Attachment 3
continued

US Army Corps of Engineers®
St. Paul District

Appendix B: Clean Water Act Compliance

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April, 2019

Appendix B

Contents

1 Project Description 1
1.1 Location and General Description 1
1.2 Authority and Purpose 2
1.3 General Description of Dredged or Fill Material 2
1.3.1 General Characteristics 2
1.3.1 Source of Material 2
1.3.2 Quantity of Material 2
1.4 Description of the Proposed Discharge Site 2
1.4.1 Location 2
1.4.2 Site and Habitat Description 2
1.5 Description of Disposal Method 3

2 Factual Determinations 3
2.1 Physical Substrate Determinations 3
2.1.1 Substrate Elevation and Slope 3
2.1.2 Sediment Type 3
2.1.3 Fill Material Movement 3
2.1.4 Actions Taken to Minimize Impacts 3
2.2 Water Circulation, Fluctuation and Salinity Determination 4
2.2.1 Water 4
2.2.2 Current Patterns and Circulation 4
2.3 Suspended Particulate/Turbidity Determination 5
2.3.1 Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site 5
2.3.2 Effects on Chemical and Physical Properties of the Water Column 5
2.3.3 Actions Taken to Minimize Impacts 5
2.4 Contaminant Determinations 5
2.5 Aquatic Ecosystem and Organism Determination 5
2.5.1 Effects on Plankton 5
2.5.2 Effects on Benthos 5
2.5.3 Effects on Nekton 6
2.5.4 Effects on Aquatic Food Web 6
2.5.5 Effects on Special Aquatic Sites 6

2.5.6 Threatened and Endangered Species 6
2.5.7 Other Wildlife 6
2.5.8 Actions Taken to Minimize Impacts 7
2.6 Proposed Disposal Site Determinations 7
2.6.1 Mixing Zone Determination 7
2.6.2 Determination of Compliance with Applicable Water Quality Standards 7
2.6.3 Potential Effects on Human Use Characteristics 7
2.7 Determination of Cumulative Effects on the Aquatic Ecosystem 7
2.8 Determination of Secondary Effects on the Aquatic Ecosystem 8

3 Finding of Compliance with Restrictions on Discharge 8

4 Section 401 Water Quality Certification Waiver 9

LIST OF TABLES

Table 1: Project Features 1

1 Project Description

1.1 Location and General Description

The US Army Corps of Engineers (Corps), St. Paul District is proposing to restore, protect and create aquatic and wetland habitats in the Minnesota Valley National Wildlife Refuge in Scott County, Minnesota. The study area includes Blue Lake, Fisher Lake, Rice Lake and Continental Grain Marsh which are located south of the Minnesota River between river miles 15 and 21 (see Figure 14 in the Main Report).

The overall purpose of the project is to partially restore the hydrologic regime in the study area by allowing varied water levels to provide optimal quality habitat for migratory birds each season. Objectives include increasing the diversity and percent cover of both emergent and submergent aquatic plant species and providing quality feeding and resting habitat for a wide variety of waterfowl and waterbirds with particular emphasis on fall migrating waterfowl. To accomplish this, the project would include the replacement of five water control structures, construction of one new water control structure and one earthen plug (see Figure 14 in the Main Report). Each water control structure would have an excavator pad on each side of the structure to allow for routine maintenance. To access the water control structures, road improvements would be needed and a new road would need to be constructed to access the earthen plug (Figure 14 in the Main Report).

A wetland delineation has not been completed at this stage; however, the majority of the project area is identified as wetland on the National Wetland Inventory update for Minnesota (https://www.dnr.state.mn.us/eco/wetlands/nwi_proj.html). It is anticipated that all features will have impacts to wetlands; however, the fill action will help wetland plant communities and associated biota. A general summary of the extent of impacts is listed below in Table 1: Project FeaturesTable 1.

Table 1: Project Features

Project Feature	**Permanent Impact (Acres)**	**Temporary Impact (Acres)**
1 2-bay water control structure with associated excavator pads	0.07	0.09
5 1-bay water control structures with associated excavator pads	0.30	0.25
2 earthen plugs	0.24	
Access roads	4.67	
Channel dredging	3.55	
Rock-lined overflow channels	0.30	
Coffer dams (if needed)		0.20
Total fill	**5.58**	**0.54**
Total dredging	**3.55**	

The project will discharge fill material into 3.43 acres of forested/shrub wetlands and 2.15 acres of emergent wetland.

1.2 Authority and Purpose

Congress authorized the Upper Mississippi River Restoration program (UMRR) in Section 1103 of the 1986 Water Resources Development Act (WRDA) (Public Law 99-662), codified at 33 U.S.C. § 652. Over the course of its first 13 years, the UMRR program proved to be one of this country's premier ecosystem restoration programs, combining close collaboration between Federal and State partners, and an effective planning process. This success led Congress to reauthorize the UMRR program in WRDA 1999 (Public Law 106-53).

1.3 General Description of Dredged or Fill Material

1.3.1 General Characteristics

Dredged or excavated material from the project site will likely not be used as fill or backfill for the project. Impervious fill (clay) would be used for the earthen plug and for backfill associated with the water control structures and excavator pads. Gravel will be used as fill material for the access roads and riprap for the rock-lined overflow structures. Composition of the dredged material will be determined when sediment borings occur in January or February 2019.

1.3.1 Source of Material

Clay material for the earthen plug and backfill would be collected from an approved borrow area. Gravel and riprap would be purchased from a commercial, licensed source.

1.3.2 Quantity of Material

See Table 10 in the Main Report.

1.4 Description of the Proposed Discharge Site

1.4.1 Location

Blue, Fisher, and Rice Lakes and Continental Grain Marsh are located within the Minnesota Valley National Wildlife Refuge in Scott County, Minnesota. All four aquatic resources are located just south of the Minnesota River.

1.4.2 Site and Habitat Description

The study area is approximately 2,085 acres in size and includes 3 backwater lakes (Blue, Fisher and Rice) and Continental Grain Marsh. The Minnesota River banks are overtopped during high-water events, but the lakes are largely isolated from the rest of the complex during normal flows. Blue Lake is a 248-acre backwater lake in the northwest portion of the study area. During normal flows, Blue Lake has two outlets; the northwest outlet flows into the Minnesota River, and the southeast outlet flows into Fisher Lake. During flood conditions, the northwest outlet acts as an inlet and the Minnesota River discharges into Blue Lake. Fisher Lake is located downstream of Blue Lake and is 370 acres. Water from Fisher Lake can either discharge into Rice Lake or through a secondary outlet into the Minnesota River. Rice Lake is downstream from Fisher Lake and is 287 acres. Water from Rice Lake flows through the secondary outlet into the Minnesota River. Under typical summer conditions, all three backwater lakes are less than 4 feet deep.

Continental Grain Marsh is 93 acres and has an average depth of 2.5 feet. The marsh is located downstream from Rice Lake but is not hydrologically connected to the lake. Water currently flows from the marsh into Eagle Creek, a designated trout stream.

The proposed water control structures and earthen plug would be placed into emergent wetlands whereas access roads would be constructed through forested wetlands. With the exception of the Continental Grain Marsh water control structure, earthen plug and access road to the plug, all other project features will be placed within existing footprints.

1.5 Description of Disposal Method

It is anticipated that the contractor will use an excavator to remove soils from areas where water control structures, excavator pads and access roads will be constructed. For the water control structures, concrete excavator pads will be poured on site and structures will either be poured in place or pre-cast and set in place. Following installation of the water control structures and excavator pads, the areas will be backfilled with an impervious clay material. Gravel and riprap will be hauled in via dump trucks to fill in the access roads and rock-lined overflow structures following excavation. Dredging will be conducted manually using a barge with backhoe, swamp excavator or long-reach excavator.

2 Factual Determinations

2.1 Physical Substrate Determinations

2.1.1 Substrate Elevation and Slope

The existing substrate in the project area is relatively flat and the proposed water control structures, excavator pads and earthen plug will increase the substrate elevation. These areas of increased elevation are relatively small in scale compared to the aquatic resources as a whole and will have a long-term minor effect on substrate elevation and slope. The roads will be constructed by excavating and then placing geotextile material within the excavated footprint. This method of road construction will have no effect on the substrate elevation or slope within the project area.

2.1.2 Sediment Type

Sediment borings are scheduled for 2019; however, according to the U.S. Department of Agriculture Web Soil Survey, sediment types within the fill areas are expected to silty clay loam, muck or a stratified silt loam to sand.

2.1.3 Fill Material Movement

Fill material is not expected to move significantly once placed.

2.1.4 Actions Taken to Minimize Impacts

A number of procedures would be used to minimize impacts where needed, including Best Management Practices. All work performed by a contractor will be subject to adherence with a work plan and applicable agency permits and Section 401 State Water Quality certification. The work plan shall detail the contractor’s proposed methods to perform work described by contract

drawings. This plan (and other related plans) shall be submitted to Government Representative (Corps COR) for review and acceptance before any site work commences.

2.2 Water Circulation, Fluctuation and Salinity Determination

2.2.1 Water

Some minor, short-term decreases in water clarity are expected from the proposed fill actions. The project will have no effect on salinity, water chemistry, color, odor, taste, dissolved oxygen, nutrients, eutrophication or temperature.

2.2.2 Current Patterns and Circulation

2.2.2.1 Current Velocity and Patterns

Post-construction, current patterns throughout the interconnected lakes will either remain the same or be restored where structures have collapsed. With the construction of an earthen plug in Continental Grain Marsh, water will no longer be allowed to discharge into Eagle Creek.

Current patterns may be temporarily impacted if coffer dams are needed during construction of the water control structures and earthen plug.

2.2.2.2 Stratification

The proposed project would have no effect on stratification.

2.2.2.3 Hydrologic Regime

The proposed project would optimize the hydrology for submergent and emergent aquatic plant growth. The installation of water control structures will allow the refuge to remove excess water from the lakes quickly following flood events. Water levels will gradually be lowered through the spring, maintained through the summer and raised in the fall. Partial drawdowns would be conducted annually in between full drawdown years which would occur every 5 to 7 years.

2.2.2.4 Normal Water Level Fluctuations

The project would not result in water levels outside the normal seasonal range.

2.2.2.5 Salinity

Not applicable.

2.2.2.6 Actions Taken to Minimize Impacts

No special actions would be taken to minimize the effects of the proposed project on water circulation, fluctuation or salinity.

2.3 Suspended Particulate/Turbidity Determination

2.3.1 Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site

Increases in turbidity and suspended particulates would temporarily occur from the discharge of fill material and excavation in the immediate project vicinity; however, levels would return to pre-project conditions upon completion of construction.

2.3.2 Effects on Chemical and Physical Properties of the Water Column

Increased turbidity levels during construction would have a short-term and minor effect to light penetration in the immediate project vicinity. The project would have no appreciable effect on dissolved oxygen, pH or temperature during or after construction.

2.3.3 Actions Taken to Minimize Impacts

The discharge of fill material and excavation will result in disturbance to the existing substrate, causing a temporary and localized increase in turbidity and suspended particulates. As part of the project's plans and specifications, the contractor will be required to develop an environmental protection plan that will include Best Management Practices (BMPs) designed to minimize impacts of the project to the surrounding environment.

2.4 Contaminant Determinations

The existing substrate within appropriate areas of the Bass Ponds project area will be tested in January or February 2019. Contaminated sediments are not anticipated, but if found, concerns will be addressed at that time.

2.5 Aquatic Ecosystem and Organism Determination

2.5.1 Effects on Plankton

During construction of the water control structures, excavator pads and earthen plug, and channel dredging, there may be a temporary increase in turbidity and suspended solids which would locally suppress phytoplankton productivity. However, this effect would be minor and short-term. Plankton populations would quickly recover after construction. Construction of the access roads would likely take place when the ground is frozen and would not have an effect on plankton as the wetlands in these areas are seasonally flooded and would likely be dry.

2.5.2 Effects on Benthos

Prior to installing the new water control structures, the old structures, including a small area around each structure, will be dewatered and excavated. Benthos present in these areas would be destroyed, as well as in the area of the earthen plug and excavator pads. Benthic organisms would likely recolonize the excavated areas following construction. Overall, the large unaffected areas of each wetland would continue to provide habitat for benthos. Construction of the access roads could disturb present biota. However, wetlands in these areas are seasonally flooded and would likely be dry and frozen during the construction timeframe.

2.5.3 Effects on Nekton

During construction of the water control structures, excavator pads and earthen plug, nekton could temporarily be displaced. The wetland areas where access roads are planned for construction do not provide habitat for nekton. Overall, the project is likely to have a long-term positive impact on nekton.

2.5.4 Effects on Aquatic Food Web

The impacts on benthos and plankton productivity as described above could cause a short-term minor temporary impact on the local aquatic food web. Overall, the anticipated increase in aquatic vegetation coverage and diversity would likely have a beneficial effect on the aquatic food web.

2.5.5 Effects on Special Aquatic Sites

The proposed project is located in the Minnesota Valley National Wildlife Refuge. The purpose of the proposed work is to improve wetland habitat within Blue, Fisher and Rice Lakes as well as Continental Grain Marsh. The overall project will have a beneficial effect on the refuge.

Most of the proposed project features (water control structures, excavator pads, channel dredging, earthen plug and access roads) would be constructed in wetlands. All features will be designed to minimize both direct and indirect impacts. Wetlands in the project area are large and features will only impact a very small portion of each. The wetlands will continue to provide the same functions and services after construction as they do currently. These functions include water quality protection, groundwater recharge and discharge, floodwater detention and wildlife habitat.

The proposed project is not located in and will have no effect on any mud flats, coral reefs, vegetated shallows or riffle and pool complexes.

2.5.6 Threatened and Endangered Species

The Corps has determined that there may be a short-term minor effect to the Northern long-eared bat if tree clearing is needed to accommodate construction equipment access. Anticipated effects to the species from tree removal were consulted with USFWS under Section 7 of the Endangered Species Act,16 U.S.C. §1533(d), through a Section 4(d) Rule Streamlined Consultation Form. Consultation began on January 26, 2018. USFWS did not respond within the 30 days; therefore, no further consultation is required. Details on other federally listed species can be found in Section 4.5.1 of the Main Report.

2.5.7 Other Wildlife

The proposed project would have a minor and temporary effect in terms of avoidance of the area by wildlife during construction. However following construction, the project will have a positive long-term effect on wildlife such as waterfowl, shorebirds, turtles, beavers, muskrats and other wildlife species that would utilize the project area.

2.5.8 Actions Taken to Minimize Impacts

Standard BMPs will be used to minimize impacts to biota and other resources (i.e. erosion and sediment control). These actions are anticipated to ensure compliance with associated laws and regulations, including the Endangered Species Act, Bald and Golden Eagle Protection Act, and similar regulations.

2.6 Proposed Disposal Site Determinations

2.6.1 Mixing Zone Determination

The placement of fill material and channel dredging would cause a minor, temporary increase in turbidity in the immediate vicinity; however, no long-term adverse impacts to water quality would occur from any of the proposed project features.

2.6.2 Determination of Compliance with Applicable Water Quality Standards

It is not anticipated that the proposed project would violate Minnesota water quality standards for toxicity. Fill materials would be obtained from a local or licensed source and be free of contaminants. Water quality certification would be obtained from Minnesota prior to project construction.

2.6.3 Potential Effects on Human Use Characteristics

2.6.3.1 Municipal and Private Water Supply

The proposed project will not impact municipal or private water supplies.

2.6.3.2 Recreational and Commercial Fisheries

The proposed project will not impact commercial fisheries. There may be temporary and minor impacts to recreational fisheries during construction. Overall, the recreational fishery potential is limited in the study area due to the shallow depths of the lakes (averaging only 2-3 feet in depth). During construction of the water control structures, excavator pads, and earthen plug, it is possible that fish could be displaced in the areas. Fish would not be affected by the construction of the access roads. Overall, the project is likely to have a long-term positive impact on the local fishery.

2.6.3.3 Water Related Recreation and Aesthetics

The proposed project will have no appreciable impact on water-related recreation and will have a negligible temporary effect on aesthetics.

2.6.3.4 Cultural Resources

Surface reconnaissance and limited deep site testing within the project area indicate that the tentatively selected plan would preliminarily have no impacts to historic properties. There would be no permanent indirect effects to proximal recorded historic properties.

2.7 Determination of Cumulative Effects on the Aquatic Ecosystem

The proposed project would cause no significant adverse cumulative impacts on the aquatic ecosystem. Completion of the project would allow improved management capabilities which

would increase the habitat diversity of the area and have an overall positive effect on the aquatic ecosystem.

2.8 Determination of Secondary Effects on the Aquatic Ecosystem

No significant secondary effects on the aquatic ecosystem would be expected from the proposed action.

3 Finding of Compliance with Restrictions on Discharge

1. No significant adaptations of the guidelines were made relative to this evaluation.
2. The proposed fill activity would comply with the Section 404(b)(1) guidelines of the Clean Water Act. The placement of fill is required to provide the desired benefits.
3. There are no practical and feasible alternatives to the placement of fill in the proposed sites that would meet the objectives and goals of this project.
4. The proposed fill activity would comply with State water quality standards. The disposal operation would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.
5. The proposed project would not result in take of federally listed species.
6. The proposed fill activities would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing. The proposed activities would have minor short-term adverse effects and substantial long-term beneficial effects on aquatic habitat diversity and productivity, wildlife, and water quality. There would also be minor beneficial effects on fish and aesthetic and economic values.
7. On the basis of this evaluation, I conclude that the proposed discharge complies with the Section 404(b)(1) Guidelines for the discharge of dredged or fill material.

_____
Date

Samuel L. Calkins
Colonel, Corps of Engineers
District Commander

4 Section 401 Water Quality Certification Waiver

MINNESOTA POLLUTION CONTROL AGENCY

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March 5, 2019

Elliot L. Stefanik
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Regulatory Branch Chief
180 Fifth Street East, Suite 700
St. Paul, MN 55101-1678

Lee Ann Glomski
U.S. Army Corps of Engineers
180 Fifth Street East, Suite 700
St. Paul, MN 55101-1678

RE: Minnesota River National Wildlife Refuge, aka: Bass Ponds, Marsh, and Wetland Rehabilitation and Enhancement Project
Scott County, Minnesota
Section 401 Water Quality Certification Waiver

Dear Elliot L. Stefanik and Lee Ann Glomski:

This 401 Water Quality Certification Waiver decision (401 Waiver or Waiver) is made by the Minnesota Pollution Control Agency (MPCA) under authority of Section 401 of the Clean Water Act, or CWA (33 USC 1251 et seq.), Minn. Stat. chs. 115 and 116 and Minn. R. chs. 7001.1400-1470, 7050, 7052, and 7053. The MPCA has reviewed the public notice and the feasibility study/environmental assessment furnished by the U.S. Army Corps of Engineers (USACE), for the rehabilitation and enhancement project. The project is located in Scott County, Minnesota.

Decision:
The MPCA waives its Section 401 authority to certify the referenced project. The MPCA bases its certification waiver decision upon an evaluation of the rehabilitation and enhancement project and information relevant to water quality considerations. However, this action does not eliminate, waive, or vary the applicant's responsibility of complying with all applicable MPCA statutes and rules, including those regarding water quality standards.

Disclaimer:
A Section 401 Certification Waiver does not release or limit the applicant from obtaining all necessary federal, state, and local permits, nor does it limit more restrictive requirements set through any such program. It does not eliminate, waive, or vary the applicant's obligation to comply with all other laws and state water statutes and rules through the construction, installation, and operation of the project. This letter does not release the applicant from any liability, penalty, or duty imposed by Minnesota or federal statutes, regulations, rules, or local ordinances, and it does not convey a property right or an exclusive privilege.

This MPCA decision is made, in part, on the applicant's representations that environmental review under the Minnesota Environmental Quality Board's Rules, Minn. R. ch. 4410, is not needed for the project or, alternatively, that all necessary environmental reviews and related decisions have been completed. If environmental review for this project is needed and has not been completed, the MPCA does not have legal authority to issue a Certification waiver. In that situation, the MPCA reserves the right to make a Section 401 Certification decision when the environmental review process is completed.

Elliot L. Stefanik and Lee Ann Glomski
Page 2
March 5, 2019

The MPCA reserves the right to revisit or revoke the Certification Waiver due to new or additional information, updated information, changes in technology, or any other changes that could render the Certification Waiver inadequate to provide reasonable assurance that the project will be in compliance with water quality standards. If you have any questions regarding this Certification Waiver, please contact Jim Brist at 651-757-2245.

Sincerely,

Melissa Kuskie
Supervisor
Certification, Environmental Review and Rules Section
Resource Management and Assistance Division

MK/JB:ds

cc: Peter Swenson, EPA
Janice Cheng, EPA
Wendy Melgin, EPA
Andrew Horton, USFWS
Peter Fasbender, USFWS
Julie Ekman, DNR
Steve Colvin, DNR
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Chad Konickson, USACE

US Army Corps of Engineers®
St. Paul District

Appendix E: Geotechnical and Water Quality

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

March, 2019

Appendix E: Geotechnical & Water Quality

TABLE OF CONTENTS

1 General 1

2 Geology 1

3 Geotechnical Design 1
- 3.1 Subsurface Exploration 1
- 3.2 Seepage and Stability 1
- 3.3 Settlement 1
- 3.4 Erosion Protection 1

4 Phase 1 HTRW 2

5 Water Quality 2

6 References 4

7 Attachments 4

LIST OF FIGURES

Figure 1: Lower Minnesota River Watershed Monitoring and Assessment Report • June 2017 Minnesota Pollution Control Agency 3

LIST OF TABLES

No table of figures entries found.

1 General

This appendix provides the geologic and geotechnical data, analysis, and computations for the Recommended Plan for the Bass Ponds, Marsh, and Wetland Habitat Restoration and Enhancement Project (Bass Ponds HREP). The report was based on developing sufficient geotechnical engineering and design to enable refinement of the project features, prepare the baseline cost estimate, and allow detailed design of the Recommended Plan. The geotechnical data includes existing borings for the project to define soil parameters. Discussion on analysis and computation to complete stability and settlement, borrow sites, and rock fill gradations. Some of the work is acknowledged to be completed during Preconstruction Engineering and Design (PED).

2 Geology

Bass Ponds HREP study area is located between Minnesota River miles 15 and 21, in the cities of Savage and Shakopee. The Minnesota River Valley trends northeast and is approximately 2.5 miles wide in the vicinity of the project. The study area includes three shallow lakes (less than 4 ft in depth) and adjacent wetland and marsh areas. See the Executive Summary in the Main Report for a map of the study area and background information.

The region surrounding the Bass Ponds HREP study area was glaciated extensively during the Pleistocene Epoch. Advancing and retreating glaciers laid down thick deposits of unsorted till and outwash sand that today form a hummocky, poorly-drained plain dotted with numerous marshes and small lakes. The glacial drift can reach thicknesses of between 200 and 250 feet, and it overlies dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations.

The wide valley of the present Minnesota River was carved by Glacial River Warren, which carried large volumes of water discharging from the now-extinct Glacial Lake Agassiz located in western Minnesota and eastern North Dakota. Glacial River Warren cut deeply into bedrock, scouring and reworking an earlier valley filled with outwash, stratified drift, and till. Episodic increases in flow caused Glacial River warren to cut lower into the older valley fill, leaving remnants of higher channel bottoms as terraces. When Lake Agassiz eventually ceased to drain to the south, the Minnesota River was formed by local drainage and established its present floodplain in the valley.

Three alluvial and bedrock terraces rise above this floodplain and form regionally prominent benches which parallel the river valley. The lower terrace is 30 to 50 feet above the floodplain, the middle terrace is 75 to 115 feet above the floodplain, and the upper terrace is 120 to 180 feet above the floodplain. The walls of the river valley form a bluff that grades into a hummocky, poorly-drained regional highland.

3 Geotechnical Design

The following section describes the subsurface exploration, and the geotechnical work expected to be completed for future Plans and Specifications.

3.1 Subsurface Exploration

The only borings completed in the project area were for the Rice Lake HREP, which is within the Bass Ponds HREP study area. A total of 4 borings were completed for the Rice Lake HREP, during the late 1990s. Three borings were taken along the Rice Lake ditch alignment and another boring was taken near the Minnesota River bank for determining slope stability. No undisturbed or environmental testing was done on the samples taken from the borings. The strength parameters were estimated from Standard Penetration Test results. The borings are included in Attachment E-1.

It is currently proposed that during PED, additional borings will be completed within dredge cuts to determine the dredge material and environmental condition of the soil. Additionally, borings would be proposed at each of the control structures to determine the foundation condition.

3.2 Seepage and Stability

Seepage and stability are not considered to be significant concerns for the Bass Ponds HREP. The project consists mostly of control structures, earthen plug, and ditch channels. As some exploration and testing are completed, some seepage and stability analysis may be completed to verify the earthen plug and ditch channel slopes. Past analysis from the Rice Lake HREP indicates that stability should not be an issue. Attachment E-2 contains stability results from the Rice Lake project for reference.

3.3 Settlement

The main concern with settlement will be at the control structures and the ditch plug. These structures are considered be relatively small structures. It is anticipated that settlement of these structures will be small and will not require remedial action. During PED and after soil exploration and testing, settlement of the structure will be analyzed to verify this assumption.

3.4 Erosion Protection

Erosion protection will be required for the control structures and earthen plug. The erosion protection will consist of riprap, a layer of bedding, and geotextile fabric. The final gradation and thicknesses will be further developed during PED. Additionally, material sources will also be developed at that time.

4 Phase 1 HTRW

See Appendix L for the HTRW evaluation.

5 Water Quality

The study area is located along the Minnesota River in the City of Mendota Heights-Minnesota River Aggregated 12-HUC subwatershed, which is in the eastern edge of the Lower Minnesota River Watershed.

Water quality in the Minnesota River mainstem has persistent problems with excess phosphorus, nitrate, sediment, bacteria, and other contaminants. The Minnesota River is the biggest contributor of sediment and nutrient pollution to the Mississippi River in Minnesota and is a significant contributor to the oxygen-depleted dead zone in the Gulf of Mexico (MPCA 2017).

The three lakes (Blue, Fisher, and Rice) and the Continental Grain Marsh are influenced by both the main stem Minnesota River as well as increased runoff from impervious surfaces and contamination from residential and industrial point source pollutants, such as, oil, grease, toxic chemicals, lawn fertilizers, chloride, and elevated bacteria concentrations from pet waste. In addition, storm sewer runoff along the adjacent steep slopes of the Minnesota River bluffs threatens slope stability and serves as another source of sediment to the project area (LMRWD, 2018 Draft).

According to the 2017 MPCA assessment report, the most common impairments in the project's subwatershed as shown in Figure 1 below are: nutrients, mercury, E-coli, turbidity and fish and invertebrate Index of Biotic Integrity (IBI).

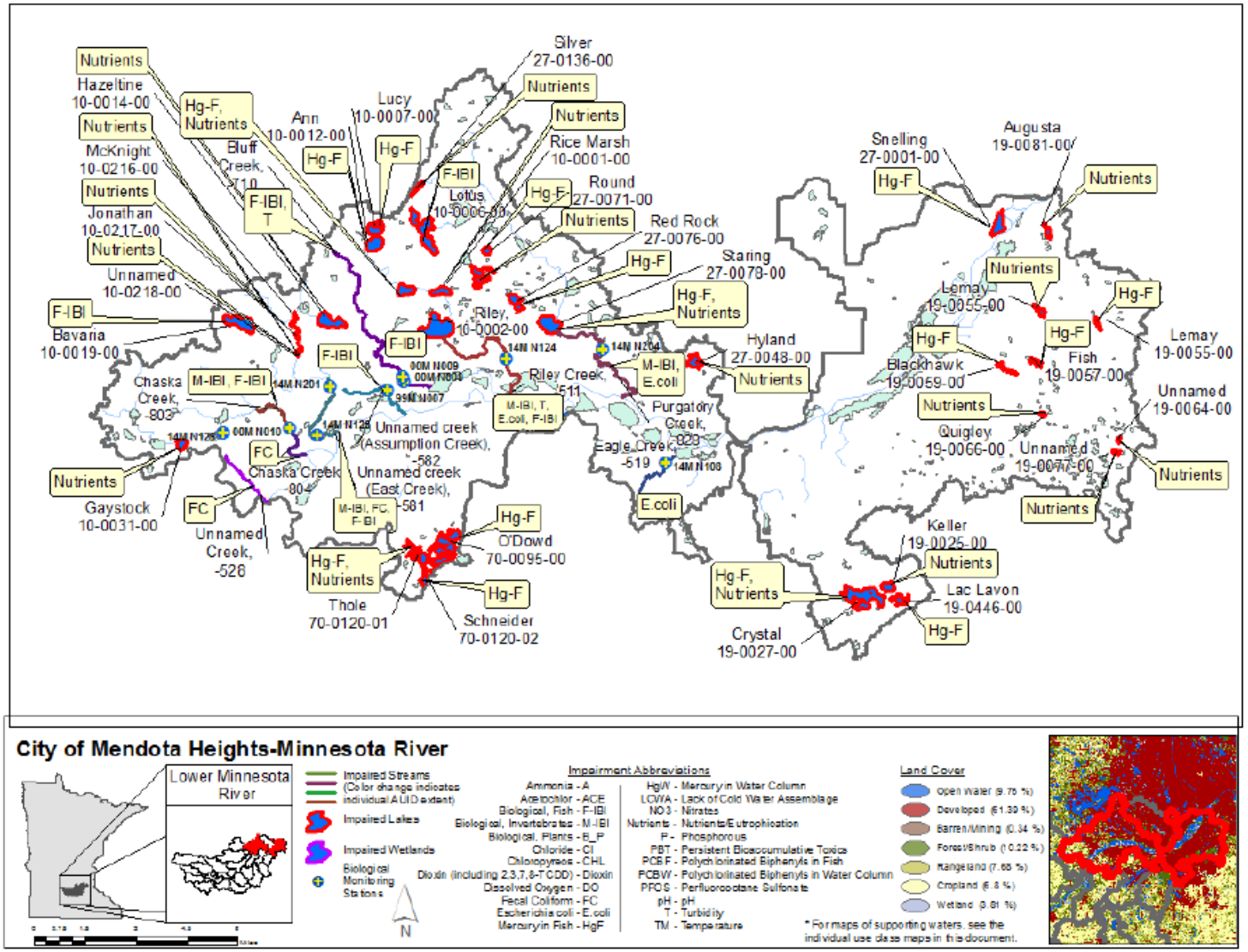


Figure 1: Lower Minnesota River Watershed Monitoring and Assessment Report • June 2017 Minnesota Pollution Control Agency

Although the lakes in the project area were not specifically addressed by the MPCA's 2017 Lower Minnesota watershed assessment report, 64 lakes in the City of Mendota Heights Subwatershed were reviewed for aquatic recreation use and only two basins were added to the impaired list of 18 basins that were previously listed impaired for aquatic recreation use based on nutrient data.

Adjacent to the project area, Eagle Creek was assessed favorably with good stream habitat scores but impacts from surrounding residential development and storm water runoff may be elevating Total Suspended Solids (TSS) levels during storm events and some high bacteria concentrations have triggered aquatic recreation use impairment on Eagle Creek. In 2018, a Lower Minnesota River Watershed District Capital Improvement Project was initiated for the East Branch of Eagle Creek to restore approximately 2,400 feet of stream and repair erosion under the 128 Street Bridge. Since 1999, the Watershed District, in cooperation with Metropolitan Council Environmental Services (MCES) and Scott Soil Water Conservation District (SWCD), has operated a stream monitoring station on Eagle Creek.

6 References

USACE. Definite Project Report/Environmental Assessment Rice Lake, 1994.

Lower Minnesota River Watershed Monitoring and Assessment Report - June 2017 Minnesota Pollution Control Agency https://www.pca.state.mn.us/sites/default/files/wq-ws3-07020012b.pdf

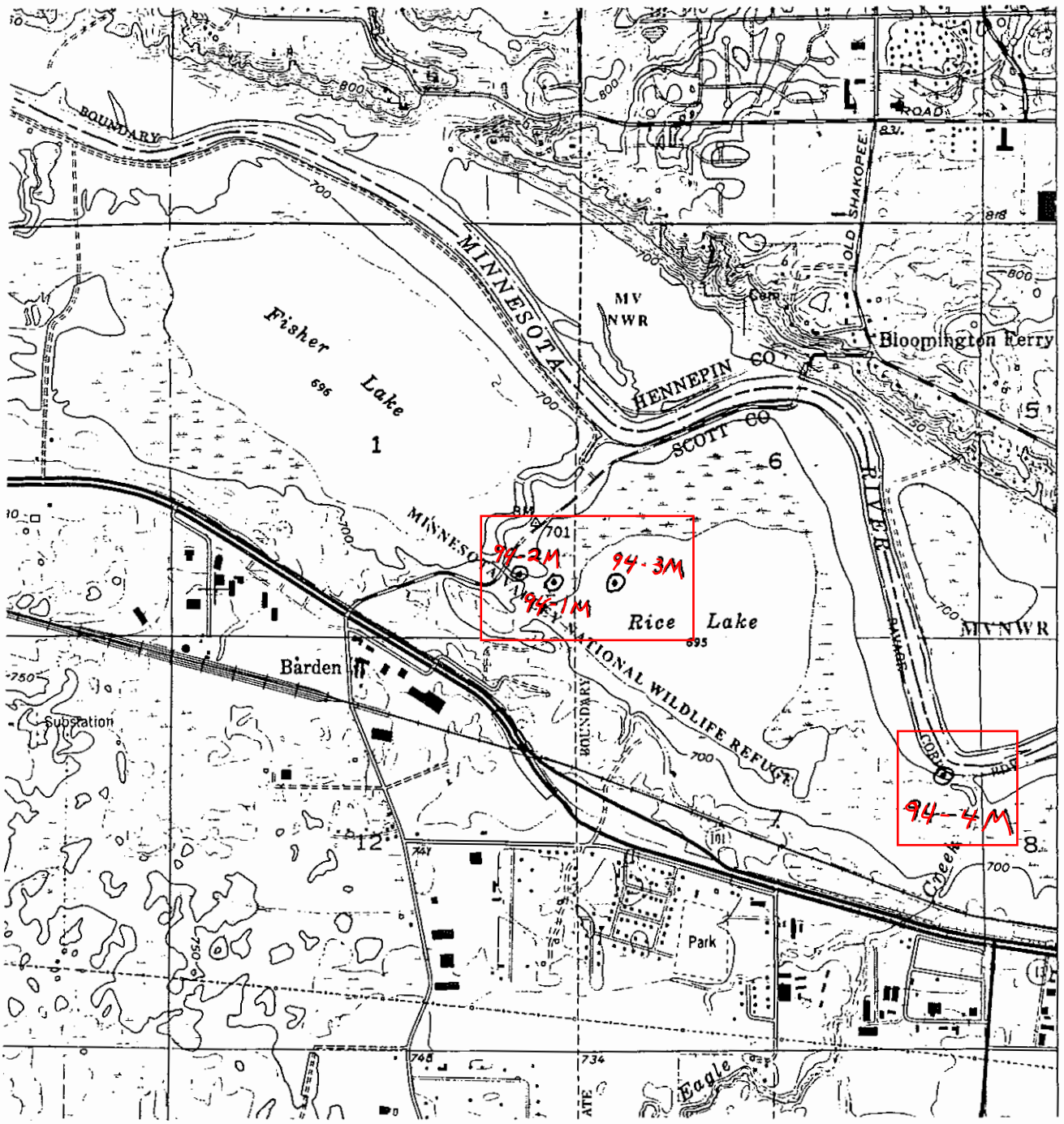
Lower Minnesota River Watershed DRAFT WATERSHED MANAGEMENT PLAN - June, 2018.

7 Attachments

Attachment E-1: Rice Lake Borings
Attachment E-2: Rice Lake Stability Analysis

Attachment E-1: Rice Lake Borings

Bass Ponds - Existing Soil Exploration for Rice Lake Project



0 2000 ft.
Scale

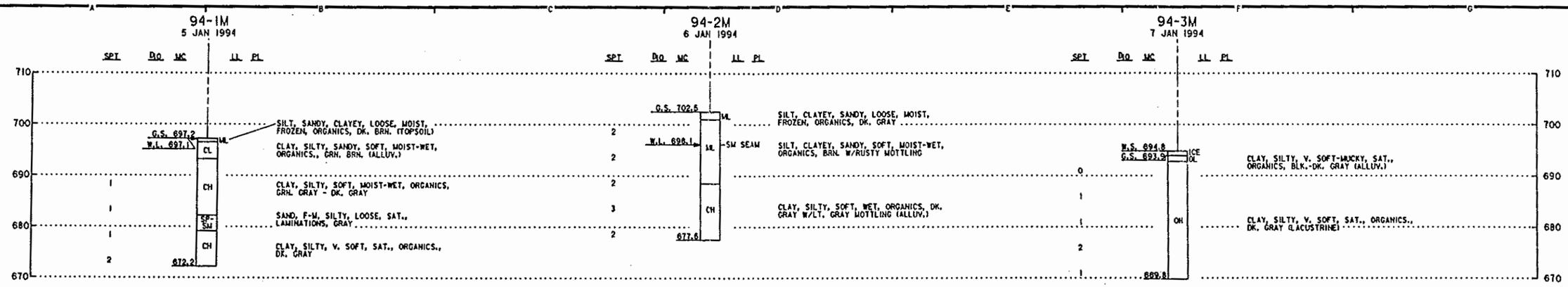
Rice Lake MVNWR

Boring Locations

HREP/EMP

Plate 6-1

Bass Ponds - Existing Soil Exploration for Rice Lake Project



NOTES

1. WATER LEVEL DETERMINED AFTER 40 MINUTES:
   BOTTOM OF AUGER AT EL. 683.2
   BOTTOM OF HOLE AT EL. 682.2.
2. HOLLOW STEM AUGER SET TO EL. 683.2. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 683.2.
3. SAMPLES FOR ENVIRONMENTAL ANALYSIS TAKEN IN OFFSET HOLE.
4. HOLE BACKFILLED WITH TREMMIED CEMENT-BENTONITE GROUT.

NOTES

1. WATER LEVEL DETERMINED AFTER 60 MINUTES:
   BOTTOM OF AUGER AT EL. 687.5
   BOTTOM OF HOLE AT EL. 687.5
2. HOLLOW STEM AUGER SET TO EL. 682.5
3. SAMPLES FOR ENVIRONMENTAL ANALYSIS TAKEN IN OFFSET HOLE.
4. HOLE BACKFILLED WITH BENTONITE CHIPS-PORTLAND CEMENT

NOTES

1. WATER LEVEL DETERMINED FROM LAKE LEVEL
2. 4" STEEL CASING SET TO 690.8. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 690.8.
3. SAMPLES FOR ENVIRONMENTAL ANALYSIS TAKEN IN OFFSET HOLE.
4. PULLED CASING AND ALLOWED HOLE TO HEAVE.

GENERAL BORING LEGEND

84-1M	YEAR OF BORING-BORING NUMBER, BORING TYPE (EG: M=MACHINE, A=AUGER, TP=TEST PIT, P=PIEZOMETER).
1 MAY 1984	DATE OF BORING
G.S. 1020.2	GROUND SURFACE ELEVATION AT BORING
GW	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURE, LITTLE OR NO FINES
GP	POORLY GRADED GRAVELS, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS, LIQUID LIMIT LESS THAN 50
MH	INORGANIC SILTS, LIQUID LIMIT GREATER THAN 50
CL	INORGANIC CLAYS, LOW TO MED. PLASTICITY, LIQUID LIMIT LESS THAN 50
CH	INORGANIC CLAYS, HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
OL	ORGANIC SILTS OR CLAYS, LOW PLASTICITY, LIQUID LIMIT LESS THAN 50
OH	ORGANIC SILTS OR CLAYS, MED. TO HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
PT	PEAT
SP-SM	BORDERLINE MATERIAL
SP&SM	STRATIFIED MATERIAL
1	LOCATION AND SAMPLE NUMBER FOR UNDISTURBED SAMPLE
	NO RECOVERY
W.L. 726.7	WATER LEVEL ON DATE OF BORING
700.0	ELEVATION AT BOTTOM OF BORING

GENERAL BORING NOTES

1. GENERAL: THE UNIFIED SOIL CLASSIFICATION SYSTEM IS USED TO IDENTIFY BASIC SOIL TYPE. THE LEGEND REPRESENTS ONLY THE BASIC SOILS. TO COMPLETE THE CLASSIFICATION, PERTINENT INFORMATION IS ADDED TO THE RIGHT OF THE BORING STAFF. NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.

2. MOISTURE CONTENT: THE NATURAL MOISTURE CONTENT IN PERCENT OF DRY WEIGHT (WC) IS SHOWN TO THE LEFT OF THE BORING STAFF.

3. BLOW COUNT (SPT): BLOW COUNTS ARE SHOWN TO THE LEFT OF THE BORING STAFF AND, EXCEPT AS NOTED, ARE THE NUMBER OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12". STANDARD BLOW COUNTS ARE FOR A STANDARD PENETRATION TEST (SPT) USING A 1½" X 2" SAMPLER, 140 LB. HAMMER AND A 30" DROP. FOR NON-STANDARD BLOW COUNTS, SAMPLER SIZE, HAMMER WEIGHT AND HEIGHT OF DROP ARE AS SHOWN.

4. ATTERBERG LIMITS: LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL) ARE SHOWN TO THE RIGHT OF THE BORING STAFF.

5. D_{10} SIZE: THE GRAIN SIZE IN MILLIMETERS OF WHICH 10% OF THE SAMPLE IS FINER IS SHOWN TO THE LEFT OF THE BORING STAFF.

6. RQD: ROCK QUALITY DESIGNATION (RQD) IS SHOWN TO THE LEFT OF THE PERCENT RECOVERY COLUMN. RQD IS THE PERCENT RECOVERY CONSISTING OF UNBROKEN PIECES LONGER THAN 4".

7. % RECOVERY: PERCENT CORE RECOVERY IS SHOWN TO THE LEFT OF THE BORING STAFF. PERCENT RECOVERY IS LENGTH OF CORE RECOVERED/LENGTH OF CORE CUT X 100. UNLESS SPECIFIED OTHERWISE, ALL CORE IS 4" DIAMETER.

8. ELEVATIONS REFERENCED TO N.G.V.D., 1929 ADJUSTED.

9. THE BORINGS SHOW SUMMARIES OF INFORMATION RECORDED ON THE ORIGINAL FIELD LOGS. THESE LOGS ARE AVAILABLE FOR INSPECTION AT THE ST. PAUL DISTRICT OFFICE. ARRANGEMENTS TO INSPECT LOGS CAN BE MADE BY CALLING (612) 290-5599.

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MEA

SYMBOL	DESCRIPTION	DATE	APPROVAL

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ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

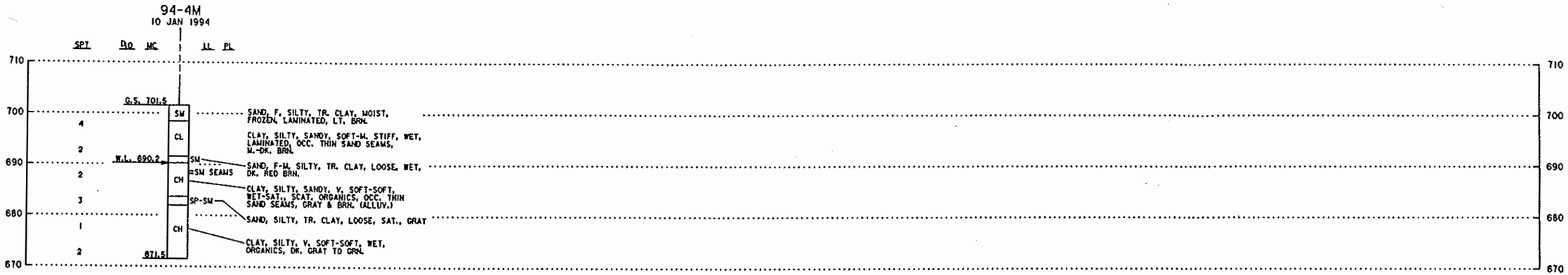
DEFINITE PROJECT REPORT/ENVIRONMENTAL ASSESSMENT
MINNESOTA VALLEY NATIONAL WILDLIFE REFUGE
ENVIRONMENTAL MGMT. PROGRAM - MINNESOTA RIVER
RICE LAKE HREP — SCOTT CO., MINNESOTA

GEOLOGICAL DATA
BORING LEGEND, GENERAL NOTES AND BORING LOGS
94-1M THRU 94-3M

PE-D: DESIGNED: JJF; CHECKED: GAR; DRAWN: PAW
PE-H: DESIGNED:; CHECKED:

CAD FILE NAME: RICESHO1.DGN
DRAWING NUMBER: PLATE 2
SHT 1 OF 2
DATE: DECEMBER 1994
SOL. NO.: DACW37-94-B-0000

Bass Ponds - Existing Soil Exploration for Rice Lake Project



NOTES

1. WATER LEVEL DETERMINED AFTER 2 HOURS:
   BOTTOM OF AUGER AT EL. 691.5
   BOTTOM OF HOLE AT EL. 689.3
2. HOLLOW STEM AUGER SET TO EL. 687.5. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 687.5.
3. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

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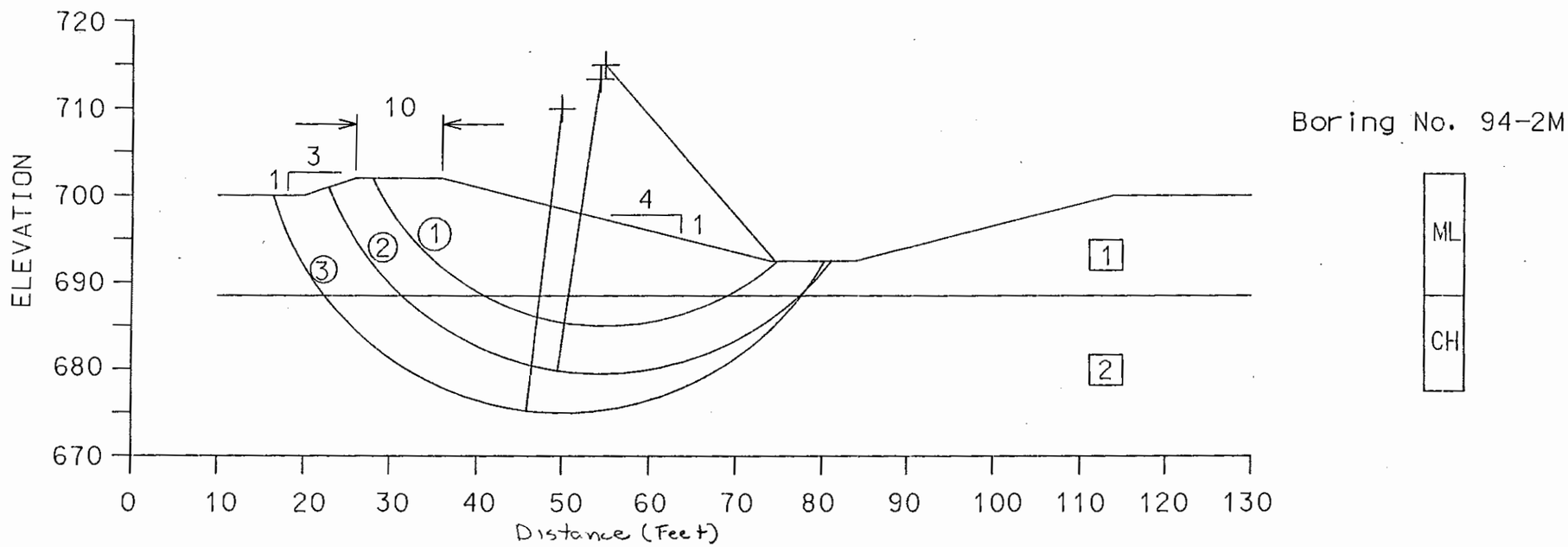
GEOLOGICAL DATA
BORING LEGEND, GENERAL NOTES AND BORING LOGS
94-4M

PE-D: DESIGNED: JJF; CHECKED: GAR; DRAWN: PAW
PE-H: DESIGNED:; CHECKED:
DATE: DECEMBER 1994
CAD FILE NAME: RICESH02.DGN
SOL. NO.: DACW37-93-B-0000
DRAWING NUMBER: PLATE 3
SHT 2 OF 2

Attachment E-2: Rice Lake Stability Analysis



END OF CONSTRUCTION
TABULATION OF ARC DATA

ARC NO.	CENTER COORDINATES X	Y	RADIUS	FACTOR OF SAFETY *
①	55.0	715.0	30.0	1.4
②	54.4	713.4	33.9	1.3
③	50.0	710.0	35.0	1.4

* - REQUIRED FACTOR OF SAFETY IS 1.3

SOIL PARAMETERS

SOIL NO.	DESCRIPTION	UNIT WEIGHT MOIST	UNIT WEIGHT SATURATED	ESTIMATED C(PSF)	Q-STRENGTH O(DEG)
1	SILT	110.0	115.0	180	0
2	CLAY	110.0	110.0	185	0

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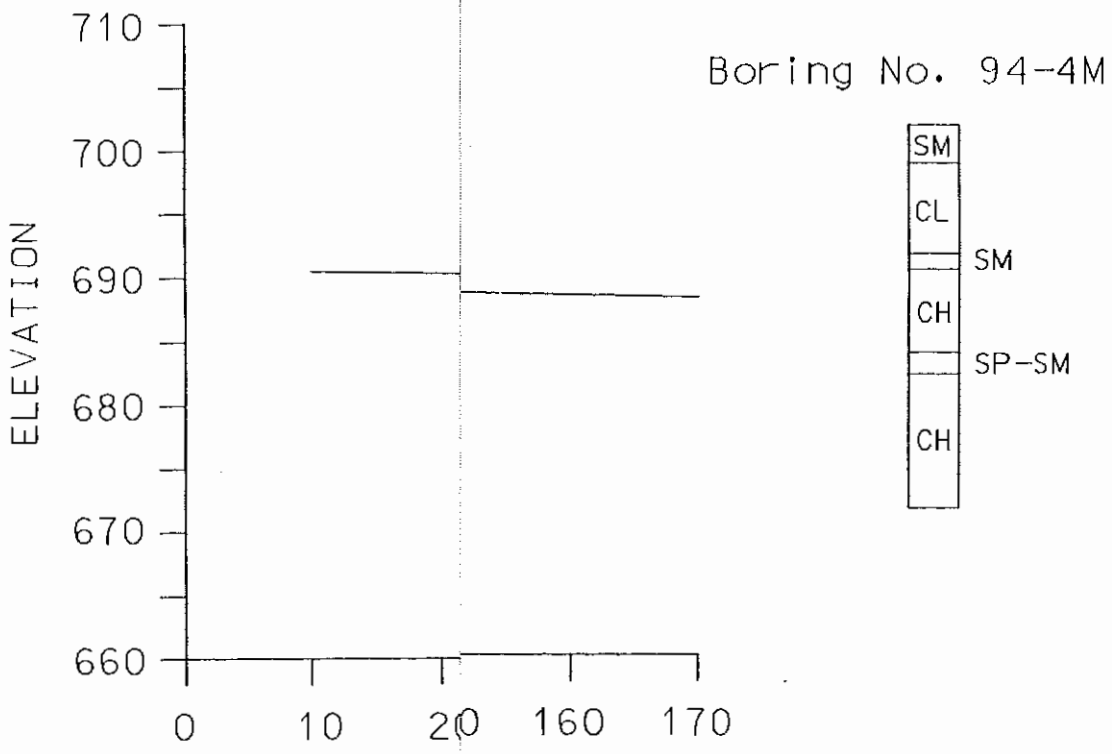
CHANNEL STABILITY

PE-D: DESIGNED: JJF; CHECKED:; DRAWN: JJF
PE-H: DESIGNED:; CHECKED:
DATE: 15 DEC. 1994
CAD FILE NAME:
SPEC NO:
PLATE NUMBER: 6-4
SHT KF



T PARAMETERS

ARC NO.	CENTER COORDINATES X	Y	ESTIMATED C(PSF)	Q-STRENGTH O(DEG)
①	109.0	713.5.0	0	28
②	108.0	708.0.0	320	0
③	107.0	704.		

