US Army Corps of Engineers ®
St. Paul District

Appendix A: Correspondence and Coordination

Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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Appendix A: Correspondence and Coordination

TABLE OF CONTENTS

ATTACHMENTS

This appendix documents the pertinent correspondence and coordination related to the Lower Pool 4 Big Lake HREP study.

1 Fact Sheet

The Fact Sheet, which provides the background on the study and is used to get approval to conduct a feasibility study, is attached at the end of this appendix. The Mississippi Valley Division (MVD) approved the Lower Pool 4 Fact Sheet in October 2020.

2 Public Outreach

2.1 Scoping Phase

The scoping phase of this study started in November 2021 with a kickoff meeting with USACE, U.S. Fish and Wildlife Service (USFWS), Wisconsin Department of Natural Resources, and Minnesota Department of Natural Resources. The kickoff meeting focused on identifying the study area problems, opportunities, objectives, constraints and documenting potential measures to address the problems identified.

A public scoping meeting was held on August 29, 2022, at the Wabasha – Kellogg High School. The meeting focused on the study process, potential restoration measures, and answered questions from the public. Pertinent materials from the public meeting are provided at the end of this appendix.

In general, the public was interested in potential work in the study area, as witnessed by the turn out at the public meeting. The comments focused on wanting more information on what potential features would be constructed, additional dredging within Big Lake proper, and ensuring the needs of the wildlife are placed above the needs of the users.

2.2 Release of Draft Report

The Draft Feasibility Report with Integrated Environmental Assessment was released for public review and comment on October 12, 2023. A public meeting was held on November 8, 2023, at the Wabasha – Kellogg High School in Wabasha Minnesota, from 6 -8 pm.

Pertinent materials related to the release of the draft report can be found at the end of this appendix.

Several members of the public attended the meeting. No public comments were received on the draft report. USFWS, the project Sponsor, provided a comment and it is contained at the end of this appendix.

3 Consultation under the National Historic Preservation Act

3.1 Consultation with State and Federal Agencies

The USACE initiated consultation with the Wisconsin State Historic Preservation Office (SHPO) on 19 March 2024. The USACE determined that the Project would have No Effect on Historic Properties and the SHPO concurred with this determination on 26 March 2024. Three archaeological sites (47BF27, 47BF37 and 47BF244) are within the northern portion of the study area, however, as no features are in this area, the Project have no effect on them. In an abundance of caution, a 100-foot buffer will surround these sites in which no work will occur. A copy of these letters and responses can be found at the end of this appendix.

3.2 Consultation with Native American Groups

On 24 July 2024, formal letters initiating consultation under Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulation 36 CFR 800 were sent to the Prairie Island Indian Community, Shakopee Mdewakanton Sioux Community, Lower Sioux Community, Upper Sioux Community, Sisseton-Wahpeton Oyate, and Ho-Chunk Nation. On 25 July 2023, the Shakopee Mdewakanton stated they are "not aware of any significant cultural sites in the proposed areas. If or when any additional archaeological work is performed, please send that information, please avoid any burial/cemetery areas that may be in or very near any proposed work".

On 19 March 2024, letters coordinating the recommended plan were sent to the above-mentioned tribes. No responses were received. A copy of these letters and responses can be found at the end of this appendix.

4 Coordination with Project Sponsor

The U.S. Fish and Wildlife Service (USFWS) is the project sponsor. The USFWS played a critical role in the development of the feasibility report. The USFWS documented the Upper Mississippi River National Wildlife and Fish Refuge goals and objectives in a formal document which can be found at the end of this appendix (see USFWS Goals and Objectives). The goals and objectives were used to guide the development of the Lower Pool 4 Big Lake goals and objectives.

The USFWS provided a formal letter on their support for Alterative 6. The letter can be found at the end of this appendix.

Fact Sheet

Lower Pool 4, Big Lake, Robinson Lake, and Tank Pond
Habitat Rehabilitation and Enhancement Project
Minnesota and Wisconsin; St. Paul District
Upper Mississippi River Restoration Program

Fact Sheet

Location

The Lower Pool 4 study area encompasses approximately 9,382 acres of open backwater, meandered side channel, main channel border, and island formations from state Highway 25 (Nelson Dike) at Wabasha, Minnesota to Lock and Dam 4 near Alma, Wisconsin. The study area extends from approximate river mile 760.2 to 752.8 (7.4 miles), and includes the main stem of the Mississippi River (8,276 acres) and portions of the Buffalo River (1,106 acres). Land ownership within the study area is a patchwork of both U.S. Army Corps of Engineers (USACE) and U.S. Fish and Wildlife Service (USFWS) with all being managed as part of the Upper Mississippi River National Wildlife and Fish Refuge (Refuge) (Figure 1).

Existing Resources

Aquatic Vegetation

In general, aquatic vegetation is abundant and diverse throughout most of the lower Pool 4 backwaters. Submersed plants are mostly stable, rooted-floating species are declining, and emergent plant coverage is increasing, which is primarily attributed to the expansion of wild rice (*Zizania aquatica*) beds. Outside of the backwaters, aquatic vegetation in side channels and within the main channel borders is comprised mainly of spatially disjunct pockets of wild celery (*Vallisneria Americana*) and water stargrass (*Heteranthera dubia*), two species known to be associated with lotic habitat.

Water Quality

Water quality data from Long Term Resource Monitoring (LTRM) indicate that summer water clarity has improved substantially in lower Pool 4 backwaters, including Big Lake, over the past two decades due to a reduction in turbidity. Chlorophyll a concentrations, an indicator of algal biomass, has declined. These improvements in water quality are primarily due to the increase in submersed aquatic vegetation (SAV).

Fisheries

The fishery resource within the study area is quite diverse with 79 species being documented. In addition, various endangered, threatened, or species of concern status have also been sampled. Habitat quality and quantity during spring, summer, and fall appears adequate for most species as does spawning habitat for a multitude of species during spring and early summer. However, winter habitat, comprised of deeper water areas that are protected from flow, appears limiting.

Avian

Monitoring of the Big Lake Closed Area has shown waterfowl use on the increase. Peak numbers of waterfowl recorded during fall aerial surveys include 26,970 tundra swans, 14,830 puddle ducks, and 30,755 diving ducks. There are 25 documented bald eagle nests, of which 10–12 are active each year.

Forestry

1

Forest inventory has been completed across the study area, but in-depth analysis has been limited to specific locations where forest enhancement projects have occurred. Forests are typical of those found across the Upper Mississippi River (UMR), characterized by reduced natural diversity and productivity and less diverse species composition, especially evident is the decline of mast-producing species.

Many of the island formations, particularly in the lower portion of the pool, are deteriorating from wind and wave action and prolonged inundation. Particularly evident are the islands and subsequently the forests at the lower end of Big Lake, which are nearly eliminated.

Current Status of Habitat Needs Assessment-II (HNA-II) Indicators

Pool 4 has the following rating for HNA-II indicators: orange (existing conditions deviates from desired, and may merit action to improve), yellow (existing condition is near defined desired condition but may merit actions to maintain or improve conditions), and gray (existing condition is near desired condition, but may merit action to maintain).

Orange: Longitudinal Aquatic Connectivity (LAC); Aquatic Functional Class 2 (AFC2); Aquatic Vegetation Diversity (AVD); Floodplain Functional Class Diversity (FFCD); Pool Flux Difference (PFD).

Yellow: Longitudinal Floodplain Connectivity (LFC); Aquatic Functional Class 1 (AFC1); Floodplain Vegetation Diversity (FVD); Total Suspended Solids (TSS).

Gray: Lateral River-Floodplain Connectivity (LRC); Tailwater Flux Difference (TFD).

Per the HNA-II, the future desired habitat condition includes: maintain and enhance existing open water area for waterfowl habitat; improve quality, depth, and distribution of lentic habitat for fish; reduce sedimentation; improve lotic habitat; maintain and enhance floodplain vegetation; restore floodplain vegetation diversity in conjunction with diversifying floodplain inundation periods; improve navigation dam gate management for native fish passage; deter invasive fish species; and adjust operation to allow for more gradual rate of change, when feasible.

Problem Identification

As with the majority of the UMR, sedimentation of the backwaters is an ongoing issue. This study area is greatly influenced by the input of sand from the Chippewa River that enters Pool 4 at about river mile 763.5. Other potential sources of sand are the historic channel maintenance dredging side-cast islands and the four active temporary placement sites within the study area. Increased flows over extended periods have transported more material into side channels, which can be seen as exposed sand bars in times of "normal" river conditions.

Big Lake has lost much of its island complex and forest to wind and wave erosion. The barrier islands between the lake and Catfish Slough have been degraded and/or eliminated over the past several years.

Tank Pond near the mouth of the Buffalo River has relatively poor water quality due to a lack of water circulation and lower abundance and diversity of SAV coupled with nutrient concentrations sufficient for algal growth, high turbidity, and chlorophyll a concentrations.

Overwintering Centrarchidae habitat in and below Big Lake is limited, in part, by high current velocities. The existing desirable overwintering areas appear to be filling with sediment and are exposed to flows that are more frequent.

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Without the implementation of forest restoration measures, continued decline will result due to the following factors: dominance of reed canarygrass; loss of native plant species diversity; loss of forest structural and age class diversity and cover including fragmentation; cumulative adverse impacts on forest-dependent wildlife species, ecosystem services (e.g., improvements to water quality), and local aesthetic and cultural resources; as well as decreases in forest habitat connectivity and forest interior habitat will be witnessed.

Project Objectives

The overall goal is to maintain/enhance/create quality habitat for native and desirable plant, animal, and fish species. The project objectives are:

- Protect/stabilize/enhance existing and constructed/reconstructed islands as well as historic and current dredge material placement sites. (LAC, LRC, AFC1, AFC2, AVD, FVD, TSS)
- Protect existing, develop additional, and promote regeneration of floodplain forest. (FVD)
- Reduce sedimentation inputs to backwater lakes. (AFC1, AFC2, AVD, TSS)
- Enhance the quality of migratory bird habitat with an emphasis on waterfowl and neotropical migrants. (LAC, LRC, AFC1, AFC2, AVD, FVD
- Reduce wind fetch in upper Big Lake. (LAC, LRC, AFC1, AFC2, AVD, FVD, TSS)
- Improve water quality in Tank Pond. (LAC, LFC, LRC, AFC1, AFC2, AVD, FVD, TSS)
- Enhance bathymetric diversity in the study area. (LAC, LFC, LRC, AFC1, AFC2, AVD, FVD)
- Maintain or increase quantity and diversity of submerged vegetation. (AFC1, AFC2, AVD, TSS)
- Maintain or increase quantity and diversity of emergent vegetation. (AFC1, AFC2, AVD, TSS)
- Enhance habitat for aquatic species. (LAC, LFC, AFC1, AFC2, AVD, TSS)

Proposed Project Features and Implementation

The project could be developed as three phases (Big Lake, Robinson Lake, and Tank Pond/Buffalo River). Big Lake and Robinson Lake phases include traditional Habitat Rehabilitation and Enhancement Project (HREP) techniques of island construction/protection with a forestry component and dredging to increase bathymetric diversity while providing fine material for the island surface. Tank Pond/Buffalo River phase is focused on connectivity and bathymetric diversity, which may not contain an element of island construction. There are also large island features (for example Island 26 in Figure 2) that could provide for opportunistic use of main channel dredge material placement along the navigation channel.

- **Island construction/enhancement and reed canarygrass reversion** could provide wave and wind fetch protection in the upper portion of Big Lake and provide for enhanced patch size of floodplain forest.
- **Mudflats and/or terraces** could increase emergent vegetation and provide bathymetric diversity to support aquatic species.
- **Dredging backwater areas and secondary channels** to obtain island construction material would create bathymetric diversity and benefit aquatic species.

3

- **Increasing wild celery beds and perennial emergent vegetation** could increase habitat for migratory waterfowl.

Financial Data & Sponsorship

The proposed Lower Pool 4 study area features are located within the Refuge boundary and on lands owned in fee title by the USFWS and USACE; therefore, the project cost would be 100 percent federal. In accordance with Section 107(b) of the Water Resources Development Act (WRDA) of 1992, all costs for operation, maintenance, and rehabilitation of project features would be the responsibility of the USFWS. Operation and maintenance (O&M) is estimated at $10,000/year provided by the USFWS. During the study, if any project features are proposed that are located outside the Refuge boundaries, the states of Minnesota or Wisconsin would be the non-federal sponsor required to provide the cost share implementation and maintenance of those features in accordance with Section 107(b) of the WRDA of 1992. The estimated cost of the Lower Pool 4 project area is $28 million to $45 million as estimated by sub-area:

- Big Lake/Indian Slough: $12 million to $18 million
- Robinson Lake: $6 million to $12 million
- Tank Pond/Buffalo River: $10 million to $15 million

Point of Contact

Angela Deen, Program Manager, St. Paul District, U.S. Army Corps of Engineers, 651-290-5293, angela.m.deen@usace.army.mil

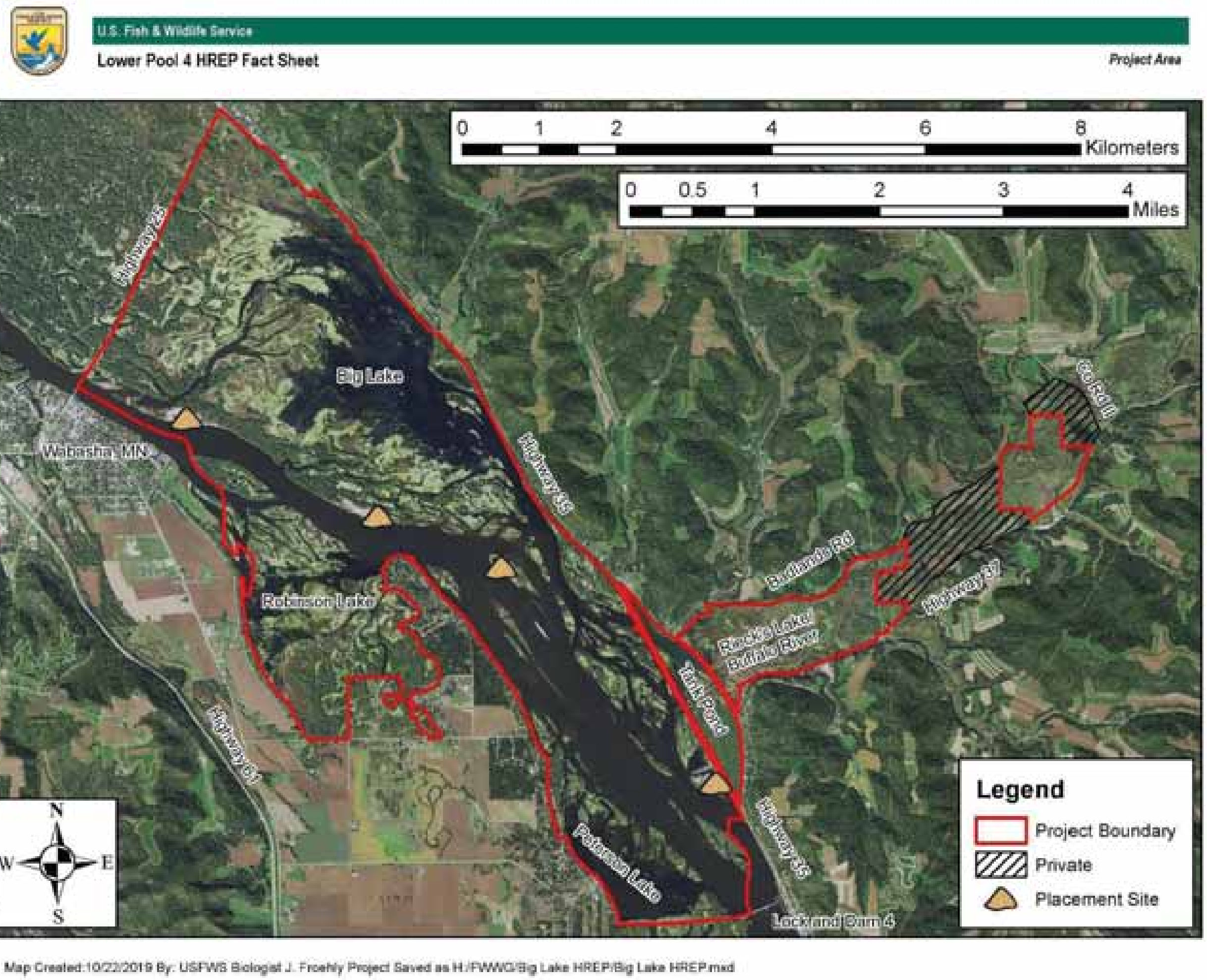
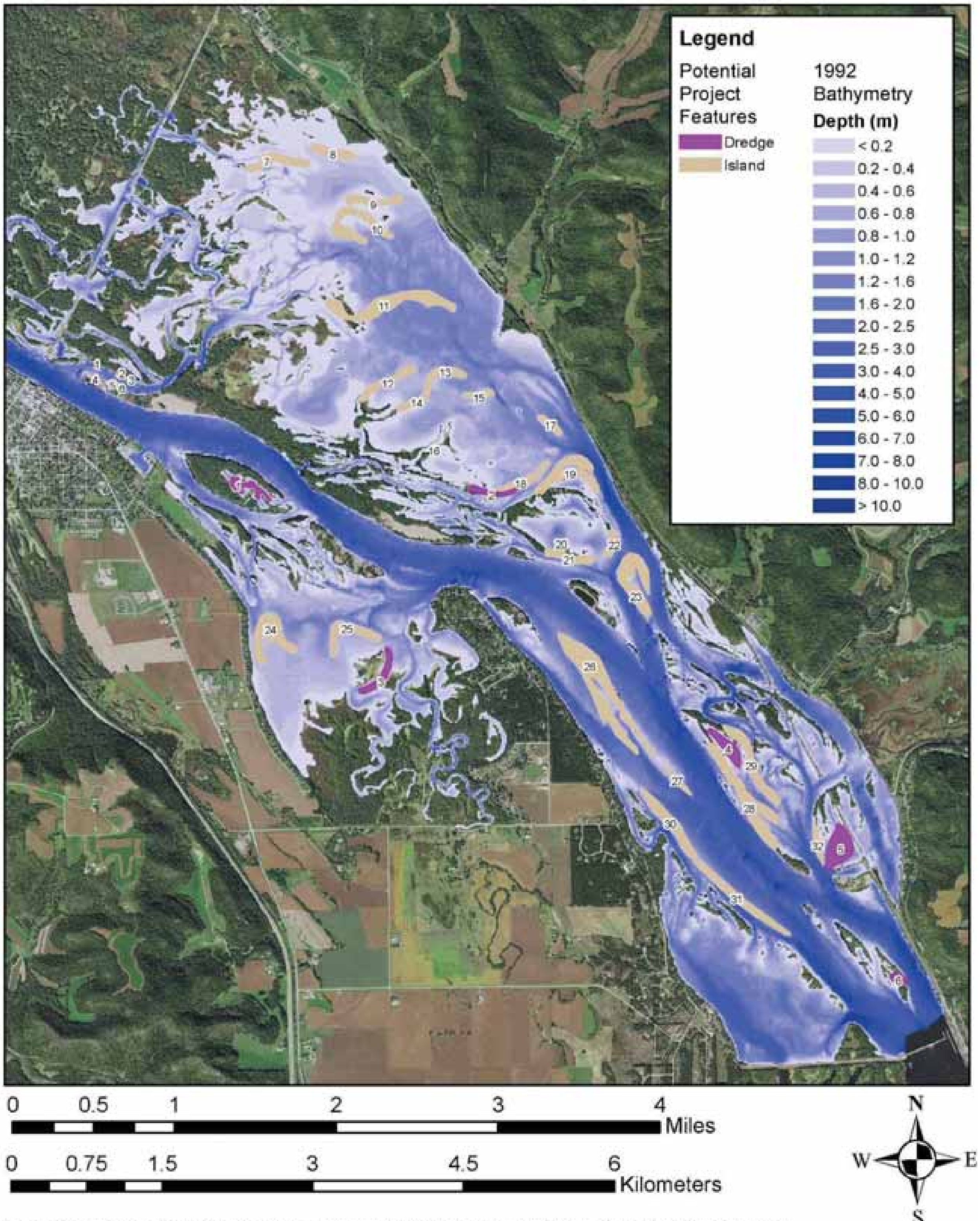


