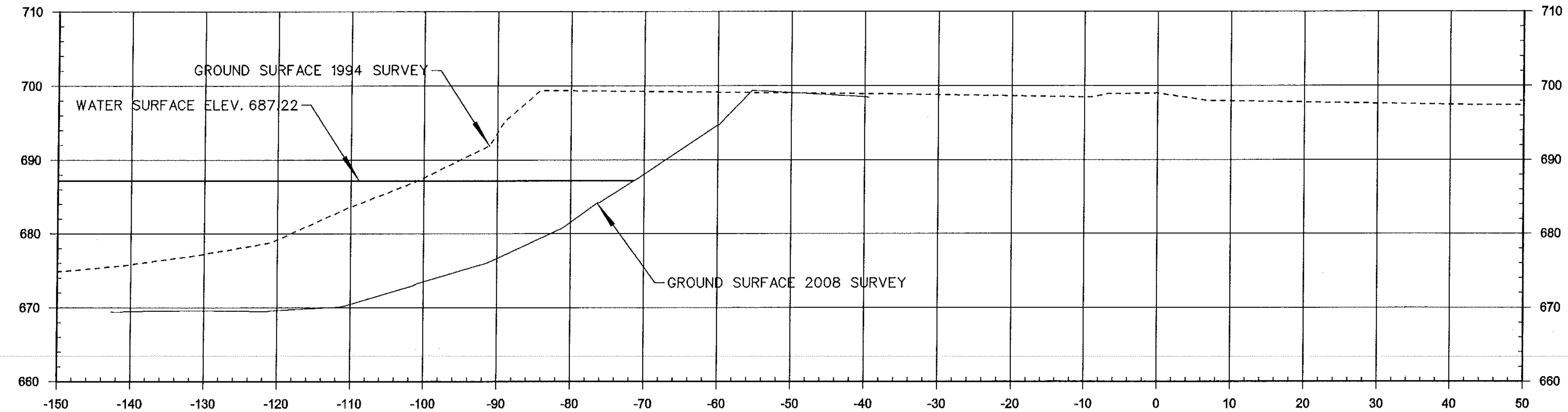
RICE LAKE
MINNESOTA RIVER
RICE LAKE

SECTIONS
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

SHEET IDENTIFICATION
V-303

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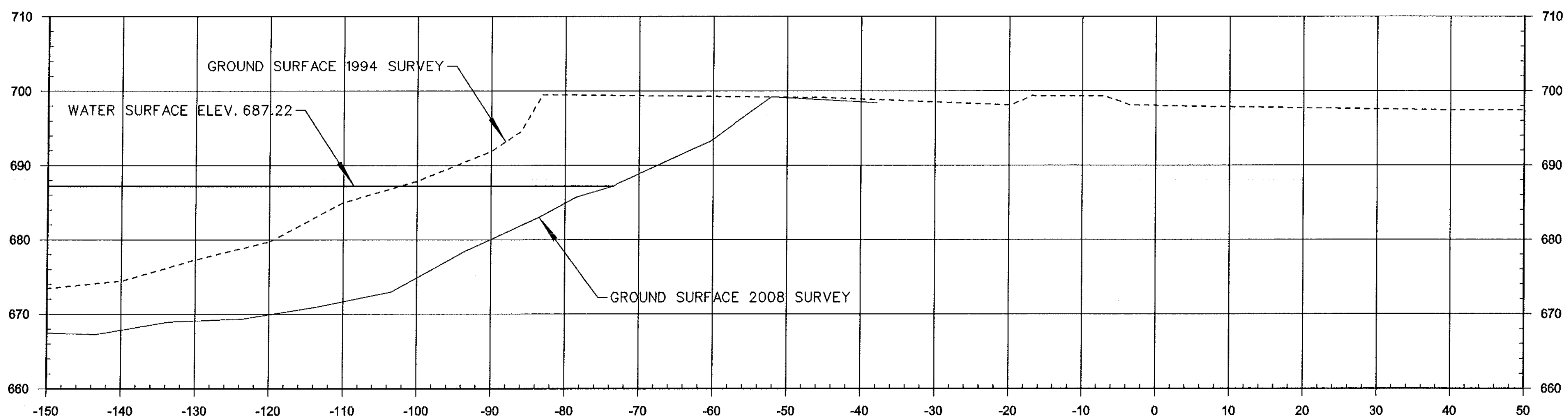
RICE LAKE