* - REQUIRED FA

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PLUG OF NATURAL OUTLET STABILITY

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DESIGNED:
CHECKED:
DATE: 15 DEC. 1994
CAD FILE NAME:
SPEC NO:
PLATE NUMBER: 6-5
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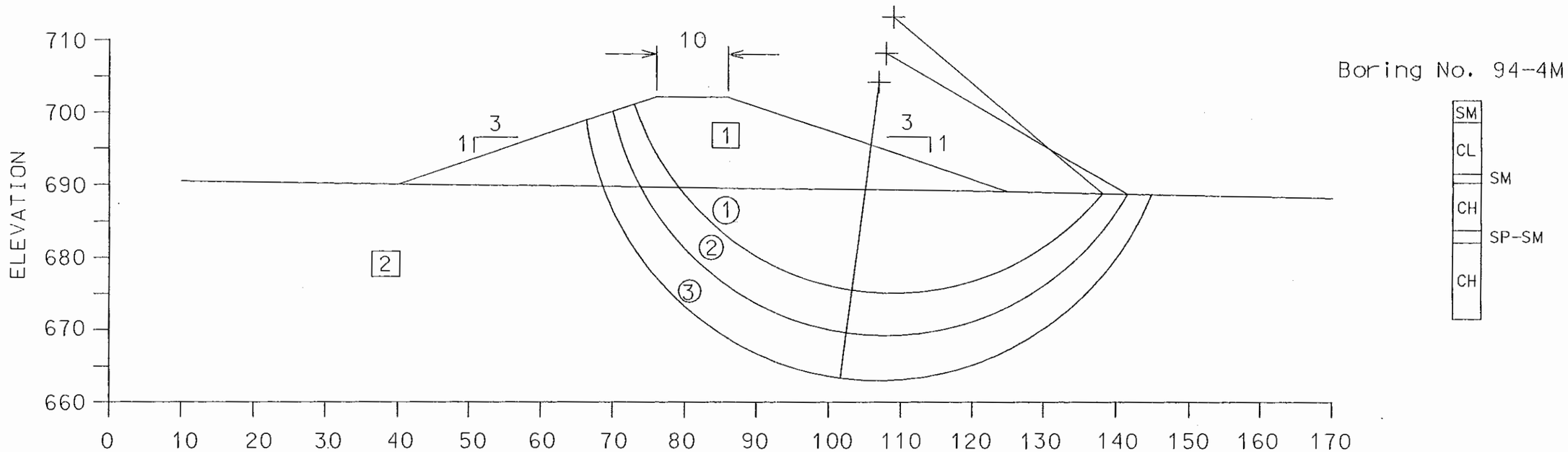
OF



END OF CONSTRUCTION
TABULATION OF ARC DATA

ARC NO.	CENTER COORDINATES X	Y	RADIUS	FACTOR OF* SAFETY
1	109.0	713.0	38.0	1.32
2	108.0	708.0	38.8	1.30
3	107.0	704.0	41.0	1.35

* - REQUIRED FACTOR OF SAFETY IS 1.3

SOIL PARAMETERS

SOIL NO.	DESCRIPTION	UNIT WEIGHT MOIST	UNIT WEIGHT SATURATED	ESTIMATED C(PSF)	Q-STRENGTH O(DEG)
1	SANDFILL	120.0	125.0	0	28
2	CLAY	100.0	100.0	320	0

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PLUG OF NATURAL OUTLET STABILITY

DESIGNED: JJF
CHECKED:
DRAWN: JJF
DESIGNED:
CHECKED:
DATE: 15 DEC. 1994
CAD FILE NAME:
SPEC NO:
PLATE NUMBER: 6-5
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St. Paul District

Appendix F: Hydrology & Hydraulics

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

February, 2019

Appendix F

TABLE OF CONTENTS

1 Introduction 5

2 Existing Conditions 5

3 Study Alternatives Considered 9

4 Tentatively Selected Plan 15
- 4.1 Tentatively Selected Plan - Lakes 15
- 4.2 Tentatively Selected Plan – Continental Grain Marsh 15
- 4.3 TSP Identified Risks 18

5 Hydrology 24
- 5.1 Discharge – Frequency, Discharge - Duration 24
- 5.2 Climate Change Assessment 27

6 Sedimentation 55

7 Hydraulics 57
- 7.1 Future without Project 57
- 7.2 Flood Stage Impacts 58
- 7.3 Ground Water 58

8 Hydraulic Modeling 59
- 8.1 HEC-RAS Inputs 60
- 8.2 HEC-RAS Results 64
- 8.3 Project Feature Potential – Drawdown, Drought and Major Flooding Analysis at Project Area 71

9 Refuge Summary 80
- 9.1 Major Flooding 80
- 9.2 TSP Structure Drawdown 81

10 References 83

LIST OF FIGURES

Figure 1: Blue/Fisher/Rice Lake Existing Conditions Flow Path Diagram- Flood & Drawdown Operation 7

Figure 2: Continental Grain Marsh Existing Conditions Flow Path Diagram 8

Figure 3: Blue/Fisher/Rice Lake Post-Project Major Flooding Flow Path Diagram.....10
Figure 4: Blue/Fisher/Rice Lake Post-Project Drawdown Flow Path Diagram 11
Figure 5: Continental Grain Marsh Post-Project Major Flooding Flow Path Diagram.....13
Figure 6: Continental Grain Marsh Post-Project Drawdown Flow Path Diagram.....14
Figure 7: Magellan Pipeline Location and Right of Way with Respect to Survey Data Points 19
Figure 8: Fiber Optic Cable Location.....20
Figure 9: Silted Stoplog Structure and Overflow Located on Cargill Private Property 21
Figure 10: Valleyfair Wetland Mitigation Grading Plan from Barr Engineering 23
Figure 11: Bass Ponds HREP – Tentatively Selected Plan ..... **Error! Bookmark not defined.**
Figure 12: Minnesota River near Jordan, MN Analytical Frequency Curve (Minnesota River Integrated Watershed Study – Discharge and Elevation Frequency Update, 2017) 25
Figure 13: Rating Curve for USGS Gage at Jordan, MN (05330000) Based on the Full Period of Record (1935-2018).....26
Figure 14: Projected Changes for the Middle of the Current Century (2041-2070) Relative to the End of the Last Century (1971-2000). (Figure source: NOAA NCDC / CICS-NC).....30
Figure 15: Summary of climate trends and literary consensus (USACE, 2015) 31
Figure 16: Location of Project Area within HUC2 and HUC4 32
Figure 17: Range of Projected Annual Maximum Monthly Streamflow among Ensemble of 93 Climate-Changed Hydrology Models, HUC 0702 Minnesota 32
Figure 18: Mean Projected Annual Maximum Monthly Streamflow, HUC 0702 Minnesota. Trendline Equation: Q = 9.69702*[Water Year] – 8918.99, p <0.0001.....33
Figure 19: Projected Vulnerability for the Minnesota (0702) with respect to Ecosystem Restoration 35
Figure 20: Projected Vulnerability for the Minnesota (0702) with respect to Flood Risk Reduction 36
Figure 21: Nonstationary Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014.....40
Figure 22: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014.....41
Figure 23: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1990 to 2014.....42
Figure 24: Peak Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017.....43
Figure 25: Nonstationary Analysis of Average Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2017 using the Time Series Toolbox 44
Figure 26: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1981 Breakpoint 45
Figure 27: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1990 Breakpoint 45
Figure 28: NOAA National Climatic Data Center MSP Station Location 46
Figure 29: Nonstationary Analysis of Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox 48
Figure 30: Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 & Subsets of Data Selected Based on the 1976 Nonstationarity.....49
Figure 31: Nonstationary Analysis of Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox.....50
Figure 32: Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 with Trend Lines for the 1997 Breakpoint 51
Figure 33: MNDNR Minnesota Spring Inventory for the Bass Ponds Project Area 59
Figure 34: Minnesota River Cross Sections with Channel Bathymetry Surveyed in 2013 and 2015.....61

Figure 35: HEC-RAS 2D Model Layout 63
Figure 36: Bathymetry Map with Respect to Operating Conditions.....65
Figure 37: Rice Fill Operating Scenario using 2012 USGS Gage Data 67
Figure 38: Fisher Fill Operating Scenario using 2012 USGS Gage Data.....69
Figure 39: Inundation Area at the Project Area at River Stage 704.5 feet (RM 20) – Major Flooding Condition 74
Figure 40: Period of Record Analysis (Mean Daily Data) with Major Flooding and Successful Full Drawdown Reference.....76
Figure 41: Number of days and events each year that the discharge at the Jordan, MN USGS gage (Gage Number 05330000) exceeded 26,600 cfs from 1935 to 2018 77
Figure 42: Operation Water Surface Elevation Inundation Areas 82

LIST OF TABLES

Table 1: Summary of Existing Water Level Management Structures in the Study Area – Flood & Drawdown Operation 6
Table 2: Minnesota River near Jordan, MN Analytical Flow Frequency Summary Table (Minnesota River Integrated Watershed Study - Discharge and Elevation Frequency Update, 2017) 24
Table 3: Annual Peak Discharge Frequency Analysis with Corresponding Stage.....27
Table 4: Projected Vulnerability with respect to Ecosystem Restoration.....35
Table 5: Comparison of Different Indicators for the Minnesota Watershed with respect to Ecosystem Restoration 35
Table 6: Projected Vulnerability with respect to Flood Risk Reduction 36
Table 7: Comparison of Different Indicators for the Minnesota Watershed with respect to Flood Risk Reduction.....37
Table 8: Select large dams within the Minnesota River Basin 38
Table 9: Nonstationarities Detected Using Maximum Annual Flow.....39
Table 10: Nonstationarities Detected Using Average Annual Flow.....44
Table 11: Nonstationarities Detected Using Total Annual Precipitation 47
Table 12: Nonstationarities Detected Using Average Annual Air Temperature.....50
Table 13: Bass Ponds Climate Risks 54
Table 14: Floodplain Sediment Deposition Estimates on the Lower Minnesota River Based on Four Different Methods or Studies.....56
Table 15: Flood Stage Impacts: Existing and Proposed Structure.....58
Table 16: Wastewater Treatment Plant Input Values into Blue Lake 60
Table 17: HEC-RAS Input - NLCD Land Type Manning's n Values.....61
Table 18: Lake Condition vs Lake Elevation.....64
Table 19: Volume of Water Discharged during Full Drawdown Scenario (Optimal Pool to Full Drawdown Elevation) 64
Table 20: River Receded - HEC-RAS and Nomograph Results Comparison 70
Table 21: Marsh Conditions vs Marsh Elevation.....70
Table 22: Continental Grain Marsh Drawdown results using Culvert Nomographs.....71
Table 23. Period of Record Analysis Conditions.....73
Table 24: Successful Drawdown Summary (30-day Duration, prior to Mid-July) based on the period of record at the Jordan Gage.....79
Table 25: Maximized Drawdown Time (Minnesota River Receded to 10,000 cfs or less at Jordan) 80
Table 26: NWS Flood Categories at USGS Gage at Jordan, MN 81
Table 27: Lake/Marsh Water Surface Elevations (Feet - NAVD 88) 81
Table 28: Maximized Drawdown Time (River Receded to 10,000 cfs).....81

1 Introduction

The study area includes three lakes and a marsh, situated southwest of St. Paul, Minnesota adjacent to the Minnesota River. Currently the lakes, wetlands, and marshes experience prolonged full pool conditions with depths of 3-to-4 feet throughout the year. The lack of seasonal variability in water levels has resulted in a degraded habitat in the study area by reducing wetland habitat quality, aquatic plant diversity, and the availability of quality habitat for migratory waterbirds and waterfowl. The objectives of the project are to increase the diversity and percent cover of desirable emergent and submergent aquatic plant species and to provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds.

2 Existing Conditions

The study area includes three interconnected backwater lakes (Blue, Fisher, and Rice) and the Continental Grain Marsh. There are currently eight existing structures in this system. Seven of the existing structures no longer function as intended and/or do not operate effectively for the current desired management of the system. Almost all of the existing structures are deteriorating, no longer functional, or are frequently clogged with debris. Table 1 presents the structure location and condition of the current structures.

During major flood events, the Minnesota River natural levees, which enclose the project are overtopped resulting in complete inundation of the study area. During low flows, the lakes are largely isolated from Minnesota River inputs and water recedes by passing through water level management structures. Under current conditions, most often the flow path throughout the system starts with water entering Blue Lake from the Minnesota River through the Blue Lake control structure. The water then can be inputted into Fisher Lake through the Interlake structure between Blue Lake and Fisher Lake. The Fisher Lake structure is completely collapsed which has resulted in the erosion of an adjacent Department of Transportation (DOT) holding pond natural levee separating the pond and the lake, as well as the displacement of a DOT culvert. Water currently flows out of Fisher Lake through eroded ditches and then out to the Minnesota River. At present, Rice Lake is frequently managed separately due to the existing conditions of the surrounding structures. Rice Lake flows into the secondary pond and then out the secondary structure to the Minnesota River. The Blue Lake Structure and the Interlake Structure operate as both an inlet and outlet depending on the river flow conditions. An existing conditions flow path diagram can be viewed in Figure 1.

Continental Grain Marsh currently drains into Eagle Creek (designated trout stream) briefly before flowing out into the Minnesota River. This is due to a blown out beaver dam that had been previously plugging this outlet and holding water in the marsh. An existing conditions flow path diagram can be viewed in Figure 2.

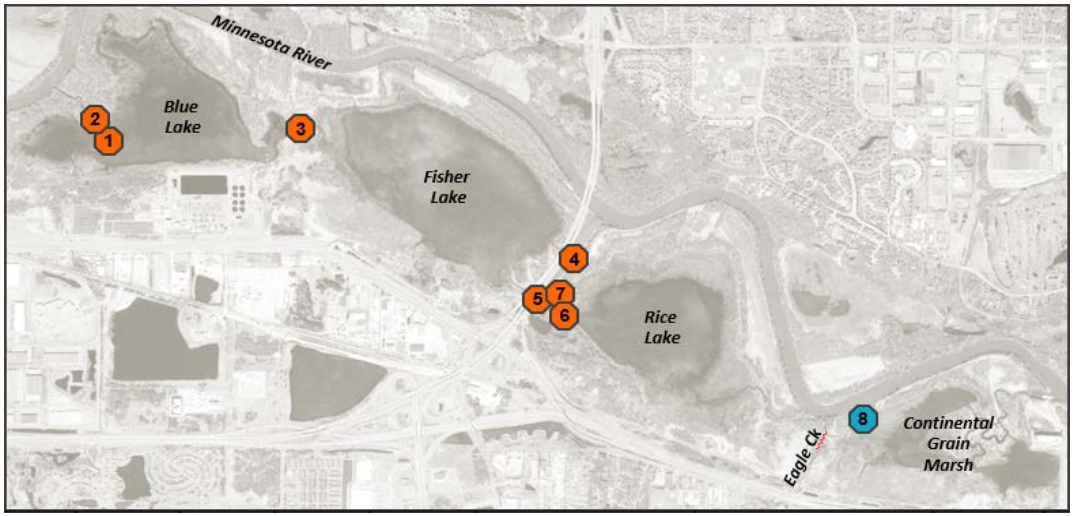


Table 1: Summary of Existing Water Level Management Structures in the Study Area – Flood & Drawdown Operation

Structure Location		Structure Name	Type	Size	Material	Year Built	Structure Objective	Condition	Currently meets Objective	Projected to meet objective over 50 year Project Life
1	Blue Lake	Blue Lake	Gated Stoplog	10x8'	Metal	1985[1]	Drawdown Blue Lake	High O&M, design difficulties	**Partial**	**No**
2	Blue Lake	Blue Lake	Culvert	84"	Metal	1985[1]	Road crossing for O&M	Rusting, high debris	**Yes**	**No**
3	Blue Lake-Fisher Lake	Interlake	Stoplog	30"	Metal	1985[1]	Move water from Blue to Fisher Lake	Unable to fill Fisher or Rice (invert 3ft higher), undersized	**No**	**No**
4	Fisher Lake	North Fisher Lake	Stoplog	36"	Metal	1985[1]	Move water from Fisher to Minnesota River	Silted in, does not pass flows	**No**	**No**
5	Fisher Lake	South Fisher Lake	Stoplog	36"	Metal	Unknown	Drawdown Fisher, Fill Rice Lake	Collapsed, undersized	**No**	**No**
6	Rice Lake	Rice Lake	Stoplog	42"	Metal	1998	Drawdown/Fill Rice Lake	Rusting, undersized	**Yes**	**No**
7	Secondary Pond	Secondary Outlet	Stoplog	48"	Metal	Unknown	Move water from Fisher to Rice Lake[3]	Rusting, clogged with debris, undersized	**Yes**	**No**
8	Continental Grain Marsh	Con Grain Marsh[2]	Overflow	30x100'	Rock	1998	Maximum level of marsh	Silted, does not impact functionality	**Yes**	**Yes**

[1]MNDNR Permit #85-6039; [2]Rice Lake HREP feature, [3] The Secondary Outlet Structure is designed to move water from Fisher to Rice Lake is not used during drawdown or flood operation.

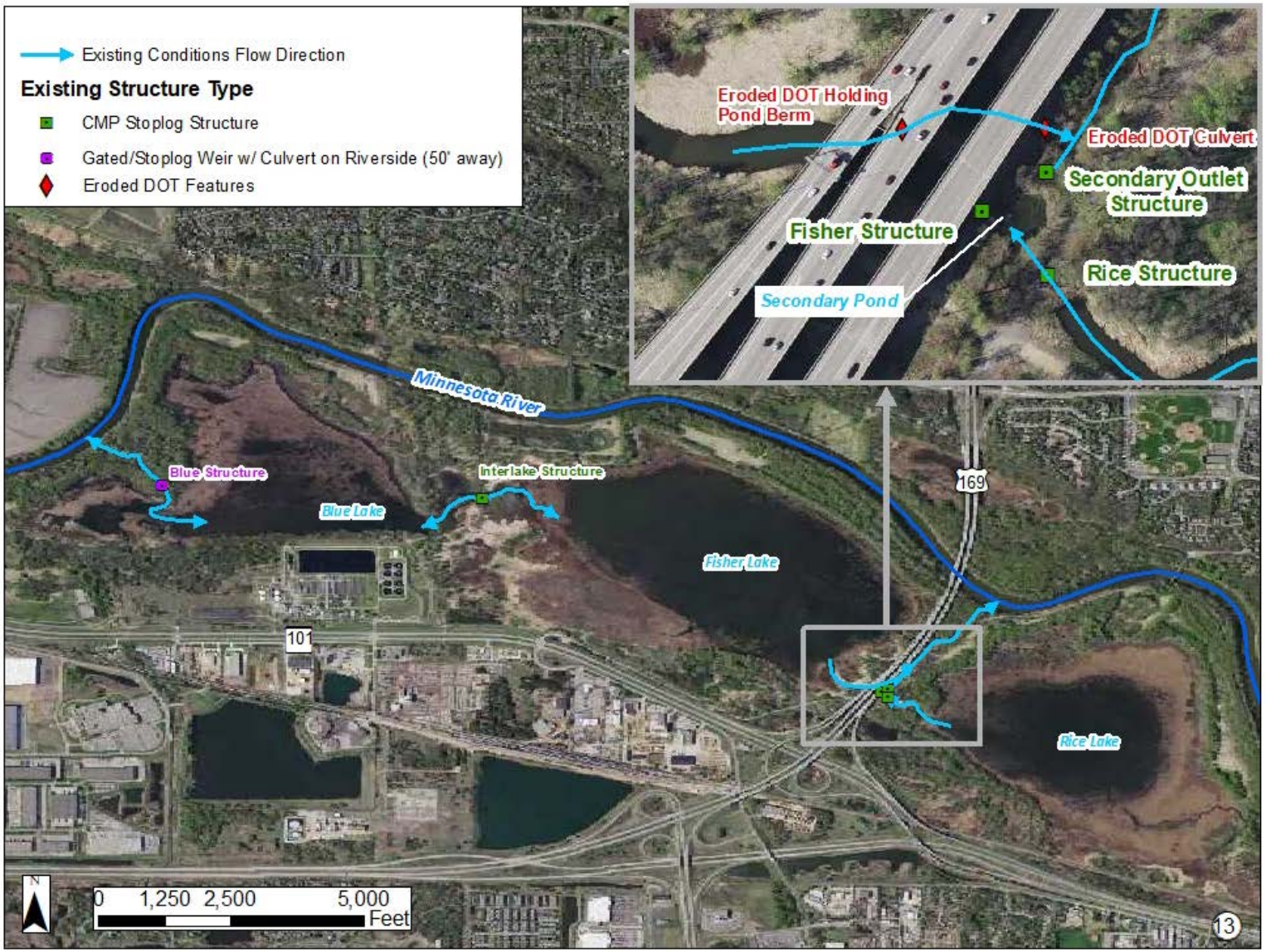


Figure 1: Blue/Fisher/Rice Lake Existing Conditions Flow Path Diagram- Flood & Drawdown Operation

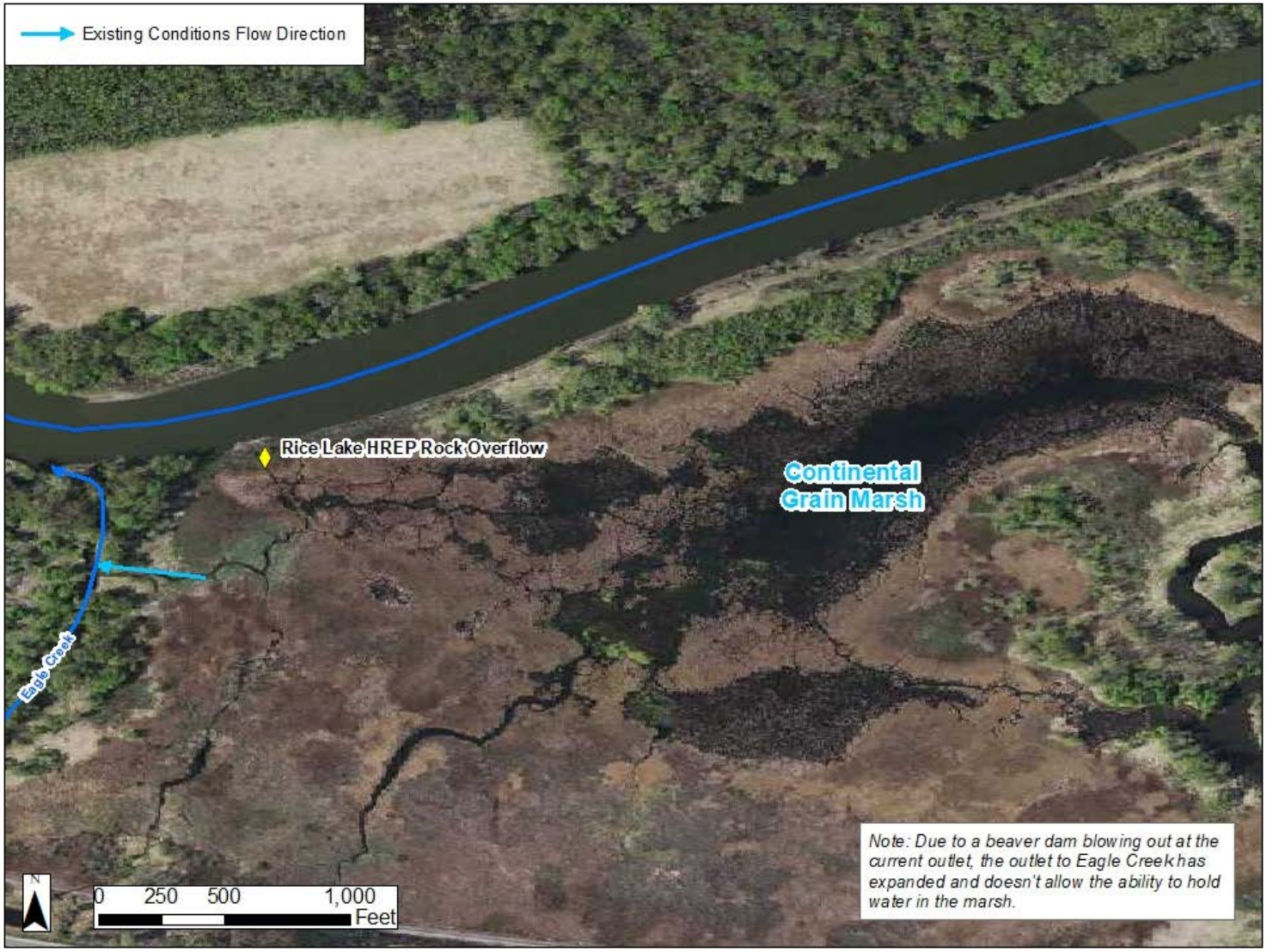


Figure 2: Continental Grain Marsh Existing Conditions Flow Path Diagram

3 Study Alternatives Considered

A variety of measures were identified to achieve project objectives, including water level management structures (single and double bay stoplog structures), earthen ditch plugs, access dredging, and rock-lined overflow channels. The measures were combined in various logical combinations to form alternative project plans. Initial alternatives included standard round culvert sizes of 42”, 60”, and 72”. The Tentatively Selected Plan consists of 5’x6’ rectangular culverts (as used in the Long Meadow Lake HREP). As compared to the adopted rectangular conveyance structures included as part of the Tentatively Selected Plan (TSP), circular culverts resulted in almost twice as many days to drawdown the system. Additionally, anecdotal information from the U.S Fish and Wildlife Service (USFWS) suggested that the round culverts experienced more debris build-up than the rectangular culverts. More detail on the TSP can be found in the main report.

With the construction of the proposed rectangular culvert system, the water will be able to be efficiently transferred during both drawdown and major flooding conditions. The flow paths during these scenarios differ. During major flooding, flow enters the Blue Lake Structure, travels through the Interlake Structure and then out the Fisher and Secondary Structures to the Minnesota River or into Rice Lake. During the lakes’ drawdowns, the Interlake Structure should be closed forcing Blue Lake to flow out through the Blue Lake Structure to the Minnesota River and forcing Fisher Lake to release flows through the Fisher Lake Structure and Secondary Structure to the Minnesota River. During drawdown, Rice Lake will release water through the Rice Lake Structure and the Secondary Structure to the Minnesota River Figure 3 and Figure 4 help to visualize the post-project flow directions for Blue, Fisher and Rice Lake for major flooding and drawdown scenarios.

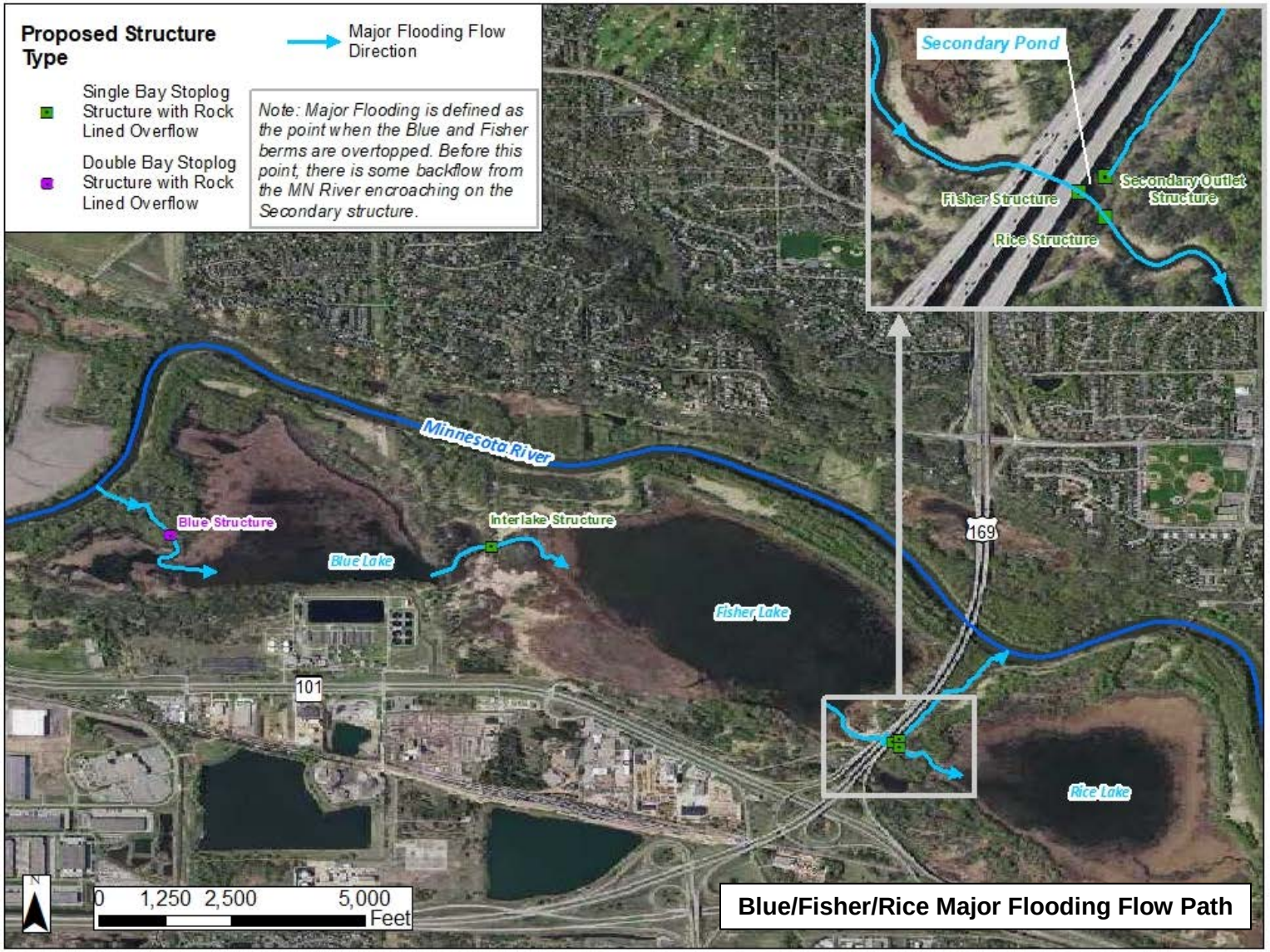


Figure 3: Blue/Fisher/Rice Lake Post-Project Major Flooding Flow Path Diagram

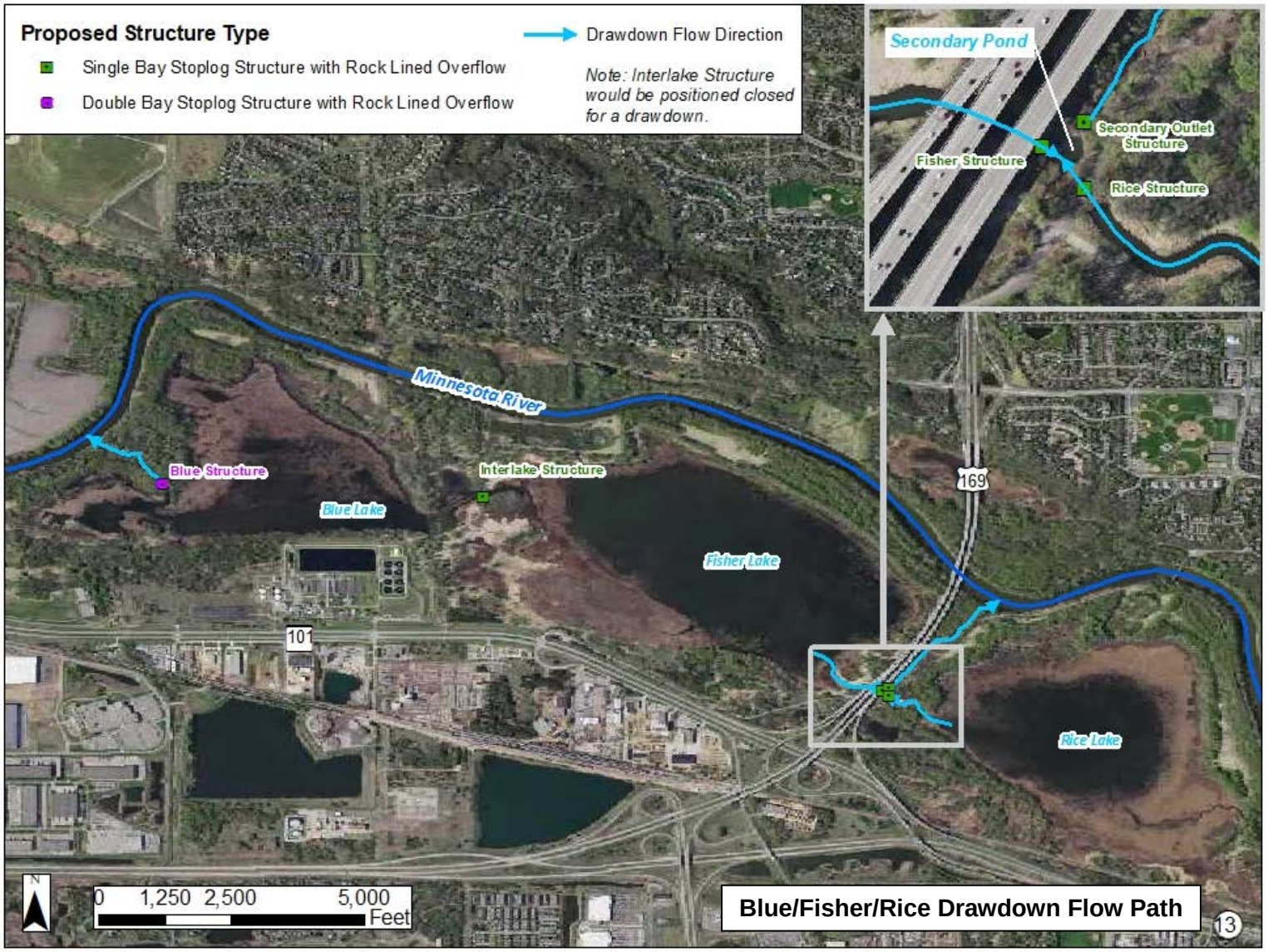


Figure 4: Blue/Fisher/Rice Lake Post-Project Drawdown Flow Path Diagram

As compared to existing conditions, the Continental Grain Marsh will have significantly different flow directions post-project. During major flooding, the stoplog structure will most likely be closed. During flood conditions flow will enter the Continental Grain Marsh if the natural levee surrounding the Continental Grain Marsh is overtopped. This first occurs when the natural levee is overtopped at the Rice Lake HREP rocklined overflow channel (constructed in 1998). The rocklined channel invert is 698.4 feet, so the structure will convey flow when the Minnesota River reaches elevations higher than this value. The next point of overtopping during major flooding will be the Continental Grain Marsh water control structure. During drawdown, the stoplog structure will be the primary outlet. Figure 5 and Figure 6 help to visualize the post-project flow directions for Rice Lake and the Continental Grain Marsh for major flooding and drawdown scenarios.

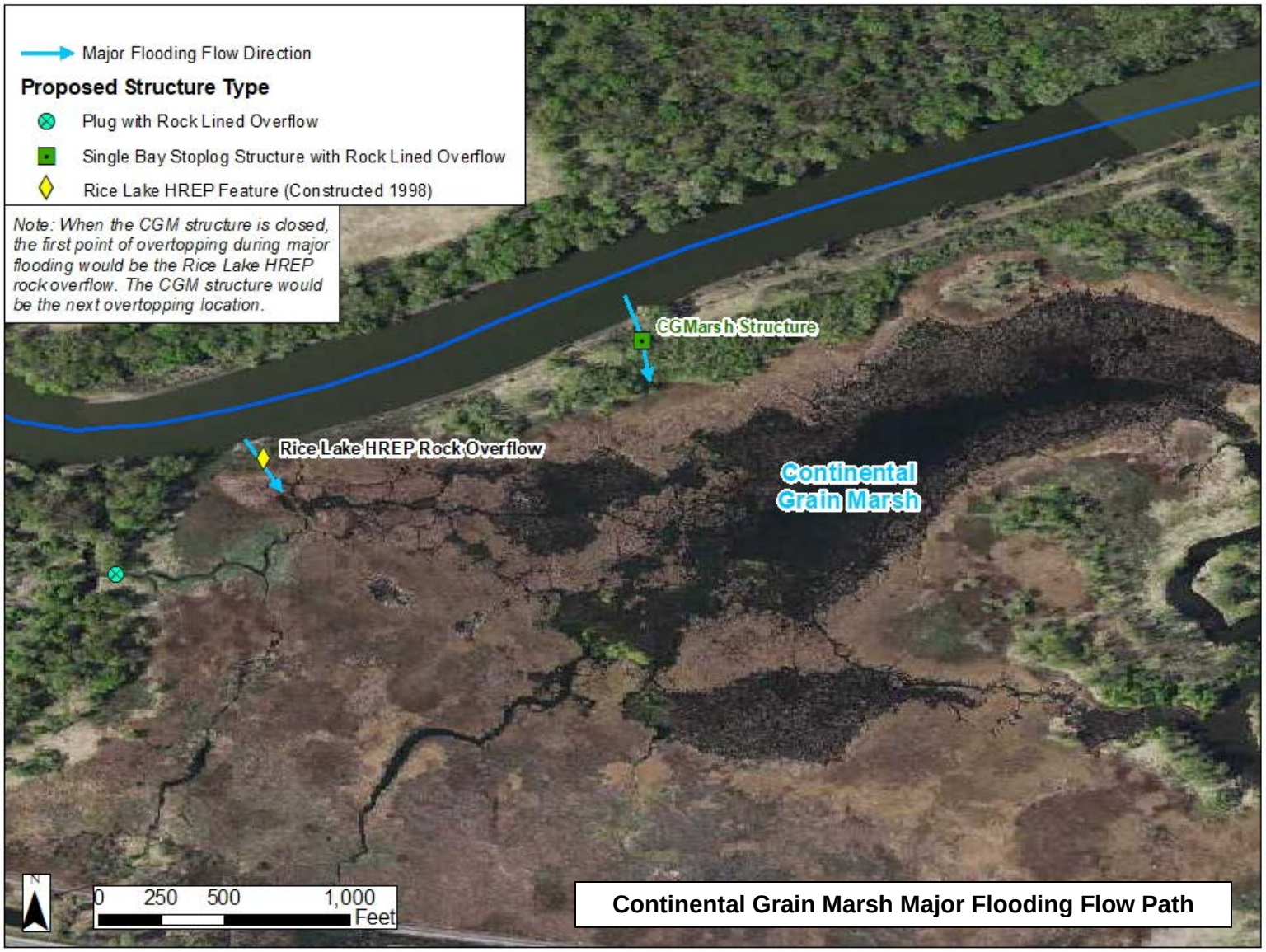


Figure 5: Continental Grain Marsh Post-Project Major Flooding Flow Path Diagram

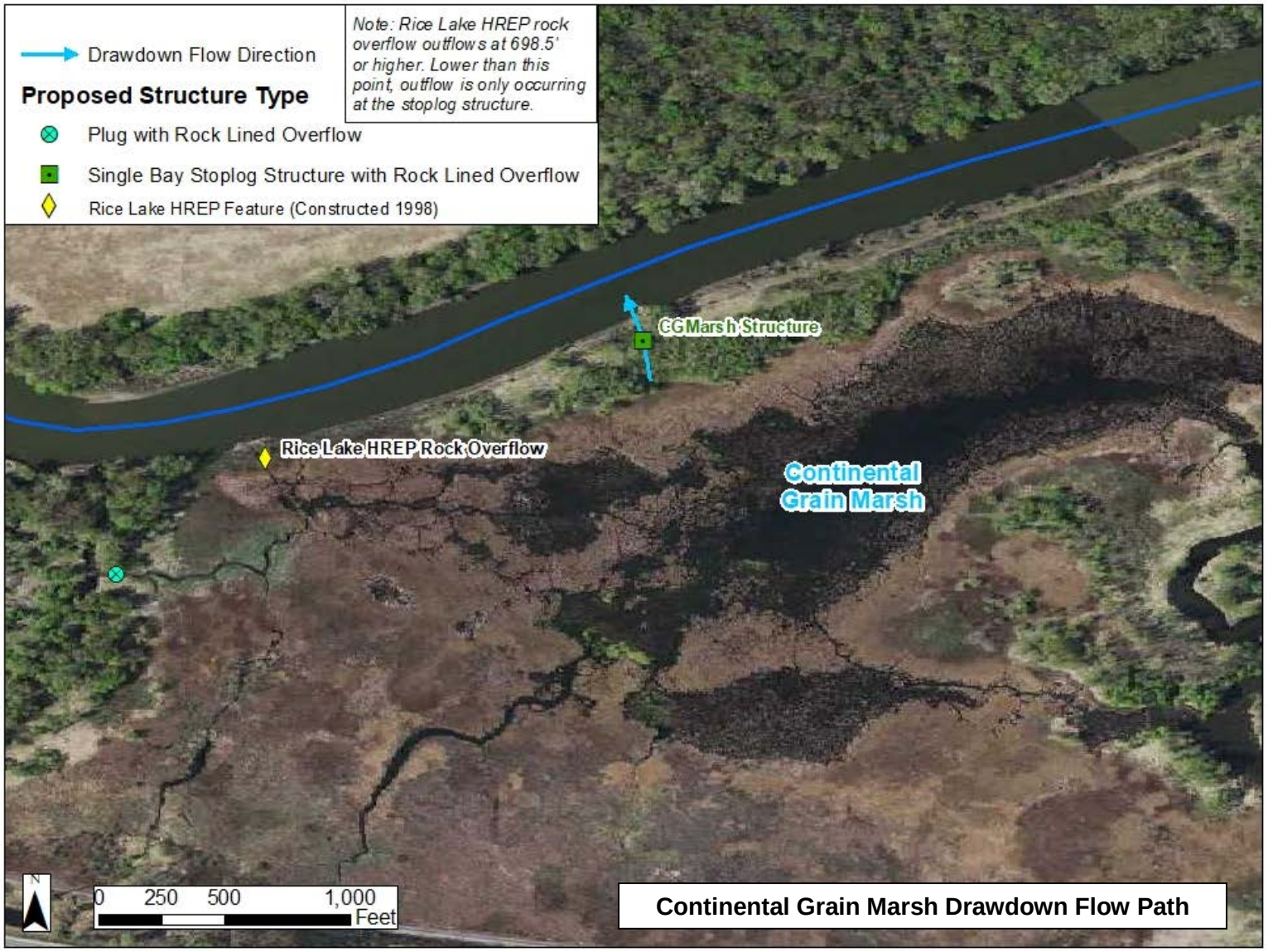


Figure 6: Continental Grain Marsh Post-Project Drawdown Flow Path Diagram

4 Tentatively Selected Plan

4.1 Tentatively Selected Plan - Lakes

The tentatively selected plan (TSP) consists of water level management structure removal and replacement at all three lakes. The structures to be replaced are listed below.

- Blue Lake Outlet Structure
- Interlake Structure (Blue-Fisher)
- Fisher Lake Outlet Structure
- Rice Lake Outlet Structure
- Secondary Outlet Structure (Fisher-Rice)

The structures are all concrete box culverts set at inverts of 693 feet (NAVD 88). The structures are designed to be 5' wide by 6' tall with aluminum stoplogs. Blue Lake will have two concrete box culverts (5'x6' each) while the other structures will only have one box culvert. The size and inverts of the TSP structures were evaluated using drawdown event modelling in HEC-RAS. These structure sizes provide flexibility in drawdown times and the ability to adapt to the more frequent major flood conditions of the lakes. Due to O&M costs, the local sponsor expressed the need for two boxes rather than one at Blue Lake.

The TSP also consists of inlet and outlet channel dredging at the structures at an elevation of 692.5 feet (NAVD 88) and the addition of permanent O&M access roads. All structures will include a rock lined overflow channel adjacent to the structure to reduce the head differential during flood events. All structures will also include inlet and outlet pre-formed scour holes due to the potential head differential of the different management methods. See Figure 7 for TSP feature locations.

4.2 Tentatively Selected Plan – Continental Grain Marsh

The Continental Grain Marsh TSP consists of plugging the current existing western outlet to Eagle Creek (designated trout stream) and redirecting the flow to the Minnesota River through a water control structure on the north end of the marsh. The earthen, rock armored ditch plug will be flush with adjacent topography at approximately 700.5 feet (NAVD 88). An adjacent rocklined overflow channel will be included in the plug design to lower the head differential at the plug during high water events. The rocklined overflow is designed a foot and a half lower than the adjacent land at approximately 699 feet (NAVD 88).

A water level management structure is included in the TSP at the northeastern side of the marsh. This structure will be the main outlet of the marsh into the Minnesota River. The structure is designed as a 5' wide by 6' tall concrete box culvert set at an invert of 693 feet (NAVD 88) with aluminum stoplogs. The TSP also consists of dredging an inlet channel to the structure at an elevation of 692.5 feet (NAVD 88) and the addition of permanent O&M access roads. The water level management structure will include a rock lined overflow channel adjacent to the structure to reduce the head differential during flood events. Preformed scour holes will be included to reduce the erosion at both the inlet and outlet channels. See Figure 7 for TSP feature locations.

There is an existing Rice Lake HREP (completed in 1998) rocklined overflow channel on the northwest side of the marsh that is currently set at an invert of 698.4 feet. This structure will remain in the Continental Grain Marsh design with no work completed to this feature.

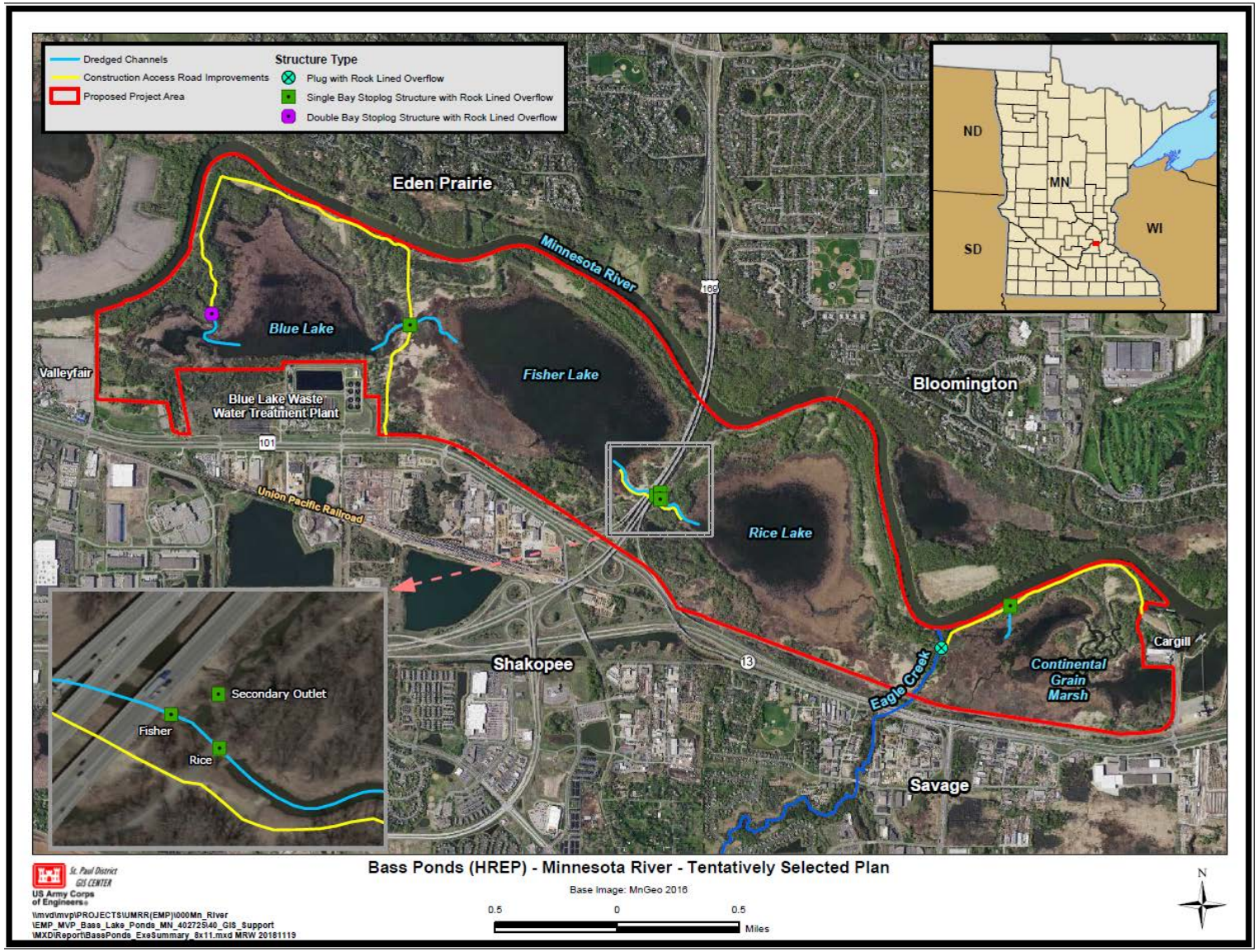


Figure 7: Bass Ponds HREP – Tentatively Selected Plan

4.3 TSP Identified Risks

Areas of risk and uncertainty have been analyzed and were defined so that decisions could be made with some knowledge of the degree of reliability of the estimated benefits and costs of alternative plans. Risk depends on the probability or likelihood for an outcome and the consequences of that outcome. Uncertainty refers to a lack of knowledge about critical elements or processes contributing to risk or natural variability in the same elements or processes.

The team worked to manage risk during plan formulation. One way this was done was by using experience from past projects to identify potential risks and reduce uncertainty during the development of potential measures. The team referenced successful similar water level management work in the UMR (especially Long Meadow Lake, MN and Long Lake, WI), the *UMRR Design Handbook* (USACE, 2012), and used best professional judgment. The team also had several meetings to conduct an Abbreviated Risk Analysis during which project risks were factored into project costs (Appendix G – Cost Engineering).

The primary risks identified for the Bass Ponds, Wetland, and Marsh study area included constructability risks and risks associated with climate change impacts to flow discharges.

Magellan Pipeline
This 12” natural gas pipeline runs just east of the Interlake Structure. The team revised the dredging plan to avoid the pipeline at the Interlake structure by only dredging on the eastern side and staying outside the 80 ft right of way. Figure 8 below shows the location of pipeline, right of way and survey data points.

The existing structure channel is at an elevation of less than 692.5 feet in elevation in most parts of this 80 foot right of way. On the eastern edge of the right of way, the elevation ranges from 692.2 feet and 694.5 feet. A full drawdown for Fisher Lake is described as 696.2 feet or lower, so a full drawdown can still be achieved without dredging this area. Section 8.2 explains the drawdown elevation and operation in more detail.

Transferring water from Blue to Fisher Lake would still be possible. The elevation in Blue Lake would need to be higher than this potential ridge of material that is not able to be dredged. The Blue to Fisher Lake scenario was modelled assuming optimal pool in Blue Lake (698.3) and near empty pool in Fisher. If this is how this scenario is operated in reality, the scenario will still be efficient. Section 8.2 explains this scenario in more detail.

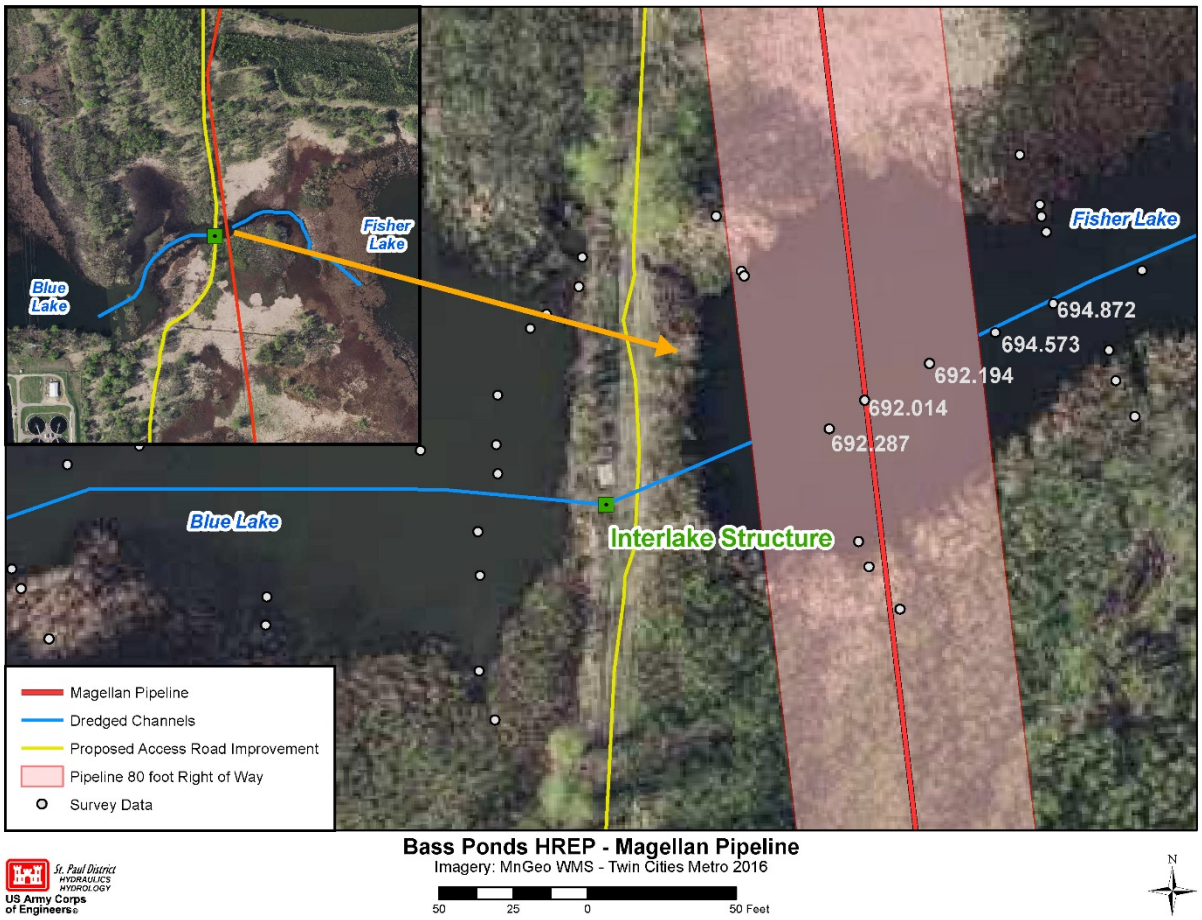


Figure 8: Magellan Pipeline Location and Right of Way with Respect to Survey Data Points

Fiber Optic Cable

The fiber optic cable is located on the most eastern side of Fisher Lake. Figure 9 below shows the location of the fiber optic cable relative the TSP features. The fiber optic cable is currently located within the footprint of the Fisher Lake proposed water level management structure and proposed access road. To manage risk with the fiber optic cable, the team had several meetings with USFWS and MnDOT to discuss a path forward. In order to manage construction of the Fisher Lake outlet structure, the team included costs associated with relocating the conduit within the Lands, Easements, Right-of-Way, Relocation, and Disposal (LERRDs) component of the cost estimate. The fiver optic cable will be relocated during construction.

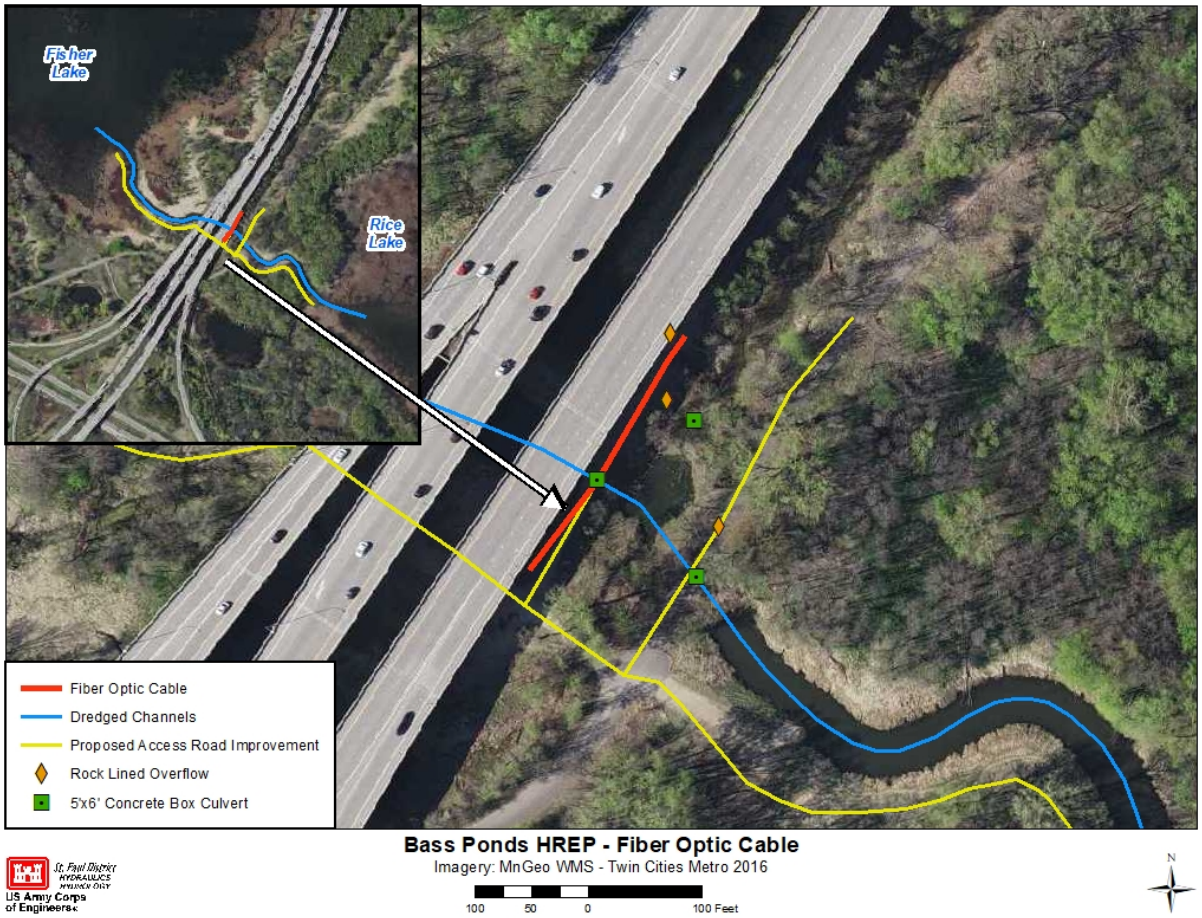


Figure 9: Fiber Optic Cable Location

Cargill Structure

During the flow analysis, the team identified a WLM structure on the east end of Continental Grain Marsh, located on Cargill property. Figure 10 below shows the location of the structure in relation to refuge land. Inspection of the structure indicated that it was silted in and functioning as a plug. There was also significant erosion observed around the failed structure. However, if this structure were to pass flow or fail completely, a new outlet would exist. This new outlet would decrease the effectiveness of the proposed project plug and water level management structure significantly. The Cargill structure was constructed in 1985 by the USFWS which was before the loss of the beaver dam on the western end of the marsh and throughout the lifespan of the Continental Grain Marsh overflow structure that was installed as a part of the Rice Lake HREP. Throughout this time, this structure did not affect the marsh water levels and has been acting as a plug. USACE is currently coordinating a plan with USFWS and Cargill to formulate a solution.