Figure 1. Lower Pool 4 study area.

U.S. Fish & Wildlife Service

Lower Pool 4 HREP Fact Sheet

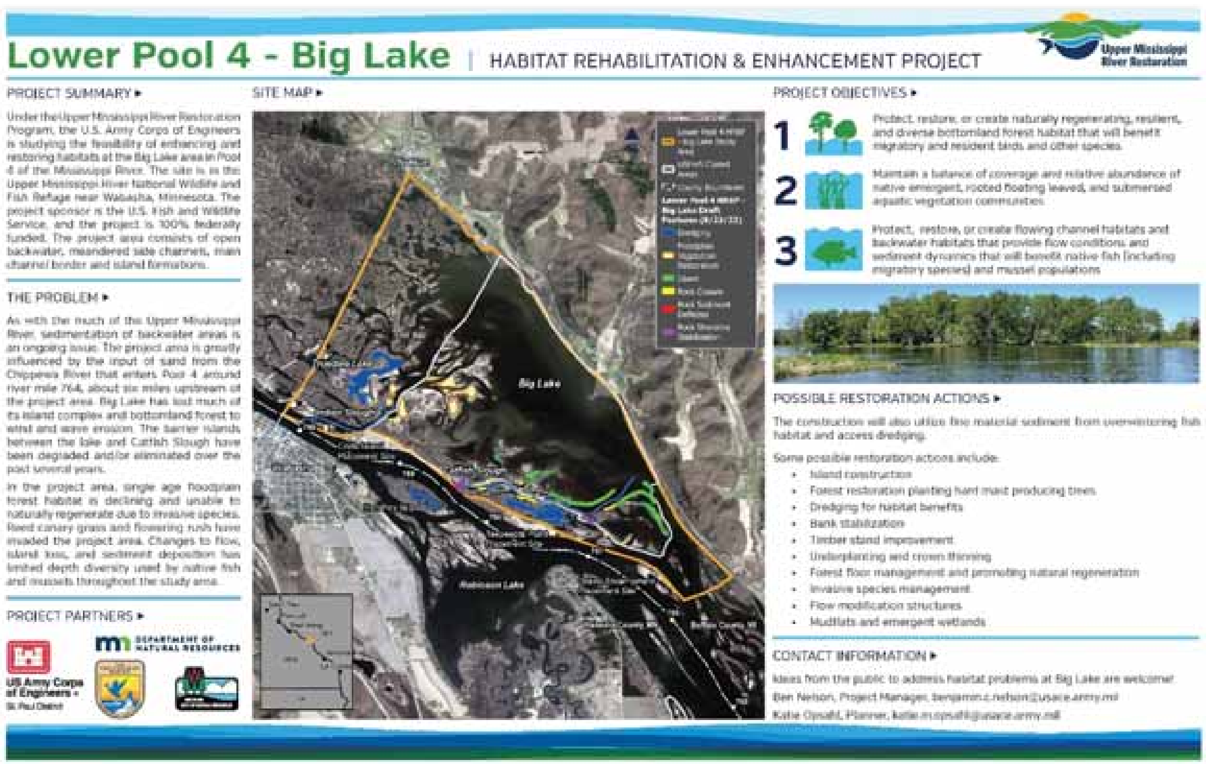
Project Features



Map Created:11/26/2019 By: USFWS Biologist J. Froehly Project Saved as H:/FWWG/Big Lake HREP/Big Lake HREP.mxd

Figure 2. Potential constructed/enhanced island locations and configurations.

Public Scoping Meeting Materials and Comments



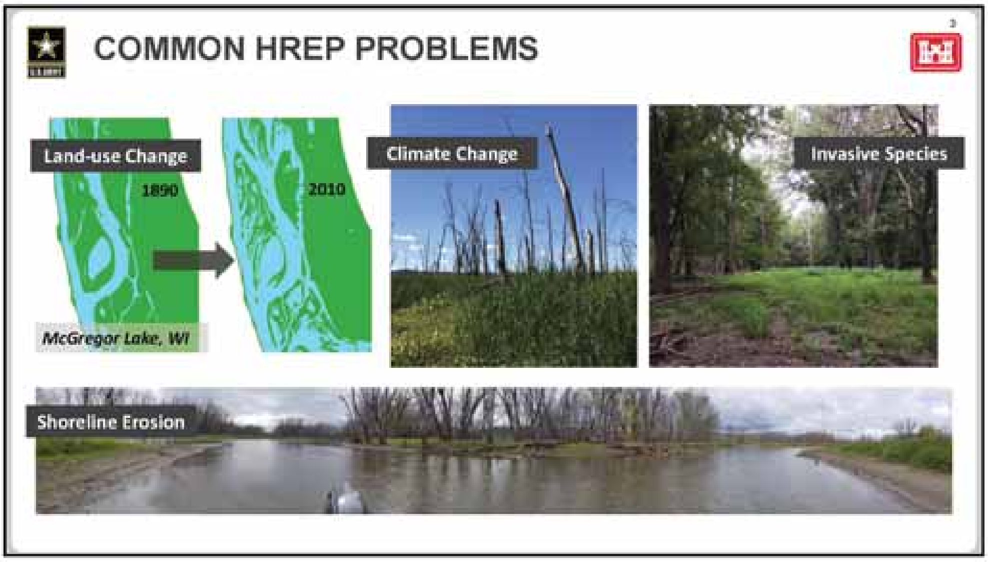

LOWER POOL 4
BIG LAKE
HABITAT REHABILITATION &
ENHANCEMENT PROJECT
PUBLIC MEETING
29 AUGUST 2022
U.S. ARMY
US Army Corps
of Engineers

1

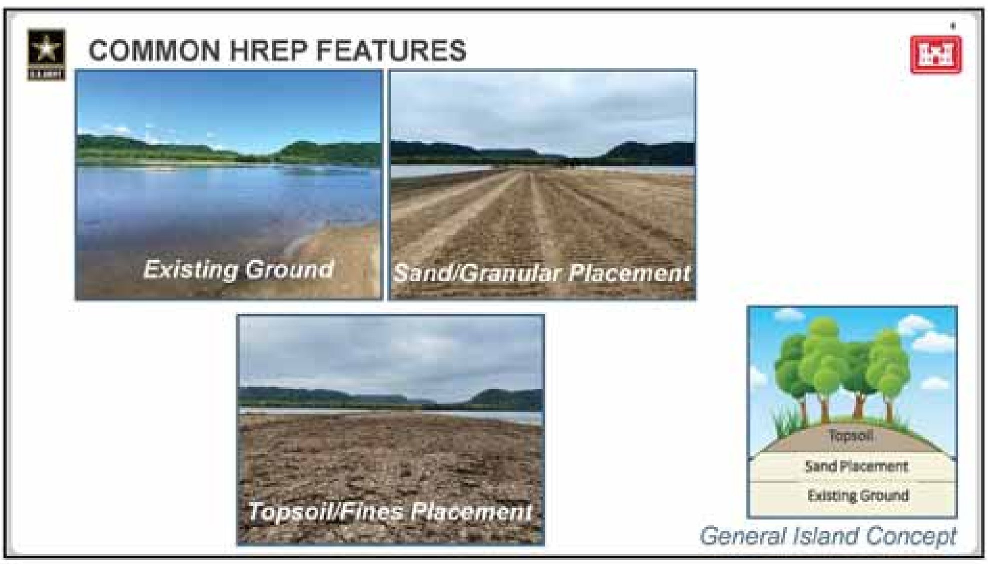

UPPER MISSISSIPPI RIVER RESTORATION (UMRR)
Upper Mississippi
River Restoration
USGS
US Army Corps
of Engineers
DNR
DEPARTMENT OF
NATURAL RESOURCES
1) Long Term Resource Monitoring (LTRM)
2) Habitat Rehabilitation and Enhancement Projects (HREPs)

2

1

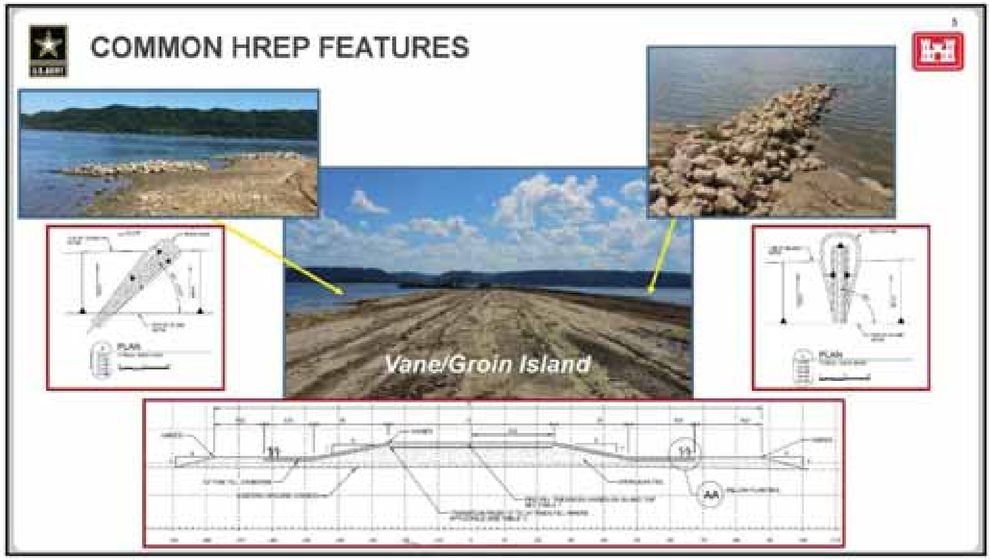

COMMON HREP PROBLEMS
Land-use Change
1890
2010
McGregor Lake, WI
Climate Change
Invasive Species
Shoreline Erosion

3


COMMON HREP FEATURES
Existing Ground
Sand/Granular Placement
Topsoil/Fines Placement
Topsoil
Sand Placement
Existing Ground
General Island Concept

4

2


COMMON HREP FEATURES
Vane/Groin Island

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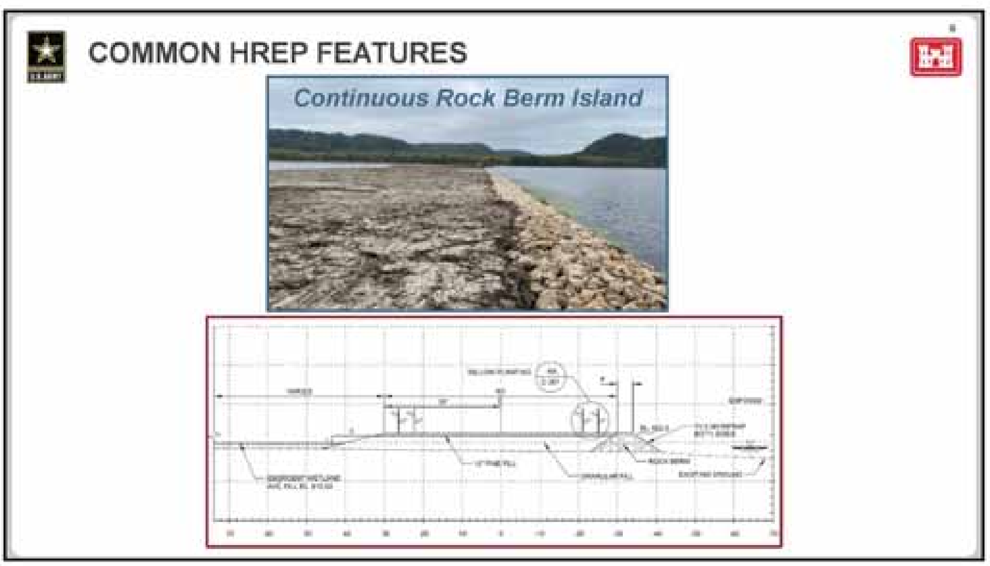
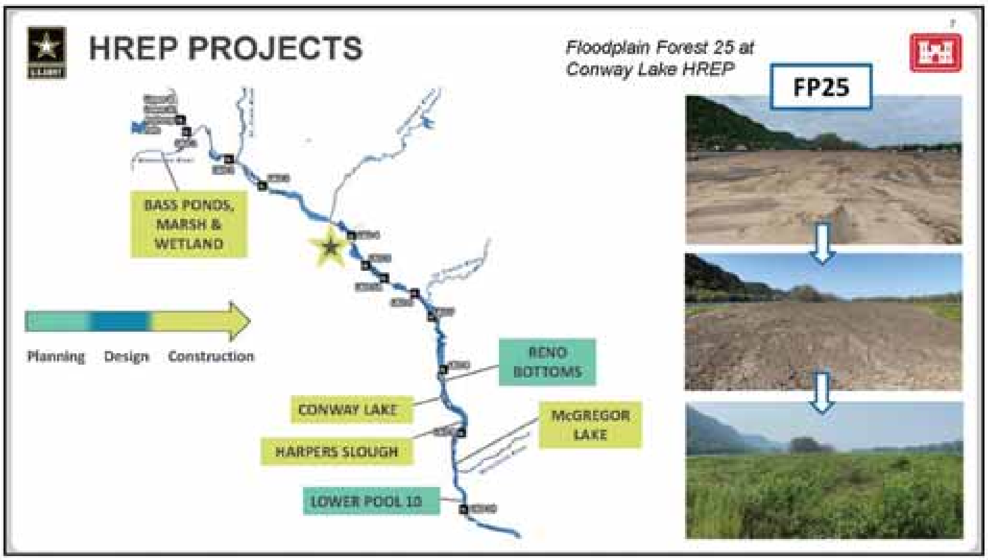