(G / V-101) SECTION
RICE LAKE

0 10' 20'

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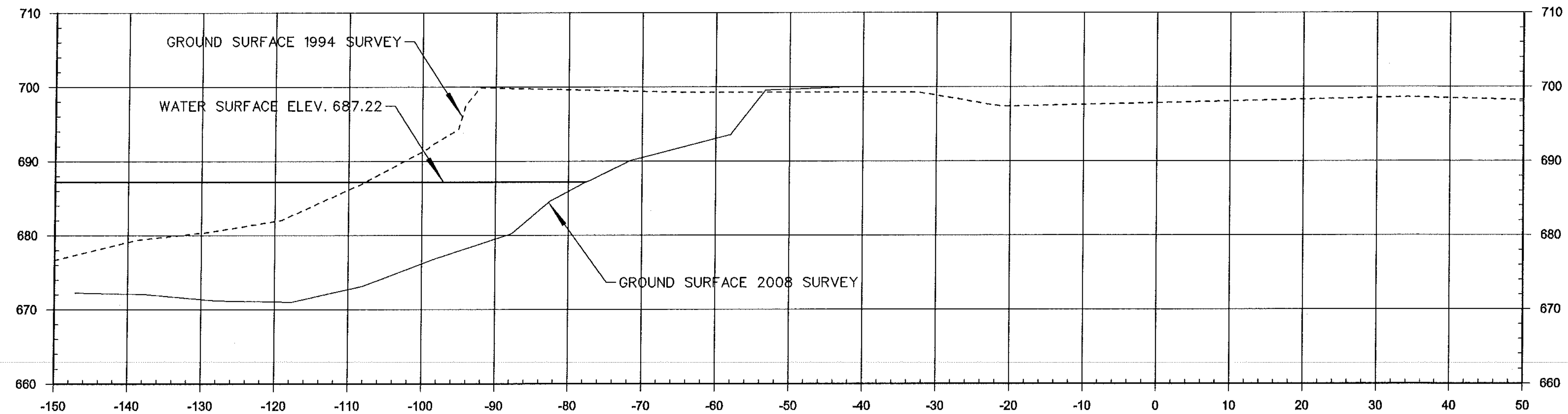
RICE LAKE
MINNESOTA RIVER
RICE LAKE

SECTIONS
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

SHEET IDENTIFICATION
V-304

USACE-MVP-0000120582

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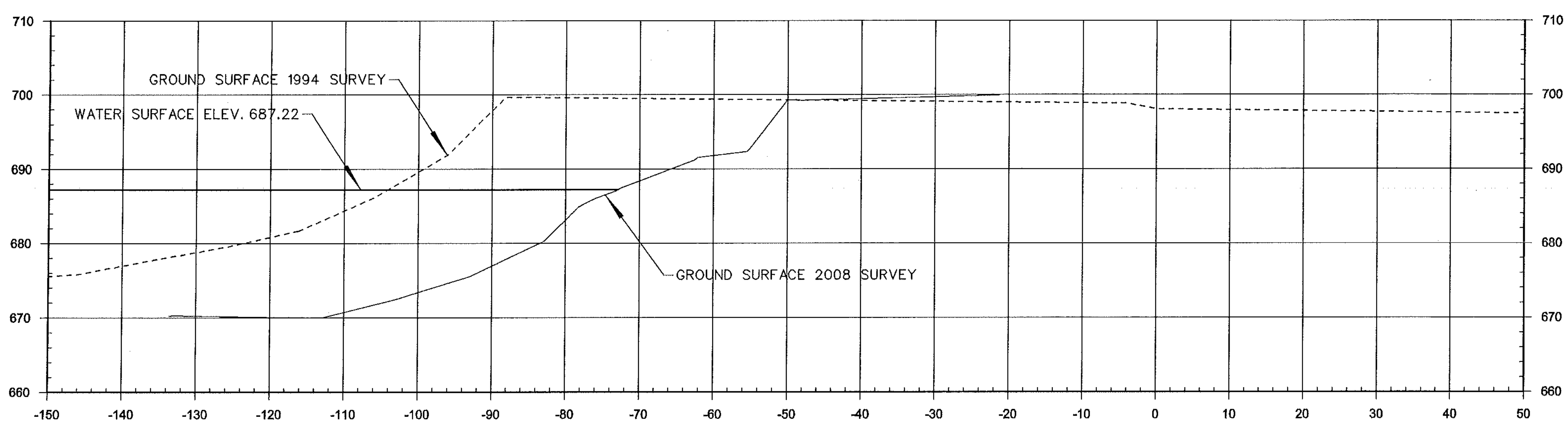
V-101
SECTION
RICE LAKE