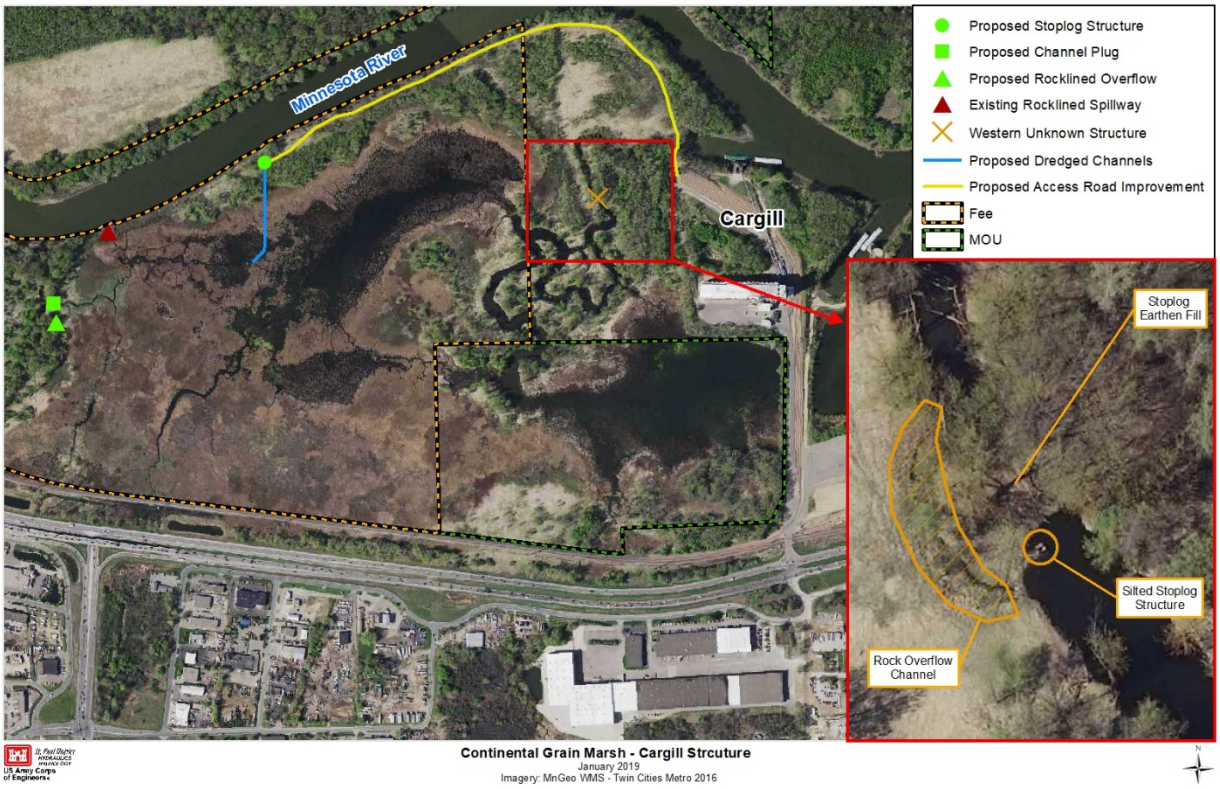


Figure 10: Silted Stoplog Structure and Overflow Located on Cargill Private Property

Valleyfair Mitigation

Valleyfair is an amusement park located to the west of the Bass Ponds HREP project. Recently, the park proposed to expand its facilities, which would result in the loss of 4.52 acres of wetland. To offset wetland impacts associated with its expansion project, Valleyfair has proposed a mitigation plan that includes the creation of 6.38 acres of floodplain forest wetland adjacent to the Minnesota River. An additional 4.64 acres of upland will be preserved and act as buffer to the wetland. The goal of the mitigation plan is to create a backwater wetland system connected to the Minnesota River during flood events that integrates into the Blue, Fisher, and Rice Lake complex. In order to create the mitigation area, Valleyfair would remove topsoil and subsoil, lowering the top of natural levee in the mitigation area. The risk associated with this mitigation plan is if/how this would affect the Bass Ponds HREP. Construction is expected to commence in 2019 for the Valleyfair expansion and mitigation.

The St. Paul District Regulatory office issued a permit and approved the mitigation plan in 2018. The permit includes hydraulics and hydrology input from the Corps concluding whether or not sedimentation and flood waters would affect Blue Lake (just east of Valleyfair). This proposed mitigation site near Blue Lake can be viewed in Figure 11 below. According to the permit, the proposed change in contours will change water circulation patterns in the immediate area. The permit also explains that the mitigation site is intended to offset the loss of flood water storage and potential changes in water fluctuations due to the parking lot construction. A short hydraulic discussion concluded that a lower bank at the mitigation site is not a concern in regards to frequency of flooding and deposition into Blue Lake because the existing high ground control

“saddle” is not breached by the project. The “saddle” location can be viewed in Figure 11. Because this high ground will remain intact, the potential for an increase in flood frequency and sediment into Blue Lake is small.

The Valleyfair mitigation plan was not factored into the modelling efforts for this project. However, the hydraulics comments from the issued regulatory permit explained above suggest this should not affect the Bass Ponds HREP features.

Figure 11: Valleyfair Wetland Mitigation Grading Plan from Barr Engineering

5 Hydrology

5.1 Discharge – Frequency, Discharge - Duration

The frequency curve for the Minnesota River at Jordan Gage (USGS 05330000) was obtained from the Minnesota River Integrated Watershed Study - Discharge and Elevation Frequency Update conducted in 2017. The frequency curve from this study can be viewed in Figure 12 below. The period of record for this analysis is listed as 1903-2015. The numerical values corresponding to this curve are listed in Table 2 below.

Table 2: Minnesota River near Jordan, MN Analytical Flow Frequency Summary Table (Minnesota River Integrated Watershed Study - Discharge and Elevation Frequency Update, 2017)

Annual Peak Discharge Frequency Analysis			
USGS Gage 05330000 Minnesota River near Jordan, MN			
Methodology: Bulletin 17C - Expected Moments Algorithm			
Exceedance Probability		**90% Confidence Limits (cfs)**	
(%)	**Peak Estimate (cfs)**	**5%**	**95%**
0.20%	150,800	321,300	85,900
0.50%	124,800	227,700	78,200
1%	106,200	173,600	71,700
2%	88,600	130,700	64,400
5%	66,800	87,500	53,500
10%	51,400	62,700	43,800
20%	36,900	42,900	32,200
50%	18,800	21,800	16,000
80%	9,000	10,800	7,200
90%	6,000	7,300	4,400
95%	4,300	5,400	2,800
99%	2,100	3,200	1,100
Statistics			
Mean	4.257	**Systematic Record (MOVE.3)**	113 Years
Standard Deviation	0.364	**Historic Record Length**	135 Years
Adopted Skew	-0.290	**Years in Record (MOVE.3)**	1881 (Historic), 1903-2015

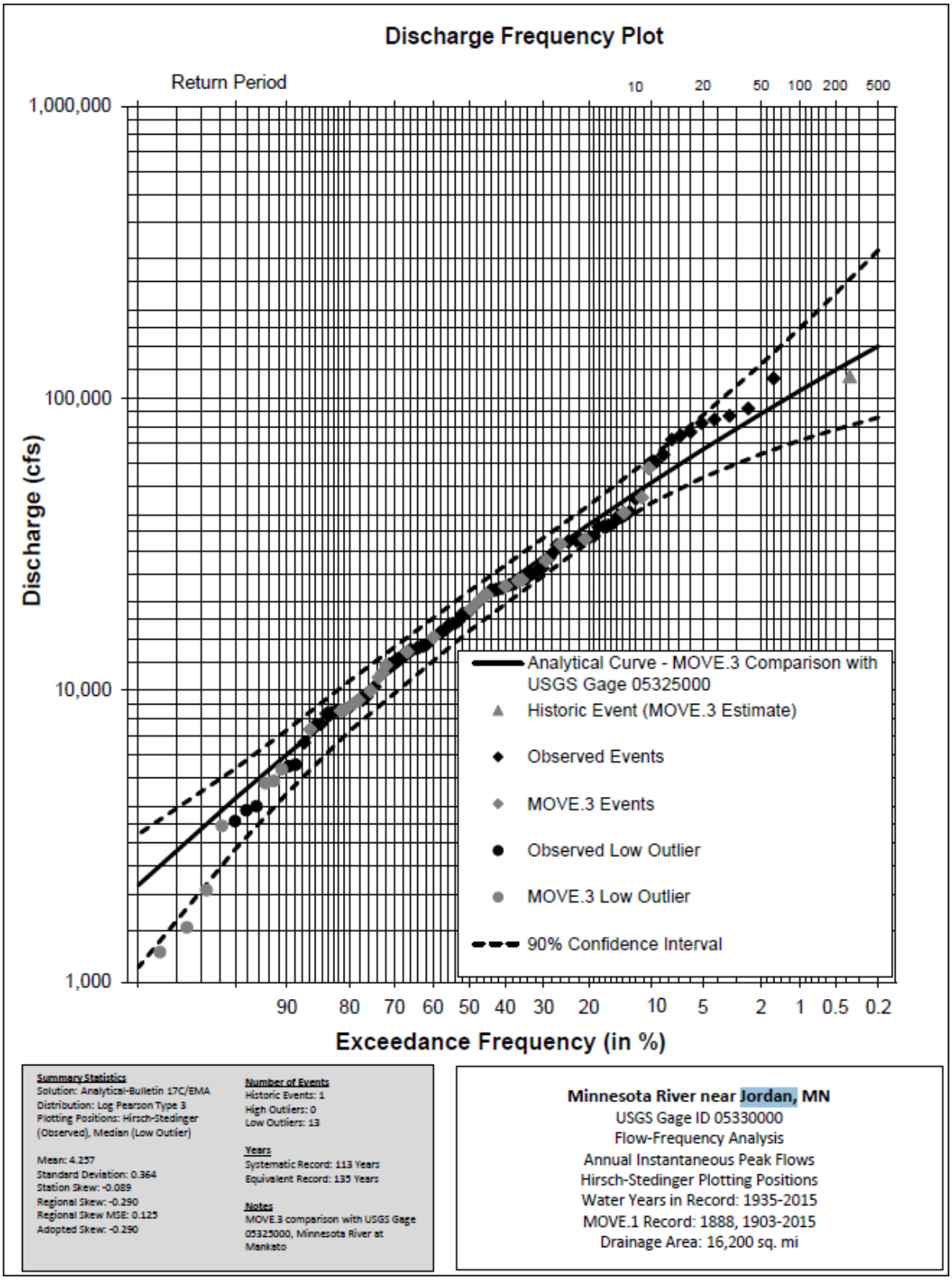


Figure 12: Minnesota River near Jordan, MN Analytical Frequency Curve (Minnesota River Integrated Watershed Study – Discharge and Elevation Frequency Update, 2017)

The USGS rating curve was obtained from the National Ratings Depot for shift-adjusted rating curves for stream gages. Figure 13 below shows the USGS rating curve. This rating curve was last updated in June of 2018. Stage-discharge relations (ratings) are developed from a graphical analysis of numerous discharge measurements. Measurements are made on various schedules and sometimes for different purposes. All discharge measurements are compiled and maintained in a database. Each measurement is carefully made, and undergoes quality assurance review. Some measurements indicate a temporary change in the rating, often due to a change in the streambed (for example, erosion or deposition) or growth of riparian vegetation. Such changes are called shifts; they may indicate a short- or long-term change in the rating for the gage. In normal usage, the measured shifts (or corrections) are applied mathematically to a defined rating. The tables being provided are shift corrected, incorporating the mathematical adjustments for ease of use by the user. The shift adjustments are applied to the individual ratings as measured data becomes available, resulting in an adjusted rating.

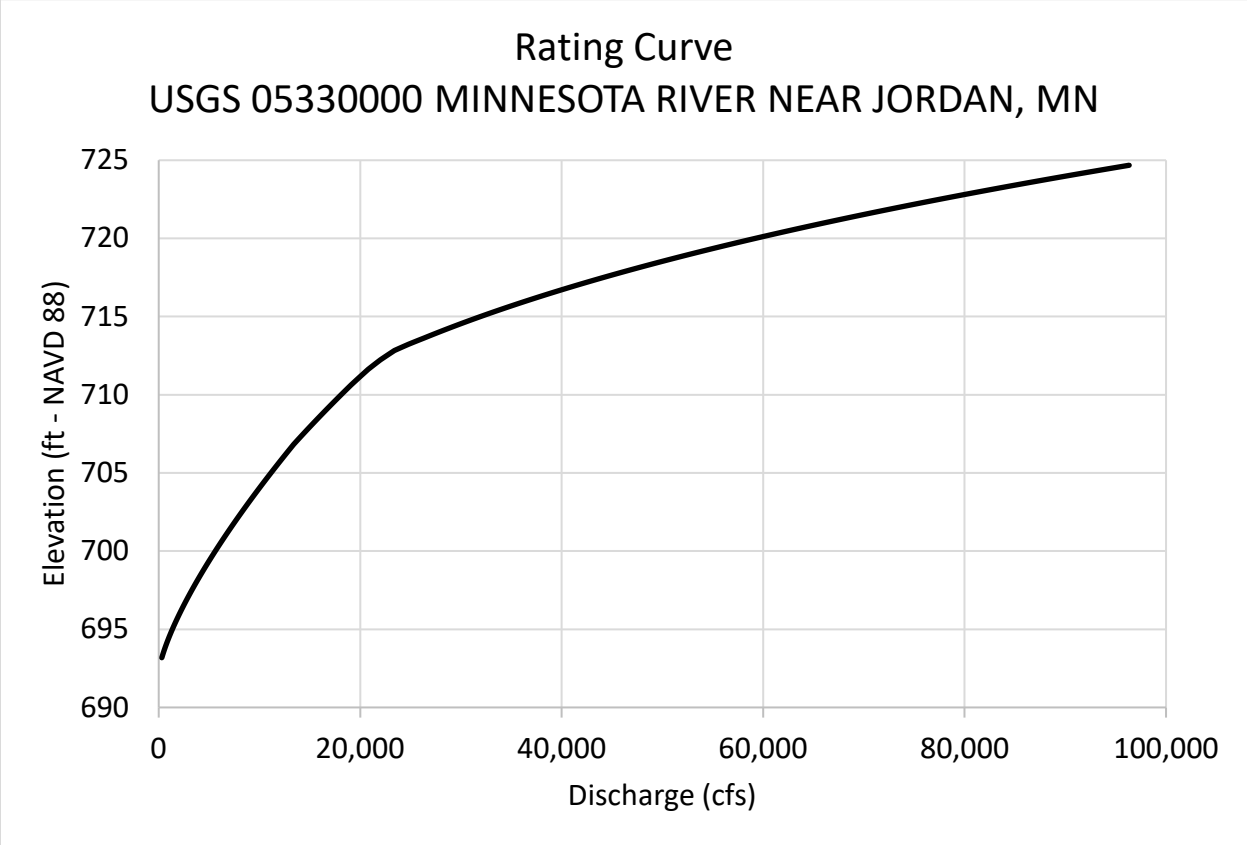


Figure 13: Rating Curve for USGS Gage at Jordan, MN (05330000) Based on the Full Period of Record (1935-2018)

The exact frequency corresponding to various river discharges is not critical to project design. However, it is important to note the frequency the project area experiences major flooding. It's estimated that the discharge at the Jordan Gage that produces major flooding at the project area is about 26,600 cfs. Major flooding for this project is considered the point when the natural levee at Blue Lake is overtopped which produces sheet flow over the three lakes. The annual exceedance probability corresponding to the major flooding discharge is approximately 39%. Section 8.3 discusses the major flooding and potential project drawdown periods in depth. Other flood frequency discharges are related to river stage and project stages in Table 3 below. It is

important to note that these values are estimated and could be refined after project construction by using observed project stage data.

Table 3: Annual Peak Discharge Frequency Analysis with Corresponding Stage

Annual Peak Discharge Frequency Analysis with Corresponding Stage			
Exceedance Probability (%)	Jordan Peak Estimate (cfs)	Jordan Stage (NAVD 88)	Project Stage (NAVD 88)
0%	150,800	NA	NA
1%	124,800	NA	NA
1%	106,200	NA	NA
2%	88,600	723.8	715.3
5%	66,800	721.1	712.7
10%	51,400	718.8	710.5
20%	36,900	716.1	707.9
50%	18,800	710.4	702.6
80%	9,000	703.2	695.7
90%	6,000	700.4	693.1
95%	4,300	698.6	691.4
99%	2,100	696.0	689.0

5.2 Climate Change Assessment

Engineering Construction Bulletin (ECB) No. 2018-14 (USACE 2018) provides guidance for incorporating climate change information in hydrologic analyses in accordance with the USACE overarching climate change adaption policy. This guidance requires the inclusion of a qualitative analysis of potential climate threats and impacts to USACE hydrology-related projects. The goal of this analysis is to describe the observed present and possible future climate threats, vulnerabilities, and impacts of climate change specific to the study goals or engineering designs. This includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant climatic and hydrologic variables.

The important hydrologic variables affecting the proposed Bass Ponds HREP study include water surface elevation (stage) and river discharge. Besides fluctuations in climate, stage can be influenced by long-term geomorphic change, changes to the operation of hydraulic structures, and gage relocation. Discharge can be influenced by changes in upstream water storage due to dam construction, changes in land-use, and measurement techniques. These factors can make it difficult to determine the role of climate change in affecting the hydrologic signal at the project scale The most relevant questions to answer are: (1) Have past climate change events affected the ecological conditions and flood risk within the study area? (2) Is there an observable trend towards a climate change in the future? (3) How will this potential future event impact the resilience, operation and maintenance of the proposed project? Lake stage was chosen as the primary hydrologic variable to analyze for this project with discharge as its proxy. The other hydrologic variable that was analyzed for this project was the flood duration. These variables were chosen for this project to accurately analyze the effects of prolonged high water surface elevations in the lakes on the ecological benefits captured.

5.2.1 Literature Review: Climate Change Trends at a Regional Scale

Both historic, observed hydrometerological datasets, as well as projected, climate changed hydrometerological data was looked at to support some broader statements about how the climate may change over the 50 year project life and 100 year, project performance horizon. Driving hydrometerological variables include streamflow, precipitation, and temperature. The magnitude, seasonal and interannual variation, duration, and rate of change of these variables can affect physical, chemical, and biological characteristics of ecosystems.

A series of regional summary reports on trends in both observed and projected hydrometerological variables were published by the USACE in 2015. In Water Resources Region HUC 07, the Upper Mississippi Region, the report concludes that "increased air temperatures and increased frequencies of drought, particularly in the summer months, will result in increased water temperatures. This may lead to water quality concerns, particularly for the dissolved oxygen levels, which are an important water quality parameter for aquatic life. Increased air temperatures are associated with the growth of nuisance algal blooms and influence wildlife and supporting food supplies. Increased mean annual precipitation in the region may pose complication to planning for ecosystem needs and lead to [increased] variation in flows (Civil Works Technical Report CWTS-2015-13, USACE (2015))." These conclusions were based on a large body of research cited in the report, some of which is summarized below.

In the Upper Mississippi Region, a statistically significant trend of increasing air temperature was found based on observed temperature data for the winter, spring, and summer months; however, a slight decreasing trend was observed in fall temperatures based on the 1950 to 2000 time period (Wang et al. 2009, Westby et al. 2013). Westby et al. (2013) quantified statistically significant warming for the most northern portion of the Upper Mississippi Region and a general cooling trend for the southern region and Johnson and Stefan (2006) identified numerous trends in 20th century hydro-climate data for sites across Minnesota suggestive of a warming climate. These include earlier ice-out dates and later ice-in dates for lakes and earlier spring runoff.

Multiple authors have identified significant, increasing trends in total precipitation in historical records for the study region. Palecki et al. (2005) quantified statistically significant increases in winter storm precipitation totals for the 1972 to 2002 time period. Grundstein (2009) identified significant, positive linear trends (period 1895 – 2006) in both annual precipitation and the soil moisture index for multiple sites within the Upper Mississippi Region. Wang et al. (2009) identified a significant increasing trend in precipitation for the Upper Mississippi Region, particularly in the summer and fall (1950 to 2000). For the northern half of the region, a mild decreasing trend was identified during the winter and spring. McRoberts and Nielsen-Gammon (2011) found that the positive trend in annual precipitation indicates an increase on the order of 5 – 20% per century (1895 to 2009 time period).

Streamflow and duration are the most important hydrometeorological variable affecting ecological conditions and engineering resilience for the project. Elevated water surface elevations, which are directly related to streamflow, can affect all of the project's objectives - increase the diversity and percent cover of desirable emergent and submergent aquatic plant species and provide quality feeding and resting habitat for a wide variety of waterfowl and waterbirds. Trends in streamflow and the corresponding water surface elevations will be considered when designing project features. The 2015 USACE literature synopsis cites a number of studies that identified trends of increasing flow metrics in the Upper Mississippi River

Basin (Mauget 2004, Small 2006, Novotny and Stefan 2007, Kalra 2008, Xu 2013). Mauget (2004) analyzed 42 daily streamflow gages throughout the U.S., nine of which are located within the Upper Mississippi Region. He identified an increasing trend (1939 – 1998) in observed, mean annual river flow in the Mississippi watershed as a whole, including the Upper Mississippi and a significant increase in "surplus" flow days and a decrease in drought incidences for the latter part of the record compared to earlier years. Xu et al. (2013) identified statistically significant positive trends in both observed annual streamflow and baseflow for multiple stream gages in the Upper Mississippi Region. Novotny and Stefan (2007) analyzed 20th century historic streamflow data from 36 gages scattered across Minnesota, most of which were located in the Upper Mississippi Region and applied trend analysis to a number of different flow metrics, including mean flow, 7-day low flow, and peak flows. The analysis results suggested statistically significant (p-value <0.1) increasing trends for the period of 1913 to 2002.

In addition to consulting the USACE literature synthesis for Water Resources Region 07, the Upper Mississippi Region, results from the US Global Research Program's Third National Climate Assessment for the Upper Midwest were evaluated. Figure 14, from the US Global Research Program's Third National Climate Assessment (NCA) completed in 2014, shows estimates of increased precipitation throughout the Upper Midwest for the middle of the current century (2041-2070) relative to the end of the last century (1971-2000). Across the entire Midwest, the total amount of water from rainfall and snowfall is projected to increase. The Third National Climate Assessment states that "in the Upper Midwest extreme heat, heavy downpours, and flooding will affect infrastructure, health, agriculture, forestry, transportation, air and water quality, and more. Climate change will tend to amplify existing risks climate poses to people, ecosystems, and infrastructure. Direct effects will include increased heat stress, flooding, drought, and late spring freezes." The US Global Research Program's Fourth National Climate Assessment was released in 2018. This report explains that in the Midwest the annual average precipitation has increased and the precipitation increases are projected to occur in winter and spring. The Fourth National Climate Assessment also states that "Over the contiguous United States, annual average temperature has increased by 1.2°F (0.7°C) for the period 1986–2016 relative to 1901–1960, and by 1.8°F (1.0°C) when calculated using a linear trend for the entire period of record."

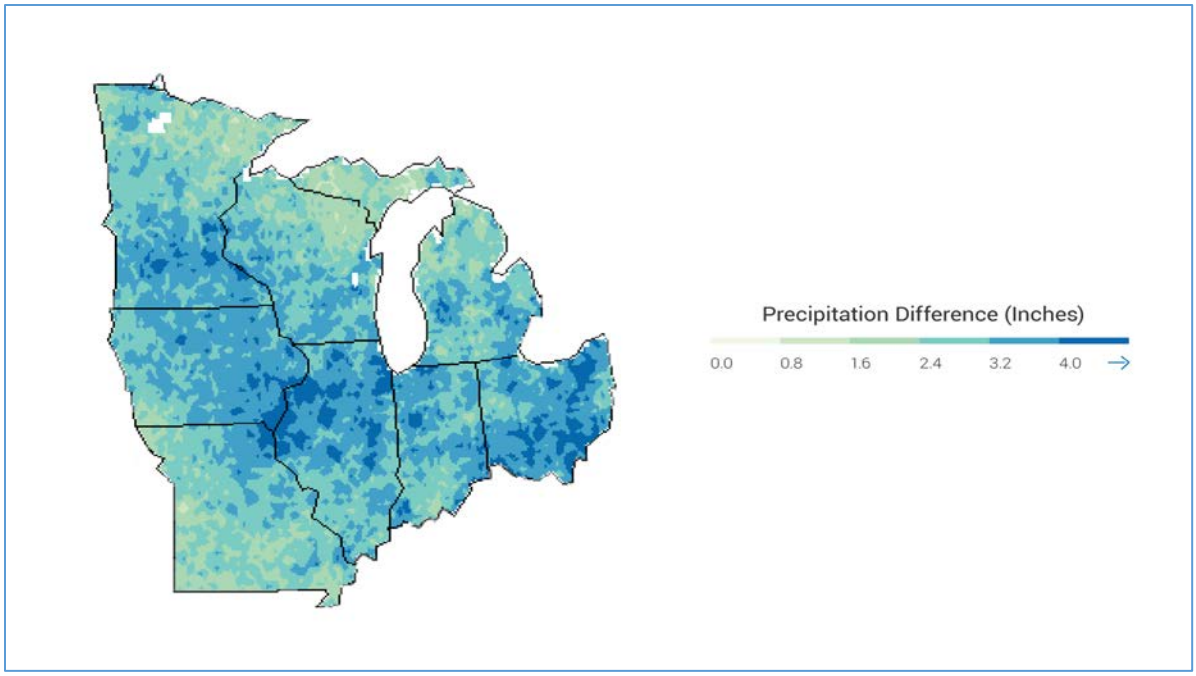


Figure 14: Projected Changes for the Middle of the Current Century (2041-2070) Relative to the End of the Last Century (1971-2000). (Figure source: NOAA NCDC / CICS-NC)

According to the NCA, projected future air temperatures are expected to trend upward, as will annual precipitation. Future increases in the frequency and magnitude of large storm events is expected. Projected changes in temperature, soil moisture and precipitation indicate an increase in the severity of droughts and extreme precipitation events. As a result of projected temperature increases, the number of frost-free days is anticipated to rise. Streamflow has increased over the past century; however, a clear consensus is lacking with regards to projections in future hydrology. Some studies predict increases in projected streamflow and others predict decreases. Figure 15 shows a summary of observed and projected trends in climate variables as well as an indication of the level of consensus within the literature according to the USACE literature synthesis.

These observed and projected increasing trends in air temperature and precipitation as well as observed streamflow could affect ecosystem conditions in the project area and the engineering resilience of project features and was considered during this design.

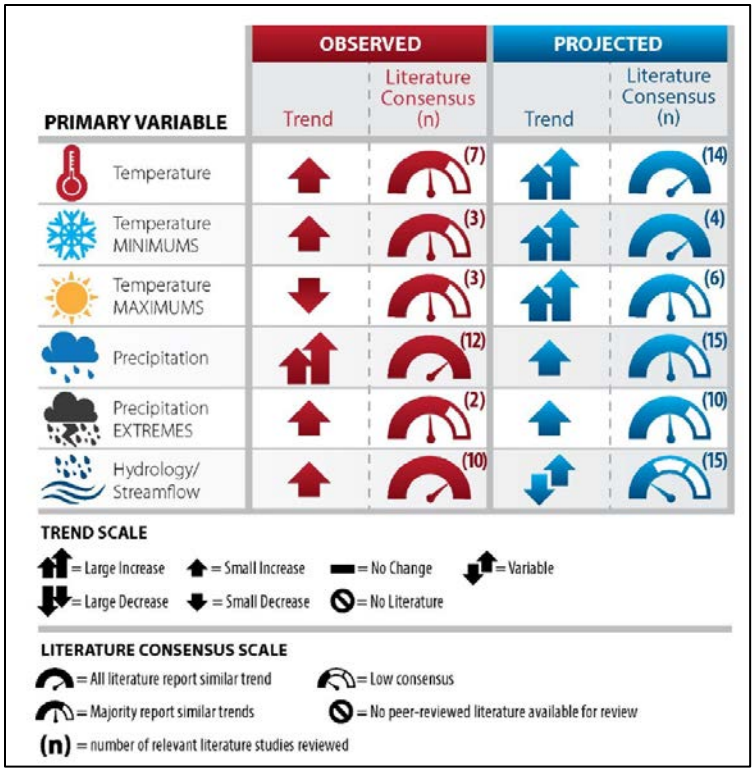


Figure 15: Summary of climate trends and literary consensus (USACE, 2015)

5.2.2 First Order Statistical Analysis: Trends in Streamflow & Climate Change at a Regional Scale

The USACE Climate Hydrology Assessment Tool was used to investigate potential future trends in streamflow for HUC 0706 (Minnesota Watershed). Figure 16 below shows the location of the project area relative to the HUC02 and HUC04 watershed delineations, while Figure 17 displays the range of projected, mean annual maximum monthly streamflows computed from 93 different climate changed hydrologic model runs for the period of 1951-2099. This mean annual maximum monthly discharge variable is relevant to this project because the ecological conditions in the study area and the study objectives are most significantly impacted by high flow conditions and because one of the primary constraints to this project is the need to maintain the current level of flood risk in the study area.

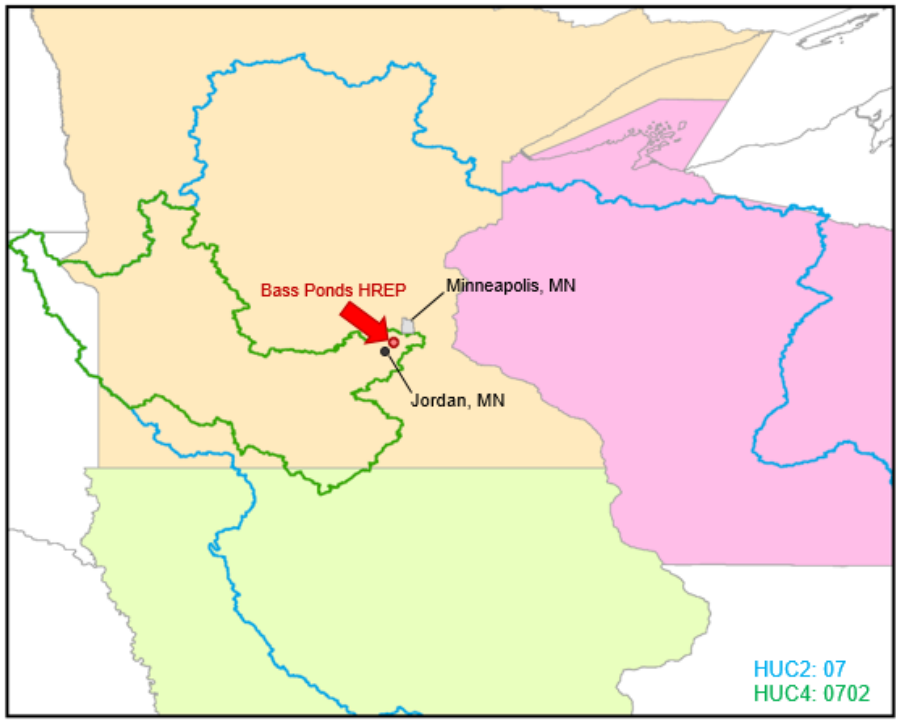


Figure 16: Location of Project Area within HUC2 and HUC4

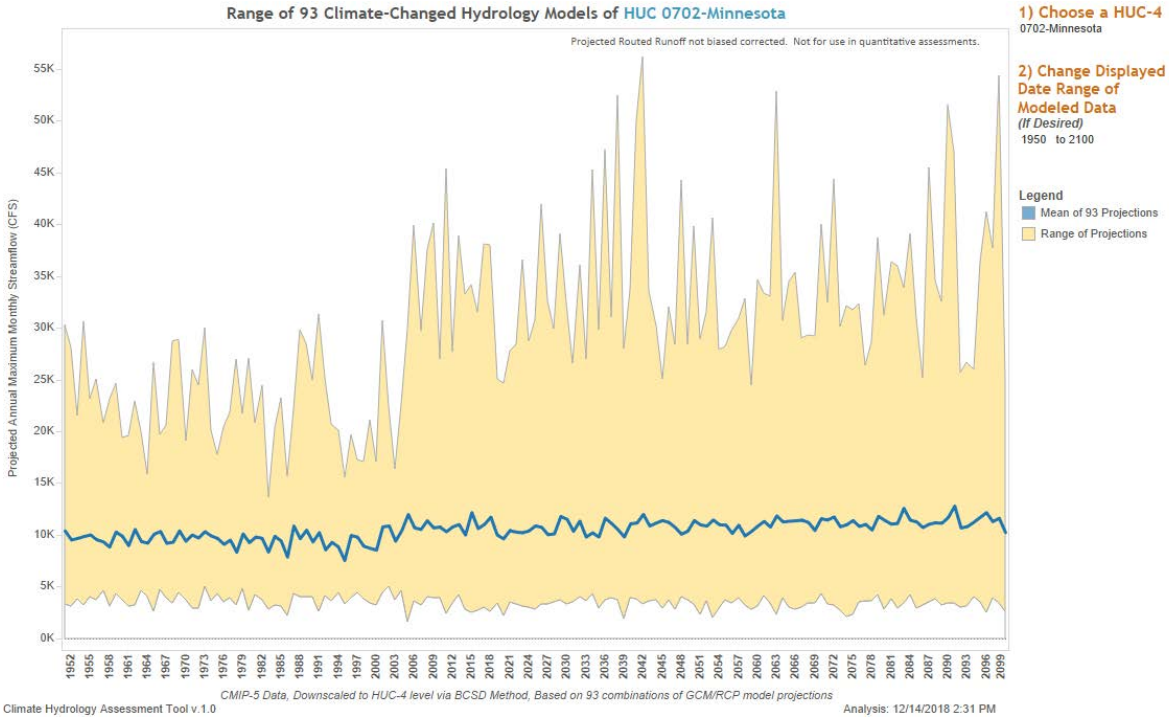


Figure 17: Range of Projected Annual Maximum Monthly Streamflow among Ensemble of 93 Climate-Changed Hydrology Models, HUC 0702 Minnesota

Climate Changed hydrology output is generated using various greenhouse gas emission scenarios (Representative Concentration Pathways, RCPs) and global circulation models (GCM) to project precipitation and temperature data into the future. These meteorological outputs are spatially downscaled using the Bias Corrected Spatial Disaggregation statistical method and then inputted in the U.S. Bureau of Reclamation's (USBR) Variable Infiltration Capacity (VIC) precipitation-runoff model to generate a streamflow response. The effects of regulation are not included within the USBR VIC model.

As expected for this type of qualitative analysis, there is considerable, but consistent spread in the projected annual maximum monthly flows. The spread in the projected annual maximum monthly flows is indicative of the high degree of uncertainty associated with projected, climate changed hydrology.

As shown in Figure 18 below, there is a statistically significant increasing trend in the mean projected annual maximum monthly streamflow. The p-value associated with this trend is less than 0.0001. This is significantly less than the generally accepted threshold for significance of 0.05. This finding suggests that there is potential for annual maximum monthly streamflows to increase in the future in the study area, relative to the current conditions.

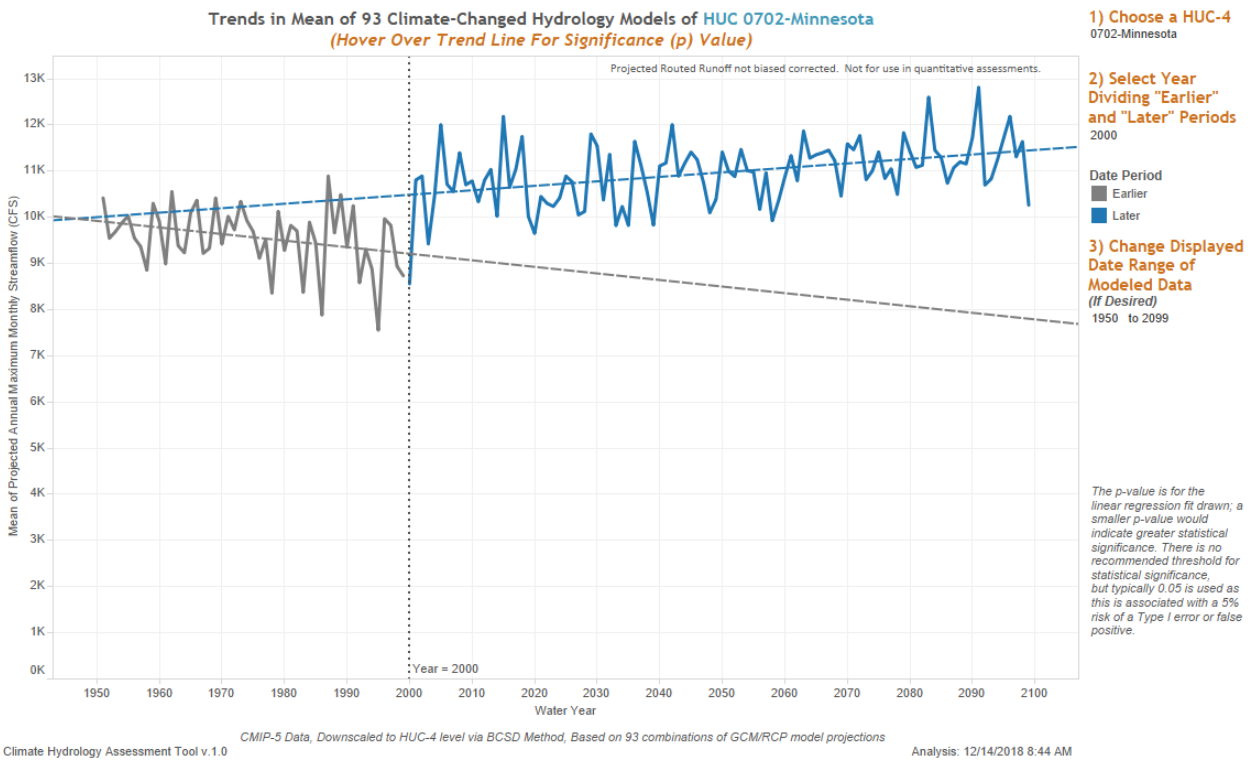


Figure 18: Mean Projected Annual Maximum Monthly Streamflow, HUC 0702 Minnesota. Trendline Equation: Q = 9.69702*[Water Year] – 8918.99, p <0.0001

5.2.3 Screening Level Vulnerability Assessment to Climate Change Impacts

The USACE Watershed Climate Vulnerability Assessment Tool was also used to compare the relative vulnerability of the HUC 0702, the Minnesota Watershed, to climate change to the other 201 HUC-04 watersheds across the continental United States (CONUS). The tool facilitates a screening level, comparative assessment of how vulnerable a given HUC-04 watershed is to the impacts of climate change. The tool can be used to assess the vulnerability of a specific USACE business line to projected climate change impacts. For this study, both the Ecosystem Restoration and Flood Risk Reduction business lines are analyzed. This project is primarily related to ecosystem restoration, but because of the flood stage impacts constraints, flood risk reduction is also relevant. Assessments using this tool help to identify and characterize specific climate threats and particular sensitivities or vulnerabilities, at least in a relative sense, across regions and business lines. The tool uses the Weighted Order Weighted Average (WOWA) method to estimate a vulnerability score which represents a composite index of how vulnerable a given HUC-4 watershed is to climate change specific to a given business line. The HUC-4 watersheds with the top 20% of vulnerability scores are flagged as being vulnerable.

Indicators considered within the vulnerability score for Ecosystem Restoration include: change in sediment load, short-term variability in hydrology, runoff elasticity (ratio of streamflow runoff to precipitation), macroinvertebrate index (sum score of six metrics indicating biotic condition), two indicators of flood magnification (indicator of how much high flows are projected to change overtime), mean annual runoff, change in low runoff, and percent of at risk freshwater plant communities.

Indicators considered within the vulnerability score for Flood Risk Reduction include: long-term variability in hydrology, runoff elasticity (ratio of streamflow runoff to precipitation), two indicators of flood magnification (indicator of how much high flows are projected to change overtime) and urban area (acres) within the 500 year floodplain.

When assessing future risk projected by climate change, the USACE Climate Vulnerability Assessment Tool makes an assessment for two 30-year epochs of analysis centered at 2050 and 2085. These two periods were selected to be consistent with many of the other national and international analyses. The tool assesses how vulnerable a given HUC-04 watershed is to the impacts of climate change for a given business line using climate changed hydrology based on a combination of projected climate outputs from the general climate models (GCMs) and representative concentration pathway (RCPs) resulting in 100 traces per watershed per time period. The top 50% of the traces by flow volume are called the “wet” subset of traces and the bottom 50% of the traces are called the “dry” subset of traces. Meteorological data projected by the GCMs is translated into runoff using the USBR Variable Infiltration Capacity (VIC) Macroscale hydrologic model. For this assessment, the default, National Standards Settings are used to carry out the vulnerability assessment.

5.2.3.1 Ecosystem Restoration Vulnerability Assessment

Based on the results of the USACE Watershed Climate Vulnerability Assessment Tool presented in Figure 19 below, relative to the other 201 HUC04 watersheds in the CONUS, the Minnesota watershed (HUC 0702) is relatively less vulnerable to the impacts of climate change on ecosystem restoration. For the Minnesota watershed, the major drivers of the computed vulnerability score are, “At Risk Freshwater Plants”, “Runoff Elasticity”, and “the Measure of Short-term Variability in Hydrology”. Table 4 shows the vulnerability scores for the two 30 year epochs and the scores are relatively constant between both epochs and their wet and dry

subsets of traces. Additionally, Table 5 shows the vulnerability score contributions of the different indicators for the 2050 epoch.

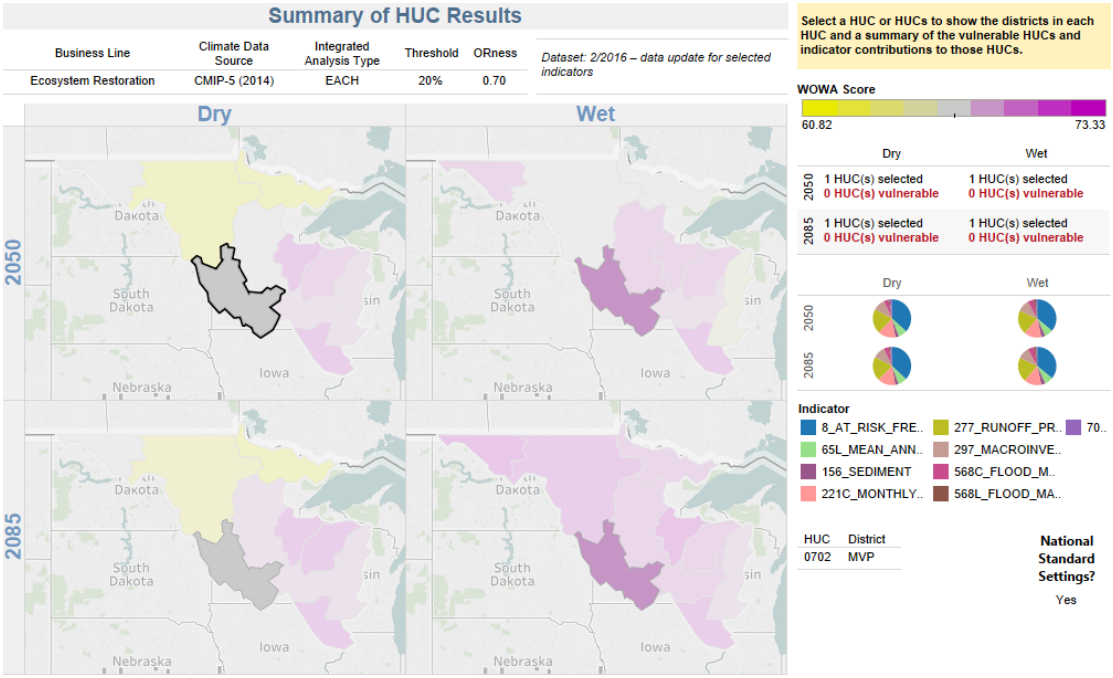


Figure 19: Projected Vulnerability for the Minnesota (0702) with respect to Ecosystem Restoration

Table 4: Projected Vulnerability with respect to Ecosystem Restoration

HUC 4 Watershed	Projected Vulnerability with Respect to Ecosystem Restoration			
	Ecosystem Reduction Vulnerability Score			
	2050 Dry	2050 Wet	2085 Dry	2085 Wet
Minnesota River (0702)	66.92	68.11	66.46	68.30

Table 5: Comparison of Different Indicators for the Minnesota Watershed with respect to Ecosystem Restoration

2050 Epoch	Minnesota River (0702)			
Indicator	Contribution to WOWA Ecosystem Restoration Vulnerability Score			
	Dry		Wet	
Change in Sediment Load Due to Change in Future Precipitation	1.49	3.6%	2.23	5.1%
Short-term Variability in Hydrology (75th Percentile of Annual Ratios of Standard Deviation of Monthly Runoff) - Cumulative	10.02	23.9%	10.08	23.1%
Runoff Elasticity (% Change in Runoff / % Change in Precipitation)	13.88	33.2%	13.87	31.8%
Macroinvertebrate Index of Biotic Condition (Sum of scores for 6 metrics that	6.83	16.3%	6.83	15.7%

characterize macroinvertebrate assemblages)				
Flood Magnification Factor - Cumulative	2.52	6.0%	3.43	7.9%
Flood Magnification Factor- Local	0.77	1.8%	1.36	3.1%
Mean Annual Runoff - Local	5.02	12.0%	4.9	11.2%
Low Flow Reduction Factor	1.34	3.2%	0.88	2.0%
Percentage of Plant Communities at Risk	24.61	58.8%	24.61	56.5%

5.2.3.2 Flood Risk Reduction Vulnerability Assessment

Based on the results of the USACE Watershed Climate Vulnerability Assessment Tool presented in Figure 20 below, relative to the other 201 HUC04 watersheds in the CONUS, the Minnesota watershed (HUC 0702) is relatively less vulnerable to the impacts of climate change on flood risk reduction. For the Minnesota watershed, the major drivers of the computed vulnerability score are, “Flood Magnification Factor - Cumulative”, “Runoff Elasticity”, and “Flood Magnification Factor - Local”. Table 6 shows the vulnerability scores for the two 30 year epochs. Additionally, Table 7 shows the vulnerability score contributions of the different indicators for the 2050 epoch.

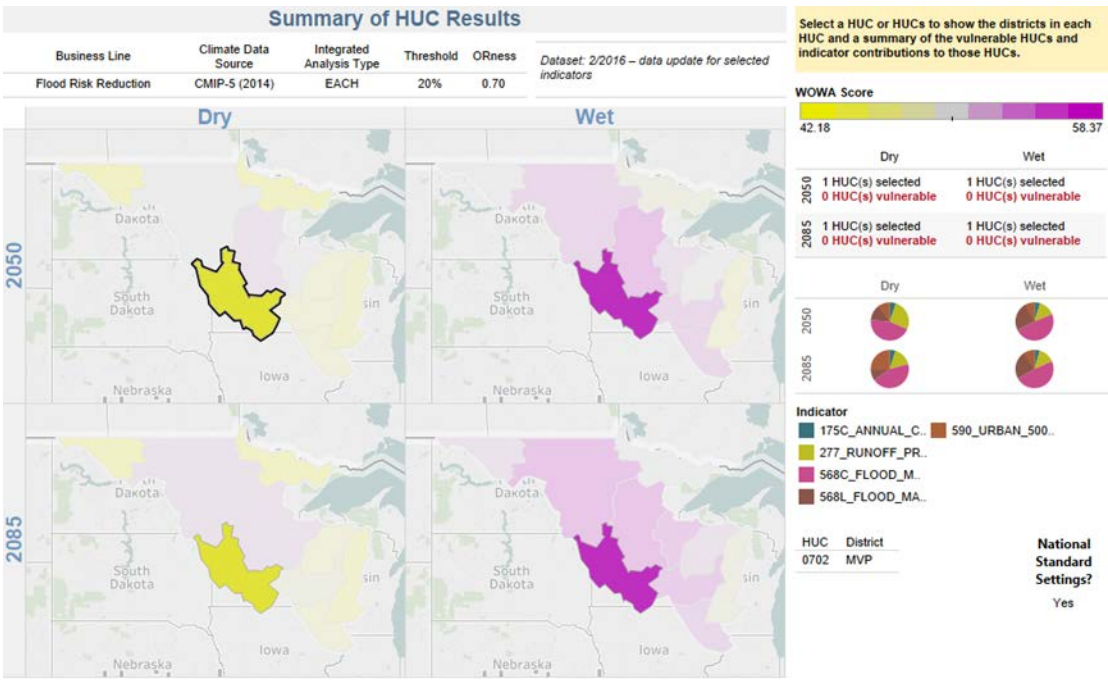


Figure 20: Projected Vulnerability for the Minnesota (0702) with respect to Flood Risk Reduction

Table 6: Projected Vulnerability with respect to Flood Risk Reduction

HUC 4 Watershed	**Projected Vulnerability with Respect to Flood Risk Reduction**			
	Flood Risk Reduction Vulnerability Score			
	2050 Dry	2050 Wet	2085 Dry	2085 Wet
Minnesota River (0702)	45.62	54.85	45.28	56.55

Table 7: Comparison of Different Indicators for the Minnesota Watershed with respect to Flood Risk Reduction

2050 Epoch	Minnesota River (0702)			
Indicator	Contribution to WOWA Ecosystem Restoration Vulnerability Score			
	Dry		Wet	
Runoff Elasticity (% Change in Runoff / % Change in Precipitation)	12.08	26.5%	7.65	13.9%
Long-term Variability in Hydrology (Ratio of Standard Deviation of Annual Runoff to the Annual Runoff Mean) - Cumulative	2.38	5.2%	2.60	4.7%
Flood Magnification Factor - Cumulative	20.22	44.3%	26.84	48.9%
Flood Magnification Factor - Local	6.64	14.6%	13.56	24.7%
Acres of Urban Area within 500-Year Floodplain	4.3	9.4%	4.19	7.6%

5.2.4 First Order Statistical Analysis: Site Specific Trends in Observed River Discharge

The primary objective of this study is to improve ecological conditions in the watershed to provide for quality habitat for various bird species. Ecologically relevant components of river discharge include its magnitude, frequency, and duration, as well as the timing of particular discharges, rate of discharge change, and inter-annual (year-to-year) variability. In the study area more frequent and longer duration flood conditions has reduced aquatic plant diversity, resulting in a reduction in habitat quality for migrating water birds. Excessive inflows to aquatic areas increases sediment and nutrient loading affecting plant communities. Inter-annual variability within typical long term extremes helps produce the mosaic of habitats found on the Minnesota River, however increased year to year variability may affect the establishment of some species of plants and the availability of water fowl habitat in the aquatic-terrestrial transition zone.

Additionally, increased river discharges have the potential to effect the project from a flood risk management standpoint. One critical project constraint is to maintain the current level of flood risk in the study area.

Discharge data for the Minnesota River at Jordan, MN (USGS gage 05330000), which includes continuous, daily river flows from 1935 to present, was analyzed to determine if there are any patterns in discharge that might help in assessing future hydrologic conditions in the study area. The location of the Jordan gage is displayed in Figure 16. The drainage area encompassed by the Jordan gage is 16,200 square miles.

The study area is between the USGS gage at Jordan, MN (upstream of project) and the USGS gage at Savage, MN (downstream of project) Upstream of the study area, multiple large, USACE dams have been built. Table 8 below from the Minnesota River Integrated Watershed Study (2017), lists these upstream dams and the associated intervening drainage area between the dams and the USGS gage at Mankato, MN. The Minnesota River Integrated Watershed Study states that, “the USGS peak flow record for the Minnesota River at Mankato, MN USGS

gage (05325000) does not indicate effects from upstream reservoir regulation and the intervening drainage area between the significant reservoirs and the Minnesota River at Mankato, MN USGS gage (05325000) is large. A large intervening drainage area between a reservoir and a gage lessens effects of dam operation. Consequently, any change points detected are not likely due to the construction of upstream reservoirs. Detected change points are likely due to effects of anthropogenic climate change, long-term natural fluctuations in climate, and/or changes to the hydrologic properties of the basin (example: land use changes, changes in channel geomorphology, changes in land cover, etc.).” This is subsequently valid for the USGS gage at Jordan and Savage, MN because these gages are downstream of the reservoirs and the Mankato gage. The drainage area associated with the Mankato gage is 14,900 square miles. There is over 1,000 square miles of additional drainage area between the Mankato gage and the USGS gage at Jordan. The intervening drainage area between the upstream headwaters reservoirs and the Minnesota River at Jordan is assumed to be sufficiently large and effects from regulation are assumed to be negligible.

Table 8: Select large dams within the Minnesota River Basin

DAM NAME	HUC 08 WATERSHED NAME	RIVER	YEAR COMPLETED	DAM LENGTH (FT)	MAX DISCHARGE (CFS)	MAX STORAGE (AC-FT)	NORMAL STORAGE (AC-FT)	DRAINAGE AREA (MI^2)	INTERVENING DRAINAGE AREA BETWEEN DAM AND MANKATO USGS GAGE (MI^2)
BIG STONE LAKE	UPPER MINNESOTA RIVER	MINNESOTA RIVER	1937	6,300	5,600	205,000	100,880	1,160	13,740
AARON LAKE	CHIPPEWA RIVER	CHIPPEWA RIVER - TRIB	1964	10	95	190,000	178,500	6.5	14,894
LAC QUI PARLE DAM	MINNESOTA RIVER	MINNESOTA	1939	4,327	35,000	122,800	29,700	6,100	8,800
HIGHWAY 75 DAM	UPPER MINNESOTA RIVER	MINNESOTA RIVER	1974	16,160	32,300	91,000	11,700	1,890	13,010
MARSH LAKE DAM	UPPER MINNESOTA RIVER	MINNESOTA	1942	9,700	2,700	91,000	12,050	2,908	11,992

The Minnesota River gage located at Savage, MN (Port Cargill Harbor; USGS Gage 05330890 USACE maintained) cannot be utilized for any of these analyses because it only records stage measurements because it only includes stage data from 1991-2018. The recommended minimum record length for hydrologic analysis is 30 years of record (ETL 1100-2-3).

A series of twelve different nonstationarity detection tests were carried out on the peak and average annual discharge record at Jordan. Discharge data for both variables were collected at USGS gage 05330000 Mississippi River at Jordan, MN. Nonstationarities were detected using the USACE Nonstationarity Detection Tool and the Time Series Tool Box. Nonstationarities were analyzed to determine if there is “strong” evidence of nonstationary conditions within the discharge record.

A “strong” change point is one for which there is a consensus among multiple change point detection methods, robustness between changes in statistical properties, and for which an operationally significant change in the magnitude of the statistical properties (mean/variance) associated with the record is determined (ETL 1100 2-3). See below for definitions on these three characteristics of a “strong” change point.

- Consensus: minimum of two or more of the tests targeting either changes in the mean, distributional characteristics or variance are detecting a change point.
- Robustness: tests targeting changes in two or more different statistical properties (mean, variance and/or overall distribution) of the dataset are indicating a statistically significant change point.
- Magnitude: difference between the means and variances associated with the subsets of data before and after the change points being used to parse the dataset are operationally significant.