COMMON HREP FEATURES
Continuous Rock Berm Island

6

3


HREP PROJECTS
Floodplain Forest 25 at
Conway Lake HREP
FP25
BASS PONDS, MARSH & WETLAND
Planning
Design
Construction
RENO BOTTOMS
CONWAY LAKE
McGREGOR LAKE
HARPERS SLOUGH
LOWER POOL 10

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LOWER POOL 4
Location:
• 8,276 acres of open backwater, side- channel, main-channel border, and island habitat
• Fact Sheet: Big Lake/Indian Slough, Robinson Lake, Tank Pond/Buffalo River
• Current phase: Big Lake
Land Ownership:
• USACE
• USFWS
• Managed as part of Upper Mississippi River National Wildlife & Fish Refuge
Existing Resources:
• Main Channel
• Secondary Channels
• Many Smaller Channels
• Backwater Areas

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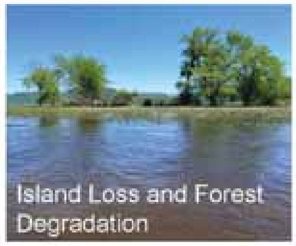
4

LOWER POOL 4 BIG LAKE – EXISTING CONDITIONS



Vallisneria – great food source for ducks & is abundant throughout the study area

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LOWER POOL 4 BIG LAKE OBJECTIVES

- Protect and restore or create naturally regenerating, resilient, and diverse **bottomland forest habitat.**
  - » Benefit migratory and resident birds and other species
- Maintain a balance of coverage and relative abundance of native emergent, rooted floating leaved, and submersed **aquatic vegetation communities.**
- Protect and restore or create **flowing channel habitats.**
- Protect and restore or create **backwater habitats.**
  - » Flow conditions/sediment dynamics that benefit native fish and mussels

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Dredging
Floodplain Vegetation Restoration
Island
Rock Closure
Rock Sediment Deflector
Rock Shoreline Stabilization
DRAFT Preliminary design layout

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COLLABORATION
DEPARTMENT OF NATURAL RESOURCES
USGS

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SURVEYS

- Collected bathymetry data (water depths) in summer 2022
- September 2022
  - Sediment information
  - Cultural resource information
- Potential surveys in Spring 2023
  - Mussels
  - Topography (land features)
  - Environmental sampling

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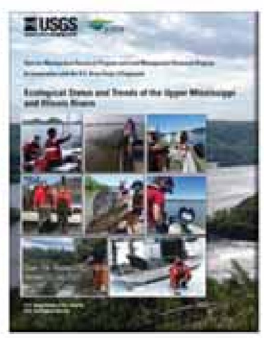
LONG TERM RESOURCE MONITORING (LTRM)

Mission - support decision makers with the information and understanding needed to maintain the Upper Mississippi River System (UMR) as a viable multiple-use river ecosystem

Short term goals:

- Develop a better understanding of UMR and its resource problems
- Monitor resource change
- Develop alternatives to better manage UMR
- Provide for management of UMRR info

Upper Mississippi River Restoration



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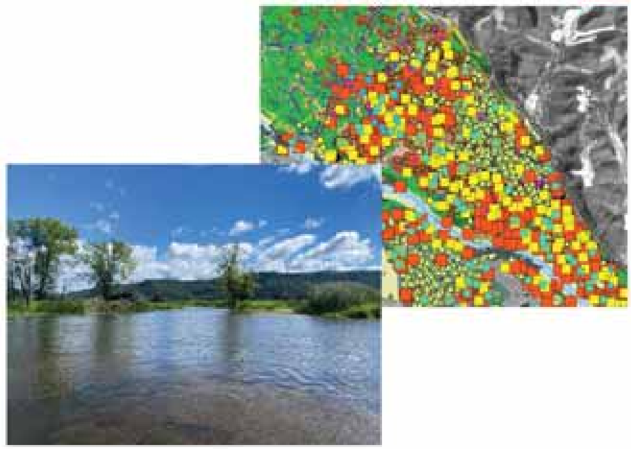
LTRM DATA

- Fish species
- Wild celery
- Water quality
- Substrate
- Land cover
- Water depth
- Wind fetch



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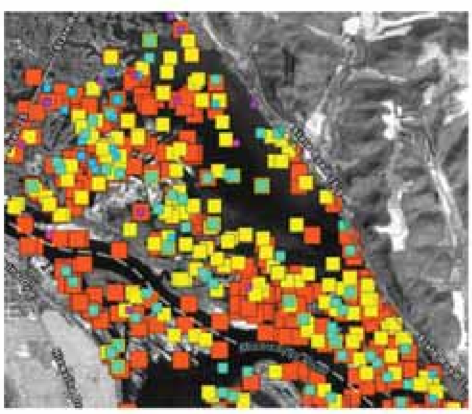
LTRM DATA – FISH SPECIES



- Shovelnose sturgeon
- Central mudminnow
- Pirate perch
- Mud darter
- Pugnose minnow
- Weed shiner

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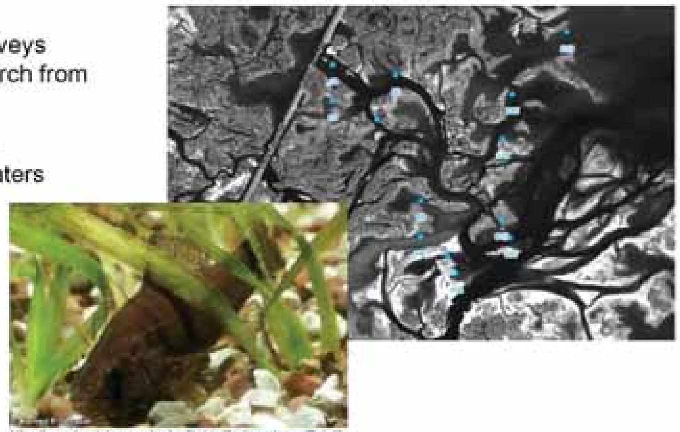
PIRATE PERCH (*Scolopsis sayanus*)

- Pools 4 and 8 fish surveys collected 50 Pirate Perch from 1993-2015
- Preferred habitat was predominately backwaters
- Total number of fish collected (*including fish other than pirate perch*)



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STUDY SCHEDULE

- Feasibility Report Development
  - **Now – Fall 2023**
- Public Review
  - **Fall 2023**
- Feasibility Report & NEPA Document Approval
  - **Spring 2024**

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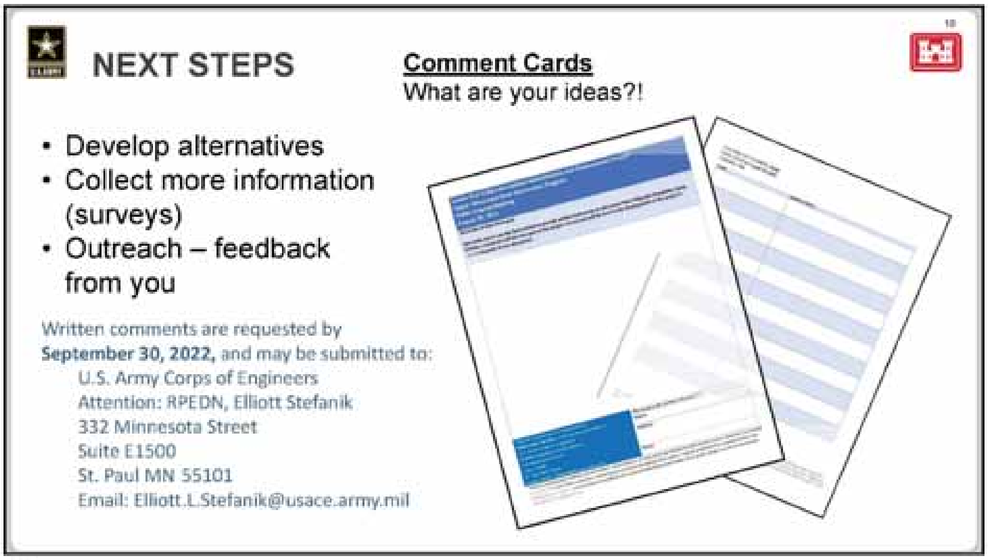
NEXT STEPS
Comment Cards
What are your ideas?!
• Develop alternatives
• Collect more information (surveys)
• Outreach – feedback from you
Written comments are requested by
September 30, 2022, and may be submitted to:
U.S. Army Corps of Engineers
Attention: RPEDN, Elliott Stefanik
332 Minnesota Street
Suite E1500
St. Paul MN 55101
Email: Elliott.L.Stefanik@usace.army.mil

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From: Stefanik, Elliott L CIV USARMY CEMVP (USA)
To: Laura Gould
Subject: RE: [Non-DoD Source] Lower Pool 4 Big Lake Feasibility Study comment
Date: Thursday, September 15, 2022 10:49:00 AM
Attachments: image001.png

Laura, thank you so much for your comments! They are very thoughtful and actually things we've been talking about for the project. I've added some responses to your email below (blue font if that comes through on this email). As we mentioned at the public meeting we will be circling back with the public when we have a more formal project proposal. But you are welcome to reach back to me at any point if you have further questions or would like an update.

Elliott Stefanik
Chief, Environmental Planning Section
USACE, St. Paul District

From: Laura Gould [redacted]
Sent: Wednesday, September 14, 2022 7:40 PM
To: Stefanik, Elliott L CIV USARMY CEMVP (USA) <Elliott.L.Stefanik@usace.army.mil>
Subject: [Non-DoD Source] Lower Pool 4 Big Lake Feasibility Study comment

My comment from the 8/29 public scoping meeting:
Light blue on map below - How long would this area stay deep after dredging? This area is extremely shallow (not even passable by kayak for much of the year) so would require a lot of labor and monetary investment to dredge. I'm not an expert, but my guess would be with periodic flooding and future low water years this would just fill right in. Seems like it might be a frivolous use of energy and funds. Is there a large conservation gain by dredging? Is that still valuable if it fills back in?

- We will be completing that estimation fairly soon in the project timeline. You're correct in that this area will likely fill back in to what's out there currently – it's more of a question of when or how quickly. This will definitely be taken into account when choosing the final project features.

Yellow on map below - A proposed block to this channel seems like it would potentially cause the light blue on the map to fill in even faster? And also cut off access to recreation for that area.

- The yellow rock closure would actually decrease the amount of flow and thus sediment entering the light blue area which would provide more longevity to the light blue area dredging. However, the yellow rock closure will be overtopped during small flood events, so some sedimentation will still take place. This rock closure would cut off recreation during typical flow conditions which is definitely a consideration for us going forward.

Red on the map - This proposed block would cut off a channel that is really unique in the area for small boats (specifically kayaks and canoes) to enjoy and gain access to the southern side of Big Lake (when water levels are high enough). I can see there are past rock pikes along the edges at the northern end of this channel (where the red line is). What were those originally put in for? Are they not serving a purpose anymore? It seems that a block here might only serve to increase sedimentation in the main slough from the Mississippi River to Big Lake. That slough was marked for potential access dredging for work in the area, but it has always in recent years been deep enough for fishing boats to my knowledge.

- The red rock closure would also cut off recreation during typical flow conditions which is definitely a consideration for us going forward.
- We're unsure when that historic rock was put in at that location, but in talking with the other agencies, it was determined that that historic rock was installed as a rock closure, but the structure has since been scoured out and is no longer effective. If a rock closure is included in this location as part of this project, it would be constructed with more resiliency than the historic structure.
- Including the red and yellow rock closures would slightly increase the sedimentation in Indian Slough (the main slough from the river to Big Lake) because the sediment would no longer be able to deposit in the side channels during typical flow conditions. This is a consideration when choosing the final project features.

Although at the 8/29 meeting presenters shared that this plan is extremely preliminary and doesn't have to look the same in the end, there was not much discussion as to how each of the projects shown really meet the project's goals (habit creation, invasive species removal, waterfowl benefits....). I would love to see the focus on conservation and habitat area creation in the project area, but for that to be sustainable. Especially in this pool, sedimentation is a huge obstacle. What's to keep the money and time invested in the proposed additions/changes/dredging from being reverted in a few short years? Is there longevity and sustainability factored into the project?

- With dredging longevity, we typically complete an estimation of expected sedimentation deposition for the 50 year project life especially for areas that already experience a lot of sedimentation. We can use that estimation and dredge even deeper to ensure the dredged channel will be usable for the 50-year project life. This analysis will be a part of our Feasibility Study. Because of the large sand and sediment input we get from the Chippewa River, the longevity of any dredging we do becomes even more important to consider. We very much want our features to be sustainable. Certain habitat types like sheltered backwaters with deeper water become very difficult to maintain with the sand inputs we have here. And obviously dredging greater volumes of sand becomes more expensive. Trying to balance that cost with the resulting habitat benefits, and all the positive and negative tradeoffs with other river uses (like recreation) is what we will try to do over the next year with the feasibility study.

Thank you for your work!

- Thank you for your engagement! I can't guarantee we can address all your concerns, but we will discuss these concerns with the natural resource agencies that we work with and hopefully identify a project that works for both habitat, recreation and all the other interests. And you will have a chance to see, review and comment on a more formal project proposal in about a year.

[Non-DoD Source] Big Lake Presentation

Renee Parcheta [redacted]

Fri 10/7/2022 9:43 AM

To: Nelson, Benjamin C CIV USARMY CEMVP (USA) <Benjamin.C.Nelson@usace.army.mil>;Opsahl, Katherine M CIV USARMY CEMVP (USA) <Katie.M.Opsahl@usace.army.mil>

Good Morning Mr. Nelson and Ms. Opsahl,

I humbly apologize for this late response after attending the meeting for Big Lake Habitat Rehabilitation And Enhancement Project at Wabasha School.

As a 20 year resident of Robinson Lake and a professional superintendent, I wanted to give some feedback about that particular meeting.

- I commend you on bringing all the parties to the meeting and it was a pleasure to ask questions of each organization involved individually. I might suggest that at the next meeting all parties get to talk and answer questions in the front of the room. From Robinson Lake Neighborhood feedback, and my own impression, questions were not clearly answered. Which leaves some lifetime residents suspicious.
- Sending a project manager in to talk to this group, without the contentious history of the USACE with Wabasha made for an uncomfortable situation. I did feel badly for him as he did not know who his audience was.
- As a Robinson Lake neighborhood group we chatted and with all the information and presentation people still don't understand the purpose or mission statement of the project. We have concluded it is to keep barge traffic open with as little impact on the environment.
- You may have underestimated the audience. I just wanted to let you know just from the people I knew in the audience there wa;: A PHD in Geology, a PHD student in environmental studies, lifelong residents who are hunting and fishing for subsistence living, Mayo Clinic Doctor, the technical coordinator of Mayo Clinic, Superintendent of a school, an organic farm cooperative, lifelong farmers that were impacted by USACE, professional fishermen, and many retired professionals that are quite knowledgeable. In spite of looking out in the audience that appears to be "grumpy old men", you had a plethora of people that are very concerned about the manipulation of the waterways for various reasons. The response of some of the answers, when the project manager was unable to respond, felt somewhat "condescending" to the audience.

Some ideas to bring to the next meeting to help residents along the river understand what is really happening might be transparency of budget resources, a clearer understanding of the geological reasoning, addressing the elephant in the room of the history of taking farmland from this area for river sand depositing, and what actually the Robinson Lake project is about.

At this time our neighborhood has all sorts of rumors about what is going to happen with Big Lake and Robinson Lake. Seeing as this is the first year we have seen Robinson Lake fill in with vegetation, further speculation is mounting for availability of hunting, dredging, and other concerns. Fancy mission statements that can't be backed by detailed questions does pose suspicion. I realize you don't need the approval of residents along the river, however it may behove you to facilitate cooperation to make the USACE employees "at the sites" have a better experience with the local communities.

I don't need any response, I just wanted to provide some feedback for the next meeting. However I do appreciate keeping informed of the Big Lake & Robinson Lake project on a regular basis. Especially any further meetings that occur.

Respectfully,
Renee' Parcheta
[redacted]
My Current Read:
<u>*Being Mortal*</u> by Atul Gawande
Buddha Doodles | Buddha doodle, Buddah doodles, Doodles

Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project
Upper Mississippi River Restoration Program
Public Scoping Meeting
August 29, 2022

We'd like to hear from you!

We invite you to use the form below to provide written comments on the Lower Pool 4 Big Lake Feasibility Study. Written comments will become part of the project record and will be used in the development of the project's environmental review document.

I Want to know why ~~you~~ they wont dredge
In the Duck Closed area. is it a law
Or why

Written comments are requested by **September 30 2022**, and may be submitted to:
U.S. Army Corps of Engineers
Attention: RPEDN, Elliott Stefanik
332 Minnesota Street
Suite E1500
St. Paul MN 55101
Email: Elliott.L.Stefanik@usace.army.mil

Please provide contact information*:
Name: Tim Adams
[redacted]

**Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.*

Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project
Upper Mississippi River Restoration Program
Public Scoping Meeting
August 29, 2022

We'd like to hear from you!

We invite you to use the form below to provide written comments on the Lower Pool 4 Big Lake Feasibility Study. Written comments will become part of the project record and will be used in the development of the project's environmental review document.