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SECTION
RICE LAKE

0 10' 20'

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RICE LAKE
MINNESOTA RIVER
RICE LAKE

SECTIONS
MINNESOTA RIVER AT RICE LAKE
MN VALLEY NATIONAL WILDLIFE REFUGE

SHEET IDENTIFICATION
V-305

USACE-MVP-0000120582

# Appendix C

Rice Lake Habitat Rehabilitation and Enhancement Project (HREP) Cost Estimate

Cost estimates have been prepared for the two preliminary alternatives described in section 8.3.1 of the main report, and are as follows:

Rock Fill Layer

The estimated cost for the 2-foot rock fill layer with contingencies amounts to approximately \$1,440,300. This is assuming the project would be marine based, and that mobilization (mob)/demobilization (demob) would have a cost of approximately \$250,000. Placement of the rock is projected at \$50/TN, therefore an estimated need of 12,000 TN of rock fill would cost approximately \$600,000. The estimated rock fill placement is based on using the existing bank slope with little or no site work. Clearing, grubbing, topsoil, and seeding have not been included in this estimate. Table 1 and 2 provide a summary and detailed analysis of estimated costs.

**Table 1** – Rock Fill Cost Estimate Summary

| Item | Item Description | Total Estimated Amount | Contingency Amount | Contingency Percent | Estimated Amount Plus Contingency |
|---|---|---|---|---|---|
| 01 | Lands & Damages | $0 | $0 | 0% | $0 |
| 06 | Fish & Wildlife Facilities | $850,000 | $359,500 | 42% | $1,209,500 |
| 30 | Planning, Engineering and Design 15% | $127,500 | $31,900 | 25% | $159,400 |
| 31 | Construction Management 7% | $59,000 | $11,900 | 20% | $71,400 |
| **Total Estimated Project Cost** | | **$1,037,000** | **$403,300** | **39%** | **$1,440,300** |

Notes:
Costs are based on November 2011 unit pricing.

**Table 2** – Rock Fill Detailed Cost Estimate

| ITEM | ITEM DESCRIPTION | QUANTITY | UNITS | UNIT PRICE | AMOUNT | CONTINGENCIES % | CONTINGENCIES AMOUNT | TOTAL AMOUNT | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| **01** | **LANDS & DAMAGES** | | | | | | | | |
| | Lands & Damages | 1.0 | LS | | $0 | 25% | $0 | $0 | |
| | Admin Costs | 1.0 | LS | | $0 | 0% | $0 | $0 | |
| **TOTAL 01 - LANDS & DAMAGES** | | | | | **$0** | | **$0** | **$0** | |
| **06** | **FISH & WILDLIFE FACILITIES** | | | | | | | | |
| **06 03** | **WILDLIFE FACILITIES** | | | | | | | | |
| **06 03 01** | **Mob / Demob** | | | | **$250,000** | | **$77,500** | **$327,500** | |
| | Mob / Demob | 1.0 | LS | $250,000.00 | $250,000 | 31% | $77,500 | $327,500 | *2,3* |
| **06 03 02** | **RIPRAP** | | | | **$600,000** | | **$282,000** | **$882,000** | |
| | Riprap Placement | 12,000.0 | TON | $50.00 | $600,000 | 47% | $282,000 | $882,000 | *2,3* |
| **TOTAL 06 - FISH & WILDLIFE FACILITIES** | | | | | **$850,000** | | **$359,500** | **$1,209,500** | |
| **30** | **PLANNING, ENGINEERING & DESIGN** | 1.0 | JOB | $127,500.00 | $127,500 | 25% | $31,900 | $159,400 | *1,2* |
| **TOTAL 30 - PLANNING, ENGINEERING & DESIGN** | | | | | **$127,500** | | **$31,900** | **$159,400** | |
| **31** | **CONSTRUCTION MANAGEMENT** | 1.0 | JOB | $59,500.00 | $59,500 | 20% | $11,900 | $71,400 | *1,2* |
| **TOTAL 31 - CONSTRUCTION MANAGEMENT** | | | | | **$59,500** | | **$11,900** | **$71,400** | |
| **TOTAL PROJECT** | | | | | **$1,037,000** | | **$403,300** | **$1,440,300** | |

Costs are based on November 2011 unit pricing.