5.2.4.1 High Flow Regime - Nonstationarity Detection Tests

The USACE nonstationarity detection tool is applied to assess the stationarity of the annual peak discharge record for the Minnesota River at Jordan, MN (USGS gage 05330000) from 1935-2014. Six of the twelve different nonstationarity detection tests applied for the high flow regime variable (peak annual discharge) indicate statistically significant nonstationarities. These tests are listed in Table 9 below. The Cramer-Von-Mises (CPM), Lombard Wilcoxon and Mann-Whitney (CPM) tests identified nonstationarities circa 1990. Two of the three nonstationarities detected occurred in 1990 and one (Lombard Wilcoxon) identified a breakpoint in 1989, so 1990 is selected as the breakpoint year. Because two tests are indicating a change in sample mean and an additional test is indicating a change in the overall distribution the nonstationarity identified in 1990 exhibits both consensus and robustness. Additionally, there is a significant increase in the mean associated with the data collected after 1990, relative to the data collected prior to 1990. Thus as shown in Figure 21 below, it can be concluded that there is an operationally significant nonstationarity in the flow record at this site (Friedman, *et al.* 2017). Figure 22 shows the Monotonic Trend Analysis for the entire period of record and statistical significant trends were detected showing a positive trend. A Monotonic Trend Analysis was completed for the timeframe 1990-2014 Figure 23 shows the Monotonic Trend Analysis for the 1990-2014 and that statistical significant trends are not detected.

Table 9: Nonstationarities Detected Using Maximum Annual Flow

Nonstationarities Detected Using Maximum Annual Flow	
Method	Year
Cramer-Von-Mises (CPM)	1990
Kolmogorov-Smirnov (CPM)	1942
Energy Divisive Method	1983
Lombard Wilcoxon	1989
Pettit	1982
Mann-Whitney (CPM)	1990

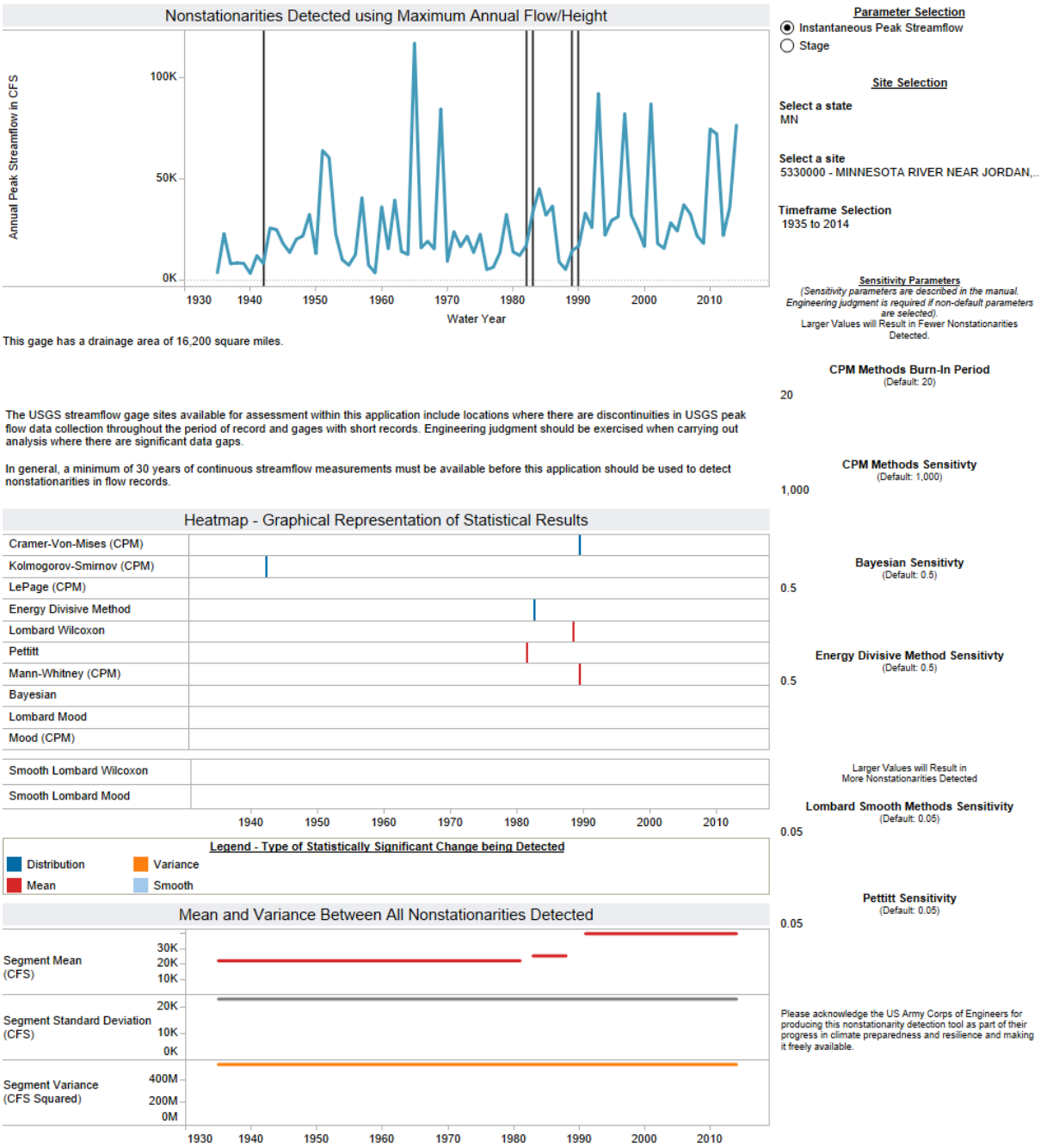
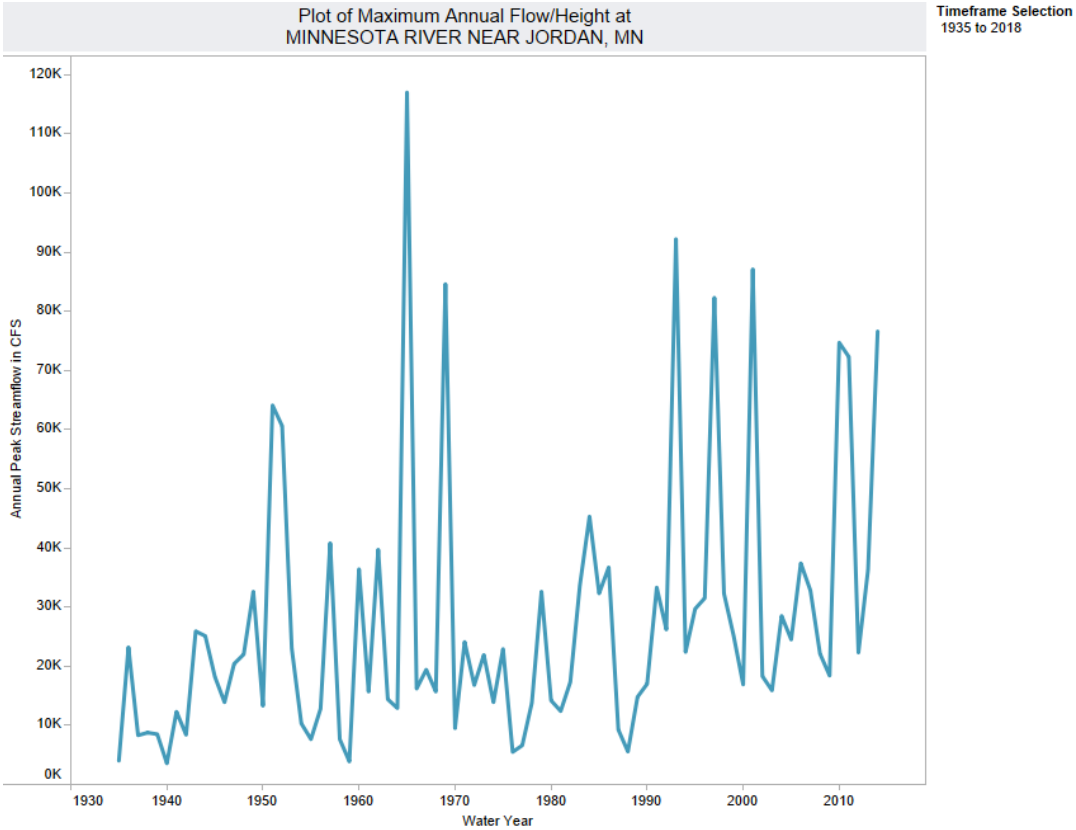


Figure 21: Nonstationary Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014



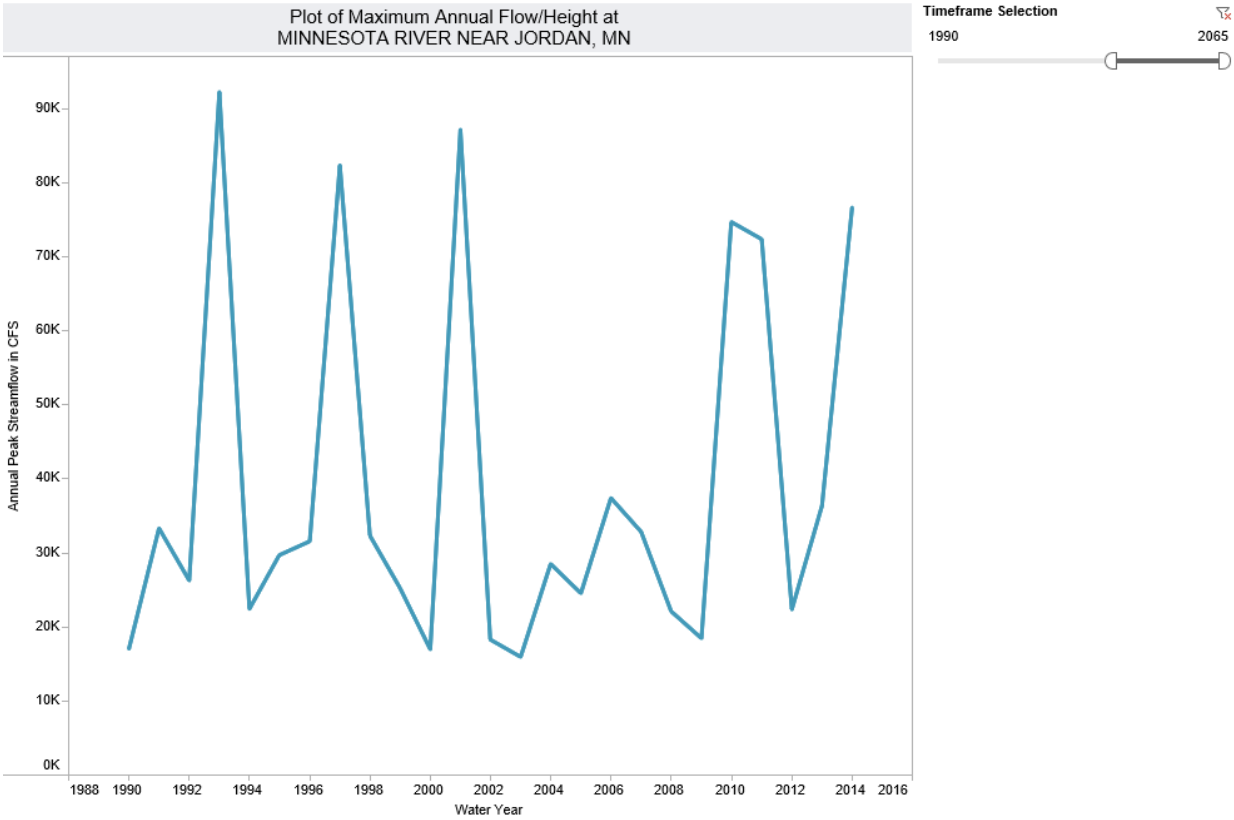
Monotonic Trend Analysis

Is there a statistically significant trend?
Yes, using the Mann-Kendall Test at the .05 level of significance. The exact p-value for this test was less than 1e-3.
Yes, using the Spearman Rank Order Test at the .05 level of significance. The exact p-value for this test was less than 1e-3.

What type of trend was detected?
Using parametric statistical methods, **a positive trend** was detected.
Using robust parametric statistical methods (Sen's Slope), **Null** was detected.

Please acknowledge the US Army Corps of Engineers for producing this nonstationarity detection tool as part of their progress in climate preparedness and resilience and making it freely available.

Figure 22: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2014



Monotonic Trend Analysis

Is there a statistically significant trend?
No, using the Mann-Kendall Test at the .05 level of significance. The exact p-value for this test was 0.624.
No, using the Spearman Rank Order Test at the .05 level of significance. The exact p-value for this test was 0.636.

What type of trend was detected?
Using parametric statistical methods, **no trend** was detected.
Using robust parametric statistical methods (Sen's Slope), **no trend** was detected.

Please acknowledge the US Army Corps of Engineers for producing this nonstationarity detection tool as part of their progress in climate preparedness and resilience and making it freely available.

Figure 23: Monotonic Trend Analysis of Peak Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1990 to 2014

Figure 24 shows the peak annual discharge at the USGS gage at Jordan, MN for the period of record from 1935 to 2017. Consistent with the results of the Monotonic trend analysis generated using the nonstationarity detection tool, there is a trend of increasing peak annual discharge for the entire period of record from 1935 to 2017 (p-value <0.05). Using the 1989 breakpoint to analyze subsets of the data prior to and after to the strong, nonstationarity detected in 1990, no statistically significant trends were found within the subsets of data in the timeframes 1935-1989 and 1990-2017 (see Figure 24 below for p-values).

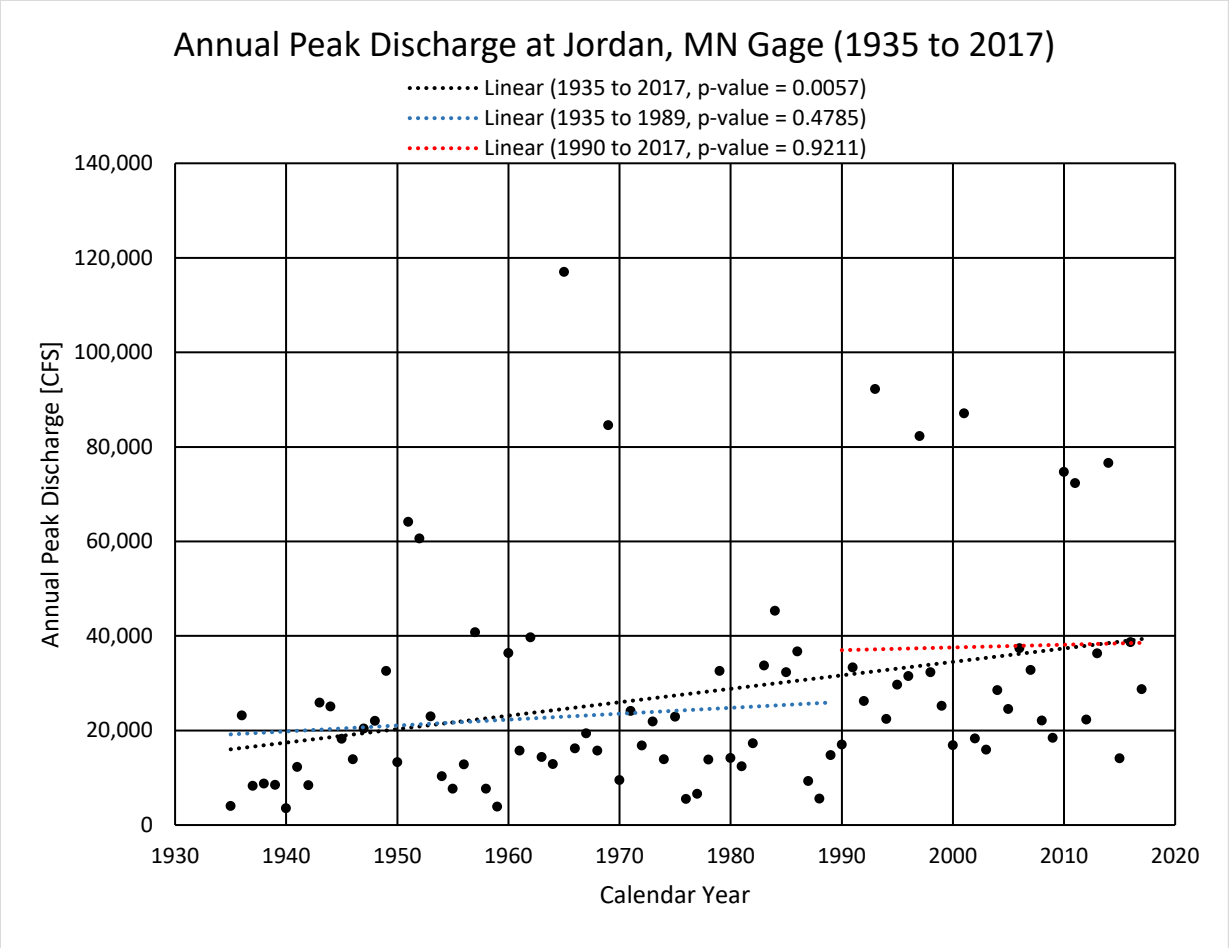


Figure 24: Peak Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017

5.2.4.2 Moderate Flow Regime- Nonstationarity Detection Tests

The USACE Time Series Toolbox application is applied to assess the stationarity of the annual average discharge record for the Minnesota River at Jordan, MN (USGS gage 05330000) from 1935 to 2017. As listed in Table 10 below, six of the twelve different nonstationarity detection tests for the moderate flow regime (average annual discharge) indicate statistically significant nonstationarities. The Cramer-Von-Mises (CPM), and Mann-Whitney (CPM) tests indicate nonstationarities in 1990. The Lombard Wilcoxon, Energy Divisive Method, LePage (CPM) and Smooth Lombard Wilcoxon method test indicate nonstationarities between 1980 and1982.

The nonstationarities detected in both the eighties and 1990 demark a significant increase in the mean of the average annual discharge. Tests indicating nonstationarities in overall distribution and sample mean flag both nonstationarities. Thus, there is a degree of robustness associated with both nonstationarities. Only the nonstationarity in the 1980s demonstrates consensus because multiple tests flagging a change in sample mean are indicating a statistically significant nonstationarity. It can be concluded that there are likely two operationally significant nonstationarities in the flow record at this site (Friedman, *et al.* 2017), as shown in Figure 25 below. The years 1990 and 1981 (middle of the 1980-1982 range) were the years chosen as the representative breakpoints. Figure 26 and Figure 27 show linear regression based trend

analyses for the entire period of record and for subsets of data prior to and post the nonstationarities detected in 1981 and 1990. Within in the period of record from 1935 to 2017, there is a statistically significant positive trend (p-value <0.05) within the average annual flow record. There is no statistically significant trend in the 1981-2017 timeframe. This implies that that the record post 1981 is relatively homogenous. If a single nonstationarity is to be selected within the average annual flow record, it is justifiable to select 1981 as the year when there is the most evidence of a change in the properties of the flow record.

Table 10: Nonstationarities Detected Using Average Annual Flow

Nonstationarities Detected Using Average Annual Flow	
Method	Year
Lombard Wilcoxon	1980
Energy Divisive Method	1981
LePage (CPM)	1982
Smooth Lombard Wilcoxon	1981-1982
Cramer-Von-Mises (CPM)	1990
Mann-Whitney (CPM)	1990

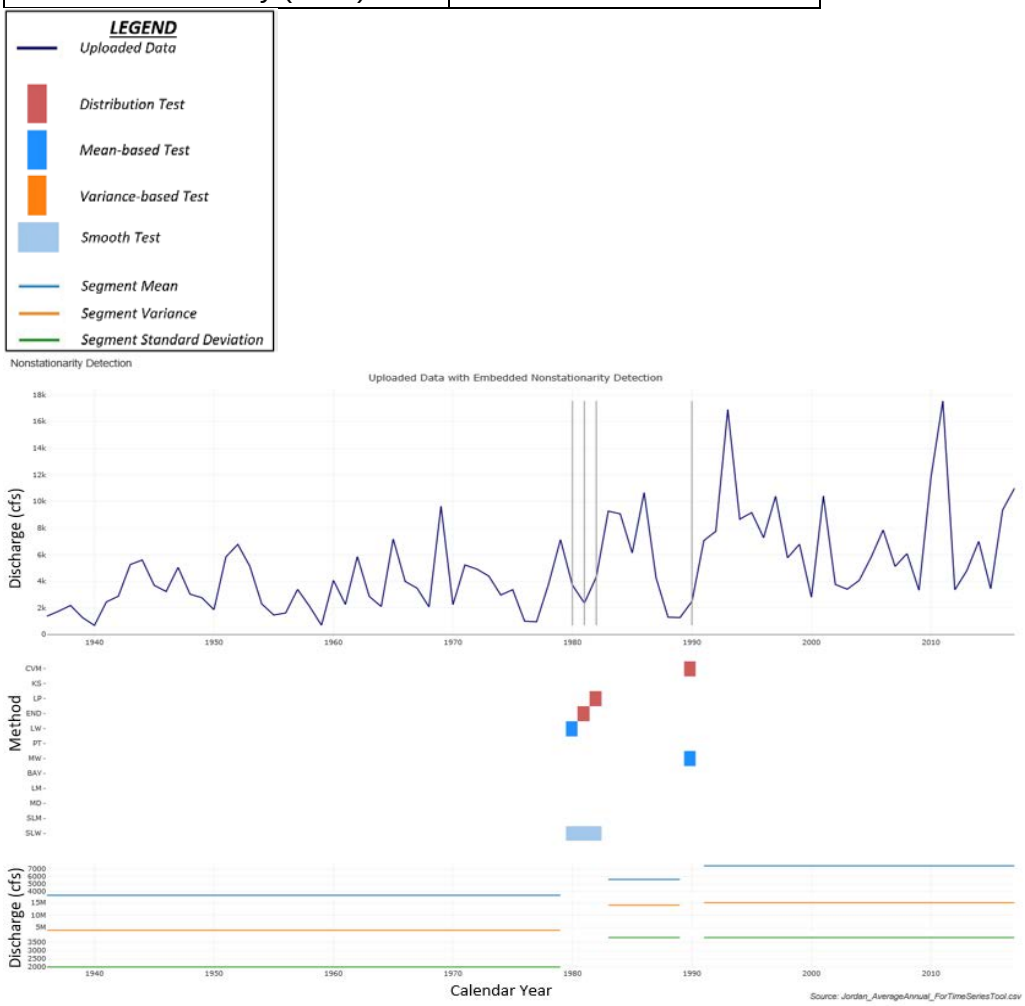


Figure 25: Nonstationary Analysis of Average Annual Discharge at the Jordan, MN USGS gage (Gage Number 05330000) from 1935 to 2017 using the Time Series Toolbox

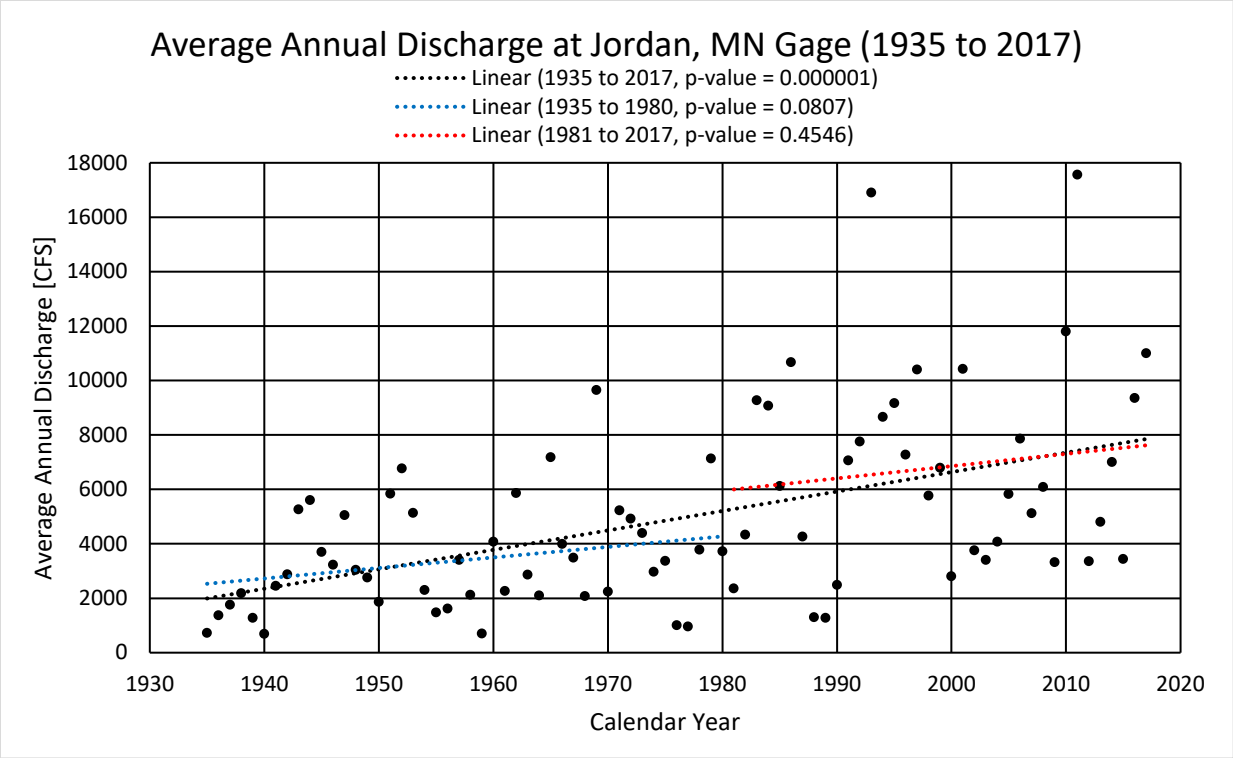


Figure 26: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1981 Breakpoint

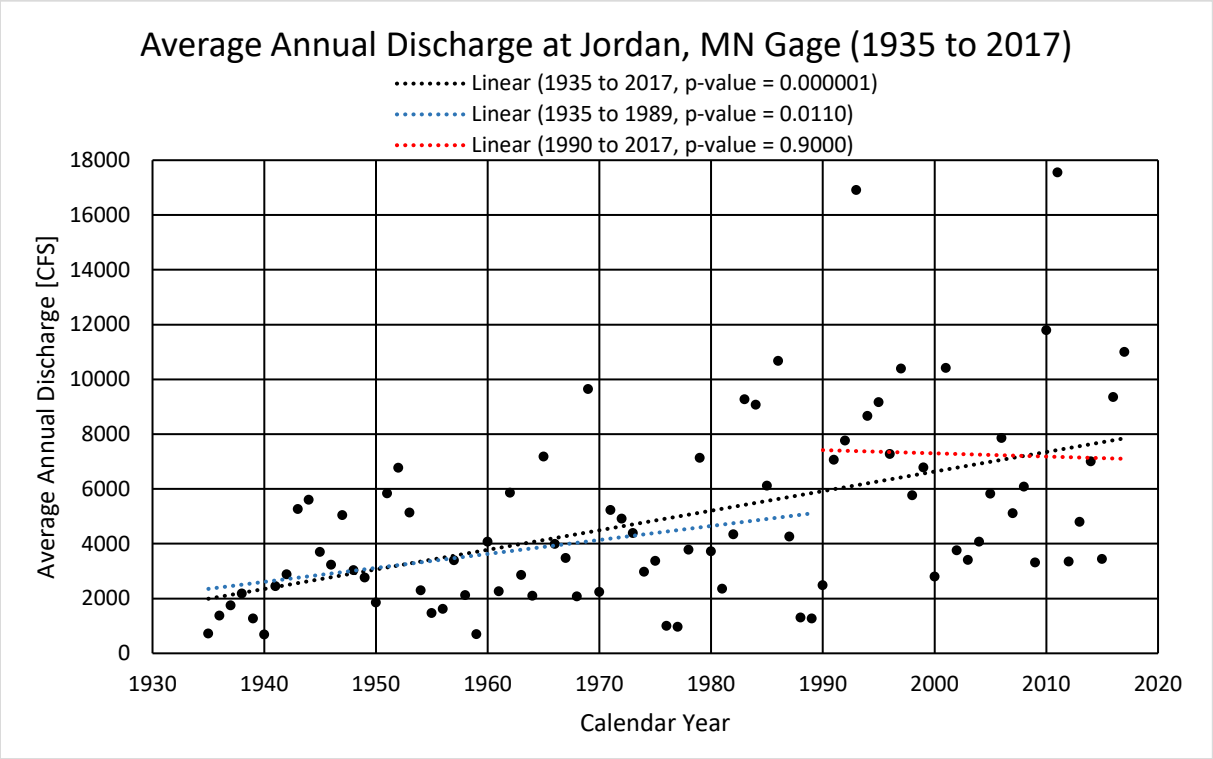


Figure 27: Average Annual Discharge at the Jordan, MN USGS Gage (Gage number 05330000) from 1935 to 2017 with Trendlines for the 1990 Breakpoint

5.2.5 First Order Statistical Analysis: Site Specific Trends in Observed Precipitation and Air Temperature Data

In addition to analyzing river discharge, ECB 2018-14 requires the climate change analysis to include information for other variables relevant to hydro-climatic conditions such as temperature, evaporation rates and precipitation. The qualitative analysis required by this ECB should focus on those aspects of climate and hydrology relevant to the project's problems, opportunities, and alternatives. The primary variables relevant to this project, besides discharge would include precipitation and air temperature. Trends in total annual precipitation and average annual air temperature are evaluated.

The data for these two variables is collected from the NOAA National Climatic Data Center (NCDC) station USW00014922 (Minneapolis St. Paul International Airport). The datasets cover 100% of the years between 1939 and 2017. The location of the station in relation to the project can be viewed in Figure 28. There is a climate station near Jordan, MN that includes data from 1942-2018, however this station has missing data which could result in inaccurate results.

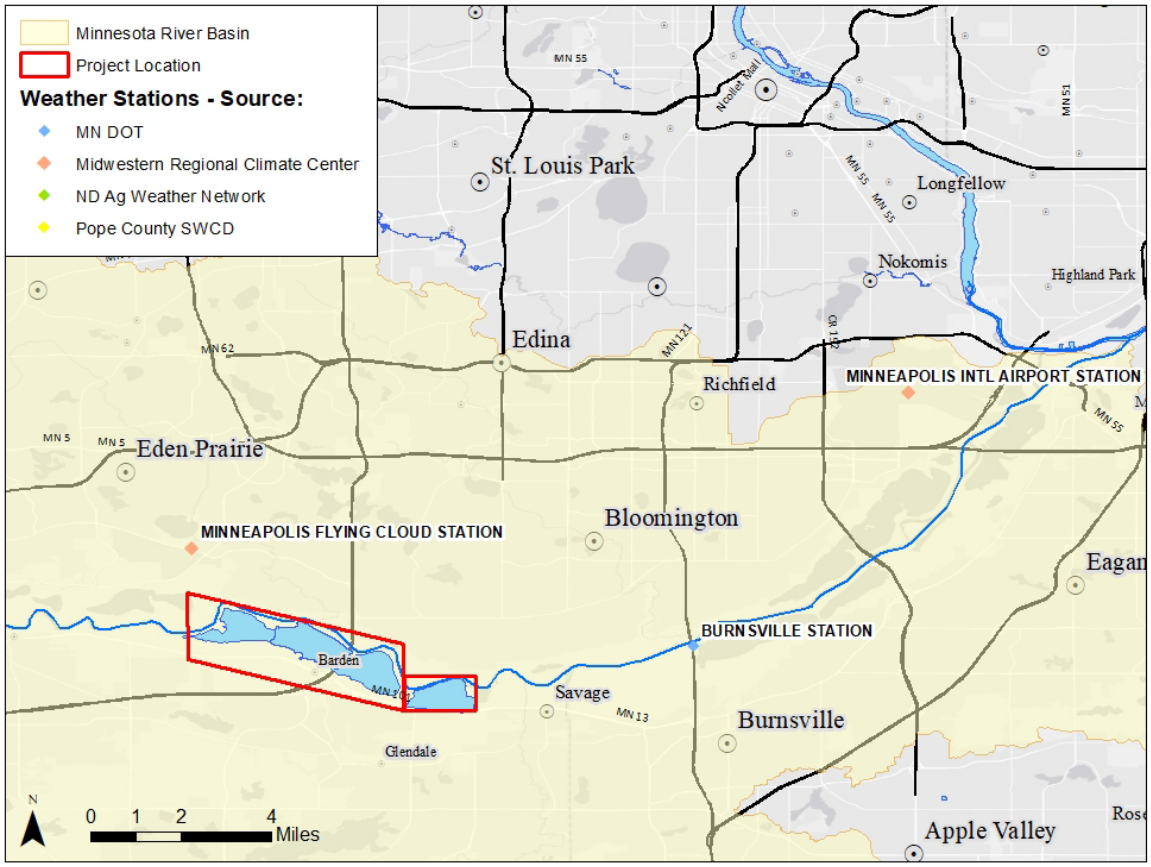


Figure 28: NOAA National Climatic Data Center MSP Station Location

5.2.5.1 First Oder Statistical Analysis – Total Annual Precipitation

The USACE Timeseries Toolbox application is used to assess the stationarity of the precipitation record recorded by the MSP gage near the Minnesota River Basin. Four of the twelve nonstationarity detection tests included within the Timeseries Toolbox indicate that there is a statistically significant, nonstationarity in the year 1976 (see Table 11, below). Two different

statistical tests are indicating a change in mean and two tests are indicating a change in overall statistical distribution. Thus, there is consensus between tests. Because multiple tests, targeting different statistical properties are indicating a nonstationarity it can be considered robust. There is a significant increase in the magnitude of the mean if the data collected pre- and post- 1976 is compared. As shown in Figure 29, it can be concluded that there is an operationally significant nonstationarity in the total annual precipitation record at this site (Friedman, *et al.* 2017). Figure 30 shows the results of a linear trend analysis for the entire period of record and for the subsets of data collected prior to and post 1976. There is a statistical significant positive trend in the dataset collected between 1935 and 2017 (p-value<0.05). If the dataset is broken up into two subsets of data collected pre- and post- 1976 there are no statistically significant trends (p-values>0.05). The frequency of high precipitation years, where annual totals are at or above 35 inches, increases dramatically in the latter half of the precipitation record, occurring in one-quarter of the years after 1976, but less than one-tenth of the first 37 years of the record. Conversely, drought years (precipitation < 20 inches) are common before 1976 and rare after.

Table 11: Nonstationarities Detected Using Total Annual Precipitation

Nonstationarities Detected Using Total Annual Precipitation	
Method	Year
Cramer-Von-Mises (CPM)	1976
Energy Divisive Method	1976
Lombard Wilcoxon	1975
Mann-Whitney (CPM)	1976

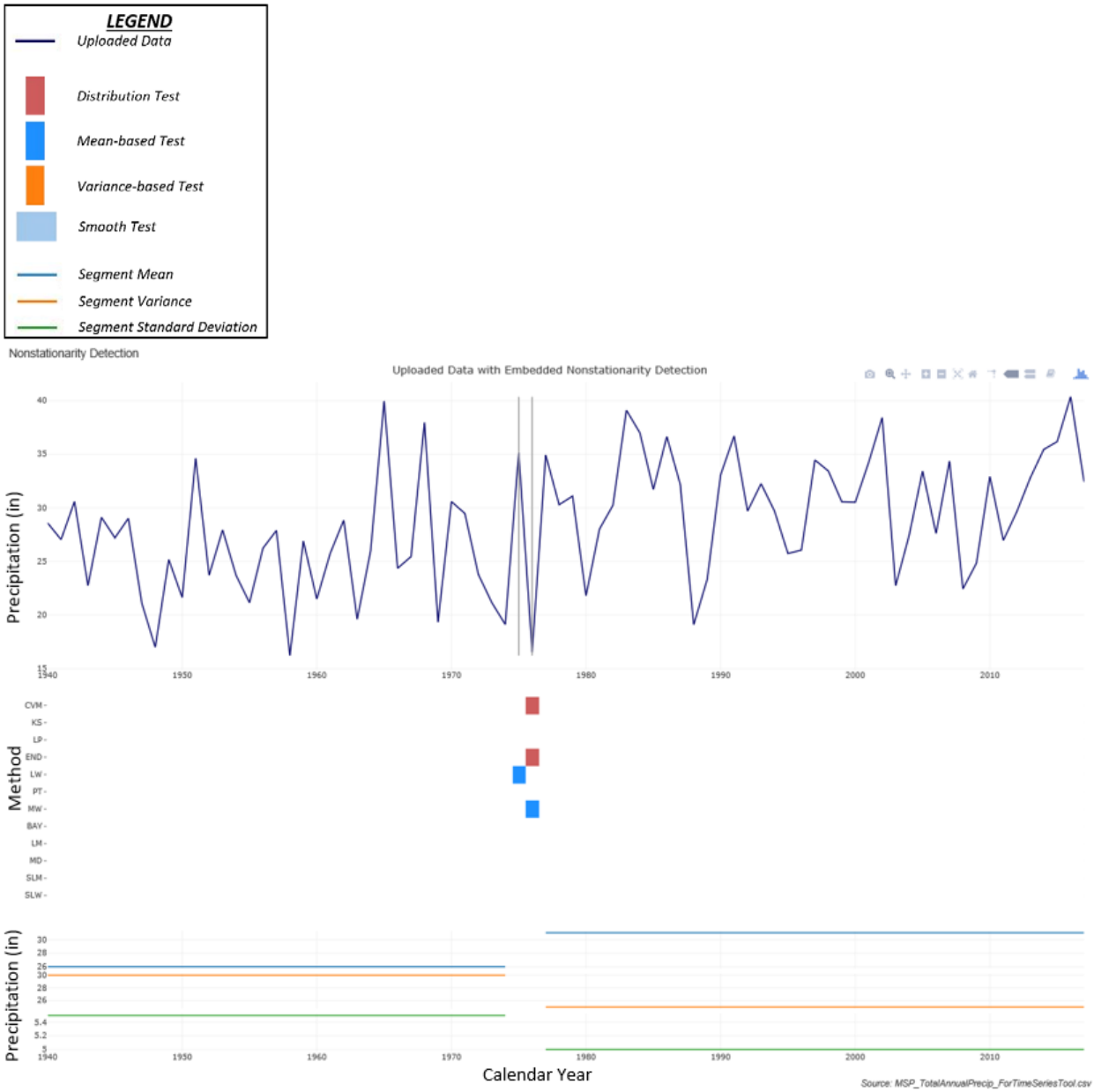


Figure 29: Nonstationary Analysis of Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox

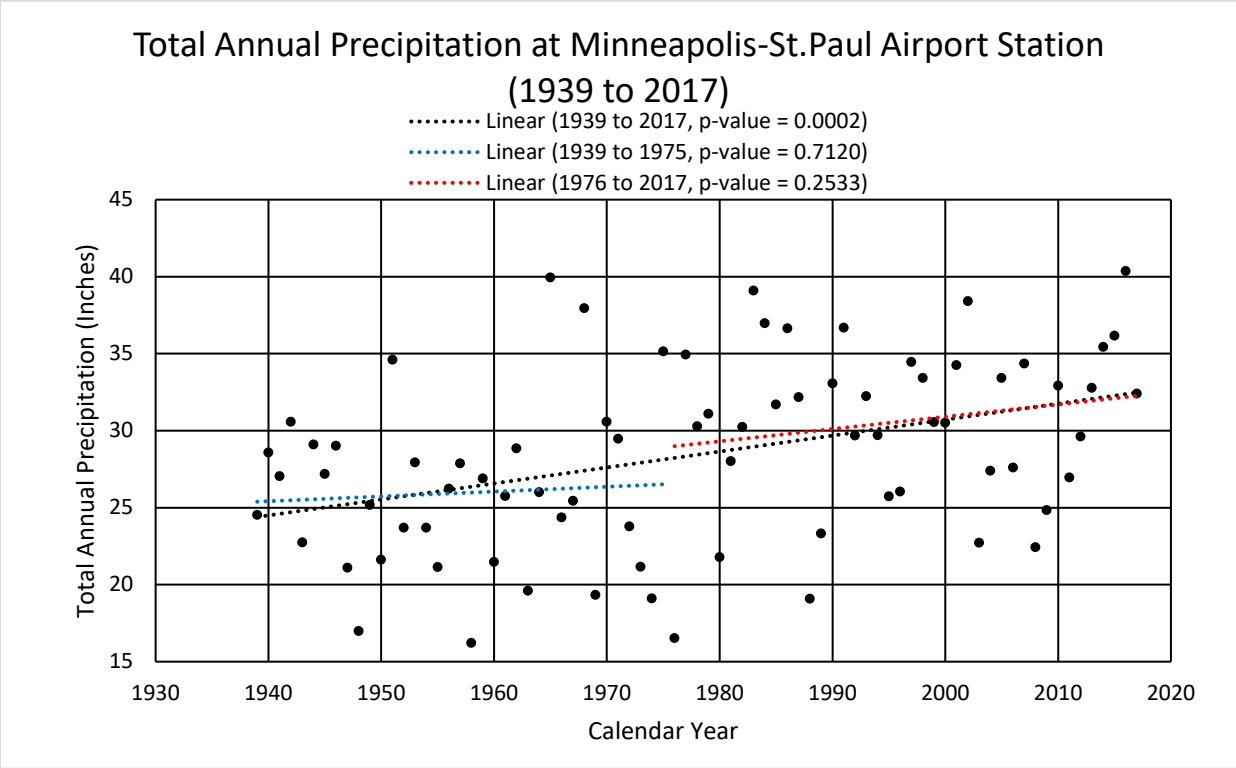


Figure 30: Total Annual Precipitation at the MSP Climatic Gage 1939 to 2017 & Subsets of Data Selected Based on the 1976 Nonstationarity.

5.2.5.2 Air Temperature Nonstationarity Detection Tests

The USACE Timeseries Toolbox application is used to assess the stationarity of the average annual air temperature record recorded by the MSP gage near the Minnesota River Basin. Six of the twelve different nonstationarity detection tests applied by the tool indicate a nonstationarity in 1997 (Table 12 below). The Cramer-Von-Mises (CPM), LePage (CPM), Energy Divisive Method, Lombard Wilcoxon, Mann-Whitney (CPM) and Bayesian tests detect nonstationarities in 1996 and 1997. The year 1997 appeared five times, so this was the year chosen for the breakpoint. Three different statistical tests are indicating a change in mean and three tests are indicating a change in overall statistical distribution. Thus, there is consensus between tests. Because multiple tests, targeting different statistical properties are indicating a nonstationarity it can be considered robust. There is a significant increase in the magnitude of the mean if the data collected pre- and post- 1997 is compared. As shown in Figure 31 below, it can be concluded that there is an operationally significant nonstationarity in the average annual air temperature record at this site (Friedman, *et al.* 2017). Figure 32 shows the results of a linear trend analysis for the entire period of record and for the subsets of data collected prior to and post 1997. There is a statistical significant positive trend in the dataset collected between 1935 and 2017 (p-value<0.05). If the dataset is broken up into two subsets of data collected pre- and post- 1997 there are no statistically significant trends (p-values>0.05). The frequency of higher average air temperature years, where average annual values are at or above 46 degrees, increases dramatically in the latter half of the air temperature record, occurring in 80% of the years after 1976, but only 20% of the first 59 years of the record.

Table 12: Nonstationarities Detected Using Average Annual Air Temperature

Nonstationarities Detected Using Average Annual Air Temperature	
Method	Year
Cramer-Von-Mises (CPM)	1997
LePage (CPM)	1997
Energy Divisive Method	1997
Lombard Wilcoxon	1996
Mann-Whitney (CPM)	1997
Bayesian	1997
Lombard Mood	1994

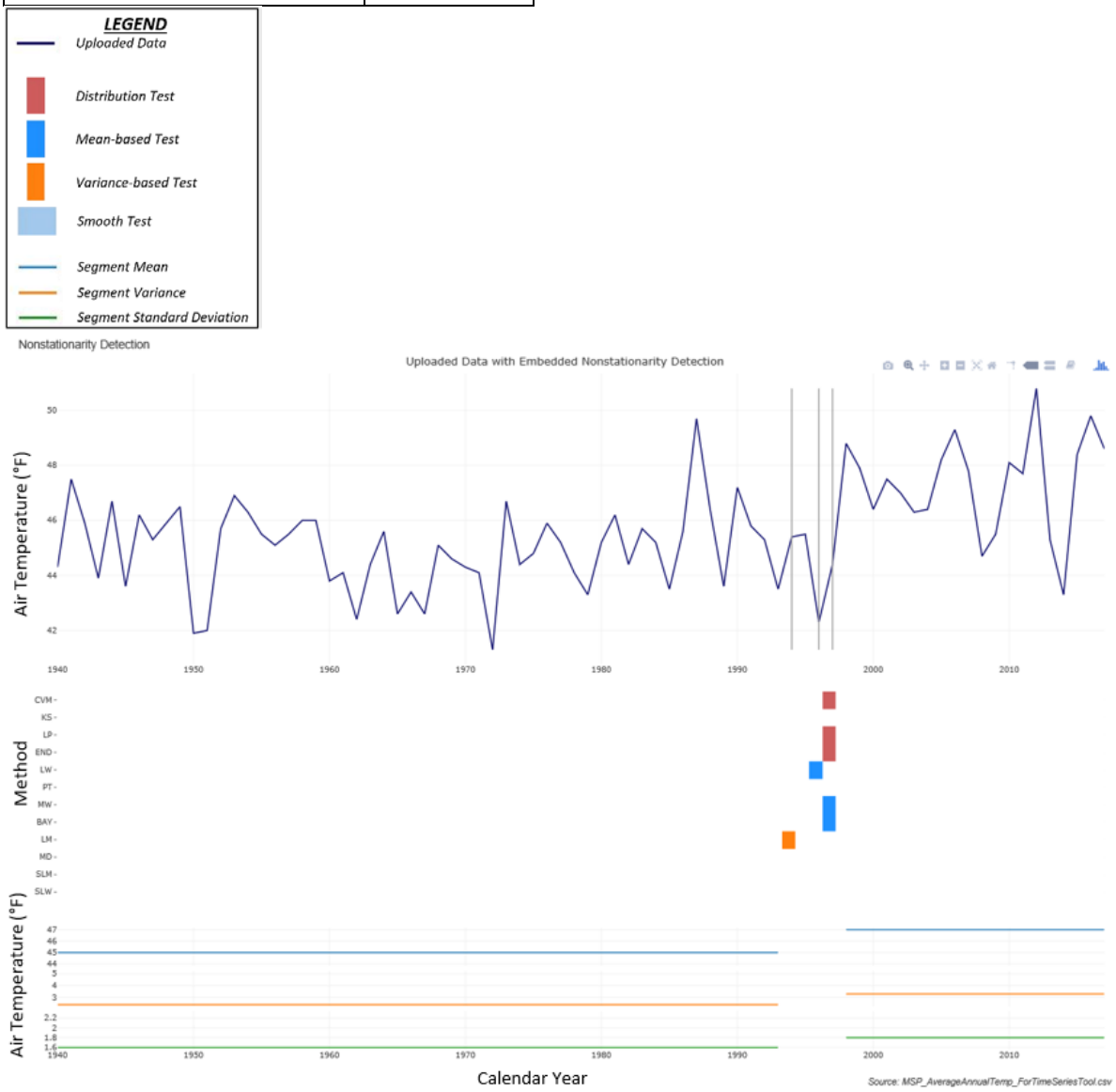


Figure 31: Nonstationary Analysis of Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 using the Time Series Toolbox

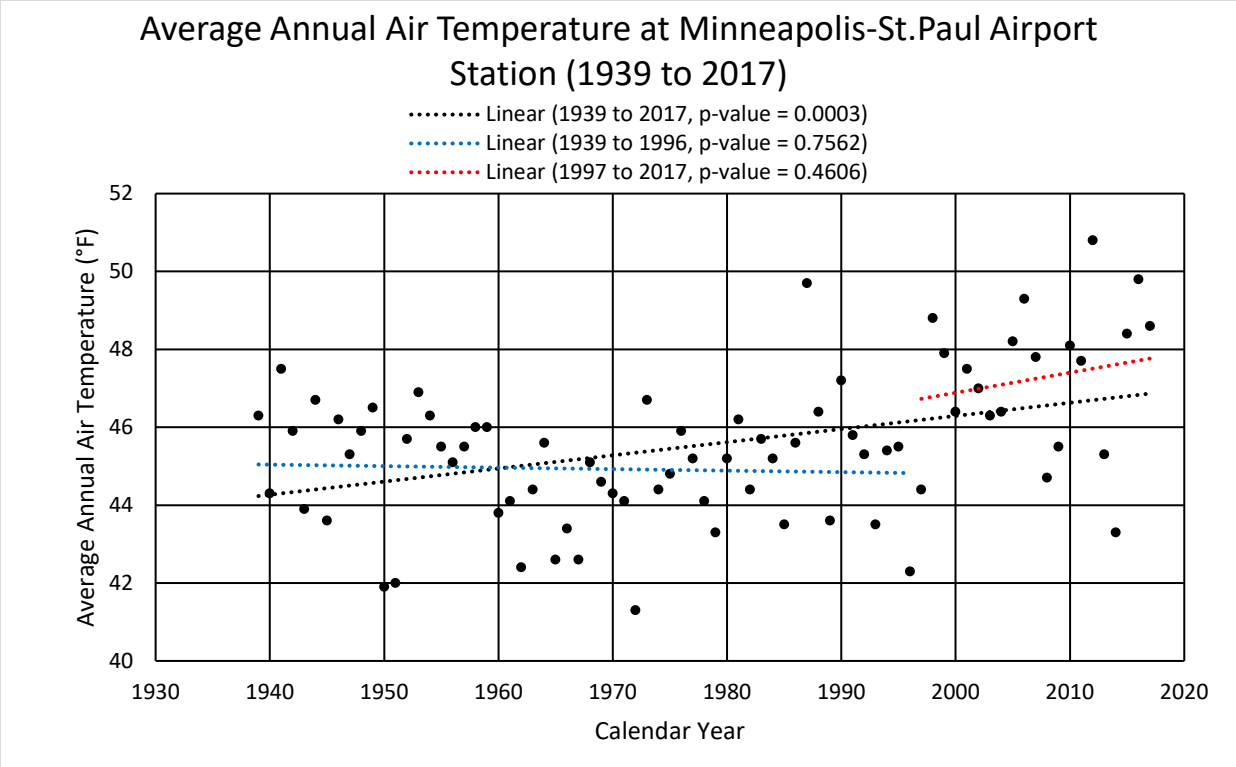


Figure 32: Average Annual Air Temperature at the MSP Climatic Gage 1939 to 2017 with Trend Lines for the 1997 Breakpoint

5.2.6 Discussion of Trends in Historic Hydrometerological Variables

A "strong," statistically significant nonstationarity in annual peak flow is detected circa 1990 and operationally significant nonstationarities in annual mean flow are detected circa 1981 and 1990. Both correspond to an increase in streamflow. A "strong," statistically significant nonstationarity in annual precipitation totals can be observed in the late seventies. An increasing trend in precipitation is observed. The coincident trends in increasing streamflow and precipitation imply that changes in climate are at least partially responsible for changes in hydrologic response. Because increased high and moderate flows have the potential to undermine key project features/functionality and can have a negative impact on migratory bird/ water fowl habitat, the TSP was selected such that it reduces the potential for changes in streamflow/precipitation to negatively impact the study area. This could be accomplished by incorporating additional resilience into project features and including adaptive management principles in habitat management. The potential for temperature increases in the future can compound habitat degradation and further justifies the need for a project that is targeted at improving ecosystem function.

5.2.7 Summary/Conclusion

Despite the USACE Watershed Climate Vulnerability Tool indicating that the Minnesota River watershed is not highly vulnerable to the impacts of climate change on ecosystem restoration or flood risk management relative to other 201 HUC-04 watersheds in CONUS, available climate change literature suggests a wetter and warmer climate in the future. A first order statistical analysis using the USACE Climate Hydrology Assessment Tool, Nonstationarity Detection Tool

and Timeseries Toolbox confirms that overall, observed flows have been increasing and will likely continue to increase in the Minnesota River Basin. Changing flow conditions further justify the need for the proposed project. If no changes are made to the study area, changing flow conditions would make effective drawdowns to support bird habitat difficult to accomplish and would continue to degrade the condition of existing water management features. With the proposed, more robust design of the water management structures, the project will be given the best chance at completing annual drawdowns.

The trends and nonstationarities detected in the annual peak flow and the average annual flow records cannot be attributed to a specific driver like the construction of a water management structure or a known, abrupt change in land use. Thus, trends and nonstationarities are likely caused by a less easily identifiable source like anthropogenic climate change, long-term, persistent natural fluctuations in climate or distributed changes to the basin's land cover/land use/geomorphology overtime.

Historic discharge data at the USGS gage at Jordan, Minnesota indicates a statistically significant trend of increasing average annual discharge ($p<0.05$) with strong nonstationarities detected in the years 1981 and 1990. There is also a statistically significant, increasing trend in annual peak streamflows over the period of record ($p<0.05$) and strong evidence of a statistically significant nonstationarity detected within the peak streamflow record in 1990. Historic total annual precipitation and average annual air temperature also indicate a statistically significant, increasing trend over the period of record ($p<0.05$) and strong evidence of a statistically significant nonstationarity detected in the years 1976 and 1997, respectively.

The high potential for increased river discharge in the future, as is evident within the historic and projected data considered as part of this analysis, was considered during the design of this project. Project features are designed to be able to handle projected changes in climate and hydrology in the basin. The TSP features include 5’x6’ concrete stoplog structures, rocklined overflow channels, a ditch plug, and access roads. The project also includes a dredging plan for the existing channels that connect the structures. The rocklined overflow channels are relief points for the structures. These channels reduce the head differential during flood conditions and protect the structure from erosion/failure. There will be a rocklined overflow channel at each water level management structure. The ditch plug is located at Continental Grain Marsh. It is a rock armored ditch plug with a rock overflow channel as described earlier. The stoplog structures are designed to be larger than the current structures to facilitate more efficient drawdowns. The original goal was to design structures to complete a drawdown in at least 10 days. These structures were overdesigned (size-wise) to enable even faster drawdowns than 10 days and to prevent debris blockage. The structures will be able to draw the lakes down in four days when the adjacent Minnesota River elevation (RM 20) is at or below the full drawdown elevations of the lakes/marsh. The drawdown analysis in Section 8.3.1 explains this in more detail. Channel dredging will be completed to improve hydraulic conveyance to and from the structures. Increasing the capacity of the stoplog structures and channel dredging will enable the structures to quickly draw down the lakes during short breaks in flood events. Access roads to and around the structures will allow the USFWS to maintain conveyance through the structures by removing obstructive debris and sediment.

In addition to design modifications aimed at creating efficient and robust structures tolerant to higher flows, resilience will be built into the proposed project by using lessons learned from successful and stable ecosystem restoration projects all constructed between 1981 and 2015. The majority of lessons learned from these projects are listed in the *Upper Mississippi River Restoration* (*UMRR) Design Handbook*, 2012. However, the handbook has not been updated in

several years and as a consequence, the effects of climate change on restorative features were not directly addressed in the handbook in great detail.

Additionally, increases in flow have the potential to stress project features and make it more difficult to fulfil management objectives in the future. Table 15 summarizes the residual risk due to climate change associated with the proposed project features identified as part of the TSP.

Table 13: Bass Ponds Climate Risks

Feature or Measure	Trigger	Hazard	Harm	Qualitative Likelihood
Stoplog Structures	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes & peaks may occur more frequently	Flood waters may remain in the lake for longer durations making habitat management more difficult. Frequent High flows of longer duration have the potential to damage the structures. Larger floods may increase debris near the structure, potentially damaging the structure.	Moderate
Rock-lined overflow structure	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Flood waters may remain on the rock-lined overflow structures for longer durations, and more frequently, potentially damaging the structures. Increased flood sizes increase water velocities over the structure, potentially damaging the structure.	Moderate
Ditch Plug	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Flood waters may remain on the ditch plug for longer durations, and more frequently, potentially damaging the structure. Increased flood sizes increase velocities over the structure, potentially damaging the structure.	Moderate
Access Dredging	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Increased flood events and sedimentation in the Minnesota River Basin	Moderate
Access Roads	Increased river discharges and precipitation events	Future flood duration may be longer than present Large flood volumes may occur more frequently	Flood waters may remain on the access roads for longer durations, and more frequently, potentially resulting in impassable roads/ roadway damage.	Moderate

6 Sedimentation

Sediment transport in the project area is affected by upstream sediment loads and channel floodplain-connectivity. Variation in upstream sediment loads occur due to annual patterns of precipitation and runoff, sediment erosion, and off-channel deposition. The majority of the sediment load in the Minnesota River and its tributaries comes from near channel sources such as bluffs, ravines, and channel banks as opposed to upland agricultural field sources (Belmont 2011, Gran 2011). Channel-floodplain connectivity is intermittent, occurring during high water events caused by snowmelt runoff in the spring and rainfall events that can occur anytime during the year. During low flow conditions, sediment is conveyed in the Minnesota River channel and bypasses the lakes in the project area (approximately river mile 15-21). For higher flow conditions, sediment enters the project lakes over the natural levees that separates the lakes from the Minnesota River channel. Overtopping of the natural levee at the project area occurs at discharge of 26,000 to 27,000 cfs (recorded at the USGS Gage at Jordan, MN), which is approximately a 39-percent annual exceedance probability (AEP) flood.