Waterfowl use of the Big Lake closed area has increased and improved migration habitat is benefitting continentally significant resources (ducks in particular). Please don't construct any features which would negatively impact that important migration habitat in Big Lake or increase disturbance of migrating waterfowl in the fall and/or spring. There are so few remaining high quality habitats for migrating water fowl... we need them all. Please place the needs of wildlife above those of people who only want to "harvest" or are too lazy to work a little.

Written comments are requested by **September 30 2022**, and may be submitted to:
U.S. Army Corps of Engineers
Attention: RPEDN, Elliott Stefanik
332 Minnesota Street
Suite E1500
St. Paul MN 55101
Email: Elliott.L.Stefanik@usace.army.mil

Please provide contact information*:
Name: Anonymous
Address:
Email:

**Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.*

Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project
Upper Mississippi River Restoration Program
Public Scoping Meeting
August 29, 2022

We'd like to hear from you!

We invite you to use the form below to provide written comments on the Lower Pool 4 Big Lake Feasibility Study. Written comments will become part of the project record and will be used in the development of the project's environmental review document.

Curious if dredging will be done in Nelson/Trevino - especially the boat access just east of the Chippewa/Hwy 35 bridge?

Written comments are requested by **September 30 2022**, and may be submitted to:
U.S. Army Corps of Engineers
Attention: RPEDN, Elliott Stefanik
332 Minnesota Street
Suite E1500
St. Paul MN 55101
Email: Elliott.L.Stefanik@usace.army.mil

Please provide contact information*:
Name: Michael Anderson
[redacted]

**Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.*

Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project
Upper Mississippi River Restoration Program
Public Scoping Meeting
August 29, 2022

We'd like to hear from you!

We invite you to use the form below to provide written comments on the Lower Pool 4 Big Lake Feasibility Study. Written comments will become part of the project record and will be used in the development of the project's environmental review document.

I would like to see more dredging tward the center of Big Lake then a deep cut along the far east, More Dredging along Robinson cut. Too much rice its cutting all of the natural flow
-Open up all sloughs from the Dike road for access.

Written comments are requested by **September 30 2022**, and may be submitted to:
U.S. Army Corps of Engineers
Attention: RPEDN, Elliott Stefanik
332 Minnesota Street
Suite E1500
St. Paul MN 55101
Email: Elliott.L.Stefanik@usace.army.mil

Please provide contact information*:
Name: Travis J Bruce
[redacted]

**Before including your address, phone number, email address, or o*[redacted] *be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.*

USFWS Goals and Objectives

UPPER MISSISSIPPI RIVER NATIONAL WILDLIFE AND FISH REFUGE

Lower Pool 4 Big Lake HREP

**U.S. FISH AND WILDLIFE SERVICE,
NATIONAL WILDLIFE REFUGE SYSTEM, AND
UPPER MISSISSIPPI RIVER NATIONAL WILDLIFE AND FISH REFUGE
GOALS AND OBJECTIVES**

Contacts: Mary Stefanski, Winona District Manager
and Stephen Winter, Wildlife Biologist

January 5, 2022

**U.S. Fish and Wildlife Service and
National Wildlife Refuge System Goals and Objectives**

Broad goals and objectives are provided by legislation that guides management of the National Wildlife Refuge System including the National Wildlife Refuge System Administration Act of 1966 and the National Wildlife Refuge System Improvement Act of 1997 16 U.S.C. 668dd to 668ee (Refuge Administration Act). These define the Refuge System and authorizes the Secretary of the Interior to permit any use of a refuge provided such use is compatible with the major purposes for which the refuge was established. The landmark National Wildlife Refuge System Improvement Act, passed by Congress in 1997, prepared the way for a renewed vision for the future of the refuge system whereby:

- Wildlife comes first.
- Refuges are cornerstones for biodiversity and ecosystem-level conservation.
- Lands and waters of the System are biologically healthy.
- Refuge lands reflect national and international leadership in habitat management and wildlife conservation.

Important provisions of this legislation and the subsequent policies to carry out its mandates include:

- The establishment of a Broad National Policy for the Refuge System whereby each refuge shall be managed to fulfill the mission and its purposes.

- Directing the Secretary of the Interior to:

    - Provide for the conservation of fish, wildlife, and plants within the System.

    - Ensure biological integrity, diversity, and environmental health of the System for the benefit of present and future generations.

1

  - Carry out the mission of the System and purposes of each refuge; if conflict exists between these, refuge purposes take priority.
  - Ensure coordination with adjacent landowners and the states.

- Providing Compatibility of Uses Standards and Procedures whereby new or existing uses should not be permitted, renewed, or expanded unless compatible with the mission of the System or the purpose(s) of the refuge, and consistent with public safety.

- Planning whereby each unit of the Refuge System shall have a Comprehensive Conservation Plan completed by 2012.

- Compatibility Policy whereby no use for which the Service has authority may be allowed on a unit of the Refuge System unless it is determined to be compatible. A compatible use is a use that, in the sound professional judgment of the refuge manager, will not materially interfere with or detract from the fulfillment of the Refuge System mission or the purposes of the national wildlife refuge. Managers must complete a written compatibility determination for each use, or collection of like uses, that is signed by the manager and the Regional Chief of Refuges in the respective Service region.

- Biological Integrity, Diversity and Environmental Health Policy whereby the Service is directed in the Refuge Improvement Act to "ensure that the biological integrity, diversity, and environmental health of the Refuge System are maintained for the benefit of present and future generations of Americans…" The biological integrity policy helps define and clarify this directive by providing guidance on what conditions constitute biological integrity, diversity, and environmental health (BIDEH); guidelines for maintaining existing levels; guidelines for determining how and when it is appropriate to restore lost elements; and guidelines in dealing with external threats to BIDEH. The policy also provides guidance for the conservation and management of a broad spectrum of fish, wildlife, and habitat resources found on refuges and associated ecosystems.

The specific legislation establishing the Upper Mississippi River National Wildlife and Fish Refuge was the Upper Mississippi River Wild Life and Fish Refuge Act of 1924 and the stated purposes of the refuge in that legislation were:

- "...a refuge and breeding place for migratory birds included in the terms of the convention between the United States and Great Britain for the protection of migratory birds, concluded August 16, 1916, and…

- …to such extent as the Secretary of Agriculture may by regulations prescribe, as a refuge and breeding place for other wild birds, game animals, fur-bearing animals, and for the conservation of wild flowers and aquatic plants, and…

- …to such extent as the Secretary of Commerce may by regulations prescribe as a refuge and breeding place for fish and other aquatic animal life."

The Upper Mississippi River National Wildlife and Fish Refuge Comprehensive Conservation Plan (USFWS 2006) identified several relevant Goals and Objectives, including:

- Environmental Health Goal: We will strive to improve the environmental health of the Refuge by working with others.
- Wildlife and Habitat Goal: Our habitat management will support diverse and abundant native fish, wildlife, and plants.
    - Management practices will restore or mimic natural ecosystem processes or functions to promote a diversity of habitat and minimize operations and maintenance costs. Mimicking natural processes in an altered environment often includes active management and/or structures such as drawdowns, moist soil management, prescribed fire, grazing, water control structures, dikes, etc.
    - Maintenance and operation costs of projects will be weighed carefully because annual budgets are not guaranteed.
    - Terrestrial habitat on constructed islands and other areas needs to best fit the natural processes occurring on the river, which in many cases will allow for natural succession to occur.
    - If project features in Refuge Closed Areas serve to attract the public during the waterfowl season, spatial and temporal restrictions of uses may be required to reduce human disturbance of wildlife.
    - The esthetics of projects in context of visual impacts to the landscape should be considered in project design.

Each refuge is required to complete a Habitat Management Plan that includes an identification of Resources of Concern associated with that refuge. Service policy (620 FW 1) defines Resources of Concern as:

> "All plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), System mission, or international, national, regional, state, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect "migrating waterfowl and shorebirds." Federal or State threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts."

Furthermore, the comprehensive list of Resources of Concern associated with a refuge is refined to a subset known as Priority Resources of Concern. A set of Refuge Priority Resources of Concern have been identified by the Upper Mississippi River National Wildlife and Fish Refuge (U.S. Fish and Wildlife Service 2019) and they serve in part to represent refuge priorities when the refuge engages in the planning and execution of partnership activities such as Upper

Mississippi River Restoration (UMRR) Habitat Rehabilitation and Enhancement Projects (HREP).

Upper Mississippi River National Wildlife and Fish Refuge
Lower Pool 4 HREP-specific Objectives and Priority Resources of Concern

The following Refuge Priority Resources of Concern (ROC) (U.S. Fish and Wildlife Service 2019) are relevant to HREP objectives as identified in the Lower Pool 4 Fact Sheet (Upper Mississippi River Restoration 2020): native invertebrate pollinators, cerulean warbler, prothonotary warbler, transient neotropical migrant passerines, tree-roosting bats, midwestern wooded swamps and floodplains, dabbling duck guild, black tern, tundra swan, secretive marsh birds, canvasback, lesser scaup, limnophilic native mussels, limnophilic native fish, fluvial-dependent native mussels, migratory fluvial-dependent native fish.

Refuge objectives and associated Priority ROC relevant to the Big Lake study area are identified in Tables 1 and 2. Restoration and enhancement activities addressing primary objectives may enhance but cannot detract from the current habitat conditions that are conducive to canvasback and lesser scaup.

Table 1: Refuge Primary Objectives and Priority ROC within the Big Lake Study Area

Primary Objective (listed in priority order)	Priority Resources of Concern
Restore, enhance, and protect bottomland forests to benefit refuge priority resources of concern and to buffer sensitive wildlife habitats from human activities.	• Prothonotary warbler • Tree roosting bats • Midwestern wooded swamps and floodplains (large trees over standing or slow moving water, live or dead trees with exfoliating bark)
Restore, enhance, and protect islands to restore, maintain or create flow conditions and sediment dynamics that will benefit submersed, emergent, and rooted floating-leaved aquatic vegetation.*	• Dabbling duck guild • Tundra swan • Secretive marsh birds
Reduce wind-fetch to restore, enhance, and protect submersed, emergent, and rooted floating-leaved aquatic vegetation.*	• Dabbling duck guild • Black tern • Tundra swan • Secretive marsh birds
Restore, enhance, and protect lotic habitats to restore, maintain or create depth and flow conditions, as well as sediment dynamics, that will benefit migratory fluvial-dependent native fish and fluvial-dependent native mussels.	• Fluvial-dependent native mussels • Migratory fluvial-dependent native fish (paddlefish and sturgeon)

4

Primary Objective (listed in priority order)	**Priority Resources of Concern**
Restore, enhance, and protect deep lentic habitats to restore, maintain or create depth and flow conditions, as well as sediment dynamics, that will benefit limnophilic native fish and mussels.	• Limnophilic native fish and mussels (mud darter, weed shiner, pugnose minnow, central mudminnow, pirate perch)
** Restoration and enhancement activities addressing primary objectives may enhance but cannot detract from the current habitat conditions that are conducive to canvasback and lesser scaup, ie: aquatic vegetation dominated by wild celery.*	

Table 2: Refuge Secondary Objectives and Priority ROC within the Big Lake Study Area

Secondary Objective (listed in priority order)	**Priority Resources of Concern**
Restore, enhance, and protect bottomland forest in areas adjacent to or in close proximity to currently existing bottomland forest to benefit refuge priority resources of concern which need large blocks of habitat.	• Red shouldered hawk • Cerulean warbler • Transient neotropical migrant passerines • Midwestern wooded swamps and floodplains (large trees with layers of canopy including gaps and edges)
Reduce wind-fetch to restore, enhance, and protect submersed aquatic vegetation communities dominated by wild celery, as well as emergent and floating-leaved aquatic vegetation.	• Native invertebrate pollinators

References

U.S. Fish and Wildlife Service. 2006. Upper Mississippi River National Wildlife and Fish Refuge Comprehensive Conservation Plan. U.S. Fish and Wildlife Service. Fort Snelling, Minnesota. 168 pp + Appendices A–G.

U.S. Fish and Wildlife Service. 2019. Upper Mississippi River National Wildlife and Fish Refuge Habitat Management Plan. U.S. Fish and Wildlife Service. Bloomington, MN. 127 pp + Appendices A–F. Available at https://ecos.fws.gov/ServCat/Reference/Profile/115578

Upper Mississippi River Restoration. 2020. Lower Pool 4, Big Lake, Robinson Lake, and Tank Pond. U.S. Army Corps of Engineers, St Paul District. 6 pp.

****

Section 106 Consultation Letter example

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
180 FIFTH STREET EAST, SUITE 700
ST. PAUL, MN 55101-1678

July 24, 2023

Regional Planning and Environment Division North

Mr. Leonard Wabasha
Cultural Resources Director
2300 Tiwahe Circle
Shakopee, Minnesota 55379

Dear Mr. Wabasha:

The U.S. Army Corps of Engineers, St. Paul District (Corps) is studying the feasibility of enhancing and restoring habitats within the Big Lake and Robinson Lake area of the Upper Mississippi River Navigation Pool 4, Wabasha County, Minnesota, and Buffalo County, Wisconsin (Figure 1). We are contacting your office to initiate consultation under Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulation 36 CFR 800. This correspondence provides an outline of the studies.

Habitat concerns in the Big Lake and Robinson Lake areas include loss and degradation of islands and floodplain habitat due to erosional forces, increased water levels, presence of invasive species, and associated detrimental conditions leading to a lack of forest diversity and reduced quality of terrestrial and aquatic habitats. The objectives of the habitat rehabilitation and enhancement projects (HREP) aim to provide resilient and diverse bottomland forests along with backwater and flowing water habitats.

Proposed features may include island and emergent wetland construction, shoreline stabilization, flowage modification structures, plantings, and invasive species control measures. As the study progresses, restoration and enhancement features will be defined and associated activities, such as access and construction access and methods, will be developed. Figures 2 and 3 presents information papers for the studies.

Previous cultural resources investigations in the area have focused on terraces and uplands where several habitation sites, burials and burial mounds and historic farmsteads and standing structures are located. Most of the information on cultural resources in this area is obtained from historic documents and maps. Surveys of the temporary dredged material placement sites Above Crats Island, Above Teepeota Point, and Grand Encampment were conducted in 1975. The alignment of Wisconsin Trunk Highway 35 between the towns of Nelson and Alma was surveyed in 1984 and 1988. Portions of a temporary pipeline route for relaying dredged material from Teepeota Point to a permanent placement site near the Wabasha Senior High School was completed along the terrace on the west side of Robinson Lake in 2007. Portions of a powerline corridor were surveyed in 2018 for installation of power pole structures just north of Trunk Highway 25 and east of the Wabasha-Nelson bridge. One site, a historic farmstead with a

-2-

precontact component, is located within the project area at the Wilcox Boat Landing near the previous mouth of the Zumbro River at Robinson Lake. Figure 4 is a portion of the Pool 4 navigation chart illustrating locations mentioned above. Cultural resources and geoarchaeological surveys are planned for this year.

The Corps is interested in the comments and opinions of your community on the proposed projects to help identify historic properties in the project area that may have cultural significance, and if such properties exist, to help assess how the project might affect them. If the project might have an adverse effect, we would like to discuss possible ways to avoid, minimize or mitigate potential adverse effects. Please find enclosed an assessment form to facilitate your response.

If you have another preferred format for response, please feel free to use it. Any comments or questions should be directed to Bradley Perkl, Ph.D. archaeologist, (651) 290-5370 or [redacted] We look forward to hearing from you.