**NOTES FOR CONTINGENCIES:**

1. *UNKNOWN QUANTITIES*
2. *LIMITED DESIGN WORK COMPLETED*
3. *UNKNOWN UNIT PRICES*
4. *ALIGNMENT NOT FINAL*
5. *LIMITED BORING INFORMATION AVAILABLE*

Rock Vanes

The estimated cost for construction of 10 rock vanes with contingencies, to stabilize the river bank is anticipated to cost approximately $1,223,500. This is assuming the project would be marine based, and that mob/demob would have a cost of approximately $250,000. Placement of the rock is projected at $50/TN, therefore an estimated need of 8,500 TN would cost approximately $425,000. The estimated rock vane placement is based on using the existing bank slope with little or no site work. Clearing, grubbing, topsoil, and seeding have not been included in this estimate. Table 3 and 4 provide a summary and detailed analysis of estimated costs.

**Table3** – Rock Vanes Cost Estimate Summary

| Item | Item Description | Total Estimated Amount | Contingency Amount | Contingency Percent | Estimated Amount Plus Contingency |
|---|---|---|---|---|---|
| 01 | Lands & Damages | $0 | $0 | 0% | $0 |
| 06 | Fish & Wildlife Facilities | $717,500 | $311,300 | 43% | $1,028,800 |
| 30 | Planning, Engineering and Design 15% | $107,600 | $26,900 | 25% | $134,500 |
| 31 | Construction Management 7% | $50,200 | $10,000 | 20% | $60,200 |
| **Total Estimated Project Cost** | | **$875,300** | **$348,200** | **40%** | **$1,223,500** |

Notes:
Costs are based on November 2011 unit pricing.

**Table 4** – Rock Vane Detailed Cost Estimate

| ITEM | ITEM DESCRIPTION | QUANTITY | UNITS | UNIT PRICE | AMOUNT | CONTINGENCIES % | CONTINGENCIES AMOUNT | TOTAL AMOUNT | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| **01** | **LANDS & DAMAGES** | | | | | | | | |
| | Lands & Damages | 1.0 | LS | | $0 | 25% | $0 | $0 | |
| | Admin Costs | 1.0 | LS | | $0 | 0% | $0 | $0 | |
| **TOTAL 01 - LANDS & DAMAGES** | | | | | **$0** | | **$0** | **$0** | |
| **06** | **FISH & WILDLIFE FACILITIES** | | | | | | | | |
| **06 03** | **WILDLIFE FACILITIES** | | | | | | | | |
| **06 03 01** | **Mob / Demob** | | | | **$250,000** | | **$77,500** | **$327,500** | |
| | Mob / Demob | 1.0 | LS | $250,000.00 | $250,000 | 31% | $77,500 | $327,500 | *2,3* |
| **06 03 02** | **RIPRAP** | | | | **$467,500** | | **$233,800** | **$701,300** | |
| | Rock Vanes Placement | 8,500.0 | TON | $55.00 | $467,500 | 50% | $233,800 | $701,300 | *2,3* |
| **TOTAL 06 - FISH & WILDLIFE FACILITIES** | | | | | **$717,500** | | **$311,300** | **$1,028,800** | |
| **30** | **PLANNING, ENGINEERING & DESIGN** | 1.0 | JOB | $107,625.00 | $107,600 | 25% | $26,900 | $134,500 | *1,2* |
| **TOTAL 30 - PLANNING, ENGINEERING & DESIGN** | | | | | **$107,600** | | **$26,900** | **$134,500** | |
| **31** | **CONSTRUCTION MANAGEMENT** | 1.0 | JOB | $50,225.00 | $50,200 | 20% | $10,000 | $60,200 | *1,2* |
| **TOTAL 31 - CONSTRUCTION MANAGEMENT** | | | | | **$50,200** | | **$10,000** | **$60,200** | |
| **TOTAL PROJECT** | | | | | **$875,300** | | **$348,200** | **$1,223,500** | |

Costs are based on November 2011 unit pricing.

**NOTES FOR CONTINGENCIES:**

*1. UNKNOWN QUANTITIES*
*2. LIMITED DESIGN WORK COMPLETED*
*3. UNKNOWN UNIT PRICES*
*4. ALIGNMENT NOT FINAL*
*5. LIMITED BORING INFORMATION AVAILABLE*