Bank erosion is occurring throughout the lower Minnesota River with significant channel widening observed over time. Lenhart et al. (2013), using aerial photographs, found that the Minnesota River had widened 52% between Mankato and St. Paul since 1938. A comparison of channel surveys completed between 2012 and 2014 by USACE personnel to earlier cross sections (circa. 1970 – 1990) for the lower 100 miles of the Minnesota River (approximately Mankato, MN to the mouth) indicated both reductions and increases in width (range = 158 feet reduction to 246 feet of increase). Overall, channel width had increased by 40 to 50 feet. Because of the uncertain vintage of the earlier cross sections, an average rate of widening could not be determined. Longitudinally, consistent channel widening occurred over the lower 55 miles of the river (approximately Belle Plaine, MN to the mouth), with more variability (primarily widening, but some narrowing) upstream of this. This geomorphic response, bank erosion, seems to correspond with the increase in average annual discharge during the period of record that was discussed in section 2.2.4 (Figures 21 and 22). If annual discharge continues to increase, more bank erosion can be expected. However if annual discharge stabilizes at the higher levels they are at now, future bank erosion may decrease though the time scale for achieving this is uncertain. Over a period of decades, channel enlargement in response to an increase in runoff may be self-limiting; the channels gradually adjust their size to a regime of larger floods (Gran et al., 2011).

While channel bank erosion is a significant source of sediment, the Lower Minnesota River from Jordan (RM 39.4) to the mouth is a net sink for sediment and nutrients (Groten et al. 2016, Lenhart 2013, James 2008). Groten et al. (2016), based on total sediment load measurements, estimated reductions from 289 tons/year/sq mi at the Jordan, Minnesota gage to 100 tons/year/sq mi at the gage at Ft. Snelling, Minnesota at the mouth of the river. Breaking this down by sediment size, fine sediments were reduced by 1.3 million tons per year and sand size sediments were reduced by 0.12 million tons per year from Jordan to Ft. Snelling. Part of the reduction in sand is due to the dredging that is done on the navigable reach of the Minnesota River (river miles 0 to 14.7) which had an average value of 20,000 cubic yards per year (0.026 million tons per year) for the years 1995 to 2017 (USACE Dredging Data). Dredging is variable from year to year, shows no upward or downward trend, and amounts to approximately 20-percent of the sand size sediment load reduction between Jordan and Ft. Snelling.

The lower Minnesota River is impaired for turbidity and is the subject of significant study and research by various government agencies and academia. A large amount of sediment data exists, however most of it is total suspended solids or turbidity data. An exception is the USGS

gage at Mankato, Minnesota which is located 50 miles upstream of the project area. From 1968 to 1995, the USACE – St. Paul District provided funds to the USGS for the collection of water samples to determine the suspended sediment concentration (SSC) at this gage. The mean SSC at this gage was 166 mg/L over this time period. The Mankato data indicates that SSC, while variable, had not increased during this time period, but that suspended sediment loads had increased due to the fact that there was an upward trend in river discharge. The more recent 2011 to 2014 sediment measurements (Groten et al. 2016) indicates a mean SSC of 194 mg/L at Mankato, 274 mg/L at Jordan, and 222 mg/L at Ft. Snelling State Park. While the Bass Ponds project is not intended to change water quality on the Minnesota River, it is noteworthy that sediment concentrations are high enough to affect light penetration during flood events.

Fine sediments enter Blue, Fisher and Rice Lake over the natural levee during flood events. All three lakes are depositional, though localized erosive conditions can occur at the connecting channels between the lakes and the river and in places where infrastructure (e.g. roads & trails) cause higher velocities. Estimates of sediment deposition rates using different methods or from different studies are given in Table 14 below.

Table 14: Floodplain Sediment Deposition Estimates on the Lower Minnesota River Based on Four Different Methods or Studies

Method or Study	Description	Deposition Rate
Existing Rice Lake Inlet Channel Analysis	A comparison of existing conditions bathymetry to as-built drawings for the Rice Lake HREP dredge channel (construction completed in fall 1998) indicates about 0-6 inches of deposition from the structure to about 150' into the lake. The deposition increases to be more than 6" from 150' to the end of the dredge cut. If it is assumed that 6 inches of sediment accumulation occurred over the 20 year time period since project construction the annual deposition rate would be 0.3 inches/year (0.76 cm/year).	0.3 inches/year
Lenhart et al., 2014	In a recent study that used soil forensics to distinguish post-European settlement alluvial sediments from earlier deposits, mean deposition rates in channel boundaries (the natural levee) were estimated to be 0.80 cm/year, and then decreased with distance from the river bank having a mean rate of 0.17 cm/year in areas farther from the channel (Lenhart et al. 2013). These areas farther from the channel are typical of much of the project area and several of the study sites were near the project area.	0.07 inches/year
Jennings et al., 2018	Sediment cores obtained in backwater lakes several miles upstream of the project area were analyzed for fossil pollen and non-pollen microscopic fossils and were then correlated to major ecological shifts as indicated by pollen assemblages to dated horizons in nearby lakes (Jennings et al., 2018) The results indicate sediment deposition rates of 1.4 cm/year for the 1993 to 2018 time period, though the authors state that additional analysis including actually dating the cores needs to be done to reduce uncertainty in the deposition rates.	0.55 inches/year

Sediment Load Changes based on Groten et al, 2016	The USGS sediment monitoring that was done at Jordan and Ft. Snelling indicates that approximately 1.3 million tons per year of fine sediment deposited in the floodplain for each year from 2011 to 2014. If this sediment load was assumed to settle out uniformly in the floodplain with the channel corridor taken out of this area and if the deposits had a density of 80 lbs/ft3, the resulting deposition rate would be 0.38 in/yr (0.98 cm/yr).	0.38 inches/year

Future geomorphic change in the project area will continue to include bank erosion and off-channel sediment deposition - the magnitude of these processes depending on long-term hydrologic conditions. The first order statistical analysis presented earlier in Section 5.2 indicates statistically significant increasing average annual discharge since the mid-1930s and projected increases in flows during the project life of 50 year. However, the nonstationarity detection tests indicated statistically significant nonstationarities in 1990 and 1980 - 1982. Trend lines fitted to these shorter time periods do not indicate statistically significant upward trends, however the fact that the nonstationarities exist creates some uncertainty regarding Future Without Project Conditions. If river discharge trends are flat in the future, erosion of river banks and mobilization of sediment from other near channel sources will probably continue, though the river may reach dynamic equilibrium if discharge does not increase. If river discharge increases, additional bank erosion, overbank flooding, and sediment deposition in the lakes will occur.

Using the average sediment deposition rate of the four values in Table 14 (0.325 inches/year) and the maximum value (0.55 inches/year), a total of 16.25 and 27.5 inches of net deposition would occur over the next 50 years, respectively. The channels will be dredged to 692.5 feet which means post-net deposition results in channel inverts increased to between 693.9-694.8 feet. The full drawdown elevations range from 695-696.2 feet for the lakes/marsh. This suggests that project features such as the control structures and channel dredging should be effective for the entire project life.

7 Hydraulics

The hydraulic stressors affecting the Bass Ponds project area include high and increasing hydraulic connectivity (i.e. the amount of water conveyed) between the lakes and river channel, and an altered water level hydrograph.

7.1 Future without Project

Based on observation of existing structures in the project area, the existing structures are predicted to deteriorate within the next 50 years. The corrugated metal pipe culverts that are currently in place will rust and collapse. The Fisher Lake outlet structure is already collapsed which has caused erosion of the natural levee separating the lake and adjacent holding pond. The flow path has now diverted through a holding pond and outlets through an eroded DOT culvert/ditch with exposed fiber optic cable. This eroded DOT culvert/ditch is expected to continue to widen in the next 50 years.

The increased duration of full lake pool due to inefficient/inoperable water level management structures will continue to occur more often according to the climate change and major flooding analysis. This full lake pool results in poor emergent and submergent vegetation for migratory birds.

7.2 Flood Stage Impacts

Flood stage impacts due to proposed project features will be unchanged. The proposed features are in the existing features' footprint and control elevations are at or below the existing topographic/built elevations. Table 15 below compares the current top of water level management structure/road elevation to the proposed structure elevation. The proposed O&M maintenance roads will be constructed by removing existing in situ material and then adding the road materials up to the existing, in situ topographic elevations to ensure flood risk is not increased. The Continental Grain Marsh plug will be constructed to be even with adjacent land elevations at approximately 700.5 feet NAVD 88. The Continental Grain Marsh rocklined overflow structure will be constructed lower than the plug and adjacent, natural low land features at approximately 699 feet (NAVD 88). By designing project features to be at or below the current adjacent topography flood stages will not be increased by the project.

Table 15: Flood Stage Impacts: Existing and Proposed Structure

Flood Stage Impacts: Existing and Proposed Structure		
Structure Location	Existing Top of Structure	Proposed Top of Structure
	Elevation (Feet - NAVD 88)	
Blue Lake Outlet	708.1	700
Interlake (Blue-Fisher)	702	702
Fisher Lake Outlet	701.4	701
Rice Lake Outlet	704.6 (Top of Access Road)	704.6
Secondary Outlet (Fisher-Rice)	701	701
Continental Grain Marsh Outlet	701.5	701.5
Continental Grain Marsh Rock Overflow	700.5	699.0

7.3 Ground Water

USFWS have reported signs of groundwater inputs into the lakes/marsh especially Blue Lake and Continental Grain Marsh. The MNDNR spring inventory shows springs in Eagle Creek (east of Rice Lake). However, the dataset shows no springs effecting the project lakes. Figure 33 below shows the spring inventory dataset near the project area (spring data point shown in blue). There are probably other groundwater inputs that might have a small localized impact on water quality during low flow conditions, but during high flow events, the amount of river water that enters the lakes is orders of magnitude greater than groundwater inputs. Due to lack of data for the project area, groundwater is an unknown and was kept in mind during design.

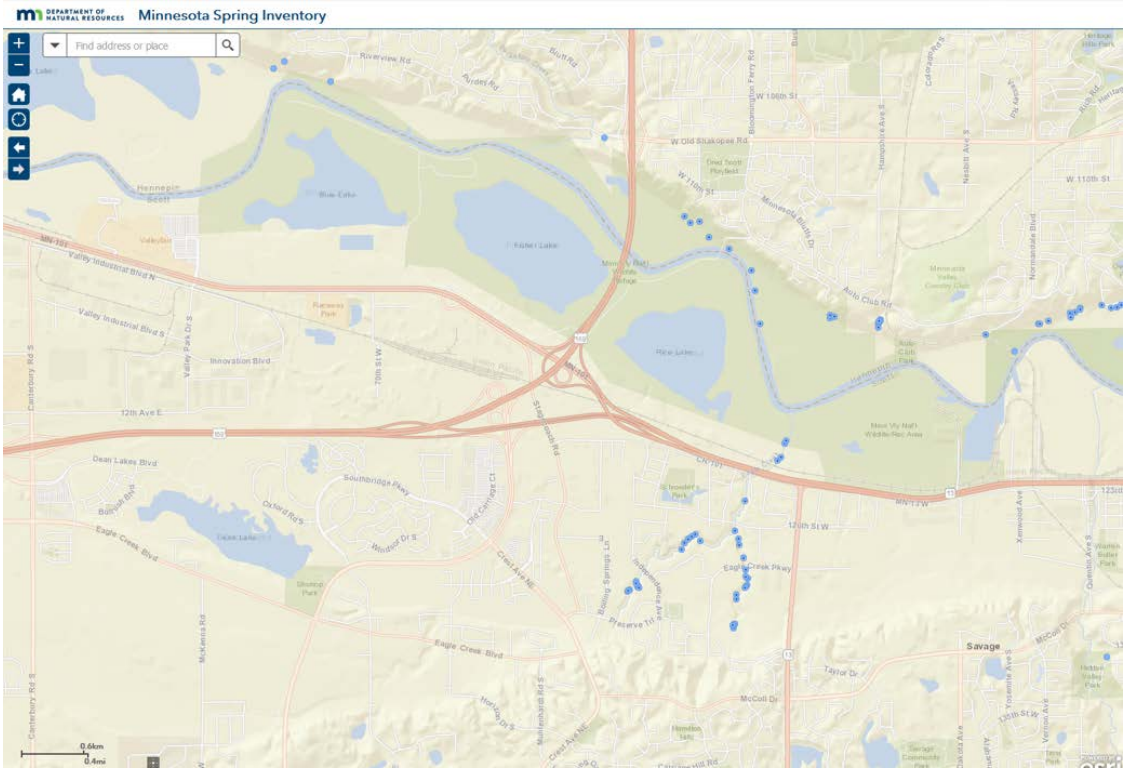


Figure 33: MNDNR Minnesota Spring Inventory for the Bass Ponds Project Area

8 Hydraulic Modeling/Design

Two-dimensional modeling was done using HEC-RAS (Hydrologic Engineering Corps Center – River Analysis System Version 5.0.4). The HEC-RAS model was used for multiple project components:

- To simulate the effects of the project on the observed 2012 and 2013 data from the Minnesota River USGS Gages at Jordan and Savage, MN.
- To compare existing structure staff gage data for the years 2012 and 2013 from the USFWS to the model results
- To estimate the maximum drawdown speed for the proposed structures.
- To complete an approximate frequency analysis for major flooding at the project area.
- To complete an approximate frequency analysis for the drawdown potential at the project area.

Modeling was completed throughout the planning stage to refine the project features. The culvert sizing was decided by maximizing the efficiency of the drawdown times. Three other scenarios were simulated using gate operations in HEC-RAS to better define the project's water level management capabilities.

This model is not calibrated and was only used for conceptual simulations. When simulating the 2012 and 2013 event, the relationship between the river and the lakes was of interest not specific values. The drawdown speed was modelled in a way that the lakes were independent

from the river, so calibration was not needed. The frequency analyses for major flooding and drawdown potential are approximate to reiterate the project relevance and potential to achieve the project goals and objectives. The project is fairly close to Savage Gage, so the river water surface elevation profile should not be considerably off.

8.1 HEC-RAS Inputs

The HEC-RAS model is a fully 2D model that uses storage areas to model the lakes, storage area connections to model the propose structures, gate operations to model the stoplog operations and a 2D area mesh encompasses the remainder of the Minnesota River basin spanning from Jordan, MN and Savage, MN. The model boundary conditions are stage hydrographs from USGS gages on the MN River. The upstream boundary condition discharge hydrograph uses observed data from the USGS Gage at Jordan (converted to NAVD 88 from NGVD 29). The downstream boundary condition stage hydrograph uses observed data from the USGS Gage at Savage (converted to NAVD 88 from MSL12). US Fish and Wildlife Service (USFWS) staff gage data at Blue, Fisher and Rice Lake is available for the years 2012-2014. The 2012 and 2013 observed gage data at Jordan and Savage, MN was used for the May-October timeframe. Figure 35 shows the HEC-RAS geometry terrain and significant features of the model.

Though the river is the main contributor to the inundation of this system, precipitation was also gathered for this model to reflect a real-time situation. Precipitation was pulled from the USACE MVP water control site in grid form. The precipitation was then converted to table form with hourly precipitation data in inches.

The Blue Lake Waste Water Treatment Plant (WWTP) is located on the south end of Blue Lake that facilitates the discharge of groundwater from the modified wastewater treatment plant dewatering system (MNDNR Permit 2000-6095). The dewatering system typically discharges to Blue Lake as requested by USFWS, but can discharge to the Minnesota River if so directed by USFWS. Flow rates represented as millions of gallons per day (MGD) for the system is listed in Table 16 below. The WWTP average daily flow value of 5.44 MGD discharging into Blue Lake was used in the model.

Table 16: Wastewater Treatment Plant Input Values into Blue Lake

Condition	Flow Output (MGD)	Flow Output (cfs)
Typical river stage	1.45	2.69
10 year flood condition	17.38	32.29
Peak 100 year flood condition	40.45	75.16
Average daily flow	5.44	10.11

Accurate terrain and land cover data is essential when completing a 2D model. Bathymetry and assumed dredge cuts were added to the LiDAR data set to create an accurate and complete terrain dataset. Minnesota River cross sections surveyed in the years 2013 and 2015 were used for the Minnesota River channel bathymetry (see Figure 34 below). Lake Bathymetry was collected for all three lakes (Blue, Fisher and Rice) at the end of May, 2018 and is included in the terrain as well. Assumed structure dredge cuts were added to the terrain at the design elevation of 692.5 feet (NAVD 88).

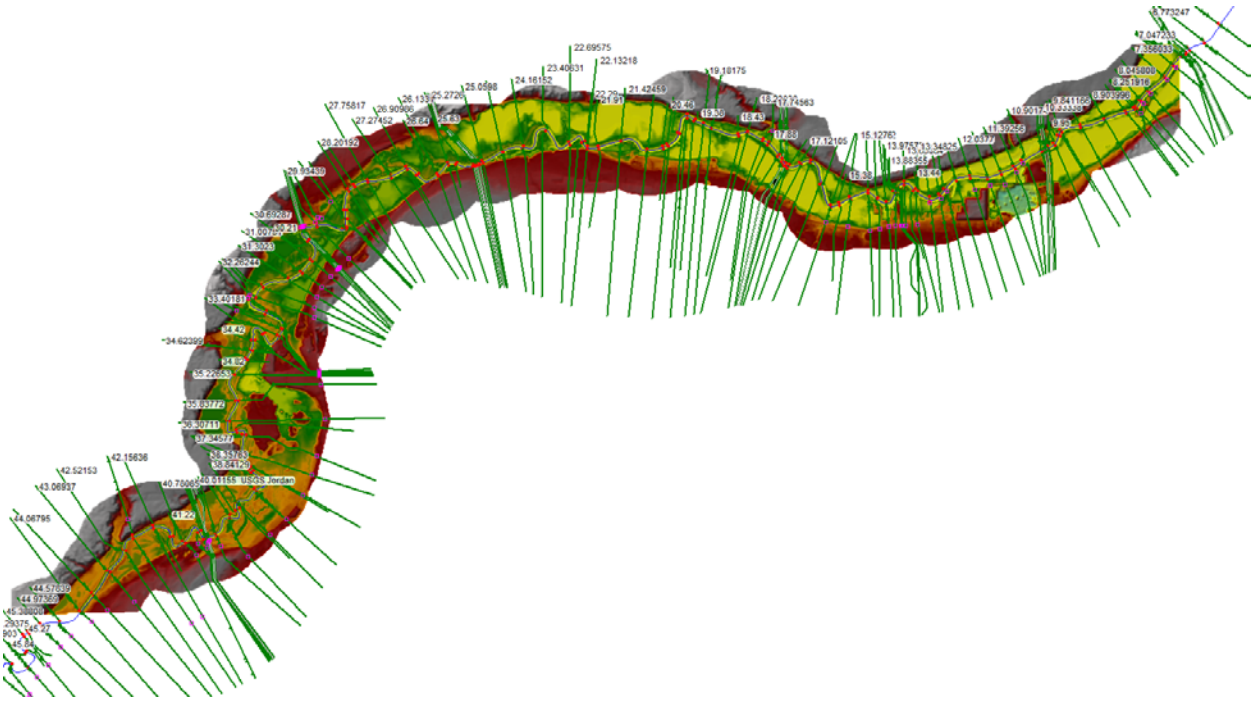


Figure 34: Minnesota River Cross Sections with Channel Bathymetry Surveyed in 2013 and 2015

The land cover dataset used was from the National Land Cover Database (NLCD 2011). The Manning's n values for each land type can be viewed in Table 17 below. As mentioned earlier in the report, the model was not calibrated which means these Manning's n values were not adjusted from the NLCD data. A sensitivity analysis using the Manning's n values could have been completed to assess the effect on the model of roughness values. At this time, a sensitivity analysis has not been completed. The relationship between the lakes and the river was of interest rather than specific water levels, so it was decided that a sensitivity analysis would not change the TSP. The main driver for the TSP was the model run "Normal Drawdown Operation River Receded Event" (Section 8.2.1). In this model run, the river and surrounding area is a non-factor to the drawdown time results of the lakes.

Table 17: HEC-RAS Input - NLCD Land Type Manning's n Values

NLCD Land Type Manning's n Values	
Land Type	Manning's n
barren land	0.030
cultivated crops	0.055
deciduous forest	0.170
developed, high intensity	0.065
developed, low intensity	0.050
developed, medium intensity	0.050
developed, open space	0.035
emergent herbaceous wetlands	0.070
evergreen forest	0.160
grasslands/herbaceous	0.070

mixed forest	0.190
open water	0.028
pasture/hay	0.060
shrub/scrub	0.100
woody wetlands	0.080

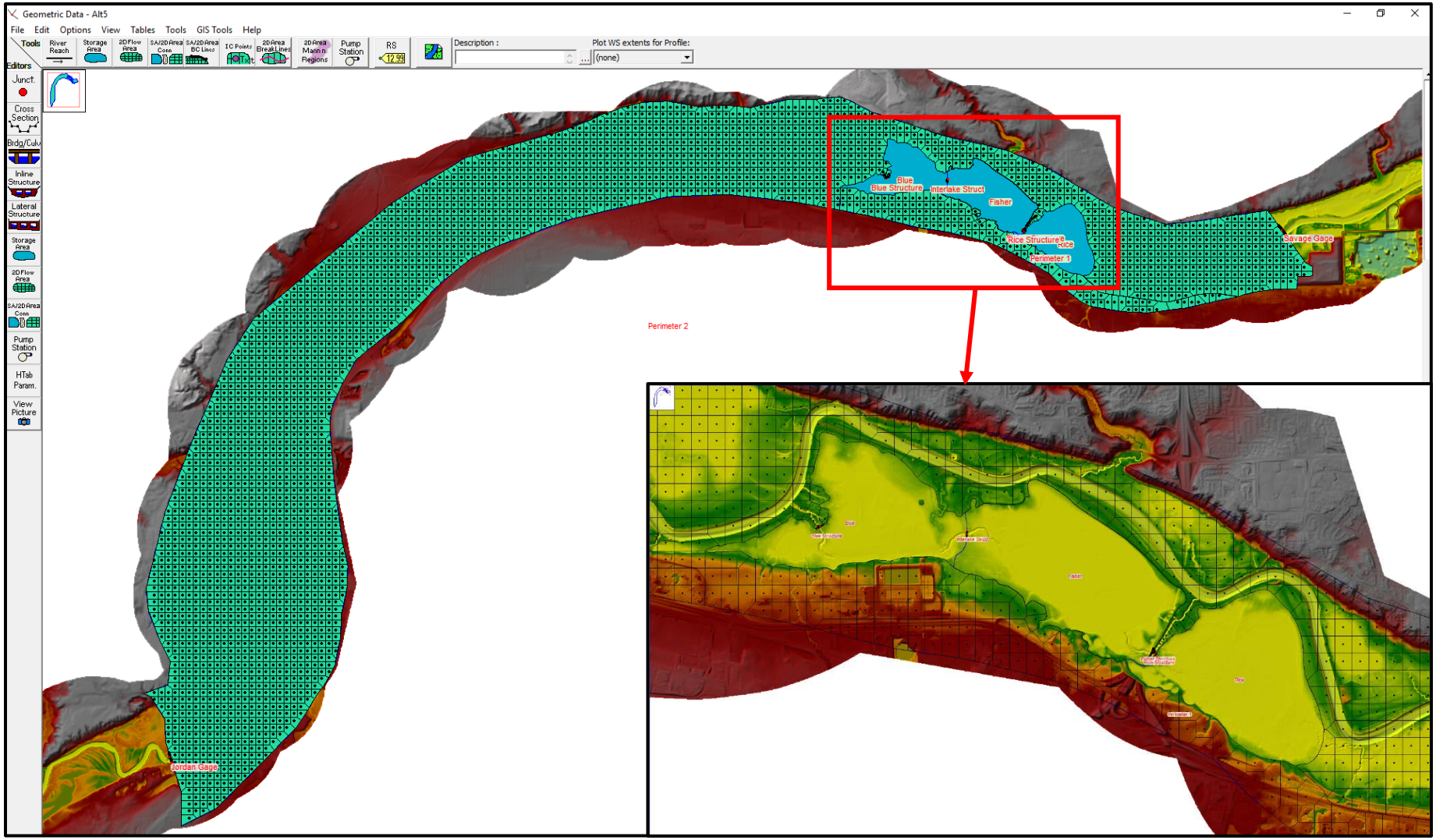


Figure 35: HEC-RAS 2D Model Layout

8.2 HEC-RAS Results

8.2.1 Blue, Fisher and Rice Lake Results/Operation

The drawdown period is defined by the lakes receding to the full drawdown elevation from its optimal pool elevation. The pool elevations were defined by the total percent of project area with surface water present. The surface water percentage goals for each pool condition is listed below.

- Optimal Pool: 80% of the project area is inundated
- Partial Drawdown: 50% of the project area is inundated
- Full Drawdown: <10% of the project area is inundated

The optimal pool, partial pool and full drawdown elevations were determined using historic staff gage data at the existing structures, LiDAR, bathymetry, imagery and USFWS operating goals. The optimal pool elevation is defined as the water surface elevation/depths that produce the most optimum habitat according to the USFWS goals. The optimal pool, partial drawdown and full drawdown elevations for the lakes are listed in Table 18 below. The volume of water discharged from the optimal pool elevation to a full drawdown elevation can be observed in Table 19. The bathymetry map with the optimal pool, partial drawdown and full drawdown elevation inundation areas can be observed in Figure 36.

Table 18: Lake Condition vs Lake Elevation

Lake Conditions vs Lake Elevation (NAVD 88)			
Condition	Blue Lake (ft)	Fisher Lake (ft)	Rice Lake (ft)
Optimal Pool	698.3	698.3	697
Partial Drawdown	697.4	697	696
Full Drawdown	696.2	696.2	695

Table 19: Volume of Water Discharged during Full Drawdown Scenario (Optimal Pool to Full Drawdown Elevation)

Volume Discharged during Full Drawdown Scenario		
Lake	Volume (acre-ft)	Volume (cubic feet)
Blue	173	7,523,763
Fisher	413	17,979,644
Rice	282	12,267,253

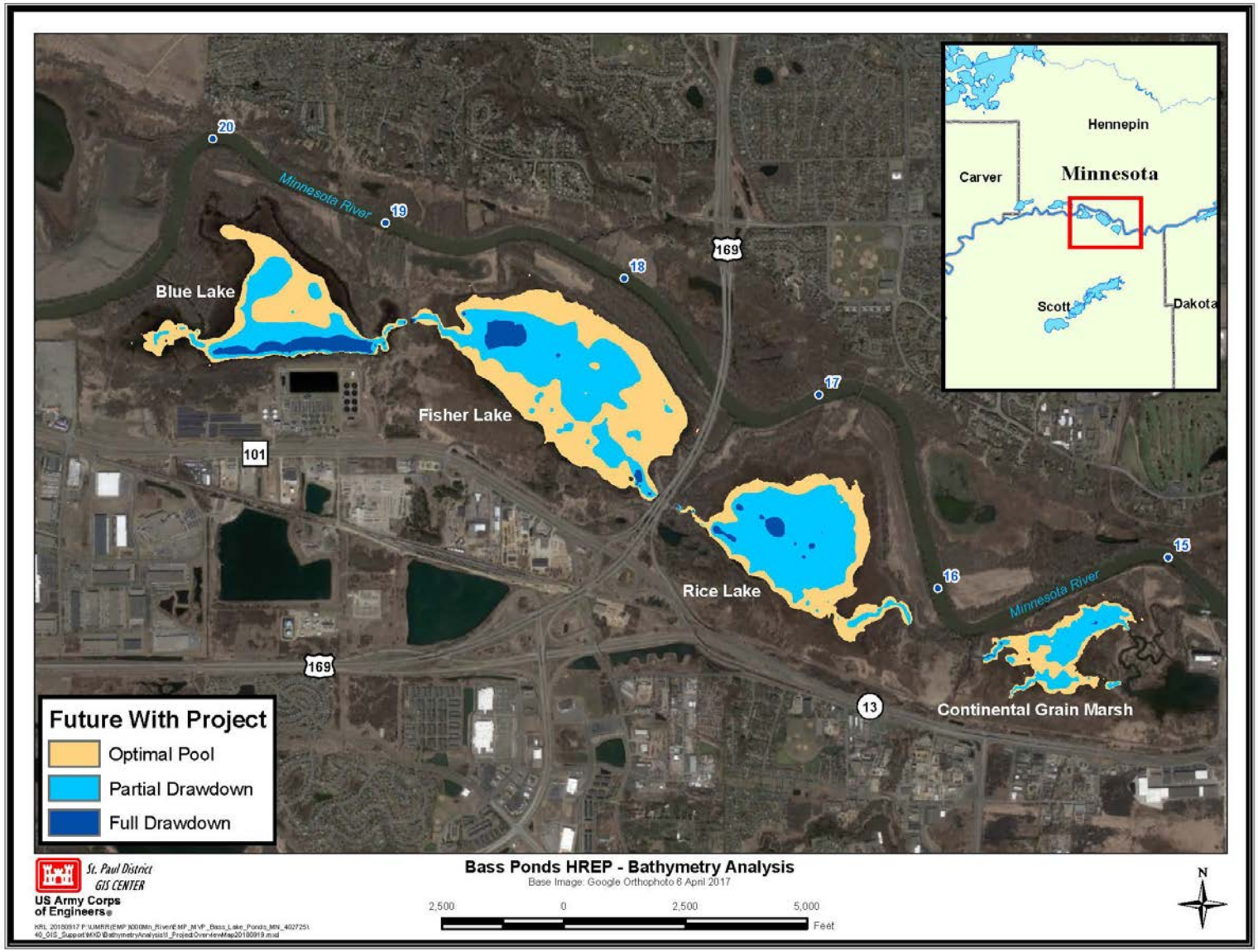


Figure 36: Bathymetry Map with Respect to Operating Conditions

There were five scenarios explored using HEC-RAS. These scenarios are listed below.

- Normal Drawdown Operation 2012 Event
- Normal Drawdown Operation 2013 Event
- Rice Fill Scenario 2012 Event
- Fisher Fill Scenario 2012 Event
- Normal Drawdown Operation River Receded Event

Normal Drawdown Operation 2012 Event
This event simulates the 2012 growing season (May 1st – September 30th). The gate operations of the water level management structures are operated to achieve a full drawdown as early and often as possible, so all gates remain open until a drawdown is achieved. A typical stoplog operation for a drawdown in the model is listed step-by-step below. This particular year, a full drawdown is achieved mid-May for approximately 10 days and in July for 30+ days. The drawdown time is dominated by the river receding rates. The river receding rate and lake drawdown rate are both approximately 6 inches per day. The 2012 growing season experienced no major flooding events and was a relatively moderate growing season (greater than 26,600 cfs at the Jordan, MN gage).

1. Wait for river level to drop to below structure channel (692.5 feet)
2. Remove stoplogs in all structures EXCEPT the Interlake Structure, so the water in the lakes can discharge to the full drawdown elevation
3. Replace all stoplogs to prevent backflow from the Minnesota River

Normal Drawdown Operation 2013 Event
This event simulates the 2013 growing season (May 1st – September 30th). The gate operations of the water level management structures are operated to achieve a full drawdown as early and often as possible, so all gates remain open until a drawdown is achieved. The stoplog operations for this event are the same as the operations above. This particular year, a full drawdown is achieved in both May and July for 30+ days (two different drawdowns). The river receding rate and lake-drawdown rate are both approximately 9 inches per day. The 2013 growing season experienced a major flooding event of 9 days at the end of June (greater than 26,600 cfs at the Jordan, MN gage).

Rice Fill Scenario 2012 Event
The goal for this scenario is to manipulate the stoplog operations of the Fisher, Rice and Secondary structures, so that Fisher outputs flow into Rice Lake. These stoplog operations are listed below. It is important to note that Blue Lake is not included in the operation because it is operating separately during this scenario. USFWS desires as much flexibility as possible when manipulating the series of lakes, so this scenario was tested hydraulically to ensure it was possible. The 2012 event is used for this simulation. The water surface elevation for all three lakes are shown in Figure 37 below. The step-by-step description of what is happening in the plot is listed in the figure. From Figure 37, this scenario proves to be hydraulically possible with Rice Lake achieving a full drawdown, then being filled using Fisher Lake outputs and finally Fisher Lake achieving a full drawdown.

1. Once the lakes are filled from precipitation and Minnesota River inputs, install all structures' stoplogs at optimal pool elevations (all lakes are at optimal pool).
2. Remove all stoplogs at the Secondary and Rice Structures (Rice Lake full drawdown).
3. Once Rice Lake is at the full drawdown elevation, install all stoplogs at the Secondary Structure (Rice Structure stoplogs still removed).
4. Remove all stoplogs at the Fisher Structure (moving water from Fisher to Rice Lake).
5. Once Rice Lake has achieved the desired elevation, install all stoplogs to prevent backflow.
6. Remove all stoplogs at the Secondary Structure and then remove all stoplogs at the Fisher Structure (Fisher Lake full drawdown).
7. Once Fisher Lake is at the full drawdown elevation, install all stoplogs at the Fisher Structure to prevent backflow.

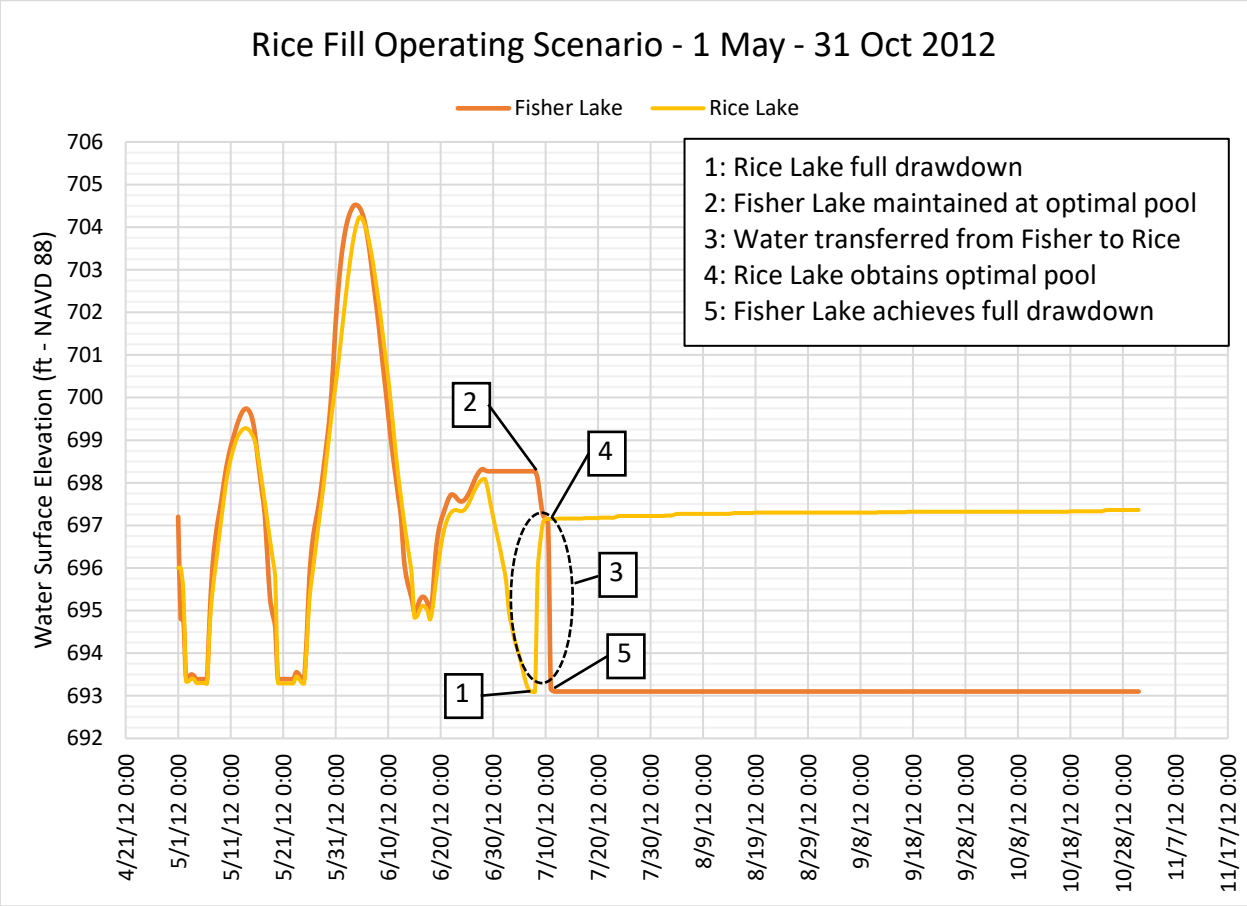


Figure 37: Rice Fill Operating Scenario using 2012 USGS Gage Data

Fisher Fill Scenario 2012 Event

Similarly to the Rice Fill Scenario, USFWS would like the ability to fill Fisher Lake from Blue Lake. This requires testing the stoplog operations in HEC-RAS to determine whether this is hydraulically possible. The stoplog operations of the Blue, Interlake and Fisher structures are

adjusted, so that Blue flow is transferred to Fisher Lake. These stoplog operations are listed below. It is important to note that Rice Lake is not included in the operation because it is operating separately during this scenario. The water surface elevation for all three lakes are shown in Figure 38 below. This scenario proves to be hydraulically possible with Fisher Lake achieving a full drawdown, then being filled using Blue Lake outputs and finally Blue Lake achieving a full drawdown.

1. Once the lakes are filled from precipitation and Minnesota River inputs, install all structures' stoplogs at optimal pool elevations (all lakes are at optimal pool).
2. Remove all stoplogs at the Secondary and Fisher Structures (Fisher Lake full drawdown).
3. Once Fisher Lake is at the full drawdown elevation, install all stoplogs at the Fisher Structure.
4. Remove all stoplogs at the Interlake Structure (moving water from Blue to Fisher Lake).
5. Once Fisher Lake has achieved the desired elevation, install all stoplogs at the Interlake Structure.
6. Remove all stoplogs at the Blue Structure (Blue Lake full drawdown).
7. Once Blue Lake is at the full drawdown elevation, install all stoplogs at the Blue Structure to prevent backflow.

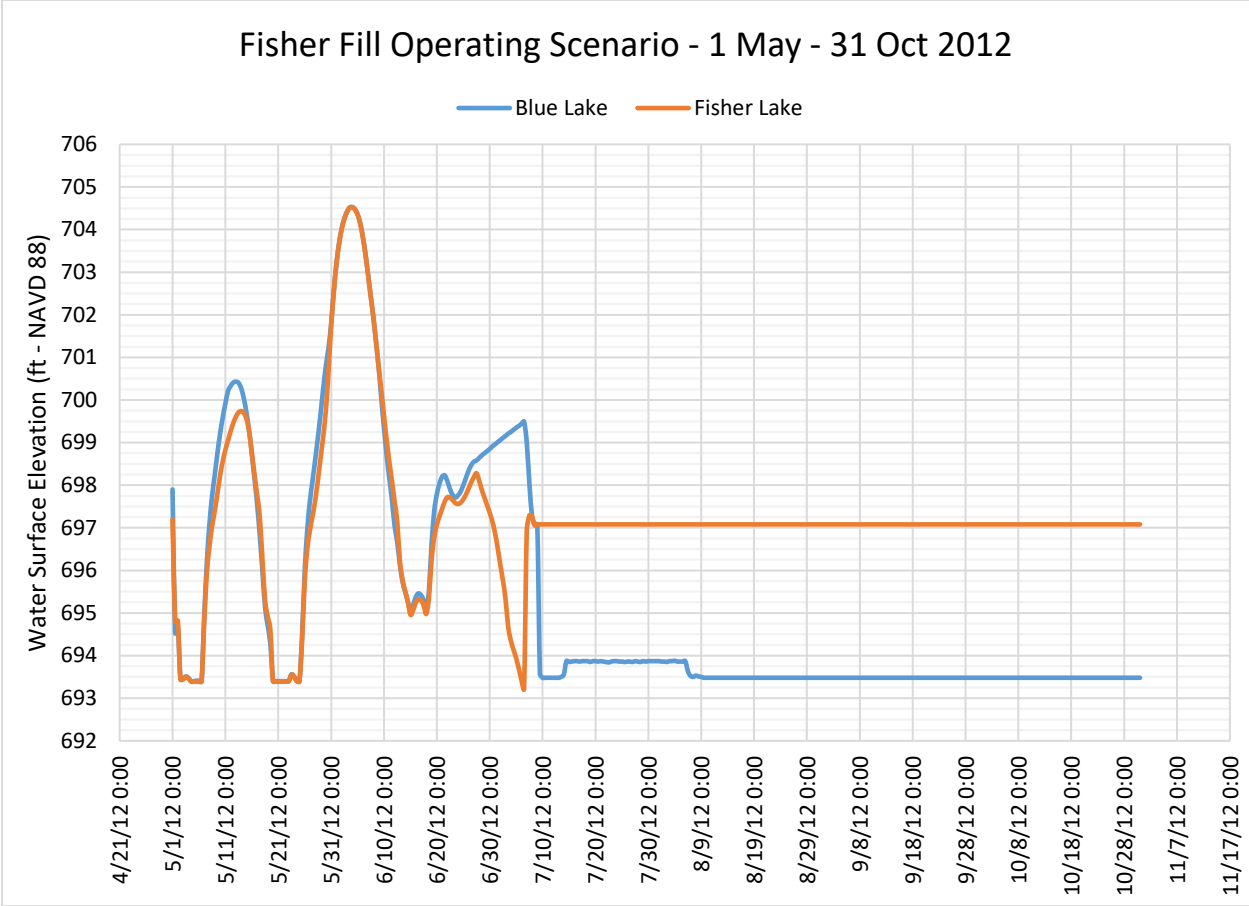


Figure 38: Fisher Fill Operating Scenario using 2012 USGS Gage Data

Normal Drawdown Operation River Receded Event

This event simulated the scenario where the river is already receded and is not affecting the lakes. The HEC-RAS model runs a single in-bank water surface elevation value at the Jordan and Savage gage throughout the simulation. The lakes initial water surface elevations are set at the optimal pool elevation. The drawdown then begins once the HEC-RAS model starts.

The HEC-RAS model results were checked using inlet and outlet control nomographs for concrete box culverts (Hydraulic Design of Highway Culverts FHWA Chart 8B and 15B, 2012) in an excel spreadsheet at 1 hour timesteps. The head differential was needed for the outlet control nomograph. The predetermined headwater value was used with the HEC-RAS corresponding tailwater value to determine the head differential. The TSP geometry in HEC-RAS resulted in slower drawdown times. This is due to the program's ability to take the outlet channel into consideration when running the simulation. The nomograph calculations are independent from the outlet channels. Adjusting the outlet channels in HEC-RAS to a constant slope resulted in a much closer drawdown time to the nomographs results.

The difference between the two geometries shown in Table 20 (HEC-RAS TSP Geometry and the HEC-RAS Channelized Outlets) is the outlet channels to the Minnesota River from the Secondary Structure and the Blue Lake Structure. The TSP geometry does not include any dredging in these two channels because the existing channels are less than 692.5 feet (planned

channel invert of the other structure channels). The channelized outlet geometry assumes these outlet channels to the Minnesota River are a constant slope and a constant width. These channels were burned into the geometry terrain for each geometry. These two geometries were compared to test the effects of the channels in relation to the nomograph calculations.

The drawdown times and max simulation flow values are listed in Table 20 below. Due to the marginal difference in the drawdown times, the Blue and Secondary structure outlet channels to the Minnesota River will not be dredged.

Table 20: River Receded - HEC-RAS and Nomograph Results Comparison

River Receded – HEC-RAS and Nomograph Results Comparison				
Result	Location	HEC-RAS TSP Geometry	HEC-RAS Channelized Outlets Geometry	Nomograph
Drawdown Time (days)	Blue Lake	0.46	0.35	0.29
	Fisher Lake	3.0	1.7	1.5
	Rice Lake	3.7	1.9	1.6
Flow (cfs)	Blue Lake	308	308	350
	Fisher Lake	154	154	175
	Rice Lake	101	101	120

8.2.2 Continental Grain Marsh Results/Operation

The drawdown period is defined by the marsh receding to the full drawdown elevation from its optimal pool elevation. The optimal pool elevation was defined using the current Rice Lake HREP (completed in 1998) rocklined overflow channel invert. This invert of 698.4 feet is the maximum pool elevation of the marsh. The partial and full drawdown elevations were determined using historic staff gage data at the existing structures, LiDAR, bathymetry, imagery and USFWS operating goals. The optimal pool elevation is defined as the water surface elevation/depths that produce the most optimum habitat according to the USFWS goals. The optimal pool, partial drawdown and full drawdown elevations for the lakes are listed in Table 21 below.

Table 21: Marsh Conditions vs Marsh Elevation

Marsh Conditions vs Marsh Elevation (NAVD 88)	
Condition	Continental Grain Marsh
Optimal Pool	698.4
Partial Drawdown	697.5
Full Drawdown	696

The maximum structure drawdown potential was calculated using inlet and outlet control nomographs for concrete box culverts (Hydraulic Design of Highway Culverts FHWA Chart 8 and 15 B, 2012) in an excel spreadsheet at 1 hour timesteps. The maximum structure drawdown potential would occur if the marsh was held at optimal pool until the river receded to below the structure channel invert and then all of the structure stoplogs were removed. The typical stoplog operations for the normal drawdown scenario are listed below.

1. Wait for river level to drop to below structure channel (692.5’)

2. Remove all stoplogs, so the water in the lakes can discharge to the full drawdown elevation
3. Replace all stoplogs to prevent backflow from the Minnesota River

This would result in the fastest drawdown time possible for the structure. The marsh discharges the least amount of water for its full drawdown when compared to the lakes. The results for these calculations can be viewed in Table 22 below.

Table 22: Continental Grain Marsh Drawdown results using Culvert Nomographs

Continental Grain Marsh Drawdown Results		
Max Flow (cfs)	Drawdown Time (days)	Volume Discharged (cubic feet)
185	0.20	3,150,259 (72 acre-ft)

8.2.3 Project Operation Expectations

Blue, Fisher and Rice should be expected to complete the following scenarios when the river allows based on the results discussed above. The typical stoplog operations are listed step-by-step for each scenario.

- Normal drawdown at each lake
- Rice Fill Scenario
- Fisher Fill Scenario

Continental Grain Marsh should be expected to complete a normal drawdown when the river allows and hold water with the installation of the ditch plug.

8.3 Project Feature Potential – Drawdown, Drought and Major Flooding Analysis at Project Area

To assess the project potential and effectiveness, two analyses were completed using the flow record at the Jordan Gage. These two analyses included a major flooding analysis and drawdown analysis. The changing flow conditions of the Minnesota River concluded from the climate change analysis suggested a need to assess the project effectiveness with respect to trends in observed historic data.

This analysis assumes post-construction alternatives, so all TSP features are assumed to be constructed including the robustly designed water control structures. This rough assessment was carried out using, the 2D HEC-RAS model described in Section 8, as well, as the stage-discharge rating curve shown in Section 5.1. The HEC-RAS model results and the rating curve are applied to relate project elevations to discharges at the Jordan USGS gage. Based on the stage to flow relationship, the flow record at Jordan could be assessed to identify instances of critically high stage and prolonged durations of high stage, as well as to evaluate drawdown potential within the study area for the period of record at the Jordan gage (1935-2018). This analysis is approximate and was only used to assess the project feature's potential to meet study objectives based on how the proposed project would have performed historically.

8.3.1 Critical Flow Equivalencies – Minnesota River at River Mile 20 versus Jordan, Minnesota

The quickest, most efficient drawdown time occurs once the Minnesota River recedes to an elevation 696.2 feet in the study area (River Mile 20). The drawdown elevation analysis is based on the assumption that in order for the lakes/marsh (Blue Lake, Fisher Lake, Rice Lake and Continental Grain Marsh) to complete a drawdown with maximum efficiency, the Minnesota River flows/stages have to be low enough to allow for Blue Lake to be drawdown. This elevation was assumed valid for the entire project area (including Continental Grain Marsh) due to the similar full drawdown elevations listed in Table 18 (lakes) and Table 21 (marsh). Please note that Rice Lake has a full drawdown invert of 695 feet rather than 696.2 feet. Due to the variability in elevation throughout the project area and the flow at the gage and the approximate nature of this analysis, using a Minnesota River elevation of 696.2 feet as the maximum allowable elevation to facilitate full drawdown was decided to be sufficient for Rice Lake as well.

When the water control structures are completely closed, flows from the Minnesota River begin flowing into the Blue, Fisher and Rice Lake study area via overtopping at the Blue Lake Control Structure at elevation 700 feet. A Minnesota River elevation of 700 feet at this location (RM 20) results in a loss of operating control. Continental Grain Marsh receives river discharges when the Minnesota River stages exceed 698.4 feet. This elevation is the Rice Lake HREP Rock Overflow structure invert (constructed 1998). A Minnesota River elevation of greater than 698.4 feet at this location (RM 15.5) results in a loss of operating control at the Continental Grain Marsh.

Using LiDAR and survey data, it was estimated that major flooding at the project area occurs when the western natural levee at Blue Lake is overtopped. This occurs when the Minnesota River stage at Blue Lake (River Mile 20) reaches approximately 704.5 feet NAVD 88. At this river stage, the natural levee between Blue and Fisher, the Fisher-MN River natural levee, the natural levee between Fisher and Rice, the Rice-MN River natural levee, the natural levee between Rice and Continental Grain Marsh and the Continental Grain Marsh-MN River natural levee are overtopped. At this elevation, the entire project area is essentially underwater and experiencing sheet flow. Figure 39 below shows the inundation area at the project location when the river stage at river mile 20 reaches 704.5 feet.

Once these elevations were established for the project location, these elevations were related to corresponding Minnesota River stage elevations at the Jordan Gage. An average river stage at Jordan was then converted to a flow discharge at Jordan using the rating curve in Figure 13. An approximate annual exceedance probability based on the discharge-frequency data in Table 2, above was also related to these discharges. These relationships are listed in Table 23 below.

Table 23. Period of Record Analysis Conditions

Period of Record Analysis Conditions					
Description	Project Elevation RM 20 (ft – NAVD 88)	Jordan Elevation (ft – NAVD 88)	Jordan Elevation (ft – NGVD 29)	Jordan Flow (cfs)	Approximate Annual Exceedance Probability (%)
Major Flooding @ Project	704.5	713.8	713.7	26,600	39%
Top of Structure at Blue Lake (upstream control point)	700	707.4	707.3	14,000	61%
Full Drawdown @ Project	696.2	704.1	704	10,000	78%
Channel Inverts @ Project	692.5	699.2	699.1	4,800	92%

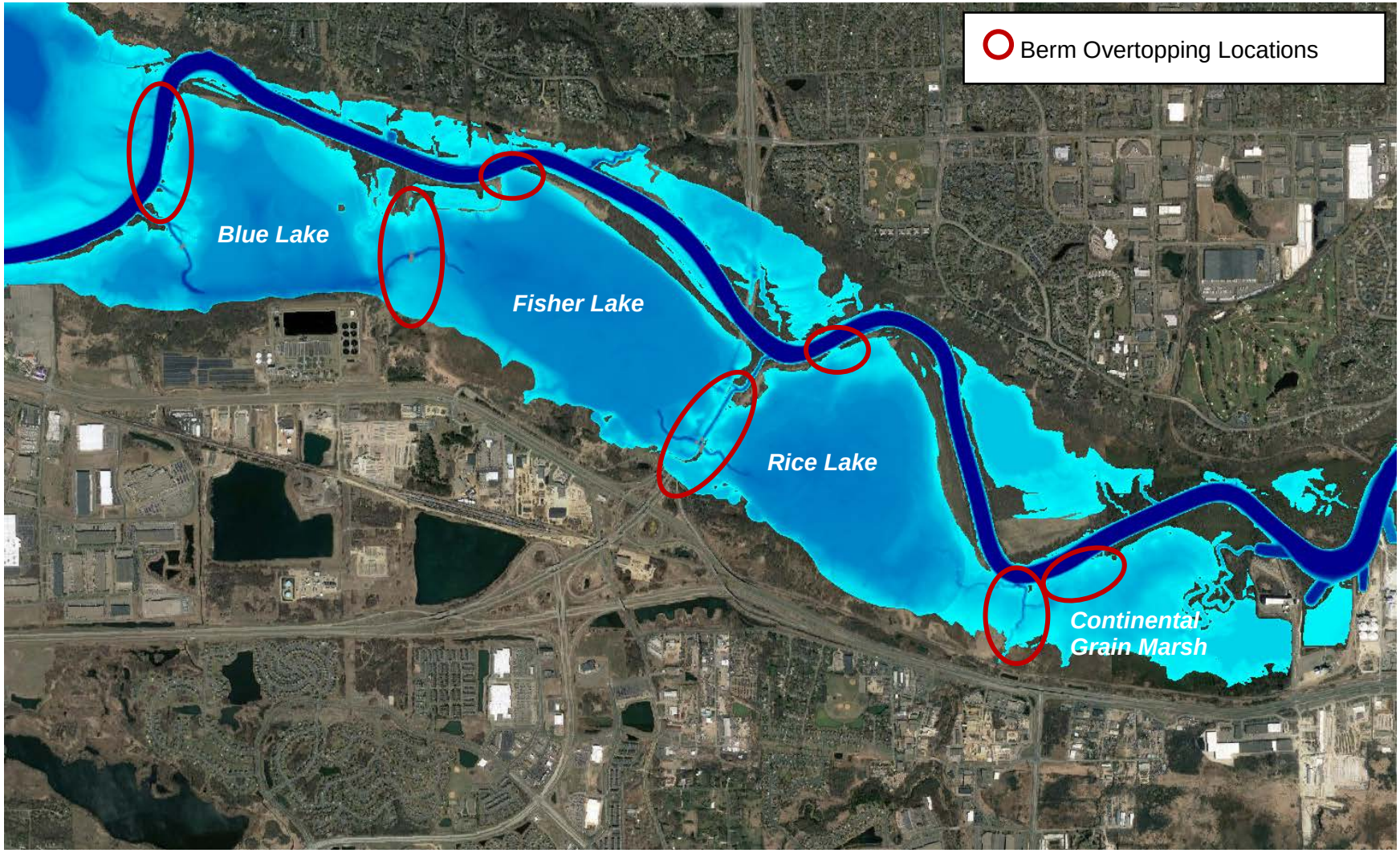


Figure 39: Inundation Area at the Project Area at River Stage 704.5 feet (RM 20) – Major Flooding Condition

8.3.2 Performance Analysis

The period of record mean daily discharge data from the USGS gage at Jordan, MN is plotted in Figure 40, below. This plot includes a reference line for the major flooding discharge. Data above this reference line indicate the days in the period of record with a mean flow value corresponding to major flooding at the project site. This river discharge value is explained in depth below. A green point on the graph indicates that a successful full drawdown could have been achieved that year if the functioning TSP features were in place. A successful full drawdown is defined as a 30 day duration drawdown achieved by mid-July. The specifics of these analyses are explained below.