Sincerely,

[redacted]
Deputy Chief, Regional Planning and
Environment Division North

Enclosure

THPO Assessment Form

-3-

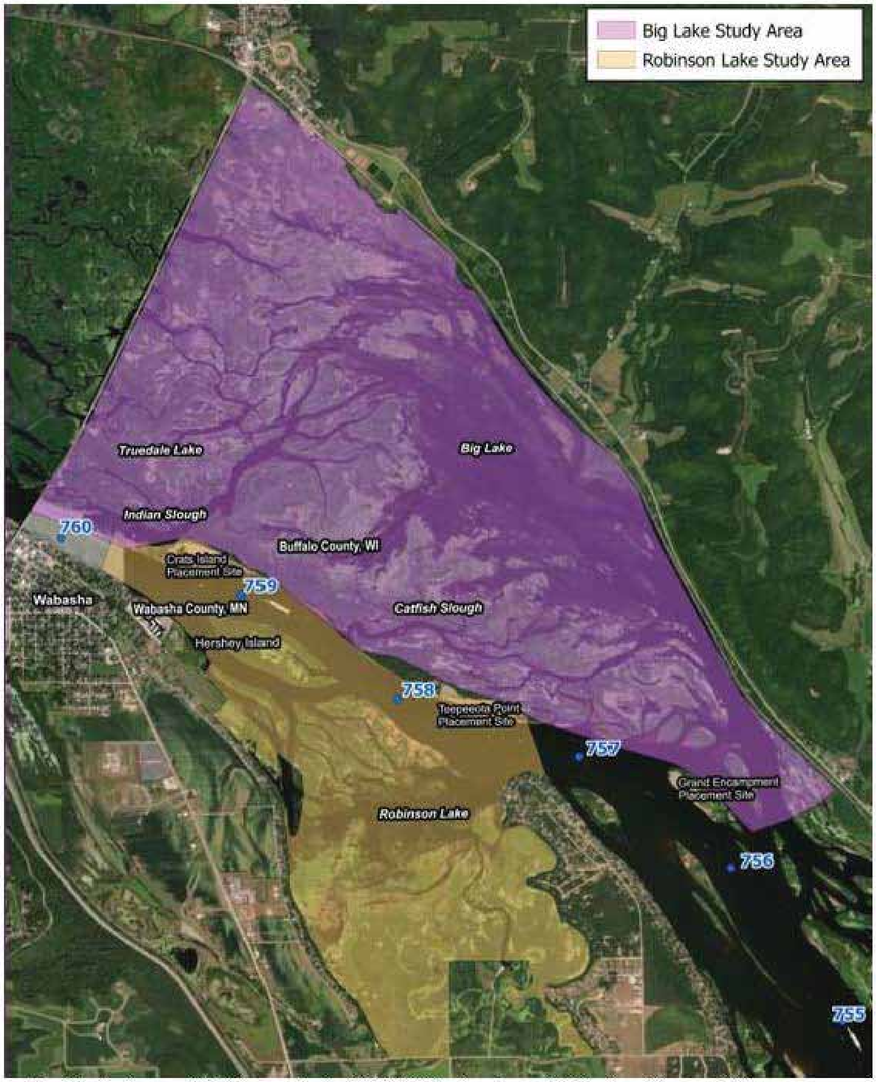


Figure 1. Big Lake and Robinson Lake HREP Study Area, Wabasha County, Minnesota and Buffalo County, Wisconsin.

-4-

Figure 2. Big Lake HREP Information Paper.

-5-

Figure 3. Robinson Lake HREP Information Paper.

-6-

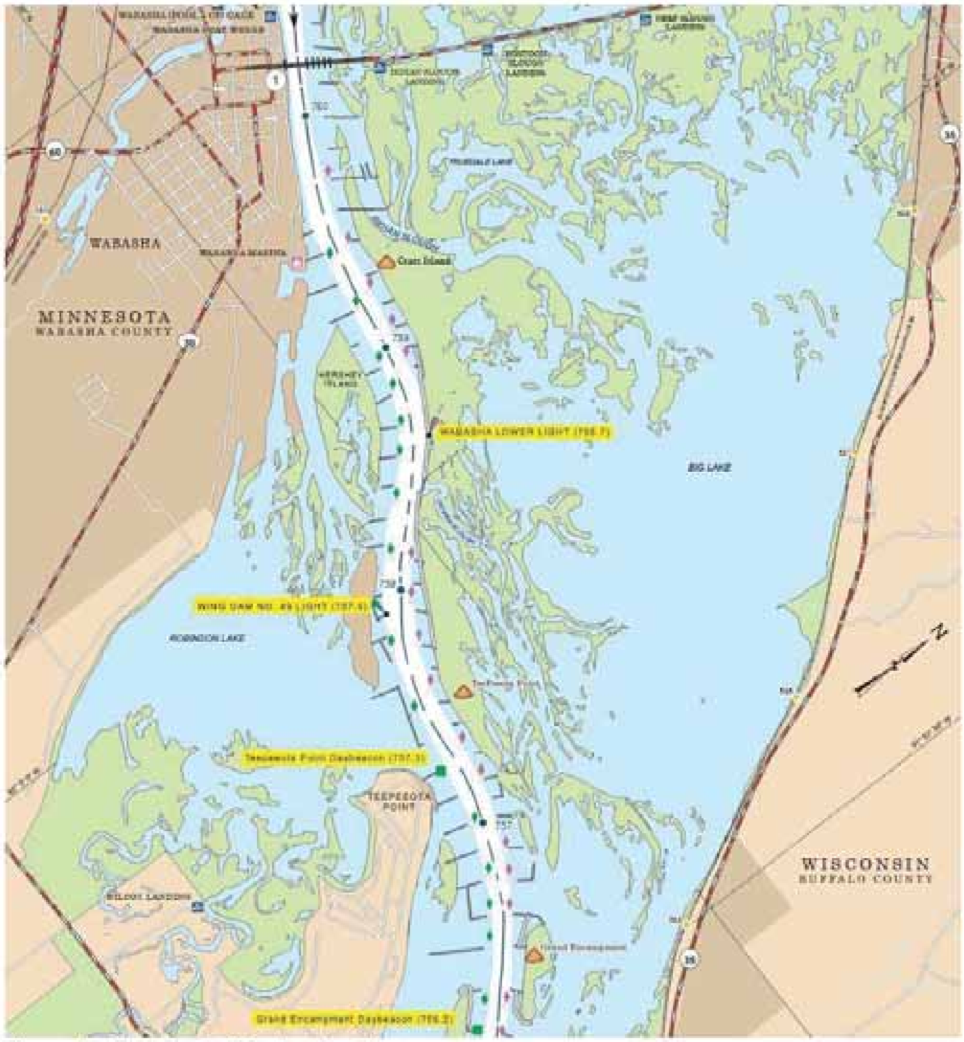


Figure 4. UMR Pool 4 Navigation Chart.

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, ST. PAUL DISTRICT
332 MINNESOTA STREET, SUITE E1500
ST. PAUL, MN 55101-1678

19 MARCH 2024

Regional Planning and Environment Division North

SUBJECT: Initiating Consultation, Lower Pool 4 Big Lake, Habitat Rehabilitation and Enhancement Project, Buffalo County, Wisconsin

Dr. Tyler B. Howe,
Wisconsin Historical Society
Division of Historic Preservation and Public History
816 State Street
Madison, WI 63706

Dear Dr. Howe,

The U.S. Army Corps of Engineers, St. Paul District (Corps) is initiating consultation under Section 106 of the National Historic Preservation Act of 1966, as amended, per its implementing regulations 36 CFR Part 800, on the Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project (Project) under the authority of the Upper Mississippi River Restoration Program. The study area of the Project is located at Big Lake on the Upper Mississippi River (UMR) navigation pool 4 between river miles 760 and 756 in Buffalo County, Wisconsin. The Corps has identified the area of potential effect (APE) to include the area of proposed project features and potential visual effects as marked in Figure 1. The Corps has determined that this Project will have No Effect on Historic Properties.

The Big Lake area has experienced degradation and loss of both island and floodplain forest habitats. Declining floodplain forests, dominated by a single age class, are unable to naturally regenerate due to invasive herbaceous cover and inundation frequency and duration. Degradation and changes to flow and depth diversity because of island loss and sediment deposition are also negatively affecting native fish and mussel populations. To remedy these issues, the Project features shown in Figure 2 have been selected. Project features include timber stand improvements, removal of invasive woody vegetation and grasses, and the planting and seeding of hard mast tress within approximately 159 acres along the main channel and catfish slough. It also includes the restoration/creation of four islands and erosion protection methods such as riprap, groins, and vanes. Dredging deep water areas would create depth diversity and improve aquatic habitat.

Shoreline stabilization would be accomplished by placing riprap on existing shorelines. Many areas are designed without the need for additional excavation to ensure that the existing landscape is minimally disturbed. A sediment deflector is planned at the head of catfish slough where it meets the main channel to prevent sediment from entering the slough. There will also be six rock closure structures designed to control or reduce the flow into existing secondary channels. These structures also include shoreline stabilization directly adjacent to the structure to prevent erosion at the tie-in locations. Access dredging would be needed to reach Catfish Slough from the main channel of the river. Dredging would also occur in the southern portion of Catfish Slough towards the Wisconsin shoreline to access areas need for island building. Dredging to a depth of six feet and 40-foot width would be done for the construction access areas throughout the project area.

-2-

WAPSI Valley Archaeology Inc., conducted archaeological and geomorphological investigations across the project area in October 2023. As documented in their draft report, *A Phase I Archaeological Survey and Geomorphological Assessment at Big Lake, for the Big Lake and Robinson Lake Habitat Rehabilitation and Enhancement Project in Upper Mississippi River Navigation Pool 4, Wabasha County, Minnesota, and Buffalo County, Wisconsin*, no archaeological sites are within the proposed location of project features (Enclosure 1). In addition, the project area is largely comprised of post settlement alluvium atop fine sand channel deposits or fine clay slack water deposits which have a low potential to contain intact archaeological deposits. The Corps has reviewed the draft report and agrees with the initial findings. If your office has no comments, the final report will be sent to your office in future correspondence.

The Corps has determined that the proposed Project will have No Effect on Historic Properties. We look forward to your review and comment. If you have [redacted] please contact Katie Leslie, Corps archaeologist, at 651.290.5493, or at [redacted]

Sincerely,

[redacted]

Jonathan J. Sobiech
Deputy Chief, Regional Planning and
Environment Division North

Enclosure:
A Phase I Archaeological Survey and Geomorphological Assessment at Big Lake, for the Big Lake and Robinson Lake Habitat Rehabilitation and Enhancement Project in Upper Mississippi River Navigation Pool 4, Wabasha County, Minnesota, and Buffalo County, Wisconsin

Copy Furnished:

Dr. Tyler Howe, Wisconsin State Historic Preservation Office
Ho-Chunk Nation of Wisconsin, Mr. William Quackenbush
Lower Sioux Indian Community, Ms. Cheyanne St. John
Prairie Island Indian Community, Mr. Noah White
Shakopee Mdewakanton Sioux Community, Mr. Leonard Wabasha
Sisseton-Wahpeton Oyate, Ms. Dianne Desrosiers
Upper Sioux Community, Ms. Samantha Odegard

-3-

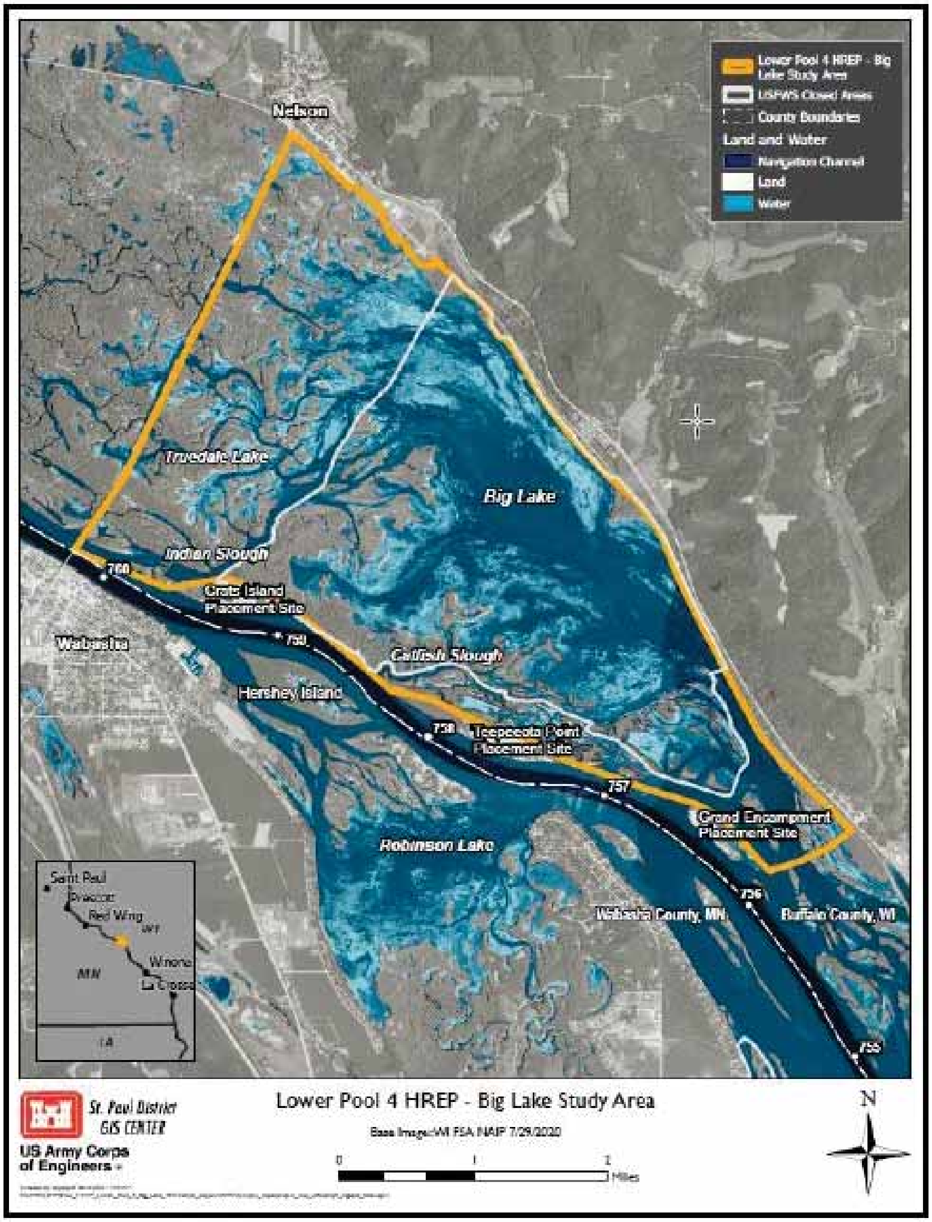


Figure 1. Big Lake HREP Study Area

-4-

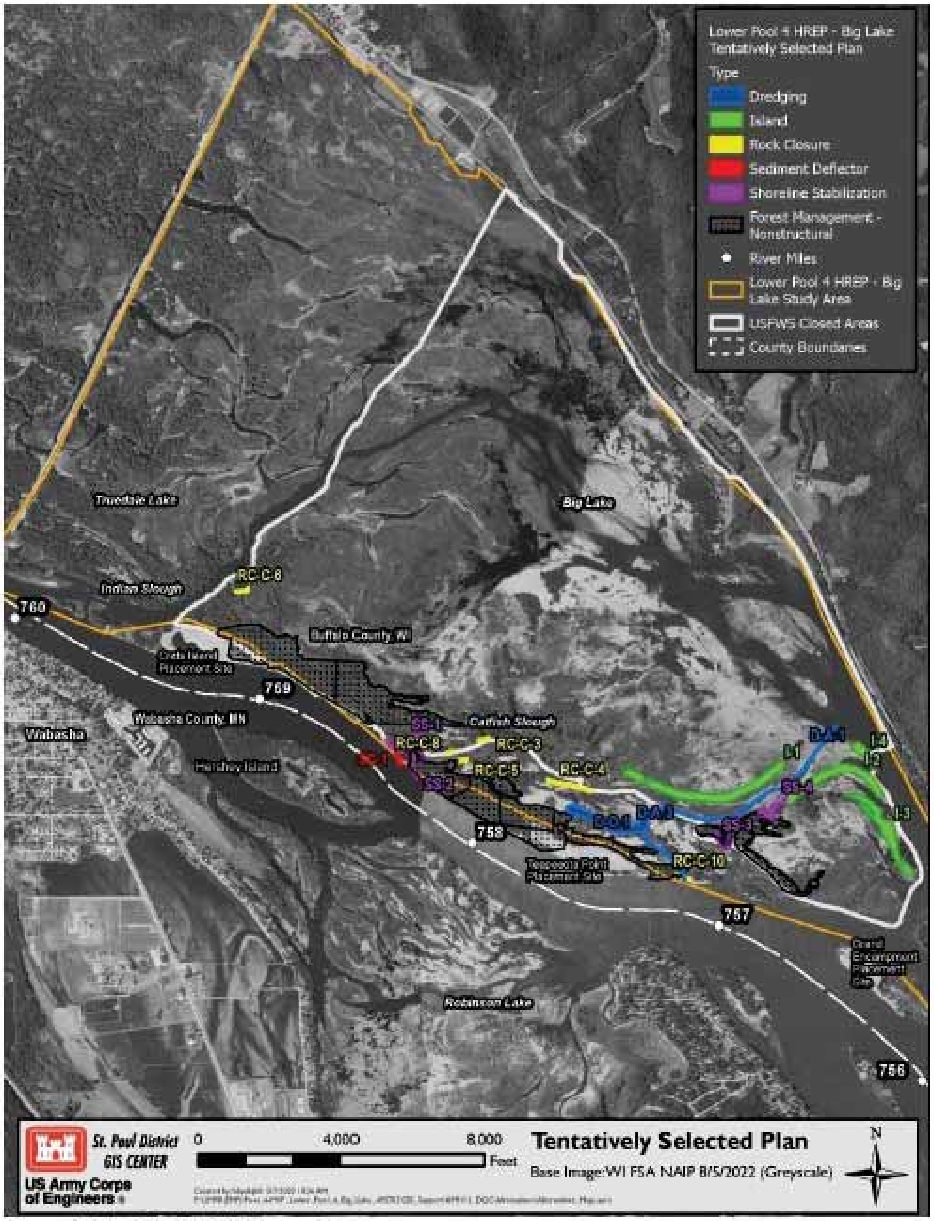


Figure 2. Big Lake HREP Project Features

From:	tyler.howe@wisconsinhistory.org
To:	Leslie, Katie E CIV USARMY CEMVP (USA)
Subject:	[Non-DoD Source] SHPO Review: 24-0606/BF - Lower Pool 4 Big Lake- Habitat Rehabilitation and Enhancement Project- Buffalo County
Date:	Tuesday, March 26, 2024 2:35:49 PM

Good afternoon, Katie:

We have completed our review of WHS #24-0606, Lower Pool 4 Big Lake- Habitat Rehabilitation and Enhancement project- Buffalo County and concur with your findings that no historic or cultural resources eligible for, or included on, the National Register of Historic Places (NRHP) were encountered within the project's Area of Potential Effect (APE), or be impacted by the project. The SHPO also concurs with your recommendation to include a 100 foot buffer around archaeological sites 47BF27, 47BF37 and 47BF244. Moreover, the WI SHPO concurs with your determination the proposed federal undertaking will have No Effect on historic properties.