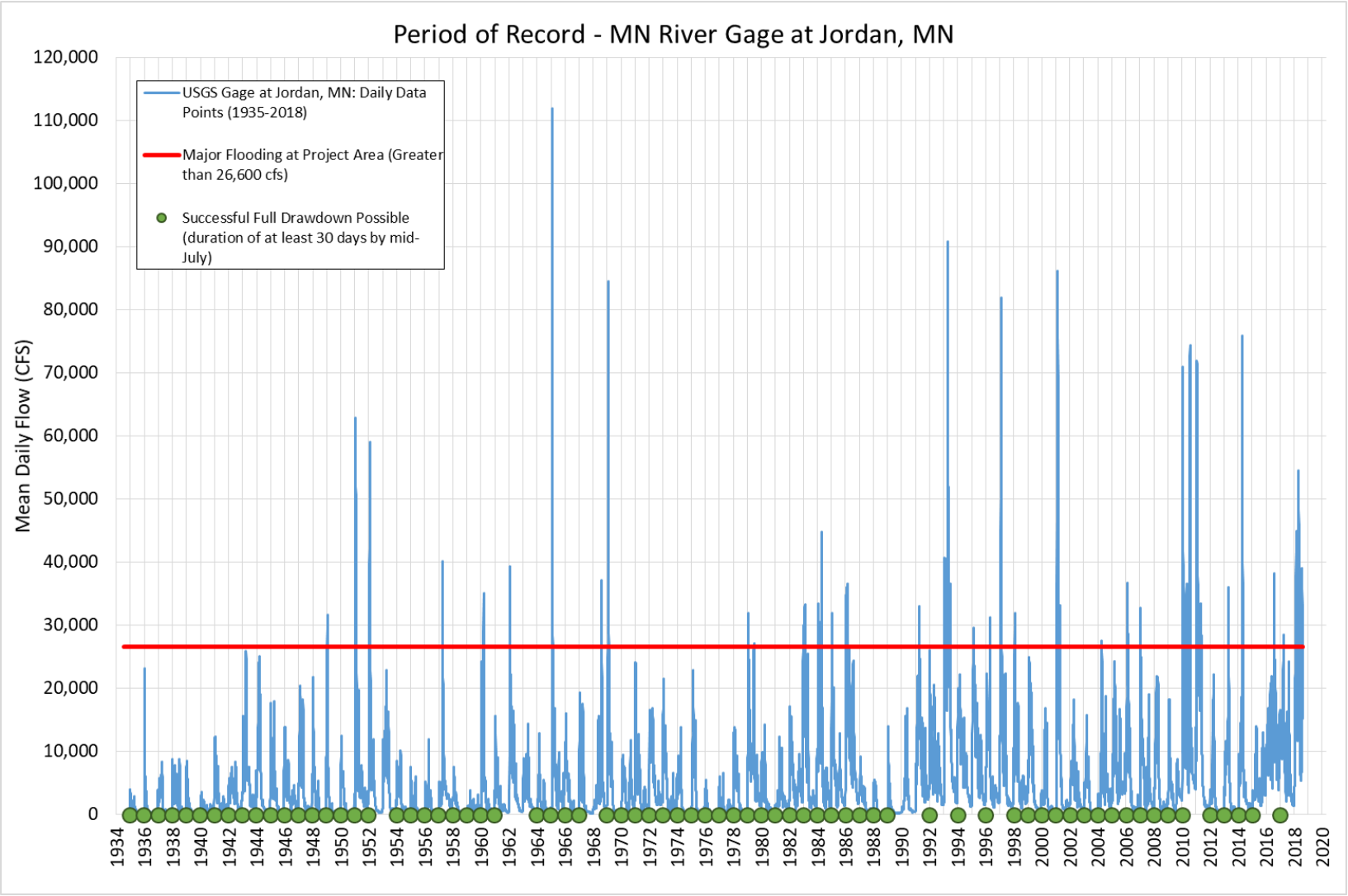


Figure 40: Period of Record Analysis (Mean Daily Data) with Major Flooding and Successful Full Drawdown Reference

8.3.2.1 Major Flood Stage Assessment

Mean daily discharge data at the Minnesota River at Jordan USGS Gage (1935-2018), is assessed to determine the annual, total number of major flood days at the project site, as well as the duration and number of independent flood events occurring on an annual basis. As described earlier, flooding at the project site is assumed to occur coincidentally with a discharge that exceeds 26,600 cfs at Jordan. Figure 41 shows the total number of major flood days each year, as well as the duration of independent high flow events occurring throughout year. The most flood events experienced in a single year is four. For example, in 2018, the study area experienced a total of 79 days of major flooding composed of four different events. The plot indicates that there has been an increase in major flooding in the project area.

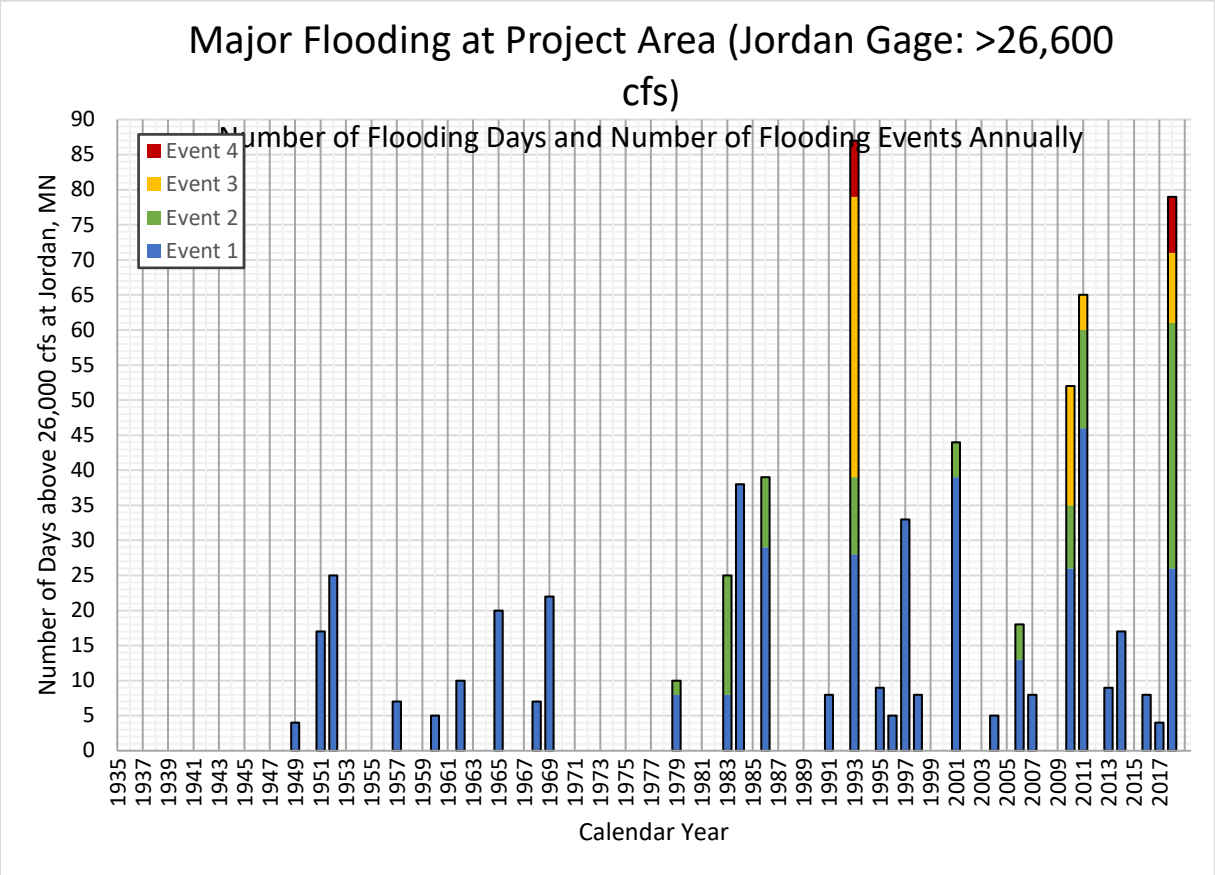


Figure 41: Number of days and events each year that the discharge at the Jordan, MN USGS gage (Gage Number 05330000) exceeded 26,600 cfs from 1935 to 2018

8.3.2.2 Drawdown Efficacy Evaluation

Mean daily discharge data at the Minnesota River at Jordan USGS gage (1935-2018), is assessed to determine if an effective drawdown could have been accomplished during the growing season (May 1st to Sept. 30th) each year. A successful drawdown is defined as a minimum 30 day drawdown by mid-July. It is assumed that drawdown can be reached when flows at Jordan are less than 10,000 cfs for 30-days or longer (Minnesota River is at 696.2 feet at River Mile 20 –study area). Accomplishing this drawdown target elevation for a 30-day (or longer) duration before mid-July, provides the best conditions for waterfowl nesting and the establishment of aquatic plant communities. Table 24 below lists the year and whether or not a

successful 30 day duration drawdown by mid-July was achieved. Based on this table, a successful drawdown was achieved 72 out of 84 years (86% of years). A nonstationarity has been identified within the average annual discharge record at Jordan in 1981. Operationally significant increases in flow have been identified when the pre- and post- 191 average annual discharge records are compared.

Looking at the more recent relatively, homogenous portion of the period of record from 1981 to 2018, the incidence of a successful drawdown decreased to 79% of years. Although a 30-day duration drawdown before July is optimal for bird habitat formation/preservation in the study area, a 14-30 day drawdown anytime during the growing season provides some habitat benefits. Consequently, drawdowns of at least 14 days in duration, anytime during the growing season were also identified. When analyzing the data for drawdowns of at least 14 days in duration, it was found that a drawdown of this duration was achieved at least once every year (growing season months only) except for the year 1993. These results imply that with the construction of the project, the likelihood of an annual drawdown will still be high even with the potential for changing river conditions due to climate change and other potential drivers like land use/land cover changes and project unknowns (groundwater, Valley Fair Project effects, etc.).

Table 24: Successful Drawdown Summary (30-day Duration, prior to Mid-July) based on the period of record at the Jordan Gage

Summary Successful Drawdowns (30+ days) Achieved by Mid-July		Summary Successful Drawdowns (30+ days) Achieved by Mid-July	
Year	Success?	Year	Success?
1935	Yes	1977	Yes
1936	Yes	1978	Yes
1937	Yes	1979	Yes
1938	Yes	1980	Yes
1939	Yes	1981	Yes
1940	Yes	1982	Yes
1941	Yes	1983	Yes
1942	Yes	1984	Yes
1943	Yes	1985	Yes
1944	Yes	1986	Yes
1945	Yes	1987	Yes
1946	Yes	1988	Yes
1947	Yes	1989	Yes
1948	Yes	1990	No
1949	Yes	1991	No
1950	Yes	1992	Yes
1951	Yes	1993	No
1952	Yes	1994	Yes
1953	No	1995	No
1954	Yes	1996	Yes
1955	Yes	1997	No
1956	Yes	1998	Yes
1957	Yes	1999	Yes
1958	Yes	2000	Yes
1959	Yes	2001	Yes
1960	Yes	2002	Yes
1961	Yes	2003	Yes
1962	No	2004	Yes
1963	No	2005	Yes
1964	Yes	2006	Yes
1965	Yes	2007	Yes
1966	Yes	2008	Yes
1967	Yes	2009	Yes
1968	No	2010	Yes
1969	Yes	2011	No
1970	Yes	2012	Yes
1971	Yes	2013	Yes
1972	Yes	2014	Yes
1973	Yes	2015	Yes
1974	Yes	2016	No
1975	Yes	2017	Yes
1976	Yes	2018	No

The structures constructed as part of this HREP are robustly designed to give the USFWS the highest chance of completing a drawdown given the potential for changing river conditions in the future. Drawdown is carried out as quickly as possible to maximize habitat availability for the longest duration possible. When the Minnesota River is below 696.2 feet in the study area (elevation of 704.1 feet at Jordan), the amount of time it would take to drawdown the system if the TSP is executed is listed in Table 25 below.

Table 25: Maximized Drawdown Time (Minnesota River Receded to 10,000 cfs or less at Jordan)

Maximized Drawdown Time	
Location	Drawdown Time (days)
Blue Lake	0.5
Fisher Lake	3
Rice Lake	4
Continental Grain Marsh	0.2

8.3.2.3 Drought Analysis

The conditions above were also used to estimate drought frequency. Drought conditions for Blue, Fish and Rice Lakes are defined as years where the lakes do not experience a river surge during the growing season (May 1st to Sept. 30th). A river surge is defined as a discharge which causes the pools to rise above the top of the Blue Lake control structure elevation (pool above>700 feet NAVD 88; flow >14,000 cfs at Jordan). Based on this assumption, a drought was estimated to occur every 1 out of every 8 years for the time period 1981-2018. The time period 1981-2018 is adopted based on the climate change nonstationarity analysis of average annual flow for the Minnesota River at Jordan.

Continental Grain Marsh was assumed to experience a drought if it did not receive an input larger than the full drawdown discharge (>10,000 cfs at Jordan). The full drawdown discharge of 10,000 cfs correlates to a water surface elevation of approximately 696.0 feet NAVD 88 at the Continental Grain Marsh. This drought assumption at Continental Grain Marsh is different from the assumption applied for Blue, Fish and Rice Lakes, because Continental Grain Marsh is operated independently. For Continental Grain Marsh a drought was estimated to occur every 1 out of 10 years for the time period 1981-2018.

9 Refuge Summary

9.1 Major Flooding

Major flooding at the project area begins at an assumed project elevation of 704.5 feet at river mile 20 of the Minnesota River (NAVD 88) just west of Blue Lake. At this elevation, the natural levees between the lakes and marsh as well as the natural levees between the project and the Minnesota River experience significant overtopping. As a result, the study area is completely inundated and flow essentially travels as sheet flow through the project area. This elevation correlates to a stage of approximately 713.8 feet and a flow of approximately 26,600 cfs at the USGS Gage at Jordan, MN. Table 26 references flood stages from the USGS Gage at Jordan on the National Weather Service (NWS) site (https://water.weather.gov/ahps2/hydrograph.php?wfo=mpx&gage=jdnm5).

Table 26 also shows when this project specifically begins to experience flood conditions as described by the NWS. When operating, the lake and marsh structures are initially overtopped at their respective low points when flows at the Jordan gage area approximately 14,000 cfs. This discharge results in a loss of operating control.

Table 26: NWS Flood Categories at USGS Gage at Jordan, MN

NWS Flood Categories (in feet)	Stage	Elevation (NGVD 29)	Elevation (NAVD 88)
Major Flood Stage:	34	724	724.1
Moderate Flood Stage:	28	718	718.1
Flood Stage:	25	715	715.1
*Project Major Flooding	23.7	713.7	713.8
Action Stage:	18	708	708.1
*Project Structure Overtopping	17.3	707.3	707.4

*Reference from the Major Flooding Analysis

9.2 TSP Structure Drawdown

The structures constructed as part of this HREP are robustly designed to give the USFWS the highest chance of completing a drawdown given changing river conditions. A full drawdown can be achieved once the Jordan gage decreases to a discharge of 10,000 cfs. This value correlates to a river surface elevation of approximately 696.2 feet (NAVD 88) at the study location (Minnesota River Mile 20). The optimal pool, partial drawdown and full drawdown elevations for each lake/marsh are listed in Table 27. These critical pool elevations are defined by the total percent of the project area inundated with surface water. Critical pool elevations are defined as follows:

- Optimal Pool: 80% of the project area is inundated
- Partial Drawdown: 50% of the project area is inundated
- Full Drawdown: <10% of the project area is inundated

The inundated areas associated with the optimal pool, partial drawdown and full drawdown water surface elevations are displayed in Figure 42. The quickest, most efficient drawdown time occurs when flows of 10,000 cfs or lower are observed at the Minnesota River gage at Jordan. The drawdown times when this condition occurs is listed in Table 28 below.

Table 27: Lake/Marsh Water Surface Elevations (Feet - NAVD 88)

Lake/Marsh Water Surface Elevations (Feet - NAVD 88)				
Condition	Blue Lake	Fisher Lake	Rice Lake	Continental Grain Marsh
Optimal Pool	698.3	698.3	697	698.4
Partial Drawdown	697.4	697	696	697.5
Full Drawdown	696.2	696.2	695	696

Table 28: Maximized Drawdown Time (River Receded to 10,000 cfs)

Maximized Drawdown Time (Minnesota River Receded to 10,000 cfs at Jordan)	
Location	Drawdown Time (days)
Blue Lake	0.5
Fisher Lake	3
Rice Lake	4
Continental Grain Marsh	0.2

A successful drawdown is defined as a 30 day minimum drawdown occurring by mid-July. A period of record analysis indicates that if these structures were installed in the 1935-2018 timeframe, a successful drawdown could be achieved 86% of the years. Looking at a more current discharge regime for the years 1981-2018, a drawdown can be achieved 79% of the years. A 14 day minimum drawdown during the growing season (May 1st -September 30th) was also analyzed using the period of record and it was found that all years were able to achieve this duration of drawdown except for the year 1993.

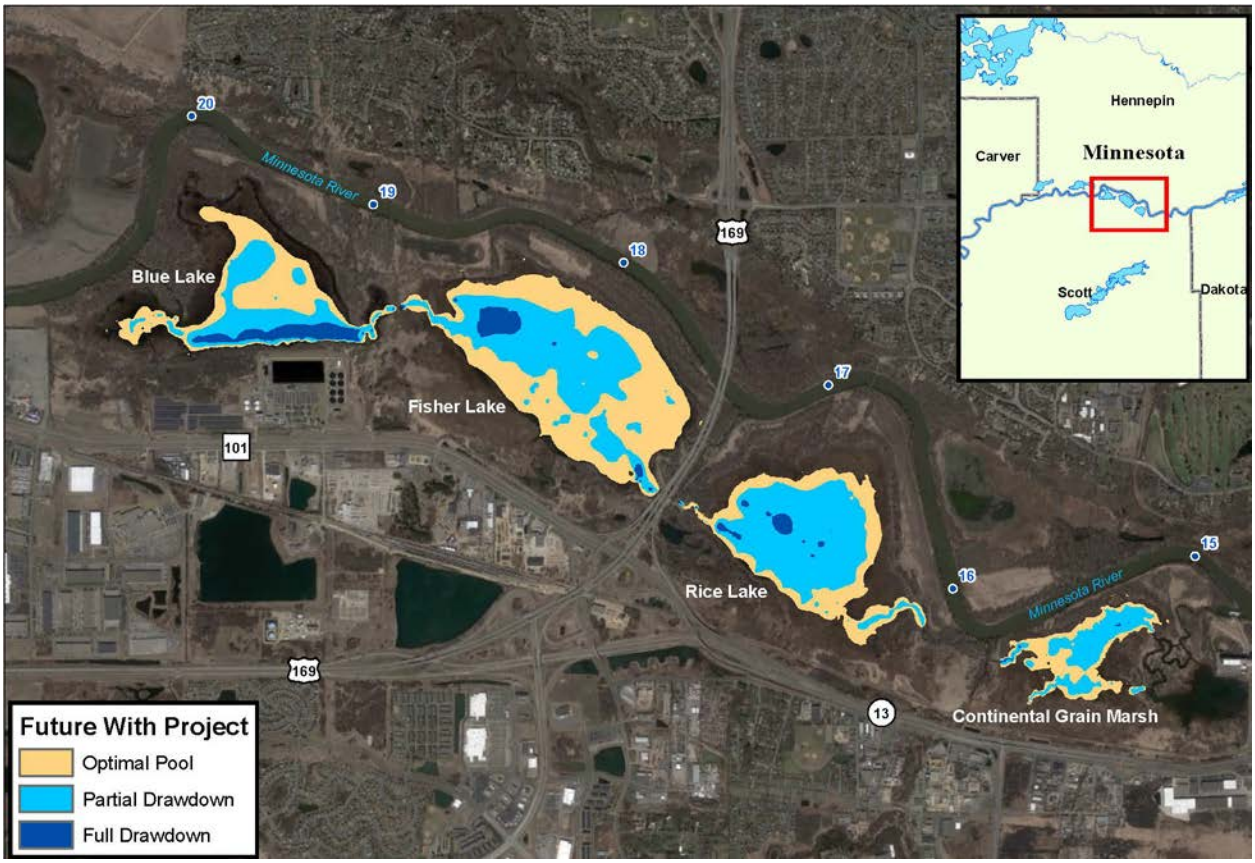


Figure 42: Operation Water Surface Elevation Inundation Areas

10 References

Angel, J.R., Palecki, M.A. and Hollinger, S.E. *Storm precipitation in the United States. Meteorological Characteristics*, 2005.

Belmont, P., K. B. Gran, S. P. Schottler, P. R. Wilcock, S.S. Day, C. Jennings, J. W. Lauer, E. Viparelli, J.K. Willenbring, D. R. Engstrom, G. Parker. *Large Shift in Source of Fine Sediment in the Upper Mississippi River. Environmental Science & Technology*, 2011.

Fletcher, B. and Grace, J. *Technical Report H-74-9. Practical Guidance for Design of Lined Channel Expansions at Culvert Outlets*, 1974.

Friedman, D., J. Schechter, B. Baker, C. Mueller, G. Villarini, and White, K. D. *U.S. Army Corps of Engineers Nonstationarity Detection. ETL 1100-2-3 Guidance for Detection of Nonstationarities in Annual Maximum Discharges*, May 2017.

Gran, K., P. Belmont, S. Day, C. Jennings, J. Lauer, E. Viparelli, P. Wilcock, G. Parker. *An Integrated Sediment Budget for the Le Sueur River Basin*, 2011.

Groten, J. T., C. A. Ellison, J. S. Hendrickson. *Suspended –Sediment Concentrations, Bedload, Particle Sizes, Surrogate Measurements, and Annual Sediment Loads for Selected Sites in the Lower Minnesota River Basin, Water Years 2011 through 2016*, 2016.

Grundstein A. *Evaluation of climate change over the continental United States using a moisture index. Climatic Change*, 2009.

Hydrologic Engineering Center*. HEC-RAS river analysis system, hydraulic reference manual version 5.0*, U.S. Army Corps of Engineers at Davis, CA, February 2016.

Hydrologic Engineering Center. *HEC-RAS river analysis system, user's manual version 5.0*, U.S. Army Corps of Engineers at Davis, CA, February 2016.

Jennings, C., Stefanova, V., and Shapley, M. Sediment Accumulation in the Floodplain of Lower Minnesota River Watershed, 2017.

Lenhart, C. F., M.L. Titov, J. S. Ulrich, J. L. Nieber, B.J. Suppes. *The Role of Hydrologic Alteration and Riparian Vegetation Dynamics in Channel Evolution Along the Lower Minnesota River. Erosion & Landscape Evolution. Transactions of the American Society of Agricultural and Biological Engineers*, 2013.

Mauget SA. Low frequency streamflow regimes over the central United States: 1939-1998, 2004.

McRoberts, D. B., and J. W. Nielsen-Gammon. *A new homogenized United States climate division precipitation data for analysis of climate variability and change*, 2011.

Minnesota Department of Natural Resources. Minnesota Spring Inventory. Accessed July 2018. Available: https://www.dnr.state.mn.us/waters/groundwater_section/springs/msi.html, 2018.

Novotny, E.V., and H.G. Stefan. *Streamflow in Minnesota: Indicator of climate change.*2007.

U. S. Army Corps of Engineers. *Recent US Climate Change and Hydrology Literature Applicable to U.S. Army Corps of Engineers Missions – Water Resources Region 07, Upper Mississippi. Civil Works Technical Report, CWTS-2015-13*, USACE, Washington, D.C, 2015.

U. S. Army Corps of Engineers. *Engineering and Construction Bulletin 2018-14: Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects*, 2018.

U. S. Army Corps of Engineers. *U.S. Army Corps of Engineers Vulnerability Assessment (VA) Tool User Guide Version 1.1. November 2016. Climate Preparedness and Resilience Community of Practice*. Washington, D.C, 2016.

U. S. Army Corps of Engineers. *U.S. Army Corps of Engineers Nonstationarity Detection Tool User Guide Version 1.1, May 2016. Climate Preparedness and Resilience Community of Practice.* Washington, D.C, 2016.

U. S. Army Corps of Engineers. *U.S. Army Corps of Engineers Climate Hydrology Assessment Tool (CHAT). December 2018.* Washington, D.C, Available: https://maps.crrel.usace.army.mil/apex/f?p=313, 2018.

U. S. Army Corps of Engineers. *U.S. Army Corps of Engineers Time Series Toolbox Tool. December 2018.* Washington, D.C, Available: http://ec2-34-205-128-255.compute-1.amazonaws.com:8080/tst_app/, 2018.

U. S. Army Corps of Engineers. *U.S. Army Corps of Engineers Nonstationarity Detection Tool. December 2018.* Washington, D.C, Available: https://maps.crrel.usace.army.mil/apex/f?p=257, 2018.

U. S. Army Corps of Engineers. U.S. Army Corps of Engineers Vulnerability Assessment (VA) Tool. December 2018. Washington, D.C, Available: https://maps.crrel.usace.army.mil/apex/f?p=170, 2018.

U. S. Army Corps of Engineers. ETL 1100-2-3, Guidance for Detection of Nonstationarities in Annual Maximum Discharges, 28 April 2017.

U. S. Army Corps of Engineers. EM 1110-2-1601. Hydraulic Design of Flood Control Channels, June 1994.

U. S. Army Corps of Engineers. EM 1110-1-4000. Sedimentation Investigations of Rivers and Reservoirs, 1995.

U.S. Army Corps of Engineers. Minnesota River Integrated Watershed Study - Discharge and Elevation Frequency Update, 2017.U.S. Army Corps of Engineers. Upper Mississippi River Restoration Environmental Management Program Design Handbook, 2012.

U.S. Army Engineer Waterways Experiment Station. “Stone Stability vs. Stone Diameter. Hydraulic Design Chart 712-1”, 1970.

U.S. Department of Transportation Federal Highway Administration. “Hydraulic Design of Highway Culverts. Chart 15B”, 2012.

U.S. Department of Transportation Federal Highway Administration. “Hydraulic Design of Highway Culverts. Chart 8B”, 2012.

U.S. Geological Survey. Office of Surface Water Technical Memorandum 2005.01. Accessed November 2018. Available: https://water.usgs.gov/admin/memo/SW/sw05.01.html, 2004.

U.S. Geological Survey. USGS 05330000 MINNESOTA RIVER NEAR JORDAN, MN. Accessed May 2018. Available: https://waterdata.usgs.gov/nwis/uv?site_no=05330000, 2018.

U.S. Geological Survey. USGS 05330890 MINNESOTA RIVER (PORT CARGILL HARBOR) IN SAVAGE, MN. Accessed May 2018. Available: https://waterdata.usgs.gov/nwis/inventory/?site_no=05330890, 2018.

U.S. Geological Survey. USGS Ratings Depot: Jordan, MN Gage. Accessed November 2018. Available: https://waterdata.usgs.gov/nwisweb/get_ratings?site_no=05330000&file_type=exsa

U.S. Global Research Program. Third National Climate Assessment. 2014. Available: https://nca2014.globalchange.gov/report

U.S. Global Research Program. Third National Climate Assessment. 2018. Available: https://nca2018.globalchange.gov/

Wang, J., J. Zhang, E. Watanabe, M. Ikeda, K. Mizobata, J. E. Walsh, X. Bai, and B. Wu. Is the dipole anomaly a major driver to record lows in Arctic summer sea ice extent?, 2009.

Westby, R. M., Y.-Y. Lee, and R. X. Black, Anomalous Temperature Regimes during the Cool Season: Long-Term Trends, Low-Frequency Mode Modulation, and Representation in CMIP5 Simulations, 2013.

Xu X., B.R. Scanlon, K. Schilling, A. Sun. Relative importance of climate and land surface changes on hydrologic changes in the US Midwest since the 1930s, 2013.

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Appendix I: Civil Drawings

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

March, 2018

A1

SITE PLAN

OVERALL PROJECT AREA
SCALE: 1" =1000'

0 800' 1600'

N

ELEVATION DATUM (VERTICAL CONTROL): NAVD 88
GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL): NAD 83 (2011)
MN SPCS, SOUTH ZONE-U.S. SURVEY FT.
COMBINED FACTOR (CF): 0.999966392

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BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

OVERALL PROJECT AREA

Sheet ID
C-001

A1 SITE PLAN

BLUE LAKE PROJECT AREA
SCALE: 1" =400'

0 400' 800'

N

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID12B

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MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

BLUE LAKE
SITE PLAN

Sheet ID
C-101

A1 SITE PLAN

FISHER LAKE PROJECT AREA
SCALE: 1" =100'

0 100' 200'

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ELEVATION DATUM (VERTICAL CONTROL): NAVD 88 GEOID12B

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BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

FISHER LAKE
SITE PLAN

Sheet ID
C-102

A1 SITE PLAN

CONTINENTAL GRAIN PROJECT AREA
SCALE: 1" =300'

0 300' 600'

N

ELEVATION DATUM (VERTICAL CONTROL): NAVD 88
GEOID12B

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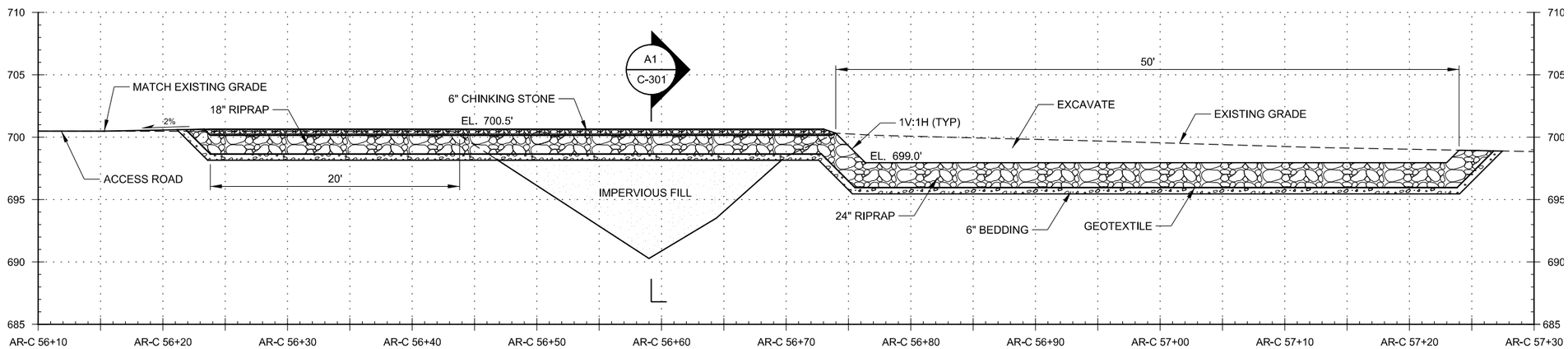
BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

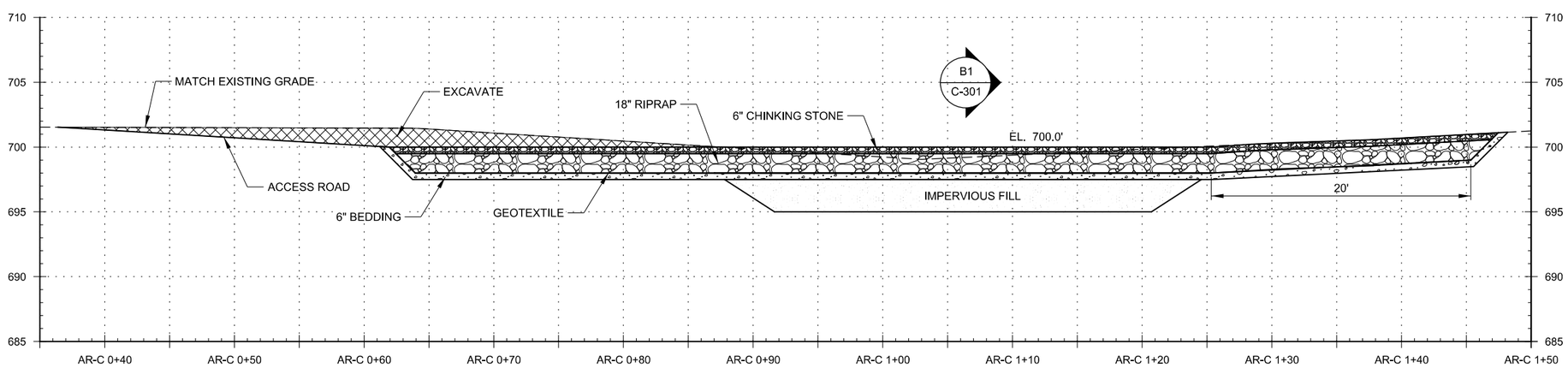
CONTINENTAL GRAIN MARSH
SITE PLAN

Sheet ID
C-103



C1 CONTINENTAL GRAIN DITCH PLUG B PROFILE ALONG ACCESS ROAD

BASS PONDS HREP
SCALE: 1" =5'



A1 CONTINENTAL GRAIN DITCH PLUG A PROFILE ALONG ACCESS ROAD

BASS PONDS HREP
SCALE: 1" =5'

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NAVD 88
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COORDINATE SYSTEM (HORIZONTAL CONTROL):
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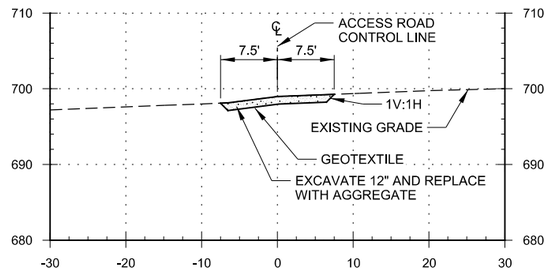
BASS LAKE PONDS HREP
MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

PROFILES

Sheet ID
C-201



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CONSTRUCTION ACCESS ROAD
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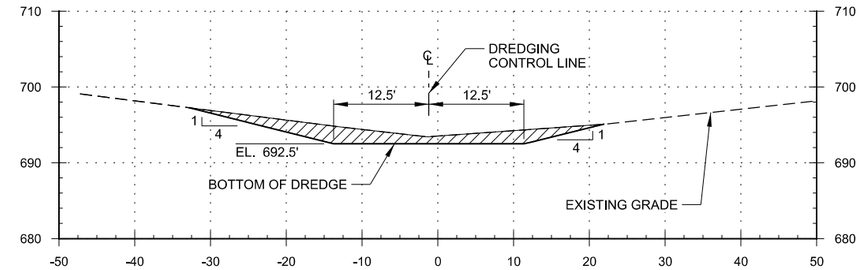

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DREDGING
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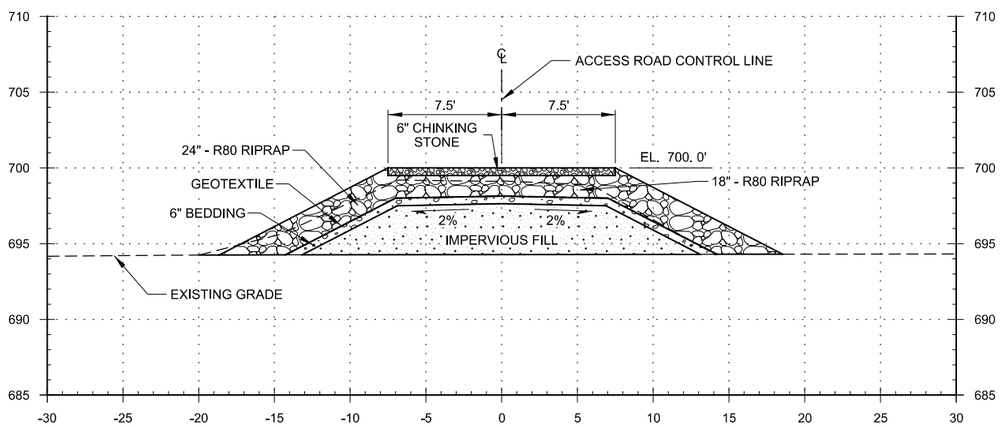

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CONTINENTAL GRAIN MARSH DITCH PLUG A
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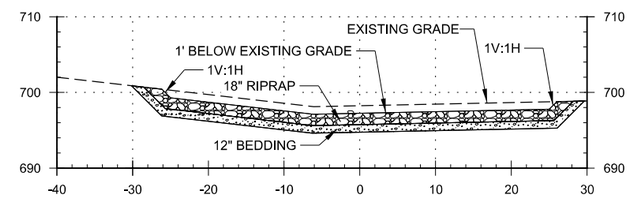
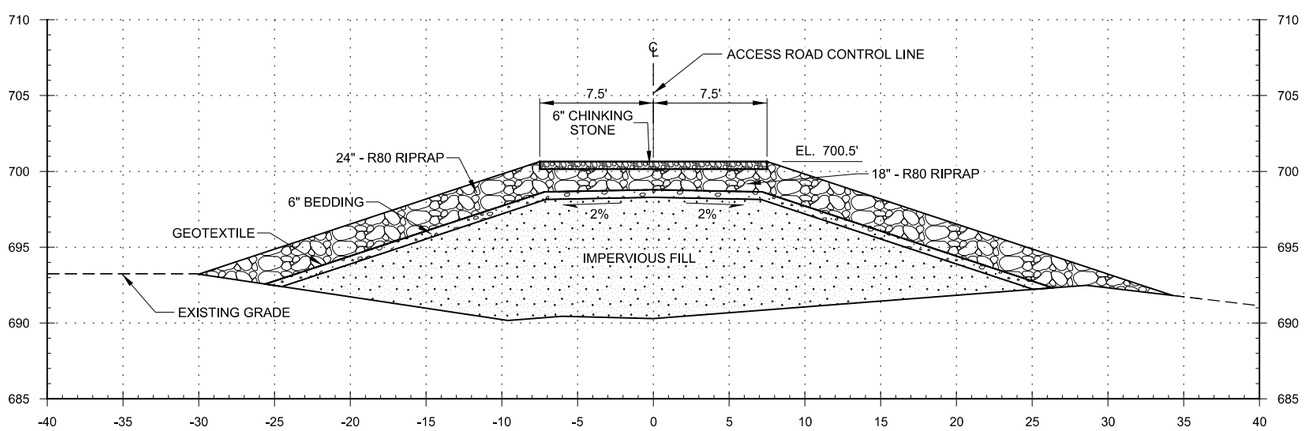


B4 TYPICAL SECTION

ROCK OVERFLOWS AT STRUCTURES
SCALE: 1" =10'



A1 SECTION

CONTINENTAL GRAIN MARSH DITCH PLUG B
SCALE: 1" =5

ELEVATION DATUM (VERTICAL CONTROL):
NAVD 88
GEOID12B

COORDINATE SYSTEM (HORIZONTAL CONTROL):
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MINNESOTA RIVER
MINNESOTA VALLEY WILDLIFE REFUGE
BLOOMINGTON, MN

SECTIONS

Sheet ID
C-301

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Appendix J: Structural Engineering

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

March, 2019

Appendix J: Structural Engineering

TABLE OF CONTENTS

1 Introduction 2

2 Technical Guidelines and Reference Standards 2
2.1 General 2
2.2 Closure Structures and Retaining and Flood Walls 3

3 Design Criteria 3
3.1 Material 3
3.2 Material Dead Load Unit Weights 4

4 Loads 4

5 Structural Design 7
5.1 Stoplogs Water Control Structures 7
5.2 Miscellaneous Drainage Features 15
5.3 Corrosion Control 15

6 Operations and Maintenance Considerations 15

7 Structural Calculations 16

LIST OF FIGURES

Figure 1: Plan view of a typical Two-Bay water control structure 7
Figure 2: Plan view of a typical One-Bay water control structure 7
Figure 3: Two-Bay Control Structure Cross Section. 11
Figure 4: One-Bay Control Structure Cross Section. 11
Figure 5: Standard MNDOT Axle Weight Limit Sign 15

LIST OF TABLES

Table 1: Stoplogs Water Control Structures Location 2
Table 2: Structural Stability Criteria 9
Table 3: Concrete Strength Criteria 9
Table 4: Two-Bay Water Control Structure Stability 12
Table 5: One-Bay Water Control Structure Stability 13

1 Introduction

This appendix provides the structural engineering in support of the Recommended Plan (RP) for the feasibility study for the Minnesota River, Bass Ponds HREP, in Scott County, MN. The report was based on developing sufficient structural engineering and design to enable refinement of the project features, prepare the baseline cost estimate, develop a construction schedule, and allow detailed designed to begin immediately following receipt of Preconstruction Engineering and Design (PED) funds.

The Recommended Plan is BFR5-M2. The main features consists of the following: a Two-Bay stoplog control structure at Blue Lake, a one-bay stoplog control structure between Blue Lake and Fisher Lake, a One-Bay stoplog control structure at Fisher Lake outlet, a One-Bay stoplog control structure at Rice Lake outlet, a One-Bay stoplog control structure at outlet to the river and a One-Bay stoplog control structure at Continental Grain Marsh (Table 1). The structural components of the design and analysis consist of reinforced concrete U-frame control structure and retaining walls. Section 6 of the Main Report provides a detailed summary of the Recommended Plan and operation.

Table 1: Stoplogs Water Control Structures Location

Structure Location	From	To	Top Elevation	Bottom Elevation	Invert Elevation
Blue Lake	Blue Lake	Minnesota River	700.00	691.75	693.00
Interlake	Blue Lake	Fisher Lake	702.00	691.75	693.00
Fisher lake	Fisher lake	Channel	701.00	691.75	693.00
Rice Lake	Rice Lake	Channel	704.60	691.75	693.00
Secondary Outlet	Channel	Minnesota River	701.00	691.75	693.00
Con Grain Marsh	Con Grain Marsh	Minnesota River	701.50	691.75	693.00

2 Technical Guidelines and Reference Standards

2.1 General

1. 2012 International Building Code, International Code Council; June 2011.
2. ACI 318-11, Building Code Requirements for Structural Concrete, ACI Committee 318; 2011.
3. AISC 325-11, Steel Construction Manual, Fourteenth Edition, American Institute of Steel Construction; February 2013.
4. ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers; 2013.
5. UFC 3-320-06A, 1 March 2005, Concrete Floor Slabs on Grade Subjected to Heavy Loads.
6. EM 385-1-1 Safety and Health Requirements, 2014.
7. Aluminum Design Manual, 2010 Edition.

2.2 Closure Structures and Retaining and Flood Walls

1. ECB 2017-2 Revision and Clarification of EM 1110-2-2100 and EM 1110-2-2502.
2. EM 1110-2-1612 Ice Engineering (October 2002)
3. EM 1110-2-2100, Stability Analysis of Concrete Structures, U.S. Army Corps of Engineers, Washington DC; 1 December 2005.
4. EM 1110-2-2102 Waterstops and Other Preformed Joint Materials for Civil Works Structures (September 1995)
5. EM 1110-2-2104, Strength Design for Reinforced-Concrete Hydraulic Structures, U.S. Army Corps of Engineers, Washington DC (November 2016).
6. EM 1110-2-2502, Retaining and Flood Walls, U.S. Army Corps of Engineers, Washington DC; 29 September 1989.
7. EM 1110-2-2504 Design of Sheet Pile Walls (March 1994)
8. ETL 1110-2-584, Design of Hydraulic Steel Structures, U.S. Army Corps of Engineers, Washington DC; 30 June 2014.

3 Design Criteria

3.1 Material

- Concrete: Compressive strength, fc’ = 4000 psi at 28 days for structural concrete
- Minimum concrete cover:
    - Unformed concrete placed against earth: 4”
    - Surfaces to be in contact with earth or water less than or equal to 2 ft. thick : 3”
    - Surfaces to be in contact with earth or water greater than 2 ft. thick: 4”
    - All other places: 2”
- Reinforcing Steel ASTM A615 Grade 60, uncoated.
- Structural Steel
    - Wide-flange sections: ASTM A992 or A572 Grade 50
    - ASTM A992 – Wide Flange Shapes.
    - ASTM A500, Grade B – Hollow Structural Shapes.
    - ASTM A36 – Other Standard Shapes.
    - ASTM A36 – Plates, bars and sheets.
    - ASTM A325 – Structural Bolts
- Stainless Steel
    - Type 316/316L – Submerged or corrosive applications.
    - Type 304/304L – All other areas.

- Aluminum
    - 6061-T6 – All applications, except as noted.
    - 6063 – Railing.

- Soil

  The material properties of the soil and associated design recommendations are based on Long Meadow Lake, which is in the vicinity, soil parameters:
    - Lateral earth pressures (psf/ft) – Equivalent fluid pressure
        - Active 50
        - Active (Below groundwater) 89
        - At-Rest 72
        - At-Rest (Below groundwater) 101
        - Passive 360
        - Passive (Below groundwater) 254
        - Traffic surcharge 2-feet of soil
        - Foundation, drained, Ø=22° , C=0 psf
        - Embankment, drained Ø=28°, C=0 psf

- Net Allowable Bearing Pressure 2000 psf
- Soil density 120 pcf
- Frost depth 4’-0”
- Coefficient of friction – Concrete on soil 0.33

3.2 Material Dead Load Unit Weights

- Concrete : 150 pounds per cubic foot (pcf)
- Non-reinforced structural grout: 130 pounds per cubic foot (pcf)
- Steel : 490 pcf
- Water : 62.5 pcf
- Moist Soil: 112 pounds per cubic foot (pcf)
- Saturated Soil: 115 pounds per cubic foot (pcf)
- Buoyant Soil: 52.5 pounds per cubic foot (pcf)

4 Loads

Live Loads. Live loading for this project will be analyzed in accordance EM 1110-2-3104.

- Floors (Heavy Equipment rooms) – 300 psf uniform.
- Ladder and Rungs – one 300 pounds concentrated load plus additional 300 pound concentrated loads as determined from the anticipated usage.
- Traffic loads. Each control structure is primarily used for pedestrian traffic using the designated hiking trails within the refuge. It is also design for service and maintenance vehicles. Per AASHTO Pedestrian Bridge Manual a minimum maintenance traffic load for this bridge width (>10') is an H-10 truck load (10 ton). It also states impact factors are not required for these cases. The USFWS mentioned a dump truck of rock maybe required to cross the structures for future maintenance operations. Thus the truck load was increased to a loaded tandem loaded truck (55,000 lbs).

Dead Loads. Self-weight and dead loads include the total weight of the concrete structure and its appurtenant features (grating and railings etc).

Incidental Loads. Incidental loads from silt, debris pile up and atmospheric ice loading is consider minimal and was neglected.

Hydrostatic Loads. Hydrostatic loading is linear and increases with the fluid depth. Hydrostatic pressure is applied perpendicular to all surfaces regardless of orientation. For the structures in this system, hydrostatic pressures will occur laterally on vertical walls or vertically on base slabs. The design fluid depth is a function of the structure's location relative to the free water surfaces on each side of the line of protection and the load case considered. Hydrostatic loads will consist of hydrostatic water pressure causing a head differential across the structure. Hydrostatic lateral and vertical pressures will be applied to all structures based on the assumed water level for each load case at a magnitude of 62.5 psf per foot depth.

Construction/Maintenance Surcharge load. A surcharge load is applied to account for vehicle loading on the backfill behind abutments. The usual load case used 100 psf to account for service vehicles (pick-ups) and unusual load case used 250 psf to account for the H-20 truck loading.

Earth Loads. The assumed soil parameters used for stability and capacity can be found in section 3.2 above. The structures will be surrounded by soils exhibiting both cohesive and cohesionless properties. The soil acts more cohesively when undrained and less cohesively when drained. Both soil states were conservatively assessed, assuming θ equals 0 for the cohesive (undrained) condition and c equals 0 for the cohesionless (drained) condition.

Lateral and vertical soil loads will be computed and applied in accordance with EM 1110-2-2502 for shallow or pile founded concrete structures. Because minimal movement or rotation is anticipated, at-rest pressures will be applied to the structures per EM 1110-2-2100. In sliding analysis of the retaining wall footing, in accordance with EM 1110-2-2502 and further USACE guidance, resisting passive pressures can be ignored due to potential of scour. Compaction induced load will be applied in accordance with Appendix J of EM 1110-2-2502 which uses both active and passive pressures.

Wind Loads. Where applicable, wind loads are computed in accordance with ASCE 7-10.

- Velocity, v: 90 mph

- Importance factor, I: 1.0
- Exposure category: C

Snow Loads. Where applicable, snow loads are determined and distributed in accordance with ASCE 7-10. Snow loads are per square foot of horizontal projection.

- Ground snow load, pg:50 psf
- Importance factor, I: 1.2
- Snow exposure factor, Ce: 0.9

Earthquake Loads. Where applicable, seismic design will be in accordance with ASCE 7-10 and the design criteria provided in the geotechnical investigation. Building structures will comply with Chapter 12. Non-Structural components will comply with Chapter 13. Non-building structures will comply with Chapter 15.

1. Short period spectral response acceleration, Ss – 0.062g
2. 1-second period spectral response acceleration, S1 – 0.022g
3. Site Class – E
4. Seismic Importance Factor – 1.5 (Table 1.5-2 and 13.1.3, Risk Category IV)
5. Design Spectral Response Acceleration at Short Period (Sds) – 0.103
6. Design Spectral Response Acceleration at 1-second Period (Sd1) – 0.0513
7. Seismic Design Category - A

Ice, Debris, and Impact Loads. Impact loads include floating debris and ice. Given the size of this structure debris and ice will tend to bridge across approaches and these loads were neglected except for stoplog design. Any debris or ice loading into to retained fill of approach walls will not govern.

Uplift Pressure. Uplift. Uplift was determined using full head on upstream and downstream side of structure. It assumes no cut-off and a linear distribution from upstream head to downstream head.

Frost Protection. All foundations are placed a minimum depth of four feet below ground surface to avoid problems with frost.

Loading conditions and Assumptions.
All control structures are to manage various lake levels depending on time of year and inflow/out flow conditions. During high water events on the Minnesota River, some control structures regulate flows into the lake. During seasonal local run-off events some structure regulate the outflow to the Minnesota River. Given these possible flow conditions the structure can be loaded load in both directions. In coordination with Hydraulics, three general load cases were assumed and listed below:

1. Normal High River Stage with Low Lake Level (Flow into lake)
2. Normal High Lake with Low River Stage (Flow into river)
3. Construction/Maintenance Condition

5 Structural Design

The Recommended Plan would be designed, constructed, and operated in accordance with current USACE standards and in accordance with the methods and references cited in USACE engineering manuals, technical letters, regulations, and other documents.
The following documents major features associated with the RP:

- Two-Bay stoplog water control structure (1 total)
- One-Bay stoplog water control structures (5 total)

5.1 Stoplogs Water Control Structures

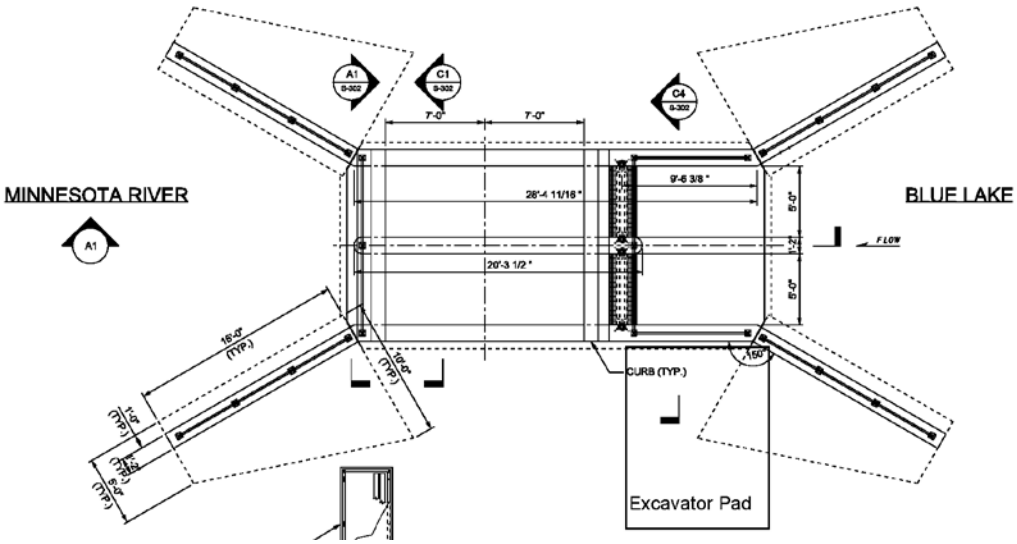

Figure 1: Plan view of a typical Two-Bay water control structure

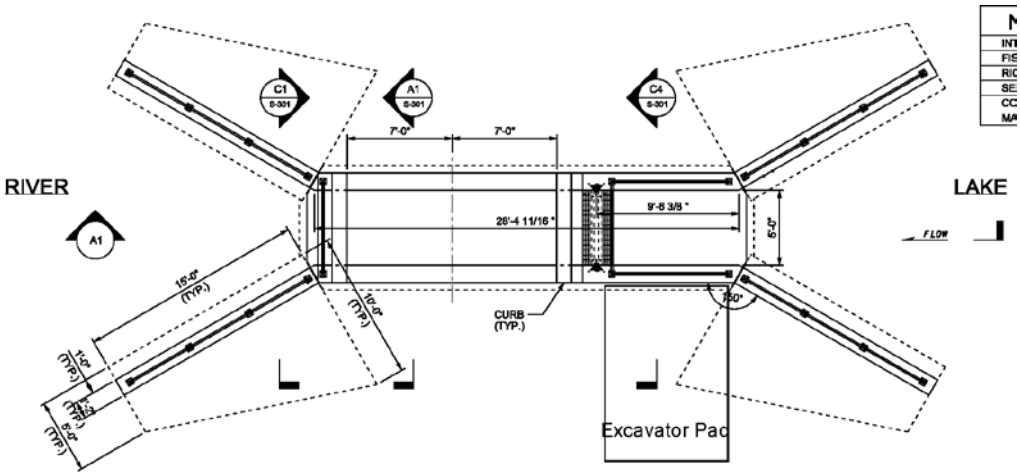

Figure 2: Plan view of a typical One-Bay water control structure

5.1.1 Structural Design Criteria

The control structure is designed in accordance with USACE guidance for design of hydraulic structures. Structural stability of the Control Structure is in accordance with EM 1110-2-2100, STABILITY ANALYSIS OF CONCRETE STRUCTURES, 2005. Structural stability of the Approach Walls are in accordance with EM 1110-2-2502, RETAINING AND FLOOD WALLS 1989. The bridge slab and associated bearing are design accordance with ASSHTO Bridge Design. Strength design of concrete U-structure and approach walls is in accordance with EM 1110-2-2104, STRENGTH DESIGN FOR REINFORCED CONCRETE HYDRAULIC STRUCTURES, 1992. Vehicle Guard Rail is accordance with MNDOT standard requirements. The excavator pad is designed in accordance with UFC 3-320-06A, EM 1110-2-2104 and ACI-318-11 requirements.

In accordance with EM 2100, structures are to be designated as Critical or Normal. Given that the Bass Ponds HREP is not a high hazard project whose failure would result in loss of life, it is designated as Normal. The required structural stability design criteria for Normal structures is listed below.

Table 2: Structural Stability Criteria

Limit State	Load Case	Load Condition Category	River Stage EL, ft	Lake Pool EL, ft	Design Criteria
					EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	1.3
	Normal High Lake	Usual	691.26	696.5	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	1.3
	Construction, Truck	Unusual	690.26	690.26	1.3
					Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	75
	Normal High Lake	Usual	691.26	696.5	100
	Normal High Lake, Truck	Unusual	691.26	696.5	75
	Construction, Truck	Unusual	690.26	690.26	100
					Assumed allowable Bearing Pressure, psf
Bearing	High River Stage	Unusual	698.26	694.3	2000
	Normal High Lake	Usual	691.26	696.5	
	Normal High Lake, Truck	Unusual	691.26	696.5	
	Construction, Truck	Unusual	690.26	690.26	
					EM2100 Required FOS
Flotation	High River Stage	Unusual	698.26	694.3	1.2
	Normal High Lake	Usual	691.26	696.5	1.3

Table 3: Concrete Strength Criteria

Load Case	**River Stage EL,ft**	**Lake Pool EL,ft**	**Load Condition Category**	**Load Factor**	**Hydraulic Factor**	**Load Condition Factor**	**Design Load Factor**
Normal High River	698.26	694.3	Usual	1.7	1.3	1	2.21
Normal High River, Truck	698.26	694.3	Unusual	1.7	1.3	0.75	1.66
Normal High Lake	691.26	696.5	Usual	1.7	1.3	1	2.21
Normal High Lake, Truck	691.26	696.5	Unusual	1.7	1.3	0.75	1.66
Construction, Truck	690.26	690.26	Unusual	1.7	1.3	0.75	1.66

5.1.2 Design and Analysis

This section outlines the design procedure and assumptions used to design the various features of the control structure. Procedures and assumptions follow applicable USACE guidelines and industry standards.

5.1.2.1 Bridge Slab and/or Grating

Concrete bridge slab is used on top of the control structure to allow pedestrian and maintenance traffic. It is designed for H-20 loading. An axle rating is used as the slab span of 72 inches only allows loading from a single axle. After discussion with USFWS on 12/19/18, bridge grating will be used instead of concrete slab to facilitate debris removal inside the structures.

5.1.2.2 Control Structure

The three load cases were used to analyze the structural stability of the control structure. Limit states that were evaluated included sliding, overturning, bearing and floatation. All applicable loads were input into an Excel spreadsheet, and vertical and horizontal resultants were determined. For overturning, moments were taken about the lake side base of footing. Location of resultants were determined and bearing pressures were calculated. The allowable bearing pressure is assumed of 2000 psf based on soil parameters from Long Meadow Lake which is in the vicinity. For all load cases the base is in 100% compression. Sliding resistance was calculated using foundation soil strengths. Any sliding resistance along the wall/embankment interface was ignored. Floatation factors of safety were also calculated. A summary of structural stability results is given in Tables 4 and 5 below.

Reinforced concrete strength design is based on determining the maximum shear and moment in the individual members. Members include the abutments, top slab and base slab. The members are part of a U-frame structure shown in Figures 3 and 4 below.

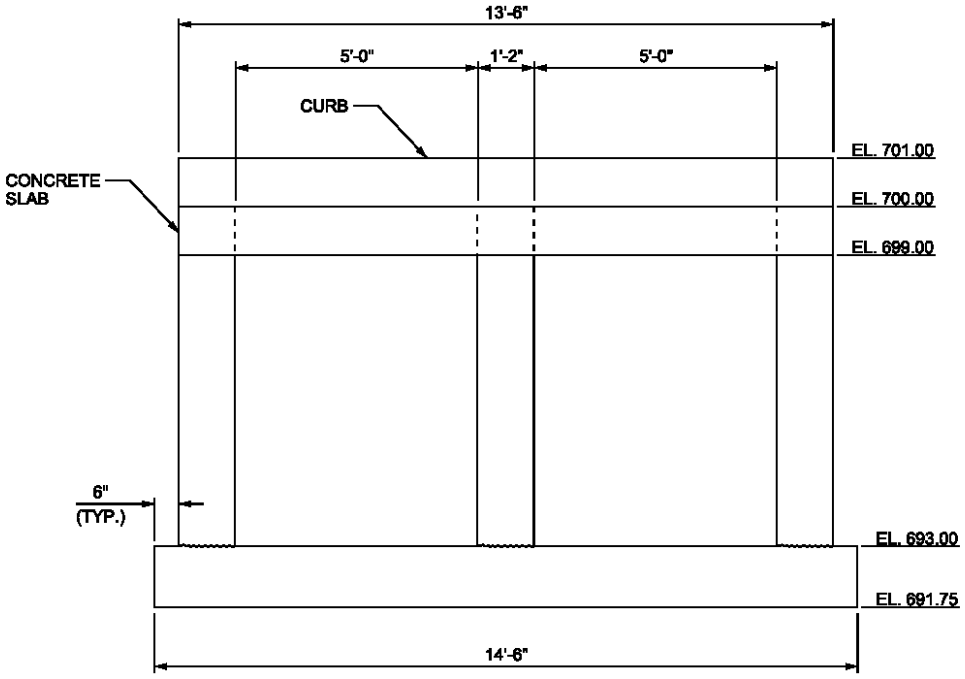

Figure 3: Two-Bay Control Structure Cross Section.

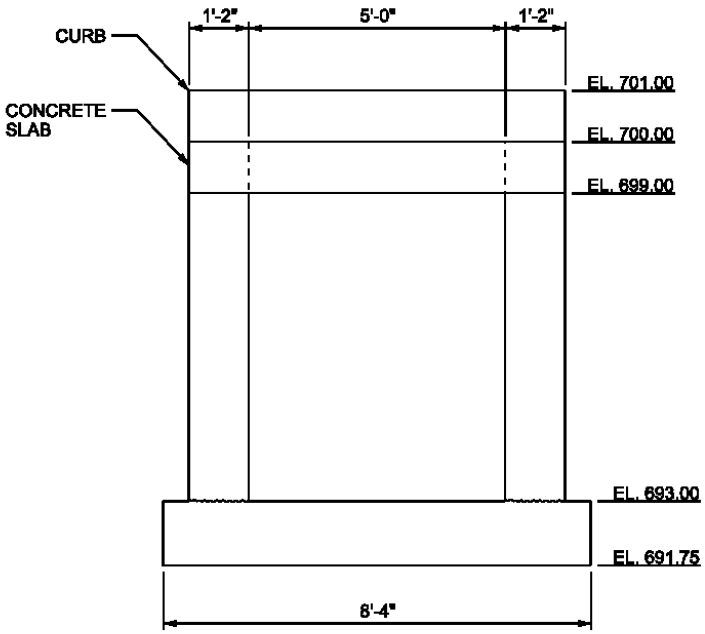

Figure 4: One-Bay Control Structure Cross Section.

Table 4: Two-Bay Water Control Structure Stability

Limit State	Load Case	Load Condition Category	River Stage EL, ft	Lake Pool EL, ft	Design Criteria	
					Calculated FOS	EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	5.05	1.3
	Normal High Lake	Usual	691.26	696.5	8.10	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	9.52	1.3
	Construction, Truck	Unusual	690.26	690.26	61.77	1.3
					Calculated Percent Base in Compression %	Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	100	75
	Normal High Lake	Usual	691.26	696.5	100	100
	Normal High Lake, Truck	Unusual	691.26	696.5	100	75
	Construction, Truck	Unusual	690.26	690.26	100	100
					Max Calculated Bearing Pressure psf	Allowable Bearing Pressure psf
Bearing	High River Stage	Unusual	698.26	694.3	487.61	2000
	Normal High Lake	Usual	691.26	696.5	461.42	
	Normal High Lake, Truck	Unusual	691.26	696.5	548.62	
	Construction, Truck	Unusual	690.26	690.26	534.01	
					Calculated FOS	EM2100 Required FOS
Flotation	High River Stage	Unusual	698.26	694.3	2.80	1.2
	Normal High Lake	Usual	691.26	696.5	3.52	1.3

Table 5: One-Bay Water Control Structure Stability

Limit State	Load Case	Load Condition Category	River Stage EL, ft	Lake Pool EL, ft	Design Criteria	
					Calculated FOS	EM2100 Required FOS
Sliding	High River Stage	Unusual	698.26	694.3	5.72	1.3
	Normal High Lake	Usual	691.26	696.5	9.43	1.5
	Normal High Lake, Truck	Unusual	691.26	696.5	11.94	1.3
	Construction, Truck	Unusual	690.26	690.26	93.43	1.3
					Calculated Percent Base in Compression %	Minimum Percent Base in Compression %
Overturning	High River Stage	Unusual	698.26	694.3	100	75
	Normal High Lake	Usual	691.26	696.5	100	100
	Normal High Lake, Truck	Unusual	691.26	696.5	100	75
	Construction, Truck	Unusual	690.26	690.26	100	100
					Max Calculated Bearing Pressure psf	Allowable Bearing Pressure psf
Bearing	High River Stage	Unusual	698.26	694.3	552.85	
	Normal High Lake	Usual	691.26	696.5	542.46	
	Normal High Lake, Truck	Unusual	691.26	696.5	702.43	2000
	Construction, Truck	Unusual	690.26	690.26	827.73	
					Calculated FOS	EM2100 Required FOS
Flotation	High River Stage	Unusual	698.26	694.3	3.12	1.2
	Normal High Lake	Usual	691.26	696.5	4.03	1.3

5.1.2.3 Concrete Abutment Walls

Abutment walls were designed as free cantilevers or simply supported on top. Analysis was performed using the Corps program CFRAME software. See calculations in Attachment 1.

5.1.2.4 Base Slab

The base slab was designed as a part of U-frame structure. It is using the Corps program CFRAME. The analysis calculated maximum moment and shear within the base slab. The

summary of results for the frame analysis are shown in the attached calculation. The governing load cases for shear and moment are highlighted.

5.1.2.5 Top Slab

Concrete bridge slab is used on top of the control structure to allow pedestrian and maintenance traffic. It is designed for H-20 loading. An axle rating is used as the slab span of 72 inches only allows loading from a single axle. The slab was designed as simply supported structure. The Box-frame structure is analyzed using the Corps program CFRAME. The analysis calculated maximum moment and shear within the slab. The summary of results for the frame analysis are shown in the attached calculations. The governing load cases for shear and moment are highlighted.

5.1.2.6 Excavator Pad

After discussion with USFWS on 5/3/19, an excavator pad is added to each structure and to be placed on the side of the access road on U/S side of the stoplogs. The pad will facilitate the parking of the excavation and trash removal vehicles on concrete surfaces. The pad is about 12 feet wide and 25 feet long and 8” thick and placed on compacted gravel. The slab is designed in accordance to UFC 3-320-06A, EM 1110-2-2104 and ACI-318-11 requirements.

5.1.3 Stoplogs

Stoplogs are designed as aluminum HSS members for the full head loading of about 8.00 ft. Each stoplog is 5.5 feet lond, 4-inch by 6-inch rectangular tube with 1/4-inch thick walls are assumed for the closures. Stoplogs are supported at the ends by grooves formed by steel embedment anchored to the concrete walls. Allowable stresses are in conformance with EM 1110-1-2101 and the Aluminum Design Manual.

5.1.4 Miscellaneous Metals (grating, guard rail and handrail

Designs for guard rail and handrail were based on standardize MNDOT designs.

5.1.5 Bridge Load Rating

The structures are designed for H-20 truck. To load rate the bridge, the maximum legal axle load under Minnesota State law (20,000 lbs single axle or 34,000 lbs tandem axle) was checked.

Based on discussions with USFWS, fully loaded dumps (55,000 lbs) were using the long meadow lake structure in the same vicinity. Several loads of gravel were brought across bridge to repair the road. Other utility trucks (Xcel Energy) have also used the bridge. Given this heavy use, the control structure is designed to accommodate such loading.

5.1.6 Approach Retaining Walls

There are 4 similar retaining wingwalls, one at each corner of the control structure. The walls are 15 lineal feet long and have varied height. No concrete keys were utilized to aid in sliding resistance for the T-wall. Design procedure for the T-wall is according to EM1110-2-2502 for load and load combination determinations and stability analyses, and EM 1110-2-2104 for reinforced concrete design. See drawings for plan sections and details.

For T-wall load Cases R1 and R2 were the only load cases investigated and only long-term soil conditions (drained condition) were analyzed. Water elevations in the soil behind the wall were taken 2 feet below top of the wall for Load Case R1 and R2. The Water elevations in the channel were taken 5 feet below top of the wall for Load Case R1 and dry channel elevation is used for Load Case R2. The bottom of the base slab is embedded 4 feet below the ground surface for frost protection. Vertical loads consist of concrete weight, water, buoyant soil, and uplift pressures along the base. Driving loads consisted of water and soil loads. Uplift pressures were obtained by the Line-of-Creep method using a seepage path from the base of the slab on the driving side to the top of soil on the resisting side. Surcharge load of 250 psf were used where heavy vehicle will be used to clean up the channel.

T-Wall was analyzed for rotational, bearing, and sliding stability. Sliding stability was evaluated for the inclined and block wedge conditions. Sliding stability under the block wedge condition was the primary controlling factor in stability analyses. Partial passive soil pressures were used in the sliding stability analysis when active soil pressures were inadequate in satisfying sliding stability criteria. Wall thicknesses were obtained from factored water pressures from the top of the wall with no resisting loads. Slab thicknesses were obtained from factored bearing pressures.

5.2 Miscellaneous Drainage Features

RCP Pipes are designed according to EM 1110 2 2902 and ACPA Concrete Pipe Handbook guidelines.

5.3 Corrosion Control

To help resist corrosion, the metals will be hot dip galvanized after fabrication.

6 Operations and Maintenance Considerations

The Operations and Maintenance (O&M) Manual should contain the following information:

- Structure and Bridge should be inspected periodically and prior to any heavy truck loads
- Any vehicles crossing the structure should reduce speed to below 5mph
- Axle limit is 10 tons and should be signed accordingly. Below is standard MNDOT Axle Weight Limit sign.

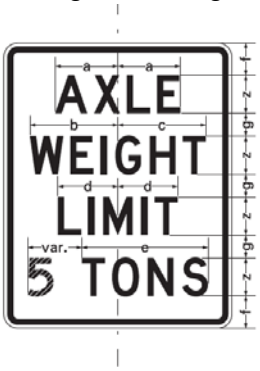

Figure 5: Standard MNDOT Axle Weight Limit Sign

Structural Calculations
The following information is included in Attachment 1 to this appendix:

- Two-Bay Control Structure Stability and Design
- One-Bay Control Structure Stability and Design
- Approach Retaining Wall Design
- Stoplog Design
- Drawings

US Army Corps of Engineers®
St. Paul District

Appendix L: HTRW

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

March, 2018

US Army Corps of Engineers ®
St. Paul District

GEOTECHNICAL & GEOLOGY BRANCH
180 5th Street East
St. Paul, MN 55101

PHASE I ENVIRONMENTAL SITE ASSESSMENT REPORT – BASS PONDS HABITAT REHABILITATION ENCHANCEMENT PROJECT

Bass Ponds HREP Feasibility Study
Scott County, Minnesota

31 January 2019

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Table of Contents

Section	*Page*
1.0 Abbreviations	1
2.0 Liability Statement	3
3.0 General Information	4
4.0 Executive Summary	5
4.1 Subject Property Description	5
4.2 Environmental Report Summary	5
4.3 Recommendations	5
5.0 Introduction	6
5.1 Purpose	6
5.2 Scope of Work	6
5.3 Limitations and Exceptions	7
6.0 Site Description	7
6.1 Location and Legal Description	7
6.2 Site and Vicinity Description	7
6.3 Current Use of the Property	8
6.4 Adjoining Property Information	8
6.5 Owner Provided Information	8
7.0 Records Review	9
7.1 Standard Environmental Records Sources	9
7.2 Physical Setting Sources	9

Table of Contents

Section	*Page*
7.3 Historical Use	10
7.3.1 Sanborn Fire Insurance Maps	10
7.3.2 City Directories	10
7.3.3 Topographical Maps	11
7.3.4 Aerial Photos	11
8.0 Site Reconnaissance	11
8.1 Methodology and Limiting Conditions	11
8.2 General Site Setting	11
8.3 Site Visit Findings	12
8.3.1 Subject Property	12
9.0 Conclusions	13

Appendices:

Appendix A: EDR Radius Map Reports with GeoCheck

Appendix B: Certified Sanborn Map Reports

Appendix C: EDR City Directory Image Reports

Appendix D: EDR Historical Topographic Map Reports

Appendix E: EDR Aerial Photo Decade Packages

Appendix F: Site Reconnaissance Photographs

1.0 Abbreviations

ACM	Asbestos Containing Material
AIRS	Aerometric Information Retrieval System
AST	Aboveground Storage Tank
AUL	Activity and Use Limitation
ASTM	American Society for Testing Materials
CDL	Clandestine Drug Labs
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CONSENT	Superfund Consent Decrees
CORRACTS	Corrective Action Report
DOD	Department of Defense Sites
EDR	Environmental Data Resources
EPA	United States Environmental Protection Agency
ERNS	Emergency Response Notification System
ESA	Environmental Site Assessment
FIFRA	Federal Insecticide, Fungicide, & Rodenticide Act
FINDS	Facility Index System
FOIA	Freedom of Information Act
FTTS	FIFRA/TSCA Tracking System
FUDS	Formerly Used Defense Sites
FR	Federal Register
HMIRS	Hazardous Materials Information Reporting System
LQG	Large Quantity Generators
LAST	Leaking Aboveground Storage Tank
LUCIS	Land Use Control Information System
LUST	Leaking Underground Storage Tank
MGS	Minnesota Geological Survey
MLTS	Material Licensing Tracking System
NFRAP	Former CERCLIS Sites
NPDES	National Pollutant Discharge Elimination
NPL	National Priorities List
NPL LIENS	Federal Superfund Liens
NWI	National Wetlands Inventory
ODI	Open Dump Inventory
PADS	PCB Activity Database System
PCBs	Polychlorinated Biphenyls
PDF	Portable Digital Format
PLP	Permanent List of Priorities
RAATS	RCRA Administrative Action Tracking System

RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Information System
REC	Recognized Environmental Condition
ROD	Records of Decision
SEMS	Superfund Enterprise Management System Archive
SHWS	State Hazardous Waste Sites
SPILLS	Spills Database
SQG	Small Quantity Generators
SSTS	Section 7 Tracking Systems
SWF	Solid Waste Facility
SWRCY	Solid Waste Recycling
TRIS	Toxic Chemical Release Inventory System
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facilities
UMTRA	Uranium Mill Tailings Sites
USACE	United States Army Corps of Engineers
USC	United States Code
USGS	United States Geological Survey
UST	Underground Storage Tank
VCP	Voluntary Cleanup Program

2.0 Liability Statement

The following excerpts, unless otherwise noted, are from ASTM E 1527-13; Appendix X1.1.5.2; CERCLA Operator Liability:

'A person may be liable as a CERCLA operator when they exercise control over a facility.'

As defined in 42 U.S.C. 9601 (20) (A) The term "owner or operator" means (ii) in the case of an onshore facility or an offshore facility, any person owning or operating such facility.

As defined in 42 U.S.C. 9601 (9) (A) The term "facility" means any building, structure, installation, equipment, pipe or pipeline, well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, or aircraft, or (B) any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located.

'Some courts have held that ***a person may be liable as a current CERCLA operator where the person did not exercise control over historic operations that caused the contamination but dispersed or moved around contaminated soil****…'*

'Like a past CERCLA owner, a past operator must have exercised control over the site "at the time of disposal" to be liable as a CERCLA operator. Many courts have held that ***disposal is not limited to the original release but can encompass subsequent dispersal or movement of hazardous substances.****'*

3.0 General Information

Project Information:	Bass Ponds HREP Feasibility Study
Site Information:	Minnesota Valley National Wildlife Refuge County-State Aid Highway 101 Shakopee and Savage, Minnesota
County:	Scott
Latitude, Longitude:	44.8033°, -93.4329° 44.7986°, -93.4098° 44.7843°, -93.3718°

Site Assessor: Colin A. Riddick, P.G.
Geologist

Environmental Professional Qualification:

I declare that, to the best of my professional knowledge and belief, I meet the definition of Environmental Professional as defined in § 312.10 of 40 CFR 312.

I have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the subject property. I have developed and performed all the appropriate inquiries in conformance with the standards and practices set forth in 40 CFR Part 312.

Colin A. Riddick, P.G.
Geologist

4.0 Executive Summary

4.1 Subject Properties Description

The subject properties are located along the Minnesota River between River Miles 15.0 and 20.0 above the mouth of the Minnesota River. These sites are in the floodplain of the Minnesota River and parallel to County-State Aid Highway 101. The subject properties dimensions are roughly 0.6 miles by 4.0 miles and encompassing an estimated 2.9 square miles.

Predominant land use in the immediate vicinity is primarily undeveloped and for recreational use. Light to heavy industrial areas are found along the southern edge of the property boundaries.

The subject properties currently do not contain any buildings and appear uninhabited. The sites are bottom land marsh and lakes with several recreational trails traversing the properties. These properties are bounded by the Minnesota River to the north and west, County-State Aid Highway 101 to the south, and heavy industrial properties to the east.

4.2 *Environmental Report Summary*

Currently the subject properties are primarily wildlife refuge land owned and managed by the U.S. Fish and Wildlife Service. Small dump sites are scattered across the subject properties containing a variety of construction debris, tires, and assorted vehicular fuel tanks. There is evidence of minor surface staining at the US Highway 169 roadway drainage discharge pipe outlets. The aforementioned items should not constitute a significant environmental risk.

4.3 *Recommendations*

Based on the information obtained during the site reconnaissance portion of the environmental site assessment a ***Phase II ESA would not be necessary*** for the subject properties. It should be noted that the complete report must be read in order to fully understand the findings associated with the subject properties.

5.0 Introduction

5.1 Purpose

The purpose of the Phase I ESA was to evaluate the current and historical conditions of the subject property in an effort to identify recognized environmental conditions (REC) in connection with the subject property and surrounding operations.

A recognized environmental condition is defined by ASTM E 1527-13 as:

The presence or likely presence of any hazardous substances or petroleum products in, on, or at a property: (1) due to release to the environment; (2) under conditions indicative of a release to the environment; or (3) under conditions that pose a material threat of a future release to the environment. *De minimis* conditions are not recognized environmental conditions.

5.2 Scope of Work

The Phase I ESA conducted at the subject property was in accordance with ASTM Standard Practice E 1527-13 and further defined below:

- USACE has gathered and reviewed available historical data, including fire insurance maps, survey plat maps, aerial photography, topographic maps from the United States Geological Survey (USGS), hydrogeology maps from the Minnesota Geological Survey (MGS), geologic maps from MGS, and interviews with knowledgeable persons.

- USACE has reviewed state and federal environmental databases including NPL, CERCLIS, CORRACTS, RCRA, ERNS, SHWS, SWF, LUST, LAST, UST, AST, CDL, HMIRS, PADS, and SPILLS.

- USACE has physically inspected the subject property via walking survey, looking for signs of recognized environmental conditions such as stressed vegetation, soil staining, dumping, and evidence of aboveground and underground storage tanks.

- USACE has physically observed adjoining properties, paying particular attention to evidence of underground storage tanks, questionable housekeeping practices, or unusual business practices.

5.3 Limitations and Exceptions

The information, conclusions, and recommendations stated in the report are based upon work undertaken by trained professional and technical staff working for the U.S. Army Corps of Engineers, and also upon information provided by others. We have accepted as true and accurate the information provided by other sources, we cannot be held responsible for the accuracy of this information.

The Phase I ESA was conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the environmental profession under similar conditions. No other warranty or guarantee, expressed or implied, is included or intended in this report or otherwise.

The scope of this assessment does not purport to encompass every report, record, or other form of documentation relevant to the subject property being evaluated. The observations contained herein are made during site reconnaissance, review of ownership records, discussions with local government personnel, and review of readily accessible environmental databases. The Phase I ESA is based upon our professional judgment concerning the significance of the data collected and in no way attempts to forecast future site conditions.

6.0 Site Description

6.1 Location and Legal Description

Address: Minnesota Valley National Wildlife Refuge
County-State Aid Highway 101
Shakopee and Savage, Minnesota

Legal Description: Fifth Principal Meridian, Minnesota
Township 116 North, Range 22 West
- Section 34, Southeast ¼
- Section 35, South ½
- Section 36, Southwest ¼

Township 115 North, Range 22 West
- Section 1
- Section 2, North ½
- Section 3, Northeast ¼

Township 115 North, Range 21 West
- Section 7, Northeast ¼
- Section 8, North ½

The areas described contains 1,856 acres of land, more or less.

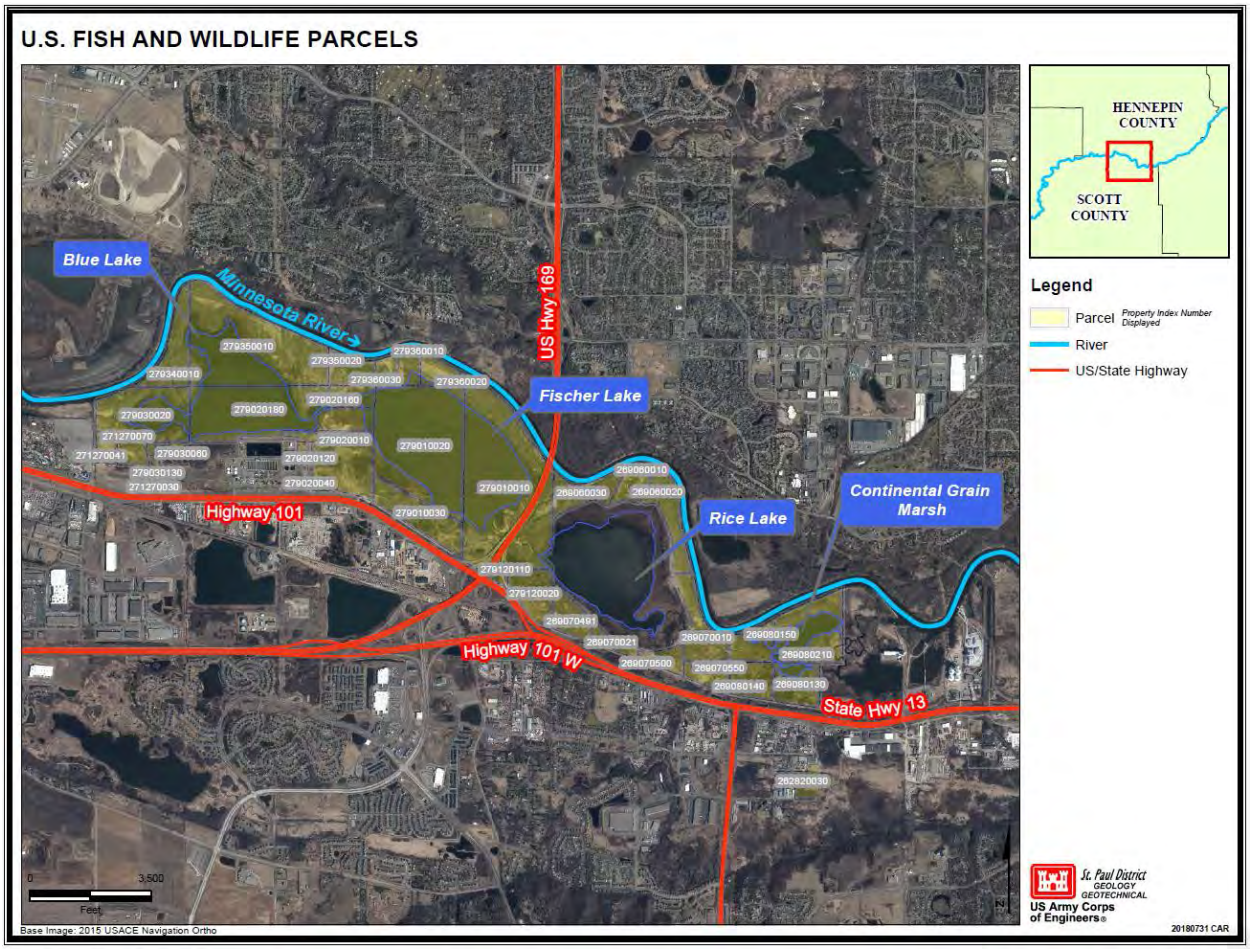

Figure 1. Parcel map with the properties of interest shown in yellow.

6.2 Site and Vicinity Description

The properties are currently uninhabited and primarily used for recreation and wildlife management, bounded by the Minnesota River to the north and west, County-State Aid Highway 101 to the south, and industrial property to the east.

The earliest use of these sites are unknown, but aerial photography reveals that by 1937 the subject properties were a mixture of bottomland marsh and agricultural fields. In 1976 the properties were established as habitat within the Minnesota Valley National Wildlife Refuge.

The properties do lie within the 100 year FEMA Federal Flood Zone and are comprised entirely of National Wetlands.

The sites are located within the city limits of Shakopee and Savage which have a population of 37,352 and 26,911 residents, respectively, according to the 2010 Census. Blue Lake Wastewater Treatment Plant is located on the southwestern extent of the subject area.

6.3 Current Use of the Property

The subject properties are currently owned by the U.S. Fish and Wildlife. The sites are part of a corridor along the Minnesota River comprised of wildlife habitat and recreation.

6.4 Adjoining Property Information

The adjoining properties are predominately recreational with a small fraction pertaining to light industrial/commercial areas and highway right-of-way. During the site reconnaissance the following properties were identified in the immediate vicinity:

Direction from Site	**Use**	**Comments**
North	Wetland/ River	Consists of the Minnesota River and associated wetlands
South	Commercial/ Industrial	Primarily highway right-of-way with the exception of the Blue Lake Wastewater Treatment Plant zoned as heavy industrial
West	Recreational/ River	Zoned as major recreation
East	Wetland/ Industrial	Zoned as heavy industrial

6.5 *Federal Government Refuge Management Provided Information*

The USACE conducted an in-person interview with Gerry Shimek, Refuge Manager, U.S. Fish and Wildlife. The purpose of the interview was to determine if there are any known past or present environmental concerns associated with the sites.

There were no unusual conditions identified from the interview.

7.0 Records Review

7.1 Standard Environmental Records Sources

At the request of the USACE, Environmental Data Resources, Inc. (EDR) conducted a search of Federal and State databases containing potential or known sites of environmental contamination. The number of listed sites identified within a one mile search radius are summarized in the following table. For a detailed listing of

databases and findings, a copy of the EDR Radius Map Reports have been included in Appendix A of this report.

Database List	Subject Property Listings	Total Number of Listings	Environmental Concerns Posed to Subject Property
CDL Sites	N	1	None
Federal NPL Sites	N	0	None
Federal CERCLIS Sites	N	0	None
Federal CERCLIS NFRAP Sites	N	1	None
RCRA CORRACTS Sites	N	0	None
RCRA TSD Facilities	N	0	None
RCRA SQG	N	1	None
RCRA LQG	N	0	None
Federal ERNS Sites	N	20	None
SPILLS Reports	N	3	None
State HW Sites	N	0	None
State CERCLIS Sites	N	0	None
Landfill/SW Disposal Sites	N	0	None
LUST/LAST Sites	N	43	None
UST/AST Sites	Y	96	None
MN AIRS Sites	N	15	None

7.2 Physical Setting Sources

Physical setting sources were provided by the EDR GeoCheck Physical Setting Source Addendum unless otherwise noted. A copy of the GeoCheck report can be found in Appendix A of this report.

Groundwater flow direction was reported by the EDR AQUIFLOW Information System. Only one well to the southeast of the target property reported data, flow direction was reported as north-northeast. Flow direction was also interpolated from the Hydrogeology of Scott County report from the MGS. The general localized groundwater flow gradient across the assessment areas is north-northeast.

The general topographical gradient is north, based upon site setting and surrounding areas, there is a likelihood that contamination could be brought to the subject site.

The GeoCheck report revealed that no water supply or monitoring wells were identified on the subject properties. However, one commercial well is located at the Cargill West Elevator and several dewatering wells are located around the Blue Lake Wastewater Treatment Plant.

7.3 Historical Use

7.3.1 Sanborn Fire Insurance Maps

Historical fire insurance maps were requested from EDR and a search of the Sanborn Library, LLC was conducted. Historical maps are detailed drawings that show the locations and use of structures on a given property during a specific year. The maps were originally used by insurance companies to assess fire risk. A copy of the Sanborn Map Report can be found in Appendix B of this report.

EDR reported these as unmapped properties and no fire insurance maps were found.

7.3.2 City Directories

Historical and current city directories of the subject property and subject property street were requested from EDR. City directories were obtained for the following years: 1967, 1972, 1977, 1982, 1987, 1992, 1995, 2000, 2005, 2010, and 2014. City directories have been published for cities and towns across the United States since the 1700s. Originally a list of residents, the city directory developed into a tool for locating individuals and businesses. While city directory coverage is comprehensive for major cities, it may be limited for rural areas and small towns. A copy of the available information for the subject property can be found in Appendix C of this report.

There were no unusual entries identified from the city directories.

7.3.3 Topographical Maps

Historical topographic map coverage of the subject property was requested from EDR. 1896, 1901, and 1958 USGS 15 Minute Topographic quadrangles and 1954, 1967, 1972, 1980, 1993, and 2013 USGS 7.5 Minute Topographic quadrangles were obtained. The 1954 and 1967 topographic maps depict the subject property and adjoining properties as similar to what was observed at the time of the property reconnaissance. Partial copies of the topographic maps can be found in Appendix D of this report.

There were no unusual conditions identified from the topographic maps.

7.3.4 Aerial Photos

Historical aerial photos of the subject property were requested from EDR. Photo coverage was available for the following years: 1937, 1940, 1947, 1951, 1957, 1966, 1969, 1972, 1978, 1984, 1987, 1991, 1997, 2006, 2010, and 2015. Copies of the aerial photos can be found in Appendix E of this report.

There were no unusual conditions identified from the aerial photos.

8.0 Site Reconnaissance

8.1 Methodology and Limiting Conditions

The site reconnaissance was conducted on 1 June 2018 by Colin Riddick, geologist with the U.S. Army Corps of Engineers, St. Paul District. The inspector was unaccompanied during the site reconnaissance. Weather conditions at the time of the site reconnaissance were partly cloudy, warm (approximately 80° F), and light winds. During the inspection thick vegetation and tall grasses covered a vast majority of the inspection area obscuring the ground surface. Photographs taken during the site reconnaissance can be found in Appendix F of this report.

8.2 General Site Setting

The subject properties are located in the floodplain of the Minnesota River along the northern boundary of Shakopee and Savage, Minnesota city limits. The land is primarily undeveloped forest and wetlands. The soil consists of alluvial overbank sediments and shallow lacustrine to marsh deposits.

8.3 Site Visit Findings

Note: All referenced photos can be found in Appendix F of this report.

8.3.1 Subject Property

- Minor surface staining was observed at the US Highway 169 roadway drainage discharge pipe outlets (Fig. 44, 45, and 49).
- Small debris piles were observed around Blue Lake that contained tires, vehicular fuel tanks, and scattered plastic, glass, metal and lumber (Fig. 22, 25, 26, 32, and 33).
- Miscellaneous debris was observed along the Fischer/Rice outlet channel (Fig. 41).

9.0 Conclusions

The USACE has conducted a Phase I Environmental Site Assessment of the subject property in conformance with the scope and limitations of ASTM Standard Practice E 1527-13. This assessment revealed that there were no observed potential risks for contamination due to recognized environmental conditions on the subject property.

The multiple dump areas on the properties would be considered a *de minimis* condition, however, cleanup and removal of said items should be determined.

A Phase II Environmental Site Assessment is not recommended for the subject properties.

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Appendix A

EDR Radius Map with GeoCheck

This appendix is available for viewing upon request.

Appendix B

Certified Sanborn Map Reports

This appendix is available for viewing upon request.

Appendix C

EDR City Directory Image Reports

This appendix is available for viewing upon request.

Appendix D

EDR Historical Topographic Map Reports

This appendix is available for viewing upon request.

Appendix E

EDR Aerial Photo Decade Packages

This appendix is available for viewing upon request.

FIGURE **PAGE**

FIGURE 1. DOWNSTREAM VIEW OF CARGILL DRAINAGE CHANNEL 7
FIGURE 2. UPSTREAM VIEW OF CARGILL DRAINAGE CHANNEL 7
FIGURE 3. GEOTEXTILE AND RIPRAP WITHIN STOPLOG BYPASS CHANNEL 8
FIGURE 4. RIPRAP WITHIN STOPLOG BYPASS CHANNEL 8
FIGURE 5. SILTED IN STOPLOG STRUCTURE 9
FIGURE 6. GENERAL VIEW OF SILTED STOPLOG STRUCTURE 9
FIGURE 7. ABANDONED AND UNMAINTAINED STOPLOG STRUCTURE 10
FIGURE 8. VIEW INSIDE OF STOPLOG STRUCTURE 10
FIGURE 9. GENERAL VIEW OF ABANDONED STOPLOG STRUCTURE 11
FIGURE 10. VIEW OF ABANDONED STOPLOG STRUCTURE LOOKING TOWARDS CARGILL 11
FIGURE 11. OUTLET/DISCHARGE AREA OF ABANDONED STOPLOG STRUCTURE 12
FIGURE 12. MINNESOTA RIVER FROM EDGE OF CONTINENTAL GRAIN MARSH PROPERTY 12
FIGURE 13. TYPICAL VIEW OF CONTINENTAL GRAIN MARSH LOOKING EAST 13
FIGURE 14. TYPICAL VIEW OF CONTINENTAL GRAIN MARSH LOOKING WEST 13
FIGURE 15. TYPICAL VIEW OF CONTINENTAL GRAIN MARSH LOOKING SOUTH 14
FIGURE 16. DOWNSTREAM VIEW OF ROCK SPILLWAY STRUCTURE 14
FIGURE 17. ROAD CROSSING AT CARGILL BARGE LOADING FACILITY 15
FIGURE 18. CARGILL BARGE LOADING FACILITY AND HARBOR 15
FIGURE 19. UPSTREAM VIEW OF PRIMARY BLUE LAKE WATERSHED CONVEYANCE CHANNEL 16
FIGURE 20. DOWNSTREAM VIEW OF PRIMARY BLUE LAKE WATERSHED CONVEYANCE CHANNEL 16
FIGURE 21. CORRUGATED METAL PIPE CONVEYING PRIMARY BLUE LAKE WATERSHED CHANNEL 17
FIGURE 22. MISCELLANEOUS METAL SCRAP ON CULVERT DISCHARGE RIPRAP 17
FIGURE 23. DISCHARGE END OF 72-INCH CORRUGATED METAL PIPE 18
FIGURE 24. TYPICAL VIEW ALONG PERIMETER OF BLUE LAKE 18
FIGURE 25. RUSTY VEHICULAR FUEL TANK ALONG BLUE LAKE REFUGE TRAIL 19
FIGURE 26. TIRES AND OTHER DEBRIS ALONG BLUE LAKE REFUGE TRAIL 19
FIGURE 27. DISCHARGE END OF 12-INCH IRON PIPE UNDER BLUE LAKE REFUGE TRAIL 20
FIGURE 28. HIGH CONCENTRATIONS OF FE IN DISCHARGE WATER 20
FIGURE 29. LOOKING DOWNSTREAM OF IRON PIPE DISCHARGE 21
FIGURE 30. LOOKING UPSTREAM OF IRON PIPE INLET 21
FIGURE 31. OBSCURED INLET OF IRON PIPE 22
FIGURE 32. MISCELLANEOUS CONCRETE DEBRIS ALONG BLUE LAKE REFUGE TRAIL 22
FIGURE 33. RUSTY VEHICULAR FUEL TANK ALONG BLUE LAKE REFUGE TRAIL 23
FIGURE 34. VIEW OF BLUE LAKE FROM BLUE LAKE TREATMENT PLANT 23
FIGURE 35. SOUTHERN PROPERTY BOUNDARY OF BLUE LAKE TREATMENT PLANT LOOKING EAST 24
FIGURE 36. SOUTHERN PROPERTY BOUNDARY OF BLUE LAKE TREATMENT PLANT LOOKING WEST 24
FIGURE 37. 345 KV TRANSMISSION LINE ACROSS BLUE LAKE 25
FIGURE 38. MAN PLACED RIPRAP ALONG SOUTHERN SHORE OF BLUE LAKE 25
FIGURE 39. GRAVEL PARKING LOT UNDER US HIGHWAY 169 26
FIGURE 40. FISCHER LAKE OUTLET CHANNEL UNDER US HIGHWAY 169 26
FIGURE 41. MISCELLANEOUS DEBRIS ALONG FISCHER/RICE LAKE OUTLET CHANNEL 27
FIGURE 42. 2ND BLUE LAKE OUTLET BENEATH THE US HIGHWAY 169 BRIDGE 27
FIGURE 43. RICE LAKE OUTLET STRUCTURE 28
FIGURE 44. US HIGHWAY 169 ROADWAY DRAINAGE DISCHARGE PIPE SCOUR 28
FIGURE 45. US HIGHWAY 169 ROADWAY DRAINAGE DISCHARGE PIPES 29
FIGURE 46. UPSTREAM END OF SCOUR AROUND REINFORCED CONCRETE PIPE CULVERT 29
FIGURE 47. SCOUR CHANNEL AND MISCELLANEOUS UTILITIES TRAVERSING SITE 30
FIGURE 48. GENERAL VIEW LOOKING NORTH ALONG US HIGHWAY 169 30
FIGURE 49. SOUTHBOUND BRIDGE PRIER OF US HIGHWAY 169 31
FIGURE 50. GENERAL VIEW LOOKING NORTH ACROSS PARKING LOT BENEATH US HIGHWAY 169 31

FIGURE 51. RICE LAKE BOAT LAUNCH.....32
FIGURE 52. RICE LAKE EMP WEST OUTLET STOP LOG STRUCTURE.....32

Continetnal Grain Marsh Photo Index

Base Image: 2015 USACE Navigation Ortho

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Blue Lake Photo Index

Base Image: 2015 USACE Navigation Ortho

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Continetnal Grain Marsh Photo Index

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Figure 1. Downstream view of Cargill drainage channel

Figure 2. Upstream view of Cargill drainage channel

Figure 3. Geotextile and riprap within stoplog bypass channel

Figure 4. Riprap within stoplog bypass channel

Figure 5. Silted in stoplog structure

Figure 6. General view of silted stoplog structure

Figure 7. Abandoned and unmaintained stoplog structure

Figure 8. View inside of stoplog structure

Figure 9. General view of abandoned stoplog structure

Figure 10. View of abandoned stoplog structure looking towards Cargill

Figure 11. Outlet/discharge area of abandoned stoplog structure

Figure 12. Minnesota River from edge of Continental Grain Marsh property

Figure 13. Typical view of Continental Grain Marsh looking east

Figure 14. Typical view of Continental Grain Marsh looking west

Figure 15. Typical view of Continental Grain Marsh looking south

Figure 16. Downstream view of rock spillway structure

Figure 17. Road crossing at Cargill barge loading facility

Figure 18. Cargill barge loading facility and harbor

Figure 19. Upstream view of primary Blue Lake Watershed conveyance channel

Figure 20. Downstream view of primary Blue Lake Watershed conveyance channel

Figure 21. Corrugated metal pipe conveying primary Blue Lake Watershed channel

Figure 22. Miscellaneous metal scrap on culvert discharge riprap

Figure 23. Discharge end of 72-inch corrugated metal pipe

Figure 24. Typical view along perimeter of Blue Lake

Figure 25. Rusty vehicular fuel tank along Blue Lake refuge trail

Figure 26. Tires and other debris along Blue Lake refuge trail

Figure 27. Discharge end of 12-inch iron pipe under Blue Lake refuge trail

Figure 28. High concentrations of Fe in discharge water

Figure 29. Looking downstream of iron pipe discharge

Figure 30. Looking upstream of iron pipe inlet

Figure 31. Obscured inlet of iron pipe

Figure 32. Miscellaneous concrete debris along Blue Lake refuge trail

Figure 33. Rusty vehicular fuel tank along Blue Lake refuge trail

Figure 34. View of Blue Lake from Blue Lake Treatment Plant

Figure 35. Southern property boundary of Blue Lake Treatment Plant looking east

Figure 36. Southern property boundary of Blue Lake Treatment Plant looking west

Figure 37. 345 kV transmission line across Blue Lake

Figure 38. Man placed riprap along southern shore of Blue Lake

Figure 39. Gravel parking lot under US Highway 169

Figure 40. Fischer Lake outlet channel under US Highway 169

Figure 41. Miscellaneous debris along Fischer/Rice Lake outlet channel

Figure 42. 2nd Blue Lake outlet beneath the US Highway 169 Bridge

Figure 43. Rice Lake outlet structure

Figure 44. US Highway 169 roadway drainage discharge pipe scour

Figure 45. US Highway 169 roadway drainage discharge pipes

Figure 46. Upstream end of scour around reinforced concrete pipe culvert

Figure 47. Scour channel and miscellaneous utilities traversing site

Figure 48. General view looking north along US Highway 169

Figure 49. Southbound bridge prier of US Highway 169

Figure 50. General view looking north across parking lot beneath US Highway 169

Figure 51. Rice Lake boat launch

Figure 52. Rice Lake EMP West outlet stop log structure

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Appendix M: Cultural Resources

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

March, 2019

Appendix M: Cultural Resources

TABLE OF CONTENTS

1 Introduction 2
1.1 Cultural Resources within the Study Area 2
1.2 Deep Site Testing (2018) 4

2 Impacts of the Recommended Plan to Cultural Resources 7
2.1 Water Control Features 7
2.2 Continental Grain Marsh Plug 7
2.3 Access Roads 7

3 References Cited 8

LIST OF FIGURES

Figure 1: Location of No Longer Extant Historic Farmsteads or Outbuildings within the Project Area. 4
Figure 2: Deep Site Test 1, Continental Grain Marsh Levee. Terminated at 120 cm Below Surface Due to High Water. September 2018. 5
Figure 3: Test 2, Continental Grain Marsh Natural Levee. September 2018. View to Southwest. 6
Figure 4: Location of Deep Site Tests along the Continental Grain Marsh Natural Levee. 6

LIST OF TABLES

Table 1: Recorded Cultural Resources Within One Mile of the Project Area. 2

1 Introduction

The Minnesota River Valley and surrounding environs has been a focus of human use and occupation for thousands of years as evidenced by the many archaeological sites associated with the diverse landscape and contemporary use of valley. The Minnesota River Valley, formed by drainage of Glacial Lake Agassiz through its southern outlet of Glacial River Warren, was regularly occupied by humans following the subsidence of high flows and episodic, catastrophic flooding approximately 9,500 years ago (e.g., Gibbon 2012; Wright et. al. 1998). The cultural sequence of the area includes Paleo, Archaic, Woodland, Mississippian/Plains Village, and Oneota traditions. The French were the first Europeans to explore the area in the mid-17th century although the effects of contact, such as trade goods, disease, and displaced peoples, were felt prior to direct interaction. Native American groups in the area at the time of French contact included the Dakota, Oto, Ioway and possibly the Illinois. Widespread agriculture and development coincided with American occupation of the area in the early 19th century (e.g., Gibbon and Anfinson 2008).

1.1 Cultural Resources within the Study Area

A total of 24 cultural resources (historic properties) are recorded within one mile of the project area (Table 1). No historic properties have been identified within the project area. Cultural resources include a variety of precontact and historic archaeological sites and standing structures. Precontact sites include lithic and artifact scatters, village sites, and burial mounds. Historic sites include structural ruins, artifacts scatters, early town sites, historic trails, and a World War II internment camp. Cultural resources in the area are situated on a variety of landforms, namely uplands and terraces. Several cultural resource sites within this locality are listed on the National Register of Historic Places (NRHP) or are eligible for listing on the NRHP.

Table 1: Recorded Cultural Resources Within One Mile of the Project Area.

Site Number	Site Name	Site Type	Cultural Period	Setting
21Hem	Hennepin	Ghost Town	Historic	Upland
21HE240	Hennepin Site III	Artifact Scatter	Precontact	Upland
21HE219	-	Artifact Scatter	Historic	Upland/Toeslope
21HE22	-	Burial Mounds	Precontact	Upland
21HE142	Riverview Heights	Artifact Scatter	Precontact	Upland
21HE92	Eck Burials	Cemetery	Precontact	Upland
21HE214	Fowler Mounds	Burial Mounds	Precontact	Upland
21HEp/HE-EPC-A36. Other segments not named.	North Minnesota Valley Trail, Schlampp Segment	Trail	Historic	Terrace
21HE17	Bloomington Ferry Mounds	Burial Mounds	Precontact	Upland
21HEi	-	Artifact Scatter	Historic	Terrace
21HE4	-	Burial Mounds	Precontact	Upland
21HE6	Cunningham Mounds	Burial Mounds	Precontact	Upland
21HE5	-	Burial Mounds	Precontact	Upland
21HE260	-	Lithic Scatter	Precontact	Upland
21SC19	Eagle Creek	Burial Mounds	Precontact	Terrace

21Scar	WW II Internment Camp	Structural Ruins	Historic	Terrace
21SC37	-	Artifact Scatter	Precontact	Terrace
21SC25	-	Burial Mounds	Precontact	Terrace
21SC80	Blue Lake #6	Village	Precontact	Terrace
21SC79	Blue Lake #5	Village	Precontact	Terrace
21SC78	Blue Lake #4	Single Artifact	Precontact	Terrace
21SC77	Blue Lake #3	Burial Mound	Precontact	Terrace
21SC76	Blue Lake #2	Lithic Scatter	Precontact	Terrace
21SC75	Blue Lake #1	Lithic Scatter	Precontact	Terrace

No cultural resources investigations have been conducted within the project area. A number of archaeological studies have occurred at sites along the uplands and more recently along the colluvial slopes and terraces in the valley both upstream and downstream of the project area (e.g., Madigan et. al 1998; Florin et. al. 2015). Several of the project features will be placed on natural levees. Natural levees have a high probability to contain deeply buried cultural deposits (e.g., Brown et. al. 2006; Monaghan et. al. 2006). While none of the previously recorded sites proximal to the project area are located on natural levees, numerous sites on natural levees have been identified in areas upstream and downstream of the project area and elsewhere on large rivers in the region (e.g., Minnesota State Historic Preservation Office Files: Stoltman 2005).

European development within the project area includes construction of roads, bridges, farmsteads, a grain elevator complex, and cultivation. All of the natural levees in the project area were cultivated, likely beginning in the late 19th century and visible in aerial photographs from the 1930s. Three farmsteads or outbuildings were located along the levees: outbuildings just downstream of the proposed water control structure at Continental Grain Marsh; one where the access road meets the natural levee and turns upstream to the Blue Lake structure; and, one where the western portion of the access road turns south to the Blue Lake structure (Figure 1). All of the farmsteads had access roads running along the natural levees. While these roads do not appear to be macadamized, it is unknown if they were gravel or two-track field roads.

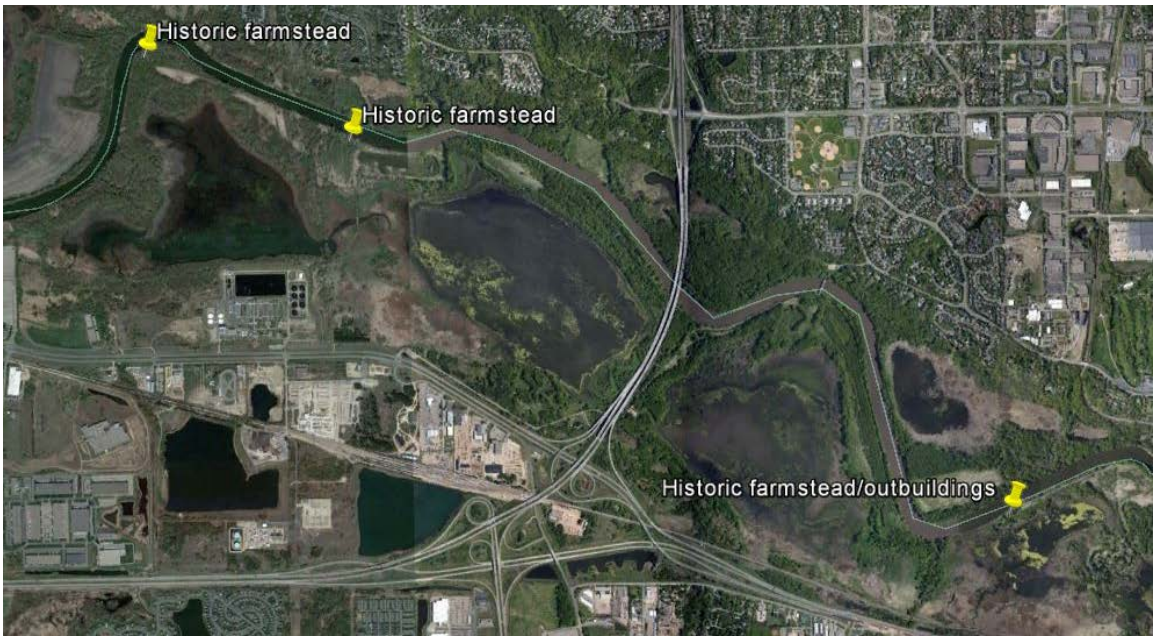

Figure 1: Location of No Longer Extant Historic Farmsteads or Outbuildings within the Project Area.

Prior to the construction of the existing elevated HWY 169 crossing the Minnesota River, a road from the Bloomington Ferry Bridge to HWY 101 traversed the floodplain between Fisher and Rice lakes, with a bridge crossing the channel between the two lakes at the approximate location of the proposed water control structures in that area.

Water control structures were previously constructed at several locations along the natural levees and between Fisher and Rice lakes. Rip-rap was also placed along stretches of the Continental Grain Marsh natural levee.

Cursory surface examination of the areas previously occupied by farmsteads reveal no evidence of foundations or extant structures. None of the farmsteads in the area are extant following establishment of the refuge in 1976. Visible traces of the farmsteads include a fencerow and tree line running to the south/southwest of the farmstead situated to the north of the Blue Lake structure and an abandoned seed drill along the Continental Grain Marsh levee.

1.2 Deep Site Testing (2018)

In the autumn of 2018, U.S. Army Corps of Engineers (USACE, or Corps) and contract archaeologists completed limited deep site testing along portions of the natural levee at the Continental Grain Marsh between flood episodes. Three 8-inch (20-cm) bucket auger tests were completed, with the soil matrix passed through ¼ inch hardware cloth. The results of Tests 1-3 are discussed below.

Test 1 was placed approximately 185 m downstream of the proposed water control structure and approximately 150 m upstream of the farmstead/outbuildings identified from aerial photographs noted in Figure 1 (the southeastern most farmstead) and at a relatively low spot along the levee. Test 1 was terminated at 120 cm due to rising water and imminent submersion of the area (Figure 2). Test 2 was placed approximately 385 m downstream of the proposed water control structure and at the eastern edge of the farmstead or outbuildings mentioned above and adjacent to an abandoned ca. 1940s seed drill. The test area is on a relatively high

portion of the levee (Figure 3). Test 3 was placed approximately 525 m downstream of the proposed water control structure and along the topographically highest portion of the levee. Figure 4 depicts the locations of the deep site tests along the natural levee at Continental Grain Marsh.

The soil profiles of the tests along the Continental Grain Marsh natural levee exhibited post settlement alluvium (PSA) from 15-40 cm below surface overlying a plowzone. Buried soil horizons (stable surfaces) were detected at depths of 40 cm, 185 cm, and 225 cm.

Test 1 contained six fragments of calcined bone between ca. 40-60 cm within the shallowest buried soil. The calcined bone suggests a cultural origin, although it is not definitive if the material represents an intact archaeological site or the age of the materials. While the faunal material is curated at the St. Paul District, and pending additional testing in the area, the find spot has not been classified as a cultural site. Several concrete fragments were observed from 10-20 cm below the surface in Test 2. No cultural materials were recovered from Test 3.

Figure 2: Deep Site Test 1, Continental Grain Marsh Levee. Terminated at 120 cm Below Surface Due to High Water. September 2018.

Figure 3: Test 2, Continental Grain Marsh Natural Levee. September 2018. View to Southwest.

Figure 4: Location of Deep Site Tests along the Continental Grain Marsh Natural Levee.