It is the opinion of the WI SHPO you have fulfilled your section 106 of the National Historic Preservation Act (NHPA) consultation requirements with our office. If your plans change or cultural materials/human remains are found during the project, please halt all work and contact our office.

Please use this email as your official SHPO concurrence for NHPA requirements of the project. If you require a hard copy signed form, please contact me and I will provide you a signed copy as soon as possible.

Take care,

Tyler

Tyler B. Howe, PhD
Compliance Section Manager
State Historic Preservation Office

Wisconsin Historical Society
816 State Street, Madison, WI 53706

[redacted]

Wisconsin Historical Society
Collecting, Preserving, and Sharing Stories Since 1846

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, ST. PAUL DISTRICT
332 MINNESOTA STREET, SUITE E1500
ST. PAUL, MN 55101-1678

19 March 2024

Regional Planning and Environment Division North

SUBJECT: Continued Coordination, Lower Pool 4 Big Lake, Habitat Rehabilitation and Enhancement Project, Buffalo County, Wisconsin

Mr. William Quackenbush
Tribal Historic Preservation Officer
P.O. Box 667
Black River Falls, Wisconsin 54615

Dear Mr. William Quackenbush,

The U.S. Army Corps of Engineers, St. Paul District (Corps) is continuing consultation under Section 106 of the National Historic Preservation Act of 1966, as amended, per its implementing regulations 36 CFR Part 800, on the Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project (Project) under the authority of the Upper Mississippi River Restoration Program. The study area of the Project is located at Big Lake on the Upper Mississippi River (UMR) navigation pool 4 between river miles 760 and 756 in Buffalo County, Wisconsin. The Corps has identified the area of potential effect (APE) to include the area of proposed project features and potential visual effects as marked in Figure 1. The Corps has determined that this Project will have No Effect on Historic Properties.

The Big Lake area has experienced degradation and loss of both island and floodplain forest habitats. Declining floodplain forests, dominated by a single age class, are unable to naturally regenerate due to invasive herbaceous cover and inundation frequency and duration. Degradation and changes to flow and depth diversity because of island loss and sediment deposition are also negatively affecting native fish and mussel populations. To remedy these issues, the Project features shown in Figure 2 have been selected. Project features include timber stand improvements, removal of invasive woody vegetation and grasses, and the planting and seeding of hard mast tress within approximately 159 acres along the main channel and catfish slough. It also includes the restoration/creation of four islands and erosion protection methods such as riprap, groins, and vanes. Dredging deep water areas wouldcreate depth diversity and improve aquatic habitat.

Shoreline stabilization would be accomplished by placing riprap on existing shorelines. Many areas are designed without the need for additional excavation to ensure that the existing landscape is minimally disturbed. A sediment deflector is planned at the head of catfish slough where it meets the main channel to prevent sediment from entering the slough. There will also be six rock closure structures designed to control or reduce the flow into existing secondary channels. These structures also include shoreline stabilization directly adjacent to the structure to prevent erosion at the tie-in locations. Access dredging would be needed to reach Catfish Slough from the main channel of the river. Dredging would also occur in the southern portion of Catfish

Slough towards the Wisconsin shoreline to access areas need for island building. Dredging to a depth of six feet and 40-foot width would be done for the construction access areas throughout the project area.

WAPSI Valley Archaeology Inc., conducted archaeological and geomorphological investigations across the project area in October 2023. No archaeological sites are within the proposed location of project features. In addition, the project area is largely comprised of post settlement alluvium atop fine sand channel deposits or fine clay slack water deposits which have a low potential to contain intact archaeological deposits.

The Corps has determined that the proposed Project will have No Effect on Historic Properties. We look forward to your review and comment. If you have any questions regarding the Project, please contact Katie Leslie, Corps archaeologist, at 651.290.5493, or at [redacted]

Sincerely,

[redacted]

Jonathan J. Sobiech
Deputy Chief, Regional Planning and
Environment Division North

Copy Furnished:

Dr. Tyler Howe, Wisconsin State Historic Preservation Office
Ho-Chunk Nation of Wisconsin, Mr. William Quackenbush
Lower Sioux Indian Community, Ms. Cheyanne St. John
Prairie Island Indian Community, Mr. Noah White
Shakopee Mdewakanton Sioux Community, Mr. Leonard Wabasha
Sisseton-Wahpeton Oyate, Ms. Dianne Desrosiers
Upper Sioux Community, Ms. Samantha Odegard

-3-

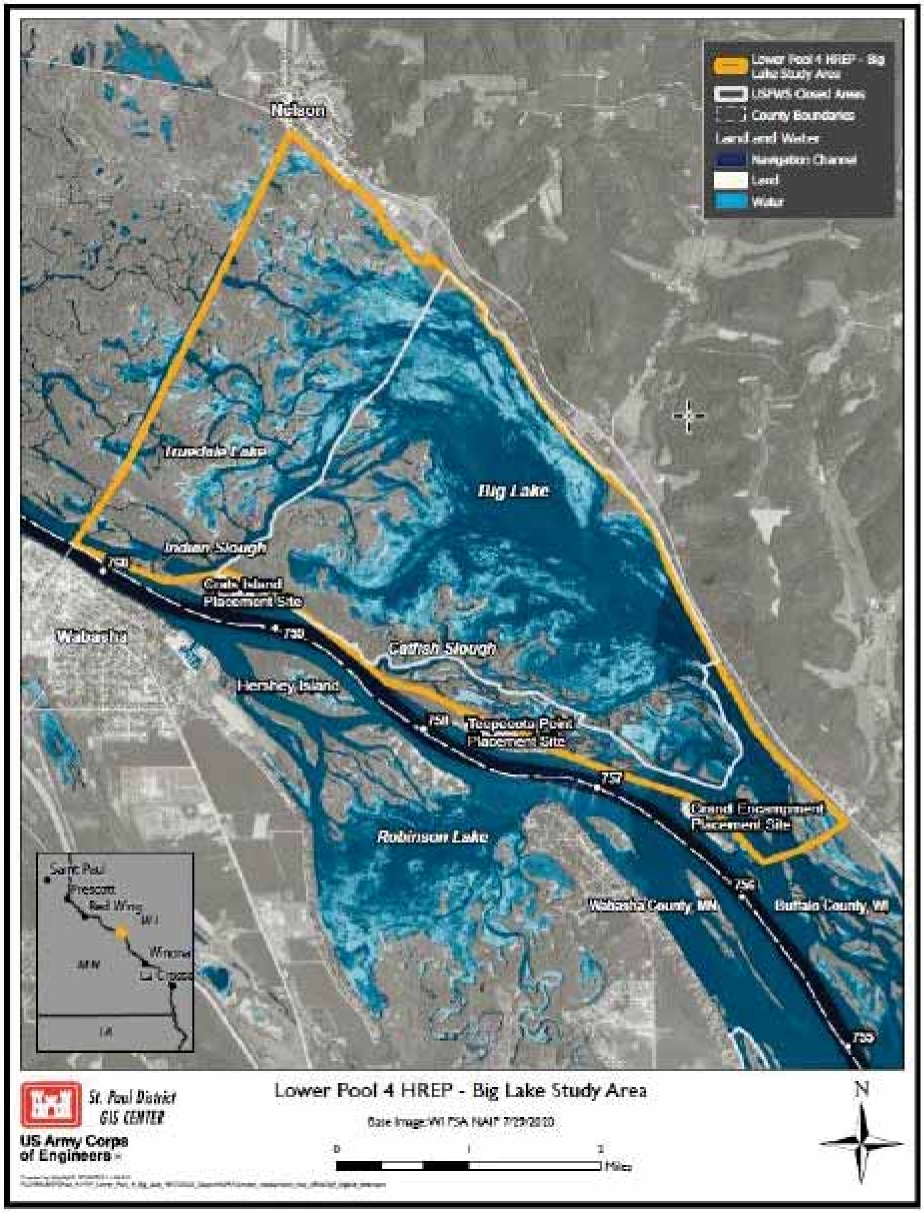


Figure 1. Big Lake HREP Study Area

-4-

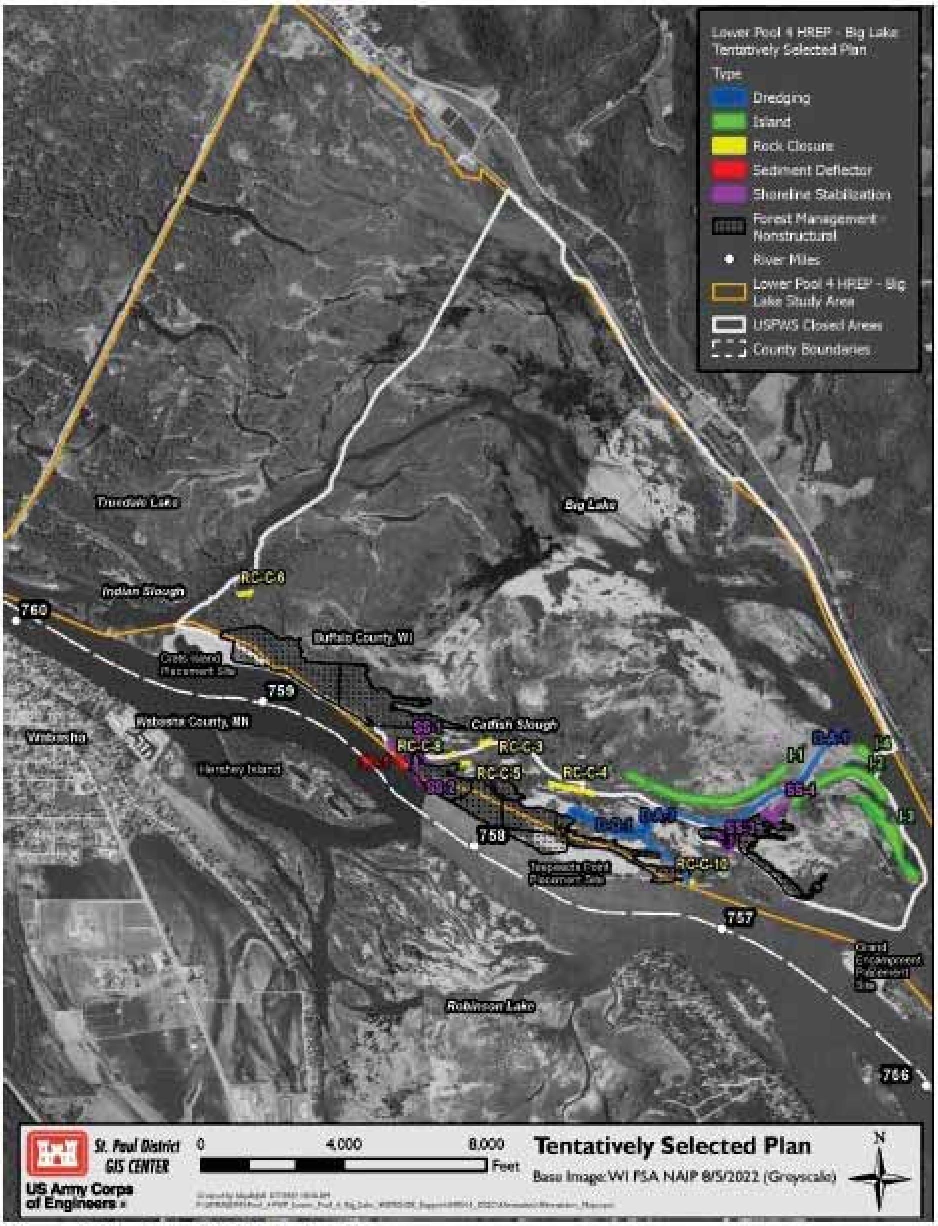


Figure 2. Big Lake HREP Project Features

From: Utrup, Nick J
To: Stefanik, Elliott L CIV USARMY CEMVP (USA)
Subject: [Non-DoD Source] Re: [EXTERNAL] Consultation for Rusty Patch Bumble Bee Determination for the USACE Big Lake UMRR HREP
Date: Wednesday, October 4, 2023 2:17:27 PM

Elliott,

This email is in response to your request for our concurrence with your determination that the U.S. Army Corps of Engineers, St. Paul District, habitat restoration project in lower Pool 4, Big Lake, Upper Mississippi River (UMRR HREP), may affect, but is not likely to adversely affect the Rusty Patch Bumble Bee.

We concur with your determination that the permitted activities may affect, but are not likely to adversely affect Rusty Patch Bumble Bee in the action area indicated in the materials provided by you. Our concurrence is based on your description of the existing habitat conditions that are likely unsuitable (or limited in suitability) for Rusty Patch Bumble Bee.

This email response concludes your consultation requirements with our office. Please let me know if you have any further questions.

Thanks,

Nick

Nick Utrup
Minnesota-Wisconsin Ecological Services Field Office
U.S. Fish and Wildlife Service
3815 American Boulevard East
Bloomington, MN 55425

Phone: (612) 600-6122
Email: [redacted]

From: Stefanik, Elliott L CIV USARMY CEMVP (USA) [redacted]
Sent: Wednesday, October 4, 2023 2:04 PM
To: Utrup, Nick J <nick_utrup@fws.gov>
Subject: [EXTERNAL] Consultation for Rusty Patch Bumble Bee Determination for the USACE Big Lake UMRR HREP

Nick Utrup:

By way of this email, I am requesting consultation on a determination of May Affect, Not Likely to Adversely Affect for the Rusty Patch Bumble Bee. This is associated with the U.S. Army Corps of Engineers, St. Paul District, habitat restoration project in lower Pool 4, Big Lake, Upper Mississippi River (UMRR HREP). This project, collaboratively developed with the U.S. Fish and Wildlife Service, and the Wisconsin and Minnesota Departments of Natural Resources, is currently in the feasibility phase and will soon have a draft report and integrated Environmental Assessment issued for public review. The first figure below provides an overview photo/map of the area and main project features. Review of the project within the USFWS Information for Planning and Consultation (IPaC) tool identified Rusty Patch Bumble Bee as one of several federally listed species that could occur in the project area.

Figure 1. Map of the project area and associated features of the UMRR Big Lake Habitat Restoration Project

The USFWS maintains an online map that displayed high and low potential zones for the rusty patched bumble bee (accessed July 2023). The Figure below shows the high and low potential zones encompassing the Project area. There is a high potential zone on the edge of project features on the east side of the Project area (Islands IB-2, 3 and 4 appear to touch or overlap with this zone), as well as a high potential zone immediately to the west.

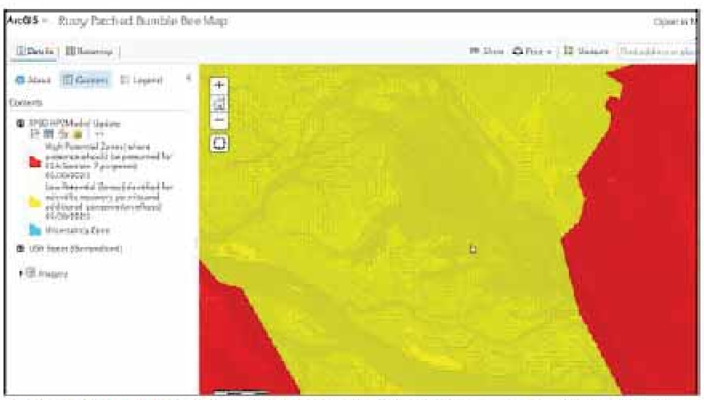


Figure 2. Rusty Patched Bumblebee High Potential and Lower Potential Zones relative the Project area. Query from USFWS July 2023.

There is extremely low probability that this species is currently found on the project site. At present, the Project area does not provide the prairie habitat that the bee prefers. The terrestrial areas proposed for island restoration on the edge of the High Potential Zone (Islands IB-2, 3 and 4) are actively eroding, have a surface only a couple feet above low control pool elevation, and experience flooding every spring. Nesting in these areas doesn't appear plausible. Such areas also aren't considered upland grasslands and shrublands assumed to be associated with nests. Overwintering is believed to occur in upland forests and woodlands, which also doesn't align with the Project area. As such, construction activities are highly unlikely to affect nesting or overwintering areas. There are likely limited plants within project footprint areas that would provide terrestrial food sources, with relatively vast areas outside of project footprints that would remain available. However, no surveys have been done to demonstrate an absence of rusty patch. USACE concludes the project may affect, but is not likely to adversely affect, Rusty Patch bumblebee.

USACE is consulting with USFWS on this determination to get your input. We will consider your response and update the Final Feasibility study accordingly prior to signing the FONSI. Please reach out to me if you have any questions, or would like to discuss further.

Elliott Stefanik
USACE, St. Paul District
651-290-5260

Lower Pool 4 - Big Lake | HABITAT REHABILITATION & ENHANCEMENT PROJECT

Upper Mississippi River Restoration

PROJECT SUMMARY ▸

Under the Upper Mississippi River Restoration Program, the U.S. Army Corps of Engineers is studying the feasibility of enhancing and restoring habitats at the Big Lake area in Pool 4 of the Mississippi River. The site is in the Upper Mississippi River National Wildlife and Fish Refuge near Wabasha, Minnesota. The project sponsor is the U.S. Fish and Wildlife Service, and the project is 100% federally funded. The project area consists of open backwater, meandered side channels, main channel border and island formations.

THE PROBLEM ▸

As with the much of the Upper Mississippi River, sedimentation of backwater areas is an ongoing issue. The project area is greatly influenced by the input of sand from the Chippewa River that enters Pool 4 around river mile 764, about six miles upstream of the project area. Big Lake has lost much of its island complex and bottomland forest to wind and wave erosion. The barrier islands between the lake and Catfish Slough have been degraded and/or eliminated over the past several years.

In the project area, single age floodplain forest habitat is declining and unable to naturally regenerate due to invasive species. Reed canary grass and flowering rush have invaded the project area. Changes to flow, island loss, and sediment deposition has limited depth diversity used by native fish and mussels throughout the study area.

STUDY INFORMATION ▸

The U.S. Fish and Wildlife Service is the Project sponsor. The Construction of the project is 100% Federally funded.

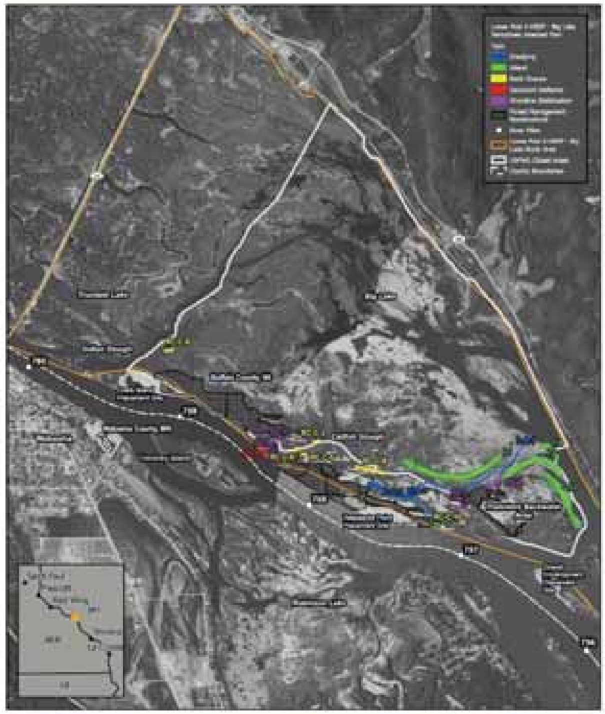
The project first cost, including contingencies; planning, engineering, and design; construction management, and monitoring is about $37 million.

PROJECT PARTNERS ▸

DEPARTMENT OF NATURAL RESOURCES

US Army Corps of Engineers ® St. Paul District

SITE MAP ▸



PROJECT OBJECTIVES ▸

Protect, restore, or create naturally regenerating, resilient, and diverse bottomland forest habitat that will benefit migratory and resident birds and other species

Maintain a balance of coverage and relative abundance of native emergent, rooted floating leaved, and submersed aquatic vegetation communities

Protect, restore, or create flowing channel habitats and backwater habitats that provide flow conditions and sediment dynamics that will benefit native fish (including migratory species) and mussel populations

PROPOSED RESTORATION MEASURES ▸

The Draft Environmental Assessment investigates the feasibility of alternative measures to address problems and opportunities associated with the project. The Tentatively Selected Plan, shown in the site map to the left, includes proposed restoration measures to achieve project objectives.

The proposed restoration measures include:

- Island creation
- Dredging for access and habitat benefits
- Forest management and promoting natural regeneration
- Shoreline stabilization features (4)
- Sediment deflector
- Rock closures (6)

Construction will also utilize fine material sediment from overwintering fish habitat and access dredging.

CONTACT INFORMATION ▸

Comments from the public on the Draft Environmental Assessment are welcome! Written comments are requested by **November 17, 2023** and may be submitted to:

Elliott Stefanik, Biologist, Elliott.L.Stefanik@usace.army.mil

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Upper Mississippi River National Wildlife and Fish Refuge
102 Walnut Street – Suite 204
Winona, Minnesota 55987

November 20, 2023

Colonel Eric Swenson
District Engineer
U.S. Army Corps of Engineers, St. Paul District
ATTN: Regional Planning and Environment Division North
332 Minnesota Street, Suite E 1500
St. Paul, Minnesota 55101

Dear Colonel Swenson:

Thank you for the opportunity to review and comment on the October 2023 Big Lake Habitat Rehabilitation and Enhancement Project (HREP) public review draft Feasibility Report with Integrated Environmental Assessment. The report thoroughly describes the biological resources of the Big Lake project area, the future with and without conditions, and how this project will benefit the biological resources of the Upper Mississippi River National Wildlife and Fish Refuge (Refuge). The Refuge, with input from USFWS project team members representing the La Crosse Fish & Wildlife Conservation Office and the Minnesota-Wisconsin Field Office, continues to support the preferred Alternative 06 as the Tentatively Selected Plan (TSP), which is described in the public review draft report.

You provided the public review draft Feasibility Report to the USFWS Big Lake HREP team in your October 12, 2023 email. USFWS team members have reviewed the draft report and have the following comments.

1. As the project sponsor, USFWS team members have been involved throughout the planning process and have provided input for the Feasibility Report. We submitted our August 2023 draft report comments on August 25 and confirmed that those comments were resolved on October 3.

2. This work will be accomplished under the authority of WRDA 1986 (Section 1103), as amended. The average annual operation and maintenance (O&M) costs are estimated at $15,753. As the project sponsor, the USFWS is responsible for 100% of the project O&M. The USFWS financial support is dependent on total cost, appropriations authority, O&M responsibility, and benefits to the natural resources.

3. The USACE St. Paul District staff has been coordinating with our Refuge staff and our Minnesota-Wisconsin Field Office Ecological Services team member, Nick Utrup, regarding threatened and endangered species. St. Paul District staff has consulted with Mr. Utrup and has documented it in the report appropriately. Please continue to coordinate with the Refuge and Mr. Utrup regarding threatened and endangered species through the design and construction phases of this project.

4. Continue to coordinate the cultural resource aspects of this project with our Regional Historic Preservation Officer, James Myster.

5. Please update the Memorandum of Agreement (MOA) FWS signature block for our new Regional Director, Will Meeks. The final Feasibility Report shall include a copy of the draft MOA for the operation, maintenance, repair, and rehabilitation of the project. The USFWS will sign the MOA once our previously submitted comments and any additional comments from the USFWS team have been appropriately addressed and incorporated in the final report.

6. Additional USFWS comments to the October 2023 public review draft report will be submitted under separate correspondence.

7. Our USFWS team will continue to work with the inter-agency team to develop the Monitoring and Adaptive Management Plan.

These and previous comments have been prepared under the authority of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.), the National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347), the Endangered Species Act of 1973, (I 6 U.S.C. I 53 I et seq.), as amended, and the U.S. Fish and Wildlife Service's Mitigation Policy.

We are pleased to see the Big Lake HREP moving forward and look forward to our continued partnership with USACE and state agencies on this beneficial project. Should you have questions regarding our comments, please contact Ms. Wendy Woyczik, Winona District Manager, at Wendy_Woyczik@fws.gov or 507-494-6229 (office); or Ms. Sharonne Baylor, Environmental Engineer, at Sharonne_Baylor@fws.gov or 507-459-2221 (mobile).

Sincerely,

Sabrina Chandler

Sabrina Chandler
Refuge Manager

cc: Angela Deen, St. Paul District
Ben Nelson, St. Paul District
Katie Opsahl, St. Paul District
Wendy Woyczik, Winona District
Sharonne Baylor, Refuge Headquarters
Nick Utrup, Minnesota-Wisconsin Field Office
Heidi Keuler, La Crosse Fish and Wildlife Conservation Office
James Myster, Region 3 RHPO
Brian Brecka, Wisconsin Department of Natural Resources
Neil Rude, Minnesota Department of Natural Resources

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Upper Mississippi River National Wildlife and Fish Refuge
102 Walnut Street – Suite 204
Winona, Minnesota 55987

April 10, 2024

Colonel Eric Swenson
District Engineer
U.S. Army Corps of Engineers, St. Paul District
332 Minnesota Street, Suite E 1500
St. Paul, Minnesota 55101

Dear Colonel Swenson:

The U.S. Fish and Wildlife Service (Service) project team members representing the Upper Mississippi River National Wildlife and Fish Refuge (Refuge), La Crosse Fish and Wildlife Conservation Office, and the Minnesota-Wisconsin Ecological Field Office have reviewed the October 2023 public review draft Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project (HREP) Feasibility Report and Integrated Environmental Assessment. Coupled with continued partner agency support, the Service is pleased to endorse the Big Lake HREP Tentatively Selected Plan (TSP).

The Big Lake HREP meets the goals and objectives of the Refuge which was established by Congress in 1924 to provide a refuge and breeding ground for migratory birds, fish, other wildlife, and plants. Since the Refuge was established, there have been many changes in environmental conditions on the Upper Mississippi River that have resulted in substantial ecosystem degradation. The Big Lake HREP provides an opportunity to address loss and degradation of islands and improve the floodplain forest habitat. It also enhances riverine, backwater, and floodplain habitats that will benefit migratory birds, fish, other wildlife, and plants. This project will also benefit several of the Refuge's Priority Resources of Concern identified in the Refuge's Habitat Management Plan.

The Tentatively Selected Plan, Alternative 6 best meets the study objectives and will increase the quality and extent of floodplain forest habitat and enhance backwater and flowing channel habitats within the study area. Work includes 159 acres of forest management, creating and restoring four islands, stabilizing four shorelines, constructing a sediment deflector at the Catfish Slough inlet, constructing six rock closures, and habitat dredging. The TSP addresses all project objectives and would be 100% federally funded. The TSP was designed to be resilient under future conditions and incorporates features to restore high quality and valuable floodplain forest and backwaters to the Upper Mississippi River.

The average annual operation and maintenance (O&M) costs are estimated at $15,753. As the project sponsor, the Service is responsible for 100% of the project O&M. The Service's financial support is dependent on total cost, appropriations authority, O&M responsibility, and benefits to the natural resources. In addition, we find that the draft Memorandum of Agreement appropriately defines agency roles and responsibilities as previously discussed with the Corps.

We are pleased to see the Lower Pool 4 Big Lake HREP moving forward and look forward to our continued partnership with the Corps and state agencies on this project. Should you have questions regarding this letter, please contact me directly or have your staff contact Ms. Wendy Woyczik, Winona District Manager, at Wendy_Woyczik@fws.gov or 507-494-6229; or Ms. Sharonne Baylor, Environmental Engineer, at Sharonne_Baylor@fws.gov or 507-459-2221.

Sincerely,

Sabrina Chandler

Sabrina Chandler
Refuge Manager

cc: Angela Deen, St. Paul District
Kendra Pednault, Upper Mississippi River NW&FR, McGregor District
Sharonne Baylor, Upper Mississippi River NW&FR
Nick Utrup, Minnesota- –Wisconsin Field Office
Heidi Keuler, La Crosse Fish and Wildlife Conservation Office
Brian Brecka, Wisconsin Department of Natural Resources
Neil Rude, Minnesota Department of Natural Resources

US Army Corps of Engineers
St. Paul District

Appendix B: 404(b)(1) Clean Water Act Compliance

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

Appendix B: 404(b)(1) Clean Water Act Compliance

CONTENTS

LIST OF TABLES

1 Clean Water Act Compliance Introduction

The US Army Corps of Engineers, St. Paul District (District) is required to comply with Clean Water Act (CWA) Sections 401 and 404 for the *Big Lake Habitat Rehabilitation and Enhancement Project* (Project). This appendix details how this project meets the conditions and requirements of CWA Nationwide Permit (NWP) #27 - Aquatic Habitat Restoration, Establishment.

2 Project Purpose

The Lower Pool 4 Big Lake study area encompasses approximately 8,276 acres of open backwater, meandered side-channel, main channel border, and island formations from Highway 25 (Nelson Dike) at Wabasha, Minnesota to approximately the Grand Encampment dredged material placement site. This includes area to the north and east of the main channel from river miles (RM) 759.5 to 756.6 (see Figure B-1). Land ownership within the study area is a patchwork of both USACE and USFWS with all being managed as part of the Upper Mississippi River National Wildlife Refuge (Refuge).

A portion of the study areas is located within the Refuge Closed Area (Figure B-1). A closed area is characterized as an area that is closed to all migratory bird hunting, closed to all other hunting and trapping from March 16 until the day after the close of the State of Wisconsin duck hunting season, except for wild turkey hunting. There is also a Voluntary Avoidance October 15 to the end of the State of Wisconsin duck hunting season. Watercraft should use designated travel corridors. There are four public boat launches on the upper end of the project area that serve as water access for a variety of activity such as: fishing, kayaking, canoeing, and bird watching. During winter ice fishing occurs throughout the project area, particularly in areas that provide quality overwintering habitat.

The Big Lake study area is a mix of marsh wetlands, floodplain forests, side channels, and backwater lakes that provide important habitat and recreational opportunities. The forest, marsh, backwaters, and flowing water areas provide vital habitat to many fish and wildlife. Big Lake is a stop on the internationally important Mississippi River migratory bird flyway. This globally significant migratory flyway is used by 40% of North America's waterfowl and shorebirds and is also an important migration corridor for raptors and neotropical songbirds and insects, including the monarch butterfly. Dabbling ducks gather in the shallow backwaters, while diving ducks, especially canvasback, rely heavily on the vast open water expanses that include greater depth and abundant wild celery rhizomes for food. Birders of all ages enjoy watching and listening for a wide variety of birds including bald eagles, red-shouldered hawks, warblers, and great blue herons. Floodplain forests and wetlands provide habitat to frogs, toads, wood ducks, woodpeckers, and river otters. The backwater lakes provide important fisheries habitat for a wide range of species that rely on protected, low velocity areas, particularly during periods of ice cover.

The Big Lake HREP presents the opportunity to restore ecological conditions and processes in the project site. The project's primary objectives are to: 1) protect, enhance, restore, and create naturally regenerating, resilient, and diverse bottomland forest habitat; 2) improving backwater overwintering fish habitat; and 3) protecting existing aquatic plant communities, especially submergent aquatic vegetation which is crucial for migratory waterfowl.

The Main Report details the project features of the Tentatively Selected Plan, which includes island creation (29 acres); non-structural forest management (159 acres); backwater dredging

(7 acres) ; six closing structures to reduce flow in select side channel connections to backwater habitat; four sections of shoreline stabilization; and a sediment deflector to reduce sediment loading to middle- and lower-Big Lake.

Island restoration will include placement of dredged material to desired elevations and planted with desired, high value forest species. This includes placement of material obtained from access dredging and backwater site dredging. Additional granular material, as needed, would be obtained from available navigation channel dredged material.

Forest management would consist of native tree and shrub planting and seeding, site preparation, and invasive species control. These activities may require minor ground disturbance with mechanical equipment.

Shoreline stabilization, side channel closures and the sediment deflector will be accomplished through placement of rock to desired dimensions and elevations. Shoreline stabilization and the sediment deflector will reduce erosion and sediment loading to Big Lake, helping to maintain historical habitat conditions for aquatic vegetation and fauna that functionally use this vegetation as habitat. Side channel closures will help restore historical hydraulic and water quality conditions which directly results in protected aquatic habitat. Figure B-1 demonstrates the general location and orientation of such features. The exact dimensions will be verified during detailed project design.

Based on the assessment in the EA and below, the impacts associated with use of NWP are anticipated to be no more than minimal and in compliance with the requirements of NWP 27.

Table B-1 describes the characteristics of dredge and fill activities for all features that will be used in the project. Additional discussion is included in Section 6.4.10 of the main report.