2 Impacts of the Recommended Plan to Cultural Resources

Surface reconnaissance and limited deep site testing within the project area indicate that the Recommended Plan would preliminarily have no impacts to historic properties. There would be no permanent indirect effects to proximal recorded historic properties.

2.1 Water Control Features

Construction of the water control features will occur within previously disturbed areas. The structure at Blue Lake will replace an existing structure within the same footprint with no new ground disturbance. The structures between Fisher and Rice lakes will occur in areas previously disturbed from road and bridge construction and placement of water control structures. This area has also suffered from erosion and placement of buried utility lines. The water control structure along the Continental Grain Marsh natural levee will be placed where a previous structure has washed out. Thus, placement of the new water control structures will have no effect to historic properties.

2.2 Continental Grain Marsh Plug

Construction of a plug between Eagle Creek and Continental Grain Marsh involves placement of material on the existing surface with no excavation. In addition, during the 1850s, Eagle Creek headed north out of the uplands and turned east in the area where the plug is proposed and entered the Minnesota River in the area where the grain elevator currently resides. It appears that the area where the plug is proposed has been modified following re-directing Eagle Creek's current debouchure with the Minnesota River. Therefore, there would be no effects to historic properties by construction of the plug.

2.3 Access Roads

Construction of access roads along the natural levee may impact deeply buried sites. However, there would be no effect to historic properties provided that any subsurface preparation for the roads would occur within the PSA. The effects of any access road construction (i.e., depth of excavation, weight of construction equipment, specs of base material, soil structure, etc.) on buried soil horizons/deeply buried sites will be reviewed using modified Boussinesq's Equation or other suitable models.

Additional archaeological investigations will be conducted prior to construction to verify the preliminary information. If significant archaeological phenomena are identified, steps would be taken to avoid, minimize, or mitigate adverse effects. Section 106 coordination and cultural resources management plans will be developed in consultation with various partners, such as the aforementioned Native American Groups, the Minnesota State Historic Preservation Office, the US Fish and Wildlife Service, and others.

3 References Cited

Brown, A.G., G. Barker, D. Brothwell, P. Bogucki, E. Slater
2006 *Alluvial Geoarchaeology: Floodplain Archaeology and Environmental Change*. Cambridge University Press, Cambridge.

Florin, F, K. Bakken, J. Lindbeck, B. Wright
2015 *Phase III Data Recovery at Site 21CR155 for the TH101/CSAH 61 Southwest Reconnection Project in Carver County, Minnesota*. Florin Cultural Resources Reports of Investigations No. 115. Boyceville.

Gibbon, G.
2012 *Archaeology of Minnesota: the Prehistory f the Upper Mississippi River Region*. University of Minnesota Press, Minneapolis.

Gibbon, G. and S. Anfinson
2008 *Minnesota Archaeology: The First 13,000 Years*. Publications in Anthropology No. 6. University of Minnesota, Minneapolis.

Madigan, T, A. Mathys, M. Murray, B. Perkl
1998 *Mound Verification at 21HE21 (Feldman Mound Group), Settler's Ridge Residential Development, Eden Prairie, Minnesota*. Institute for Minnesota Archaeology, Minneapolis.

Monaghan, G.W, K. Egan-Bruhy, M. Hambacher, D. Hayes, M. Kolb, S. Kuehn, S. Peterson, J. Robertson, N. Shaffer
2006 *Minnesota Deep Test Protocol Project*. Commonwealth Cultural Resources Group, Jackson.

Stoltman, J.
2005 Tillmont (47CR460), A Stratified Prehistoric Site in the Upper Mississippi River Valley. *The Wisconsin Archeologist* 86(2):1-126.

Wright, H.E., Jr., K. Lease, S. Johnson
1998 Lake Pepin and the Environmental History of Southeastern Minnesota. In *Contributions to Quaternary Studies,* edited by C. Patterson and H.E. Wright Jr. The Minnesota Geological Survey, University of Minnesota, St. Paul.

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Appendix O: Minnesota EAW

Bass Ponds, Marsh, and Wetland Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

March, 2018

July 2013 version

ENVIRONMENTAL ASSESSMENT WORKSHEET

This Environmental Assessment Worksheet (EAW) form and EAW Guidelines are available at the Environmental Quality Board's website at:
http://www.eqb.state.mn.us/EnvRevGuidanceDocuments.htm. The EAW form provides information about a project that may have the potential for significant environmental effects. The EAW Guidelines provide additional detail and resources for completing the EAW form.
Cumulative potential effects can either be addressed under each applicable EAW Item, or can be addresses collectively under EAW Item 19.
Note to reviewers: Comments must be submitted to the RGU during the 30-day comment period following notice of the EAW in the *EQB Monitor*. Comments should address the accuracy and completeness of information, potential impacts that warrant further investigation and the need for an EIS.

1. **Project title: Bass Ponds, Marsh and Wetland Rehabilitation and Enhancement Project**

2. **Proposer: US Army Corps of Engineers**
   Contact person: LeeAnn Glomski
   Title: Biologist
   Address: 180 Fifth Street East, Suite 700
   City, State, ZIP: St. Paul, MN 55101
   Phone: 651-290-5595
   Fax: NA
   Email: LeeAnn.M.Glomski@usace.army.mil

3. **RGU: Scott County**
   Contact person: Kate Sedlacek
   Title: Environmental Health Supervisor
   Address: 200 Fourth Avenue West
   City, State, ZIP: Shakopee, MN 55379
   Phone: 952-496-8351
   Fax: NA
   Email: ksedlacek@co.scott.mn.us

4. **Reason for EAW Preparation:** (check one)

Required:	Discretionary:
☐ EIS Scoping	☐ Citizen petition
X Mandatory EAW	☐ RGU discretion
	☐ Proposer initiated

If EAW or EIS is mandatory give EQB rule category subpart number(s) and name(s):
Subpart 27. Wetlands and Public Waters

5. **Project Location:**
   County: Scott
   City/Township: Savage and Shakopee
   PLS Location (¼, ¼, Section, Township, Range):
   Sections 1, 2, 3 and 12 Township 115N Range 22W
   Sections 6, 7, 8 Township 115N Range 21W
   Sections 34, 35 and 36 Township 115N Range 22W
   Watershed (81 major watershed scale): Lower Minnesota
   GPS Coordinates: 44.797503, -93.407073
   Tax Parcel Numbers: 139-139-271270041, 139-139-279030130, 139-139-271270070, 139-139-279030020, 139-139-271270030, 139-139-279020120, 139-139-279020130, 139-139-279020040, 139-139-279020010, 139-139-279010020, 139-139-279010030, 139-139-279120110, 139-139-279010010, 139-139-279120020, 139-139-269070491,

139-139-269060030, 139-139-269070021, 139-139-269070500, 139-139-269060010, 139-139-269070010, 139-139-269070550, 139-139-269060020, 139-139-269080140, 139-139-269080150, 139-139-269080130, 139-139-269080210, 139-139-269080040, 139-139-269080170, 139-139-269080190, 139-139-269080230, 139-139-269080180, 139-139-279360020, 139-139-279360010, 139-139-279360030, 139-139-279350020, 139-139-279020160, 139-139-279020180, 139-139-279350010, 139-139-279340010

At a minimum attach each of the following to the EAW:

- County map showing the general location of the project; Attached Figure 1
- U.S. Geological Survey 7.5 minute, 1:24,000 scale map indicating project boundaries (photocopy acceptable); and Attached Figure 1
- Site plans showing all significant project and natural features. Pre-construction site plan and post-construction site plan. Attached Figure 2

6. Project Description:

a. Provide the brief project summary to be published in the *EQB Monitor*, (approximately 50 words).

The Corps of Engineers is proposing to improve habitat within the Wilkie Unit of the Minnesota Valley National Wildlife Refuge. The area experiences a lack of seasonal variability in water levels which has resulted in reduced wetland habitat quality, aquatic plant diversity, and quality habitat for migratory waterbirds. Waterlevel management features (stoplog structures, earthen plugs) are proposed to improve habitat.

b. Give a complete description of the proposed project and related new construction, including infrastructure needs. If the project is an expansion include a description of the existing facility. Emphasize: 1) construction, operation methods and features that will cause physical manipulation of the environment or will produce wastes, 2) modifications to existing equipment or industrial processes, 3) significant demolition, removal or remodeling of existing structures, and 4) timing and duration of construction activities.

A complete project description can be found in Section 6 of the Main Report.

c. Project magnitude:

Total Project Acreage	2,085 acres
Linear project length	NA
Number and type of residential units	NA
Commercial building area (in square feet)	NA
Industrial building area (in square feet)	NA
Institutional building area (in square feet)	NA
Other uses – specify (in square feet)	NA
Structure height(s)	11.25 – 15.85 feet

d. Explain the project purpose; if the project will be carried out by a governmental unit, explain the need for the project and identify its beneficiaries.

The purpose of the project can be found in Sections 3.2.1 and 3.2.2 of the Main Report. Need for the project is discussed in Section 2 of the Main Report. The project will be carried out by the USACE in cooperation with the USFWS. The beneficiary of the project is the public.

e. Are future stages of this development including development on any other property planned or likely to happen? ☐ Yes X No
If yes, briefly describe future stages, relationship to present project, timeline and plans for environmental review.

f. Is this project a subsequent stage of an earlier project? ☐ Yes X No
If yes, briefly describe the past development, timeline and any past environmental review.

7. **Cover types:** Estimate the acreage of the site with each of the following cover types before and after development:

	Before	**After**		**Before**	**After**
Wetlands	1,832 acres	1,827 acres	Lawn/landscaping	0	0
Deep water/streams	1,766 linear feet of stream	1,766 linear feet of stream	Impervious surface	2 acres	2 acres
Wooded/forest*	0	0	Stormwater Pond	0	0
Brush/Grassland	230 acres	230 acres	Other (describe)	NA	NA
Cropland	0	0			
			TOTAL		

* floodplain forest included in wetland acreage

8. **Permits and approvals required:** List all known local, state and federal permits, approvals, certifications and financial assistance for the project. Include modifications of any existing permits, governmental review of plans and all direct and indirect forms of public financial assistance including bond guarantees, Tax Increment Financing and infrastructure. *All of these final decisions are prohibited until all appropriate environmental review has been completed. See Minnesota Rules, Chapter 4410.3100.*

Unit of government	Type of application	Status
MPCA	401 water quality certification	waived
MnDNR	Public Waters Permit	not yet applied for
MnDNR	Floodplain CUP	not yet applied for

Cumulative potential effects may be considered and addressed in response to individual EAW Item Nos. 9-18, or the RGU can address all cumulative potential effects in response to EAW Item No. 19. If addressing cumulative effect under individual items, make sure to include information requested in EAW Item No. 19

9. **Land use:**
   a. Describe:

i. Existing land use of the site as well as areas adjacent to and near the site, including parks, trails, prime or unique farmlands.

Description of existing land use in and adjacent to the project area can be found in Section 1.6 of the Main Report.

ii. Plans. Describe planned land use as identified in comprehensive plan (if available) and any other applicable plan for land use, water, or resources management by a local, regional, state, or federal agency.

The USFWS has a Comprehensive Conservation Plan as well as a Habitat Management Plan for the Minnesota Valley National Wildlife Refuge. Per the Habitat Management Plan, the goals for permanent/semi-permanent wetlands found within the project area, are to manage and enhance permanent/semi-permanent wetland systems to provide habitat for waterfowl, shorebirds and other waterbirds. And, to provide diverse habitat for other wetland-dependent wildlife while preserving the ecological integrity of the wetlands in the Eastern Broadleaf Forest Province.

iii. Zoning, including special districts or overlays such as shoreland, floodplain, wild and scenic rivers, critical area, agricultural preserves, etc.

The project area is within the Minnesota Valley National Wildlife Refuge and within the floodplain of the Minnesota River.

b. Discuss the project's compatibility with nearby land uses, zoning, and plans listed in Item 9a above, concentrating on implications for environmental effects.

The proposed project will not impact nearby land uses.

- The project will not cause flooding on nearby properties (Blue Lake Wastewater Treatment Plant, Cargill, other commercial or residential areas).
- The Refuge was established in 1976 and already serves as resting and breeding habitat for migratory waterbirds. The project will not cause any additional risk to aircraft flying into or out of Flying Cloud Airport.
- Corps H&H staff have determined the project will have no effect on Valleyfair's wetland mitigation site.

c. Identify measures incorporated into the proposed project to mitigate any potential incompatibility as discussed in Item 9b above.

No measures are needed.

10. Geology, soils and topography/land forms:

a. Geology - Describe the geology underlying the project area and identify and map any susceptible geologic features such as sinkholes, shallow limestone formations, unconfined/shallow aquifers, or karst conditions. Discuss any limitations of these features for the project and any effects the project could have on these features. Identify any project designs or mitigation measures to address effects to geologic features.

Bass Ponds HREP study area is located between Minnesota River miles 15 and 21, in the cities of Savage and Shakopee. The Minnesota River Valley trends northeast and is approximately 2.5 miles wide in the vicinity of the project. The study area includes three shallow lakes (less than 4 ft in depth) and adjacent wetland and marsh areas.

The region surrounding the Bass Ponds HREP study area was glaciated extensively during the Pleistocene Epoch. Advancing and retreating glaciers laid down thick deposits of unsorted till and outwash sand that today form a hummocky, poorly-drained plain dotted with numerous marshes and small lakes. The glacial drift can reach thicknesses of between 200 and 250 feet, and it overlies dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations.

The wide valley of the present Minnesota River was carved by Glacial River Warren, which carried large volumes of water discharging from the now-extinct Glacial Lake Agassiz located in western Minnesota and eastern North Dakota. Glacial River Warren cut deeply into bedrock, scouring and reworking an earlier valley filled with outwash, stratified drift, and till. Episodic increases in flow caused Glacial River warren to cut lower into the older valley fill, leaving remnants of higher channel bottoms as terraces. When Lake Agassiz eventually ceased to drain to the south, the Minnesota River was formed by local drainage and established its present floodplain in the valley.

Three alluvial and bedrock terraces rise above this floodplain and form regionally prominent benches which parallel the river valley. The lower terrace is 30 to 50 feet above the floodplain, the middle terrace is 75 to 115 feet above the floodplain, and the upper terrace is 120 to 180 feet above the floodplain. The walls of the river valley form a bluff that grades into a hummocky, poorly-drained regional highland.

The proposed project is not anticipated to be affected by the geology. Also, the local geology is not anticipated to be affected by the project.

b. Soils and topography - Describe the soils on the site, giving NRCS (SCS) classifications and descriptions, including limitations of soils. Describe topography, any special site conditions relating to erosion potential, soil stability or other soils limitations, such as steep slopes, highly permeable soils. Provide estimated volume and acreage of soil excavation and/or grading. Discuss impacts from project activities (distinguish between construction and operational activities) related to soils and topography. Identify measures during and after project construction to address soil limitations including stabilization, soil corrections or other measures. Erosion/sedimentation control related to stormwater runoff should be addressed in response to Item 11.b.ii.

The Bass Ponds HREP project is located in the bottom of the wide valley of the present Minnesota River. The local topography in the study area is fairly flat and consists of three shallow lakes (less than 4ft in depth) and adjacent wetland and marsh areas. The general topographical gradient is north, based upon site setting and surrounding areas. The area typically is overtopped during spring or summer flood events.

The surface soils within the project area mostly consists of alluvium. The soils are classified as organic rich sediments (OH) in the shallow lakes with silty (ML) and clay (CH) along the edges of the lakes. Some underlain sand seams were also observed. A copy of the Web Soil Survey report is attached.

Excavation of the soils will be required to construct the control structure, access road, and dredged channels. The total excavation is between 20,000 and 30,000 cubic yards. Quantities will be developed further during design.

The project is not anticipated to have any impacts related to the soils and topography. The area is predominately flat with shallow slopes which. Some erosion has been observed in the area but is

mostly due to the overtopping events and not directly related to storm water. The project will be built to help facilitate overtopping events by placing an overflow channel adjacent the control structures. Testing is being completed on the foundation soils to ensure the stability of the structures. During construction the contractor will be required to handle storm water.

NOTE: For silica sand projects, the EAW must include a hydrogeologic investigation assessing the potential groundwater and surface water effects and geologic conditions that could create an increased risk of potentially significant effects on groundwater and surface water. Descriptions of water resources and potential effects from the project in EAW Item 11 must be consistent with the geology, soils and topography/land forms and potential effects described in EAW Item 10.

11. Water resources:

a. Describe surface water and groundwater features on or near the site in a.i. and a.ii. below.

i. Surface water - lakes, streams, wetlands, intermittent channels, and county/judicial ditches. Include any special designations such as public waters, trout stream/lake, wildlife lakes, migratory waterfowl feeding/resting lake, and outstanding resource value water. Include water quality impairments or special designations listed on the current MPCA 303d Impaired Waters List that are within 1 mile of the project. Include DNR Public Waters Inventory number(s), if any.

A description of surface waters within the project area can be found in Section 4.3 of the Main Report.

Surface waters in the project area include:

- Blue Lake: Public Water 70008800, migratory waterfowl feeding/resting lake
- Fisher Lake: Public Water 70008700, migratory waterfowl feeding/resting lake
- Rice Lake: Public Water 70002500, migratory waterfowl feeding/resting lake
- Continental Grain Marsh: Public Water 70032200
- Eagle Creek: Public Water M-055-009, trout stream
- Forested/shrub and emergent wetlands surrounding each lake

Impaired Waters within 1 mile of the project area include:

- Eagle Creek (M-055-009)
- Unnamed Stream (south of Blue Lake, M-055-012-001)
- Riley Creek (M-055-013)
- Purgatory Creek (M-055-011)
- Minnesota River (M-055)

ii. Groundwater – aquifers, springs, seeps. Include: 1) depth to groundwater; 2) if project is within a MDH wellhead protection area; 3) identification of any onsite and/or nearby wells, including unique numbers and well logs if available. If there are no wells known on site or nearby, explain the methodology used to determine this.

- The MnDNR Spring inventory identified 2 seeps and 2 springs in the project area near Eagle Creek.
- The depth to groundwater varies throughout the project site, from the ground surface to approximately three feet below.

- There are no wells within the project area; however, there are 14 wells adjacent to the project area (Well # 530130, 767851, 686300, 207070, 541552, 661420, 640554, 661421, 686299, 247250, 244434, 207068, 205968, 208815).
- The project is not within a wellhead protection area. This was determined by using Scott County's Environmental GIS tool.

b. Describe effects from project activities on water resources and measures to minimize or mitigate the effects in Item b.i. through Item b.iv. below.

i. Wastewater - For each of the following, describe the sources, quantities and composition of all sanitary, municipal/domestic and industrial wastewater produced or treated at the site.

1) If the wastewater discharge is to a publicly owned treatment facility, identify any pretreatment measures and the ability of the facility to handle the added water and waste loadings, including any effects on, or required expansion of, municipal wastewater infrastructure.
2) If the wastewater discharge is to a subsurface sewage treatment systems (SSTS), describe the system used, the design flow, and suitability of site conditions for such a system.
3) If the wastewater discharge is to surface water, identify the wastewater treatment methods and identify discharge points and proposed effluent limitations to mitigate impacts. Discuss any effects to surface or groundwater from wastewater discharges.

No wastewater would be generated by the project.

ii. Stormwater - Describe the quantity and quality of stormwater runoff at the site prior to and post construction. Include the routes and receiving water bodies for runoff from the site (major downstream water bodies as well as the immediate receiving waters). Discuss any environmental effects from stormwater discharges. Describe stormwater pollution prevention plans including temporary and permanent runoff controls and potential BMP site locations to manage or treat stormwater runoff. Identify specific erosion control, sedimentation control or stabilization measures to address soil limitations during and after project construction.

The majority of the project site, with the exception of staging areas, is wetland so no stormwater runoff would occur in those areas. Access roads are to be constructed along existing roads through both upland and wetland areas. The roads will be constructed by excavating soils and replacing with aggregate to existing elevations so no stormwater runoff is expected. Existing parking lots at Cargill and Fisher Lake will be used as staging areas. Stormwater management was addressed when these parking lots were constructed. Stormwater runoff from any additional staging areas and construction would be addressed as described below.

An NPDES/SDS Construction Stormwater permit would be obtained by the contractor for the project. Once identified, the contractor obtained to construct the project would apply for the Construction Stormwater permit, and develop the required Stormwater Pollution Prevention Plan (SWPPP). This SWPPP would be reviewed by USACE prior to submittal to MPCA, which would review and approve the SWPPP. The NPDES permit would be obtained by the contractor prior to beginning any work on-site.

iii. Water appropriation - Describe if the project proposes to appropriate surface or groundwater (including dewatering). Describe the source, quantity, duration, use and

purpose of the water use and if a DNR water appropriation permit is required. Describe any well abandonment. If connecting to an existing municipal water supply, identify the wells to be used as a water source and any effects on, or required expansion of, municipal water infrastructure. Discuss environmental effects from water appropriation, including an assessment of the water resources available for appropriation. Identify any measures to avoid, minimize, or mitigate environmental effects from the water appropriation.

No water appropriation are associated with the proposed project.

iv. Surface Waters

a) Wetlands - Describe any anticipated physical effects or alterations to wetland features such as draining, filling, permanent inundation, dredging and vegetative removal. Discuss direct and indirect environmental effects from physical modification of wetlands, including the anticipated effects that any proposed wetland alterations may have to the host watershed. Identify measures to avoid (e.g., available alternatives that were considered), minimize, or mitigate environmental effects to wetlands. Discuss whether any required compensatory wetland mitigation for unavoidable wetland impacts will occur in the same minor or major watershed, and identify those probable locations.

Direct and indirect environmental effects and actions taken to minimize are discussed in Appendix B and Section 4.3 of the Main Report.

Five of the proposed water control structures are replacements for existing structures and access road improvements are along existing roads. Channel dredging is proposed in front of each water control structure to allow flow through the new structures, but will not result in a loss of wetland. New impacts resulting in wetland fill include a water control structure and earthen plug at Continental Grain Marsh and rock-lined overflow channes at each structure. The overall purpose of the project is to improve habitat to approximately 1,000 acres of wetlands within the project area. Improvement of this habitat will offset wetland loss, therefore no mitigation is proposed.

b) Other surface waters- Describe any anticipated physical effects or alterations to surface water features (lakes, streams, ponds, intermittent channels, county/judicial ditches) such as draining, filling, permanent inundation, dredging, diking, stream diversion, impoundment, aquatic plant removal and riparian alteration. Discuss direct and indirect environmental effects from physical modification of water features. Identify measures to avoid, minimize, or mitigate environmental effects to surface water features, including in-water Best Management Practices that are proposed to avoid or minimize turbidity/sedimentation while physically altering the water features. Discuss how the project will change the number or type of watercraft on any water body, including current and projected watercraft usage.

No other surface waters will be affected by the project.

12. Contamination/Hazardous Materials/Wastes:

a. Pre-project site conditions - Describe existing contamination or potential environmental hazards on or in close proximity to the project site such as soil or ground water contamination, abandoned dumps, closed landfills, existing or abandoned storage tanks, and hazardous liquid or gas pipelines. Discuss any potential environmental effects from pre-project site conditions that would be caused or exacerbated by project construction and operation. Identify measures to avoid,

minimize or mitigate adverse effects from existing contamination or potential environmental hazards. Include development of a Contingency Plan or Response Action Plan.

A phase I environmental site assessment report can be found in Appendix L. Based on the desktop search and on-site inspection, this assessment revealed that there were no recognized environmental conditions. Therefore, USACE does not recommend a Phase II assessment.

b. Project related generation/storage of solid wastes - Describe solid wastes generated/stored during construction and/or operation of the project. Indicate method of disposal. Discuss potential environmental effects from solid waste handling, storage and disposal. Identify measures to avoid, minimize or mitigate adverse effects from the generation/storage of solid waste including source reduction and recycling.

   Solid wastes generated on site include the old structures and dredged material. Contract specification will state "disposal of solid construction debris and waste disposal of solid construction debris and waste shall consist of removal from the construction site and disposal in compliance with Federal, State, and local requirements for solid waste disposal."

c. Project related use/storage of hazardous materials - Describe chemicals/hazardous materials used/stored during construction and/or operation of the project including method of storage. Indicate the number, location and size of any above or below ground tanks to store petroleum or other materials. Discuss potential environmental effects from accidental spill or release of hazardous materials. Identify measures to avoid, minimize or mitigate adverse effects from the use/storage of chemicals/hazardous materials including source reduction and recycling. Include development of a spill prevention plan.

   The only expected hazardous materials to be used during construction would be fuels and oils for construction equipment. As part of the Corps' contracting procedure, any contractor would be required to prepare and submit for approval a spill prevention and control plan for these materials prior to construction.

d. Project related generation/storage of hazardous wastes - Describe hazardous wastes generated/stored during construction and/or operation of the project. Indicate method of disposal. Discuss potential environmental effects from hazardous waste handling, storage, and disposal. Identify measures to avoid, minimize or mitigate adverse effects from the generation/storage of hazardous waste including source reduction and recycling.

   No hazardous waste expected to be stored or generated during project construction or operation.

13. Fish, wildlife, plant communities, and sensitive ecological resources (rare features):

a. Describe fish and wildlife resources as well as habitats and vegetation on or in near the site.

A description of fish and wildlife resources can be found in Section 4.5 of the Main Report. A description of habitats and vegetation can be found in Section 4.3 of the Main Report.

b. Describe rare features such as state-listed (endangered, threatened or special concern) species, native plant communities, Minnesota County Biological Survey Sites of Biodiversity Significance, and other sensitive ecological resources on or within close proximity to the site. Provide the license agreement number (LA-____) and/or correspondence number (ERDB _____) from which the data were obtained and attach the Natural Heritage letter from the DNR. Indicate if any additional habitat or species survey work has been conducted within the site and describe the results.

A review of the MDNR Natural Heritage Information System Rare Features Database (NHIS) was conducted. Natural Heritage Database information was obtained from the MDNR Division of Ecological and Water Resources through an inter-agency cooperative licensing agreement and includes the most recent July 14, 2017 update. The search included a one-mile buffer around the project area to ensure that any listed species would be included. A list of state listed species is provided in the table below (license agreement LA-670).

Unique habitat types or sensitive ecological resources within the search area include:

- Calcareous fen
- Colonial waterbird nesting site
- Dry barren prairie
- Dry sand – gravel oak savannah
- Dry sand – gravel prairie

c. Discuss how the identified fish, wildlife, plant communities, rare features and ecosystems may be affected by the project. Include a discussion on introduction and spread of invasive species from the project construction and operation. Separately discuss effects to known threatened and endangered species.

Potential effects of the proposed project to state listed species can be found in Section 4.5.2 of the main report. Specific determinations can be found in the table below.

To prevent the spread of invasive species from project construction, the contractor will be required to clean all previously used construction equipment prior to bringing it onto the project site. The contractor shall ensure that the equipment is free from soil residuals, egg deposits from plant pests, noxious weeds, plant seeds, aquatic plants, and residual water.

The adaptive management plan (Appendix K) includes methods to prevent the spread of invasive plant species during normal operations.

	Scientific Name	Common Name	Status	
Mussels	Lampsilis teres	Yellow Sandshell	END	Project area does not contain suitable habitat for mussel species. H&H analysis has indicated that the project area is one of sediment deposition. The structures will not be operated to intentionally flush out sediment to the river therefore, the project should have no effect on mussels.
	Arcidens confragosus	Rock Pocketbook	END	
	Tritogonia verrucosa	Pistolgrip	END	
	Fusconaia ebena	Ebonyshell	END	
	Megalonaias nervosa	Washboard	END	
	Arcidens confragosus	Rock Pocketbook	END	
	Elliptio crassidens	Elephant-ear	END	
	Pleurobema sintoxia	Round Pigtoe	SPC	
	Ligumia recta	Black Sandshell	SPC	
	Quadrula nodulata	Wartyback	THR	
	Elliptio dilatata	Spike	THR	
	Actinonaias ligamentina	Mucket	THR	
	Lasmigona costata	Fluted-shell	THR	
	Actinonaias ligamentina	Mucket	THR	
	Ellipsaria lineolata	Butterfly	THR	
Butterfly	Speyeria idalia	Regal Fritillary	SPC	May visit flowers in wetland areas but only breeds in prairies. No prairies are found in the project area. Construction will occur in the winter when flowering plants are dormant.
Plants	Carex sterilis	Sterile Sedge	THR	These species are only found in calcareous fens. No fens have been identified in the project area.
	Rhynchospora capillacea	Hair-like Beak Rush	THR	
	Scleria verticillata	Whorled Nutrush	THR	
	Eleocharis rostellata	Beaked Spikerush	THR	
	Cladium mariscoides	Twig Rush	SPC	
	Cypripedium candidum	Small White Lady's-slipper	SPC	These species are found in moist prairies, sedge meadows and calcareous fens. These habitats have not been identified in the project area
	Valeriana edulis var. ciliata	Edible Valerian	THR	
	Oenothera rhombipetala	Rhombic Evening Primrose	SPC	Found in dry prairies which are not found in the project area.
	Orobanche fasciculata	Clustered Broomrape	THR	Species found in prairies, dunes, woods and bluffs most of which are not found in the project area. Wooded areas in the project area experience extended periods of flooding each year which would make it unlikely these species would occur there.
	Besseya bullii	Kitten-tails	THR	
Fish	Anguilla rostrata	American Eel	SPC	This species has not been identified in the project area. Construction restrictions to protect fish species have been applied to the project.
Reptiles and amphibians	Pituophis catenifer	Gophersnake	SPC	Construction will occur in winter when these species are in hibernation. Construction restrictions have been applied to the project to avoid impacts.
	Heterodon nasicus	Plains Hog-nosed Snake	SPC	
	Necturus maculosus	Mudpuppy	SPC	
	Emydoidea blandingii	Blanding's Turtle	END	
Rodents	Perognathus flavescens	Plains Pocket Mouse	SPC	This species uses underground burrows and is likely not found in the project area due to extensive and prolonged flooding each year.
	Reithrodontomys megalotis	Western Harvest Mouse	SPC	This species builds nest directly on the ground. Due to the history of extensive and prolonged flooding in the area each year, this species is likely not found in the project area.
Birds	Gallinula galeata	Common Gallinule	SPC	Construction will take place over winter when these species are unlikely to be present. Construction restrictions require at least 1 basin to have water in the late fall to serve as a sanctuary. Project objective is to improve habitat for waterbirds.
	Sterna forsteri	Forster's Tern	SPC	
	Chondestes grammacus	Lark Sparrow	SPC	The project area does not have the habitat needed for this species.

d. Identify measures that will be taken to avoid, minimize, or mitigate adverse effects to fish, wildlife, plant communities, and sensitive ecological resources.

Construction restrictions will be put into place to avoid and minimize effects to fish and wildlife. A list of the restrictions can be found in Section 6.4.1 of the Main Report.

14. Historic properties:

Describe any historic structures, archeological sites, and/or traditional cultural properties on or in close proximity to the site. Include: 1) historic designations, 2) known artifact areas, and 3) architectural features. Attach letter received from the State Historic Preservation Office (SHPO). Discuss any anticipated effects to historic properties during project construction and operation. Identify measures that will be taken to avoid, minimize, or mitigate adverse effects to historic properties.

Information on historic properties can be found in Section 4.8 of the Main Report and Appendix M.

15. Visual:

Describe any scenic views or vistas on or near the project site. Describe any project related visual effects such as vapor plumes or glare from intense lights. Discuss the potential visual effects from the project. Identify any measures to avoid, minimize, or mitigate visual effects.

The scenic view of Minnesota Valley National Wildlife Refuge would be temporarily affected during the period of construction due to the presence of construction equipment. No vapor plumes would result from the project. Work is expected to occur during daylight hours so intense lights are not proposed for use during construction and no glare from lights would occur. No special minimization or mitigation for temporary impacts has been proposed during construction. Following construction, no impacts are anticipated to the view of the Refuge.

16. Air:

a. Stationary source emissions - Describe the type, sources, quantities and compositions of any emissions from stationary sources such as boilers or exhaust stacks. Include any hazardous air pollutants, criteria pollutants, and any greenhouse gases. Discuss effects to air quality including any sensitive receptors, human health or applicable regulatory criteria. Include a discussion of any methods used assess the project's effect on air quality and the results of that assessment. Identify pollution control equipment and other measures that will be taken to avoid, minimize, or mitigate adverse effects from stationary source emissions.

There are no stationary sources of air emissions proposed with this project.

b. Vehicle emissions - Describe the effect of the project's traffic generation on air emissions. Discuss the project's vehicle-related emissions effect on air quality. Identify measures (e.g. traffic operational improvements, diesel idling minimization plan) that will be taken to minimize or mitigate vehicle-related emissions.

Minor and temporary effects to air quality in the immediate project area from vehicle emissions would occur during construction, including emissions from on-site construction vehicles. These effects would only occur during the construction period which is expected to be short. No special mitigation measures are proposed.

c. Dust and odors - Describe sources, characteristics, duration, quantities, and intensity of dust and odors generated during project construction and operation. (Fugitive dust may be discussed under item 16a). Discuss the effect of dust and odors in the vicinity of the project including nearby sensitive receptors and quality of life. Identify measures that will be taken to minimize or mitigate the effects of dust and odors.

Sources of dust and odors from the project would primarily come from the construction process and specifically the construction equipment and its placement of rock for the overflow channels and aggregate for the access roads. This dust is expected to be minimal and localized to the immediate construction area. Clean fill material would be used to reduce any potential dust releases. Since dust generated as part of the project is anticipated to be minimal and localized, it is not anticipated to affect any nearby sensitive receptors or the area quality of life. Therefore, no additional mitigation measures have been proposed. No sources of dust are expected during the operational phase of the project.

17. Noise

Describe sources, characteristics, duration, quantities, and intensity of noise generated during project construction and operation. Discuss the effect of noise in the vicinity of the project including 1) existing noise levels/sources in the area, 2) nearby sensitive receptors, 3) conformance to state noise standards, and 4) quality of life. Identify measures that will be taken to minimize or mitigate the effects of noise.

The Minnesota Valley National Wildlife Refuge is located in an urban area and existing noise levels are consistent with urban areas. The most significant producers of noise in the area are Highways 101 and 169, Valleyfair and Cargill. Construction would require heavy equipment to operate in the area which would generate noise during construction. This effect would only occur during construction and is anticipated to be temporary and minor. There are no sensitive receptors in the immediate vicinity; therefore, noise is not anticipated to impact quality of life. Given the temporary and minor effects of noise, no minimization or mitigation measures are proposed.

18. Transportation

a. Describe traffic-related aspects of project construction and operation. Include: 1) existing and proposed additional parking spaces, 2) estimated total average daily traffic generated, 3) estimated maximum peak hour traffic generated and time of occurrence, 4) indicate source of trip generation rates used in the estimates, and 5) availability of transit and/or other alternative transportation modes.

The project may cause temporary traffic disruptions in the area when construction equipment is brought into and out of the site. No long-term effect to transportation in the area will occur as a result of the proposed project. The proposed habitat restoration project will not result in the need for additional parking spaces or cause an increase in traffic to the area.

b. Discuss the effect on traffic congestion on affected roads and describe any traffic improvements necessary. The analysis must discuss the project's impact on the regional transportation system. *If the peak hour traffic generated exceeds 250 vehicles or the total daily trips exceeds 2,500, a traffic impact study must be prepared as part of the EAW.* Use the format and procedures described in the Minnesota Department of Transportation's Access Management Manual, Chapter 5 *(available at: http://www.dot.state.mn.us/accessmanagement/resources.html)* or a similar local guidance,

The proposed project should have no effect on traffic congestion in the area. No traffic improvement are necessary.

c. Identify measures that will be taken to minimize or mitigate project related transportation effects.

No measures are needed.

19. Cumulative potential effects: (Preparers can leave this item blank if cumulative potential effects are addressed under the applicable EAW Items)

a. Describe the geographic scales and timeframes of the project related environmental effects that could combine with other environmental effects resulting in cumulative potential effects.

The geographic scale of the environmentally relevant area for the following project related environmental effects is the entire study area (outlined in red on attached Figure 2) plus Valleyfair, Blue Lake wastewater treatment plant and Cargill. The project is proposed to take place over a winter season, approximately 4 months.

Wetlands: Short-term negative impacts to wetlands, primarily associated with increased water turbidity and sedimentation would occur due to construction activities. BMPs would be used to minimize effects on wetlands. Long-term beneficial impacts to aquatic vegetation would occur in the study area. The proposed project would allow the Refuge to quickly remove flood waters from the area each spring and conduct drawdowns to increase the density and distribution of aquatic plant species, ultimately improving habitat for migrating waterbirds and waterfowl.

Fish and wildlife: Fish and wildlife species are likely to avoid areas under construction; however, this effect would be minor and temporary. Following construction, the project will have a positive long-term effect on wildlife such as waterfowl, shorebirds, turtles, beavers, fish, muskrats and other wildlife species that would utilize the study area by improving habitat.

Recreation: Short-term impacts to recreation during construction which would limit public access to the area. In the long-term, recreation would improve as a result of a more diverse aquatic plant community (emergent and submergent) and increased populations of waterfowl and waterbirds utilizing the area during fall migration.

Water quality: The proposed project would have temporary, short-term adverse impacts to water quality by increasing turbidity in the immediate area where construction and excavation occur. There could also be the potential for oil spills from construction equipment; however, Best Management Practices (BMPs) would be used to minimize impacts to water quality during construction. Overall, the proposed project would have a long-term, beneficial effect on water quality by increasing the overall percent coverage of aquatic vegetation. Aquatic vegetation can slow the velocity of flood waters entering the study area, allowing suspended materials to settle to the sediment surface. Excess nutrient or toxic chemicals entering the system, can be taken up by aquatic vegetation, trapped with settled soil particles or converted to less harmful chemical forms by biological processes.

Noise: The construction of the project would generate a temporary increase in noise levels associated with heavy equipment. This may lead to temporary displacement of some wildlife species and decreased recreational use; however, no long-term impacts would be expected. There are no sensitive receptors in the immediate vicinity; therefore, noise is not anticipated to impact quality of life.

b. Describe any reasonably foreseeable future projects (for which a basis of expectation has been laid) that may interact with environmental effects of the proposed project within the geographic scales and timeframes identified above.

The Refuge and MnDOT have no reasonably foreseeable future projects planned for the area. Valleyfair may be conducting work on their wetland mitigation site (adjacent to Blue Lake) during the Bass Ponds construction timeframe. Work would include removal of the topsoil and subsoil to lower the ground surface. Following excavation and grading, topsoil from adjacent wetlands would be placed into the mitigation area and seeded. Work also includes tree planting.

c. Discuss the nature of the cumulative potential effects and summarize any other available information relevant to determining whether there is potential for significant environmental effects due to these cumulative effects.

Wetlands: Both the Valleyfair and Bass Ponds projects would have short-term negative impacts to wetlands, primarily associated with increased water turbidity and sedimentation would occur due to construction activities. BMPs would be used to minimize effects on wetlands. Both projects would have a long-term beneficial effect on wetlands by improving wildlife habitat, water quality and floodwater detention.

Fish and wildlife: Fish and wildlife species are likely to avoid both areas when under construction; however, this effect would be minor and temporary. One basin within the Bass Ponds study area will remain at full pool to serve as a refuge for wildlife during construction. Following construction, both projects will have a positive long-term effect on wildlife such as waterfowl, shorebirds, turtles, beavers, fish, muskrats and other wildlife species that would utilize wetland habitat.

Recreation: The Valleyfair mitigation site will not have public access and is not meant to be used for recreation; therefore this project would not have a cumulative effect on recreation in the area.

Water quality: Both projects would have temporary, short-term adverse impacts to water quality by increasing turbidity in the immediate area where construction and excavation occur. There could also be the potential for oil spills from construction equipment; however, Best Management Practices (BMPs) would be used to minimize impacts to water quality during construction. Overall, both projects would have a long-term, beneficial effect on water quality by increasing the overall percent coverage of vegetation. Vegetation can slow the velocity of flood waters, allowing suspended materials to settle to the sediment surface. Excess nutrient or toxic chemicals entering the system, can be taken up by aquatic vegetation, trapped with settled soil particles or converted to less harmful chemical forms by biological processes.

Noise: The potential of conducting work at the Valleyfair mitigation site and in the project area at the same time would cause noise levels to be higher than noise from either project alone. Construction timeframes for both projects are short and effects from noise would be temporary. Increased noise in the area may lead to temporary displacement of some wildlife species and decreased recreational use; however, no long-term impacts would be expected. There are no sensitive receptors in the immediate vicinity; therefore, noise is not anticipated to impact quality of life.

20. Other potential environmental effects: If the project may cause any additional environmental effects not addressed by items 1 to 19, describe the effects here, discuss the how the environment will be affected, and identify measures that will be taken to minimize and mitigate these effects.

NA

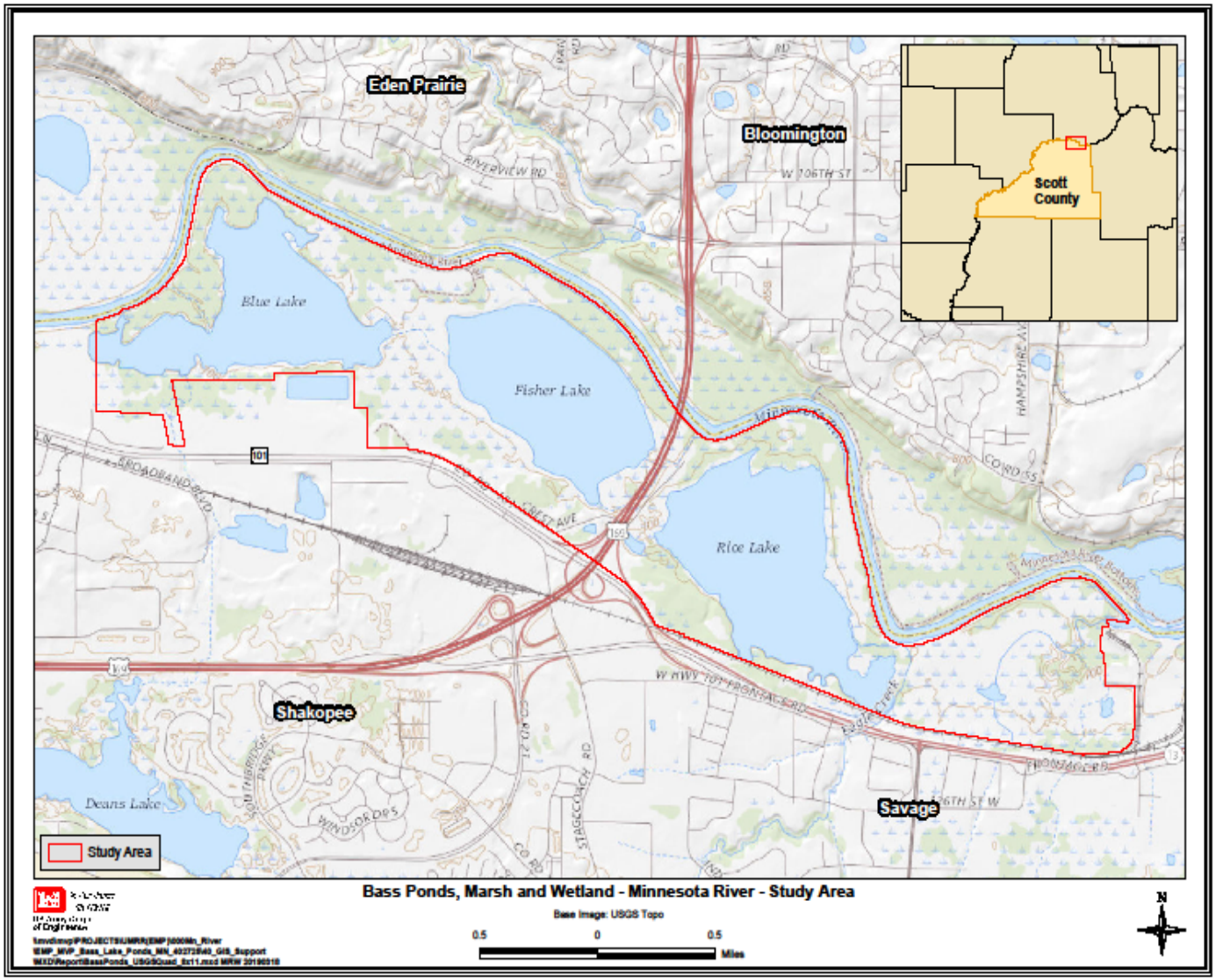
RGU CERTIFICATION. *(The Environmental Quality Board will only accept **SIGNED** Environmental Assessment Worksheets for public notice in the EQB Monitor.)*

I hereby certify that:

- The information contained in this document is accurate and complete to the best of my knowledge.
- The EAW describes the complete project; there are no other projects, stages or components other than those described in this document, which are related to the project as connected actions or phased actions, as defined at Minnesota Rules, parts 4410.0200, subparts 9c and 60, respectively.
- Copies of this EAW are being sent to the entire EQB distribution list.

Signature _____ Date _____

Title _____


Eden Prairie
Bloomington
Scott County
Blue Lake
Fisher Lake
Rice Lake
Shakopee
Deans Lake
Savage
Study Area
Bass Ponds, Marsh and Wetland - Minnesota River - Study Area
Base Image: USGS Topo
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N

Figure 1

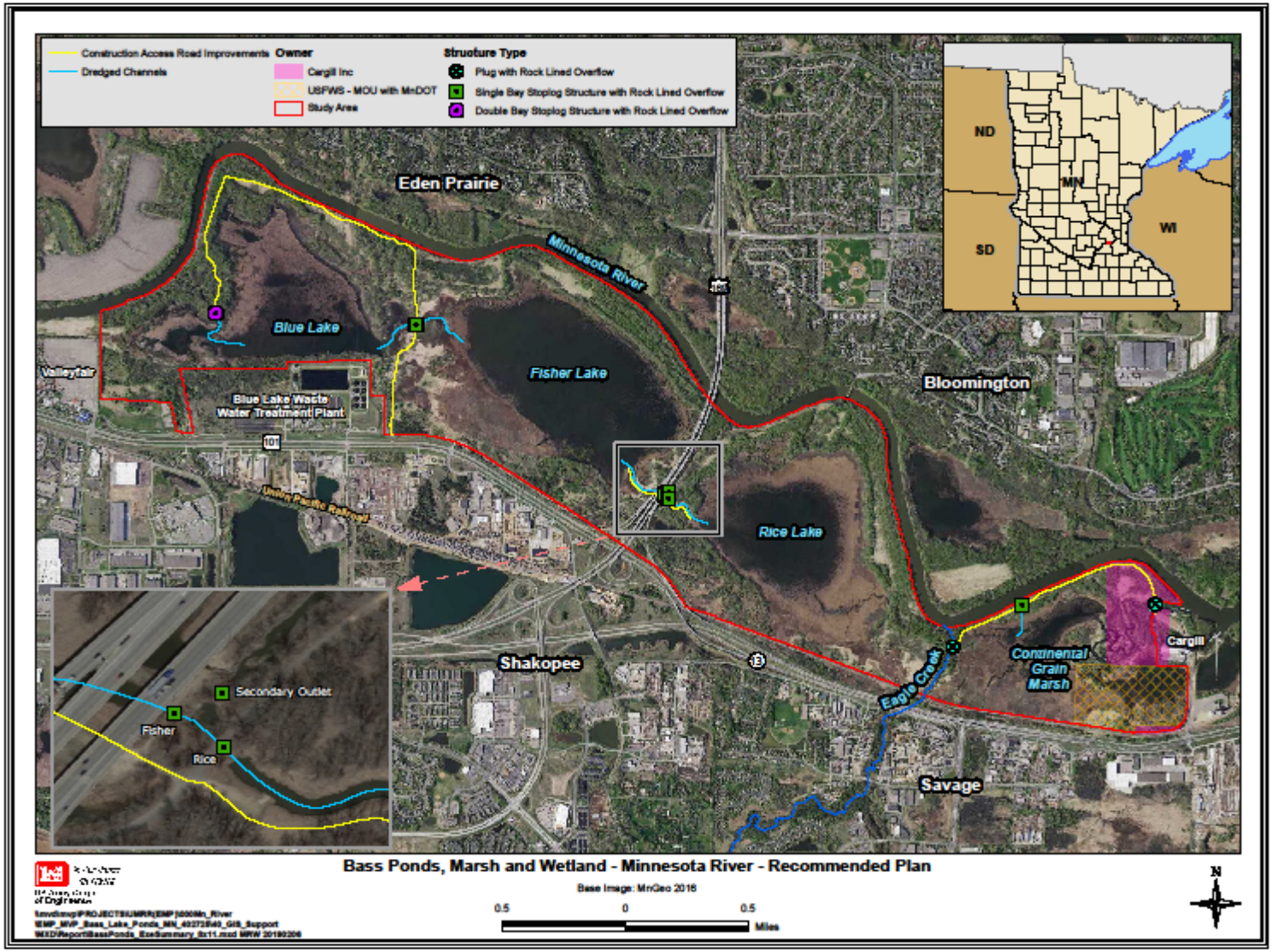
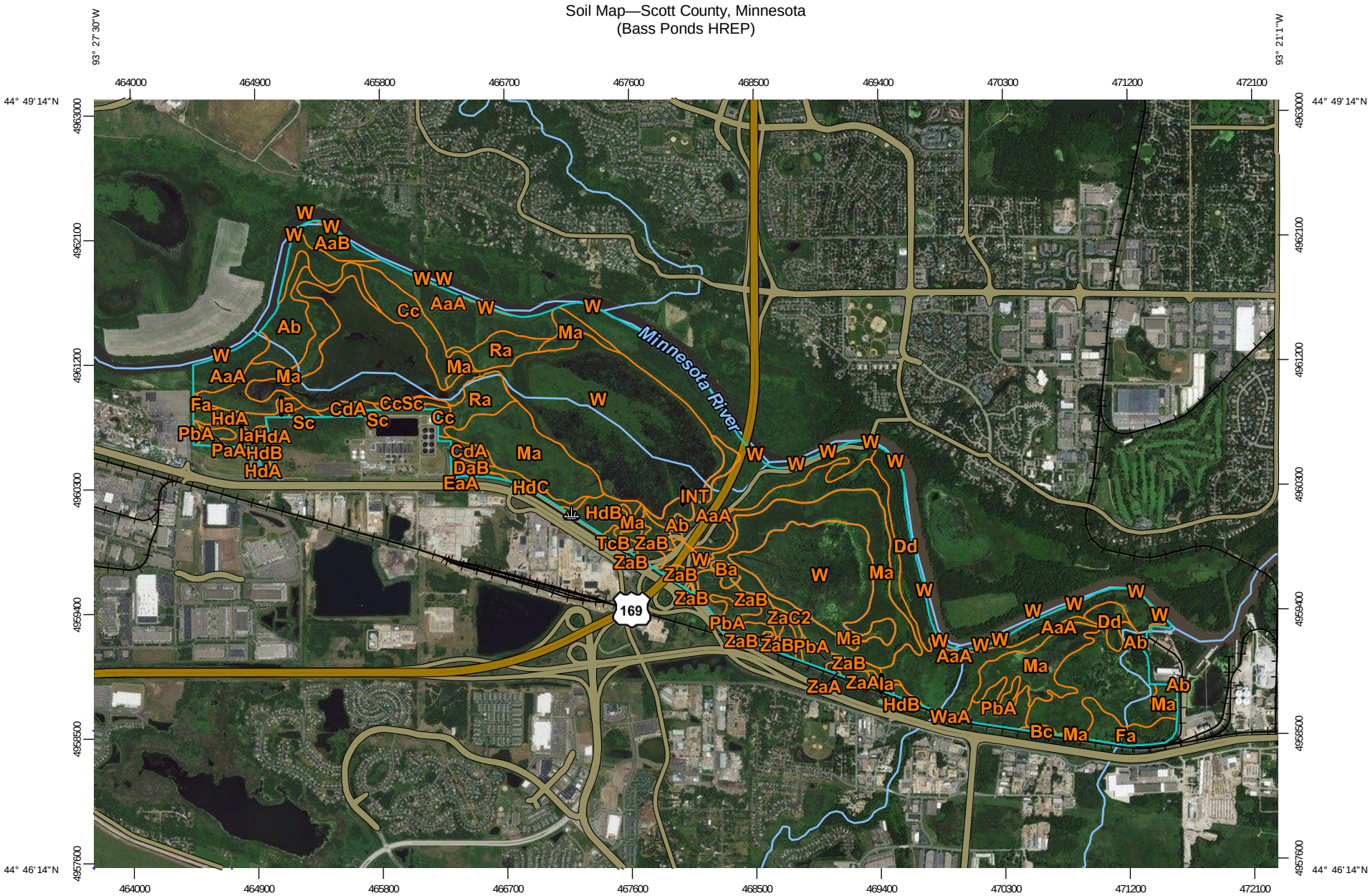

Construction Access Road Improvements
Dredged Channels
Owner
Cargill Inc
USFWS - MOU with MnDOT
Study Area
Structure Type
Plug with Rock Lined Overflow
Single Bay Stoplog Structure with Rock Lined Overflow
Double Bay Stoplog Structure with Rock Lined Overflow
Eden Prairie
Minnesota River
Blue Lake
Fisher Lake
Valleyfair
Blue Lake Waste Water Treatment Plant
Bloomington
Rice Lake
Union Pacific Railroad
Shakopee
Secondary Outlet
Fisher
Rice
Eagle Creek
Continental Grain Marsh
Cargill
Savage
ND
MN
SD
WI
Bass Ponds, Marsh and Wetland - Minnesota River - Recommended Plan
Base Image: MnGeo 2018
0.5
0
0.5
Miles
N

Figure 2

Soil Map—Scott County, Minnesota
(Bass Ponds HREP)



Map Scale: 1:39,100 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 500 1000 2000 3000

Feet: 0 1500 3000 6000 9000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AaA	Alluvial land, 0 to 2 percent slopes	316.2	15.2%
AaB	Alluvial land, 2 to 6 percent slopes	19.3	0.9%
Ab	Alluvial land, frequent overflow, 0 to 6 percent	288.9	13.8%
Ba	Beach materials, sandy	3.3	0.2%
Bc	Blue Earth mucky silt loam, 0 to 1 percent	2.4	0.1%
Cc	Comfrey silty clay loam	48.8	2.3%
CdA	Copaston silt loam, 0 to 2 percent slopes	18.0	0.9%
DaB	Dakota loam, 2 to 6 percent slopes	6.3	0.3%
Dd	Dorchester silty clay loam	62.4	3.0%
EaA	Estherville loam and sandy loam, 0 to 2 percent	4.9	0.2%
Fa	Faxon silty clay loam, 0 to 2 percent slopes	30.6	1.5%
HdA	Sparta fine sand, 0 to 2 percent slopes	14.9	0.7%
HdB	Sparta fine sand, 2 to 6 percent slopes	30.2	1.4%
HdC	Sparta fine sand, 6 to 12 percent slopes	9.1	0.4%
Ia	Isanti fine sandy loam	17.2	0.8%
INT	Water, intermittent	20.1	1.0%
Ma	Marsh	401.1	19.2%
PaA	Klossner muck, 0 to 1 percent slopes	6.4	0.3%

PbA	Houghton muck, 0 to 1 percent slopes	62.9	3.0%
Ra	Oshawa silty clay loam	51.0	2.4%
Sc	Stony land	8.4	0.4%
TcB	Terril loam, 2 to 6 percent slopes	1.7	0.1%
W	Water	595.2	28.5%
WaA	Waukegan silt loam, 0 to 2 percent slopes	0.0	0.0%
ZaA	Sartell fine sand, 0 to 2 percent slopes	6.7	0.3%
ZaB	Sartell fine sand, 2 to 6 percent slopes	53.6	2.6%
ZaC2	Sartell fine sand, 6 to 12 percent slopes,	7.3	0.3%
Totals for Area of Interest		**2,086.9**	**100.0%**