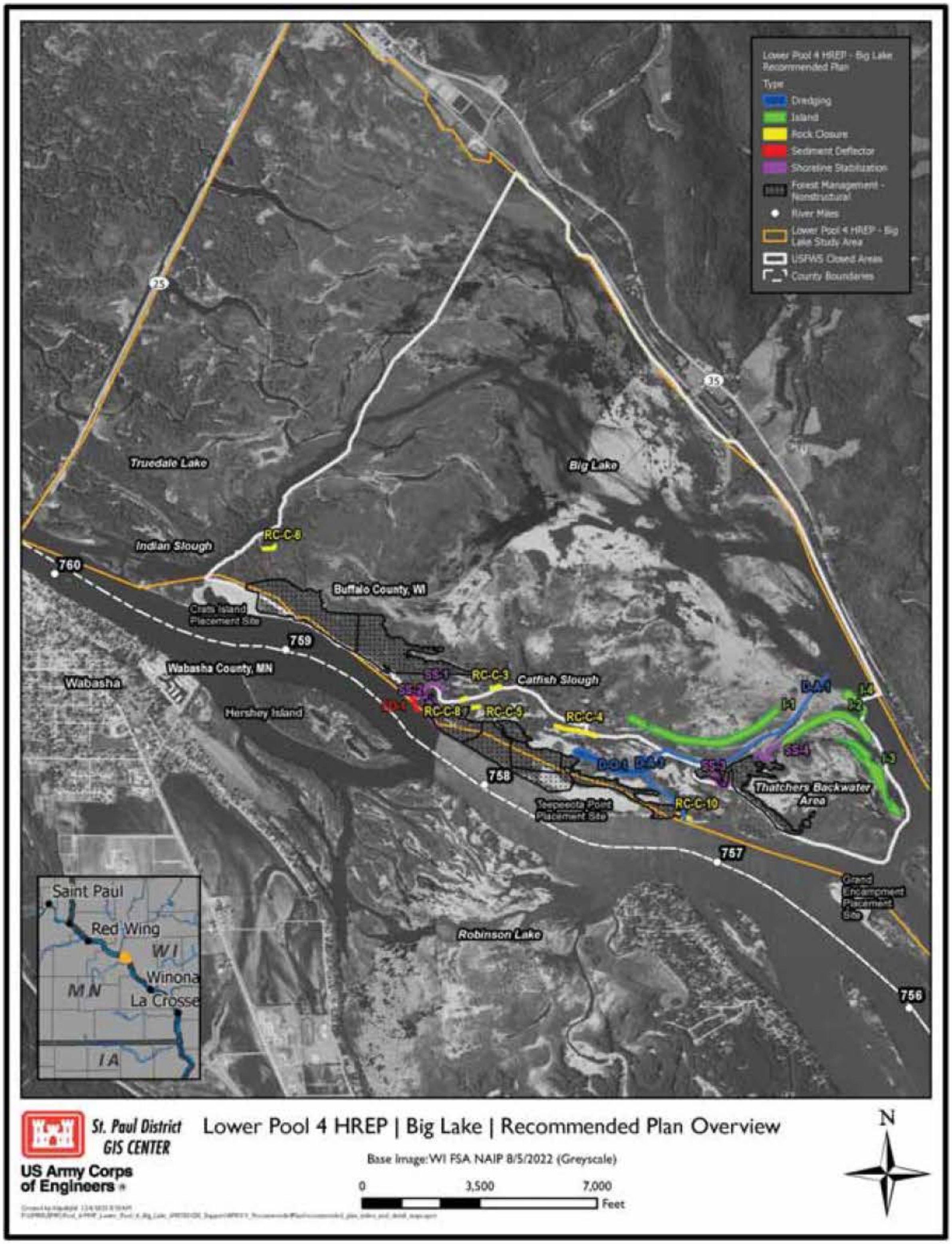


Figure B-1. Recommended Plan

Table B-1. Estimated characteristics of dredging and placement activities associated with the Recommended Plan.

Feature	Cut Volume Granular CY	Cut Volume Fines CY	Fill Volume Granular CY	Fill Volume Fines With Shrinkage CY	Fines Thickness	Underwater Placement Rock Vol CY	Footprint Surface Area Acres
D-A-1	14,908	6,810					5.4
D-A-3	10,063	0					2.9
D-O-1		49,506					6.9
I-1			104,942	11,163	6"	12,627	11.67
I-2			68,095	7,568	6"	14,188	7.95
I-3			105,677	27,261	18"	1,866	7.7
I-4			36,595	106,399	18"	7,139	2.1
RC-C-3						866	0.12
RC-C-4						2,201	0.55
RC-C-5						480	0.17
RC-C-6						629	0.17
RC-C-8						528	0.17
RC-C-10						1,674	0.23
SD-1						11,877	0.6
SS-1			2,114	870		8,430	0.25
SS-2			2,114	1,178		19,674	0.28
SS-3			854	1,877		1,227	0.64
SS-4			0	0		3,468	0.35
Totals	24,971	56,316	320,391	56,316		86,871	48.15

3 Authority

Within its current regulatory program, the Corps has authority over work on structures in navigable waterways under Section 10 of the Rivers and Harbors Act of 1899 and over the discharge of dredged or fill material into waters of the United States under Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500). This latter authorization applies to jurisdictional wetlands and other valuable aquatic areas throughout the United States. While the Corps does not issue Clean Water Act permits to itself, projects must be developed consistent with the Section 404(b)(1) guidelines and documentation must be provided in reports demonstrating compliance. Demonstration of compliance can be accomplished through a 404(b)(1) evaluation, or in this case, that the project is in compliance with NWP 27.

The State of Wisconsin Department of Natural Resources (WDNR) has promulgated authority to issue CWA Section 401 Water Quality Certification on a case by case basis. However, for certain nationwide permits, each state has issued 401 Water Quality Certification for all projects meeting the conditions and limits of the NWPs. Each project must also comply with conditions specific to each NWP, regional NWP conditions, and 401 conditions for the NWP within the subject sate.

On December 27, 2021, the Corps published in the Federal Register (Vol. 86, No. 3245), the Final Rule for the Nationwide Permits Program under the Rivers and Harbors Act of 1899; the Clean Water Act; and the Marine Protection, Research and Sanctuaries Act. These rules became effective on February 25, 2022. The PDT used this approved version of the NWP language, terms, and conditions. The NWP is included as an attachment to this analysis.

Engineer Regulation 1105-2-100, C-6.i. dated April 22, 2000, titled, Planning Guidance Notebook states,

> *"Nationwide and regional permits fall under the category of general permits. A general permit is issued subject to the Section 404(b)(1) Guidelines and to any conditional standards pursuant to Section 404(e) of the Clean Water Act. The conditions of a general permit shall be used in lieu of this regulation for those Federal activities which the District Commander determines to be applicable. However, the use of a general permit shall not substitute for or eliminate the need for the preparation of an appropriate NEPA document, i.e., EIS or EA FONSI."*

Consistent with this policy, the District evaluated the project's impacts based on NWP #27 terms and conditions. Tables B-4-1 and B-4-2 document the District's compliance with these terms and conditions.

NWP 27 may be modified, reissued, or revoked prior to project construction. The PDT will remain informed of changes to the NWPs. Per 33 CFR 330.6(b), activities that were authorized by a NWPs, continue to be authorized by the NWP(s) for 12 months as long as those activities have commenced (*i.e.,* are under construction) or are under contract to commence in reliance upon an NWP prior to the date on which the NWP expires. If construction activities are not completed prior to 12 months from the date of the modifications or revocation of the NWP, the team will reevaluate the Project's 404 compliance status. The Project will be in full compliance with the current CWA regulations prior to any construction and activities. Prior to each contract award, the PDT will confirm CWA compliance remains current.

4 NWP Compliance Documentation

In order to use an NWP, the Project must comply with these conditions:

- General NWP conditions for NWPs (Section C)
- NWP 27 Terms and Conditions
- Regional Conditions applicable to NWP 27
- WDNR Water Quality Certification conditions

For the full language of NWP permit conditions, as well as WDNR NWP 27 conditions, refer to the St. Paul District's website: https://www.mvp.usace.army.mil/missions/regulatory/nwp/.

Table B-1 shows the 28 general NWP conditions and the District's compliance responses. Table B-2 shows the NWP 27 conditions and the District's compliance responses.

The WDNR has conditioned Section 401 water quality certification applicable to NWP 27. Department of the Army authorization pursuant to Section 404 of the CWA (33U.S.C.1344) under NWP 27 are subject to these conditions.

Table B-4-3 shows the WDNR Regional NWP Conditions. Table B-4 shows the States of Wisconsin's Section 401 Water Quality Certification conditions for NWP 27 and the District's compliance responses.

Table B-2. General NWP Conditions and Compliance Responses.

General NWP Condition		Compliance Response
1	Navigation	No navigation impacts expected. No project features are in or near the 9-foot navigation channel. The Project would not impact barge operation, safety, or tow handling.
2	Aquatic Life Movements	The project would have beneficial effects to aquatic life movement as fish gain access to overwintering sites.
3	Spawning Areas	Dredged sites would provide some spawning habitat at the margins of the dredged areas.
4	Migratory Bird Breeding Areas	Restored floodplain forest would enhance migratory bird breeding areas across the project site.
5	Shellfish Beds	Mussel beds are absent in planning area. The projects avoids and minimizes impacts to mussels to the extent possible. Activity in shellfish beds is authorized by NWP 27.
6	Suitable Material	Local material consisting of granular sand and fine material would be used for island construction. Water control features, erosion protection and the sediment deflector would require standard construction materials including riprap.
7	Water Supply Intakes	No public water supply intakes present in planning/impact area
8	Adverse Effects From Impoundments	The project would not create an impoundment of water.
9	Management of Water Flows	Project features would modify side channel flows to benefit backwater fish habitat. would handle fluctuating water levels including fluctuating river levels.
10	Fills Within 100-Year Floodplains	This Project would comply with applicable FEMA approved floodplain management requirements.
#	General NWP Condition	Compliance Response
11	Equipment	Use of heavy equipment would be done in dry conditions and would not impact the water column clarity or water quality standards

12	Soil Erosion and Sediment Controls	The Project would require standard construction guidelines to avoid erosion and sediment resuspension.
13	Removal of Temporary Fills	Temporary fills are not anticipated
14	Proper Maintenance	The USFWS would maintain Project features over the 50-year Project life
15	Single and Complete Project	The Big Lake Project would be a single project. Other projects in the same area would be single and complete.
16	Wild and Scenic Rivers	Not Applicable
17	Tribal Rights	Project will not impair reserved tribal rights
18	Endangered Species	See Main Report Section 6.4 and 6.8
19	Migratory Birds and Bald Eagles	This Project would avoid active bald eagle nests in the area. There are no concerns with other migratory birds.
20	Historic Properties	Pending review of the report, the Corps has preliminary determined that the Recommended Plan will have No Adverse Effect to historic properties. Consultation of this finding with the SHPO, THPOs and other parties is in progress. See Main Report Section 6.4 and 6.12
21	Discovery of Previously Unknown Remains and Artifacts	The project specifications will require that any discovery of remains be reported to the district engineer.
22	Designated Critical Resource Waters	Not Applicable

#	**General NWP Condition**	**Compliance Response**
23	Mitigation	This Project would not require compensatory wetland mitigation.
24	Safety of Impoundment Structures	Not Applicable
25	Water Quality	This Project would comply with Wisconsin water quality standards (See discussion below.)
26	Coastal Zone Management	Not Applicable
27	Regional Conditions	Regional conditions shown below.
28	Use of Multiple Nationwide Permits	The Project will only use NWP 27. The project would not result in a net loss of waters of the U.S.

29	Transfer of NWP Verifications	Federal ownership of the Project site is anticipated for the 50-year Project life.
30	Compliance Certification	Not Applicable for federal application.
31	Activities Affecting Structures or Works Built by the United States	Not Applicable.
32	Pre-Construction Notification	The District will comply with all pre construction notification requirements.

Table B-3: Nationwide Permit #27 Conditions and Compliance Responses

	NWP 27 Condition	Compliance Response
1	Aquatic habitat restoration enhancement, or establishment activity must be planned, designed and implemented so that it results in aquatic habitat that resembles an ecological reference. A reference may be based on characteristics of one or more intact aquatic habits or riparian habitats of the same type in the region, or a conceptual model developed from regional ecological knowledge of the target habitat type.	This Project's goals and objectives (see Main Report 4) focus on improvement of floodplain forest (wetland) and aquatic riverine backwater habitat restoration; as well as protection of submerged aquatic vegetation and migratory waterfowl habitat. Ecology reference conditions were used to design the habitat restoration features.
2	Tidal Areas	This Project does not include any tidal areas
3	Net increase in aquatic resource function and services.	As outlined in the main report and Appendix C, the Tentatively Selected Plan results in net increases in aquatic resource function and services measured with multiple models that include aquatic resource functions and services over the 50-year planning horizon. Without Project, aquatic areas would decline due to erosion and sedimentation.
4	Authorized activities for restoration, enhancement, and establishment of wetlands and riparian areas, restoration and enhancement of non-tidal streams and other non-tidal open waters.	All activities are for restoration, enhancement and establishment of wetlands and riparian areas, and restoration and enhancement of other non-tidal waters. These Project features include creation/restoration of eroding islands with floodplain forest habitat as well as non-structural forest improvement; removal of accumulated sediments in backwaters via dredging; installation of multiple small water control structure to reduce flow into backwater habitat areas; a sediment deflector to minimize sediment loading and protect submersed aquatic vegetation; and shoreline stabilization features to minimize habitat loss and reduce increases in sidechannel openings.
5	Relocation of non-tidal waters, including non-tidal wetlands and streams, on the project site is authorized provided there are net increase in aquatic resource functions and services. Except for the relocation of non-tidal waters on the project site, conversion of a stream or wetland to another aquatic habitat type (e.g., conversion of stream to wetland or vice versa) or uplands is prohibited	The proposed Project would not alter any stream or areal quantity of wetland habitats. The wetland plant community would change in the island enhancement areas. These areas would be restored to their historic forested condition. Wetter hydrology has degraded these wetlands, and the project would restore the reference hydrology. A small amount of rip rap placement would be done to minimize further erosion loss, reduce sediment loading and reduce inflow to protected backwater overwintering habitat. These placements are desirable and improve or protect habitat conditions.
6	Reversion	Not applicable..
7	Reporting	The District would comply with all pre construction reporting requirements.
8	Notifications	The District would comply with all pre construction notification requirements.

Appendix B- 404(b)(1) Clean Water Act Compliance

Table B-4: Regional NWP Conditions

#	Regional NWP Conditions for Wisconsin	Compliance Response
1	Allow the WDNR reasonable entry and access to the discharge	Wisconsin and any partner agency will be able to tour the project site during construction. Coordination with the USACE construction representative will be needed to ensure safety.
2	WQ certification is denied without prejudice for activities involving the temporary stockpiling of dredged or fill material in waters of the state, including wetland	Dredged material will not be stockpiled long-term onsite. Material will be placed in areas needed for construction, remaining in place only long enough to practically meet construction logistics and field conditions to complete habitat features.
3	WQ certification is denied without prejudice for activities that have the potential to adversely impact Area of Special Natural Resource Interest (ASNRI) waters designated under to s. NR 1.05, Wis. Adm. Code	The project will not adversely affect special interest waters. The project area is a USFWS Refuge and USFWS and WDNR have actively been involved with planning project features.
4	WQ certification is denied without prejudice for activities that have the potential to adversely impact Public Rights Features (PRFs) designated under to s. NR 1.06, Wis. Adm. Code	The project will not have permanent, adverse effects to Public Rights or use of the area.
5	Fish spawning exclusion March 1st through June 15th	Fish spawning exclusion will be abided during construction.
6	The permittee must install in-water best management practices (BMPs) to minimize total suspended solids (TSS), sedimentation and nutrient loadings for any work conducted below the ordinary high water mark (OHWM). Any visual increase in turbidity outside of the approved impact area shall result in the project operations ceasing until BMPs have been modified to address the issue	BMPs will be required for construction, with the NWP permit conditions, and the WDNR water quality certification conditions also included as construction requirements.
7	Erosion control measures shall meet or exceed the WDNR Technical Standards developed under Subch. V of ch. NR 151, Wis. Admin. Code.	Features will be stabilized following USACE engineering standards. WDNR will have the ability to review projects Plans and Specifications to verify the standards are acceptable.
8	No discharges of dredged or fill material may be placed into wetlands that are identified by the department as being one of the following community types: a) Great Lakes ridge and swale complexes, b) interdunal wetlands, c) coastal plain marshes, d) emergent marshes containing wild rice, e) sphagnum bogs that are located in the area located south of a horizontal line drawn across the state based on the routes of STH 16 and STH 21 west of Lake Winnebago and on USH 151 east of Lake Winnebago, f) boreal rich fens, or g) calcareous fens.	Island restoration sites are occurring in areas of actively eroding islands. Adjacent areas do contain wild rice. However, the project is creating islands in areas of existing or recently eroded islands and not in filling historical wild rice areas to create new island areas. We are targeting a historical reference condition for island restoration. WDNR has been involved with project planning to ensure that island footprint size and location is appropriate and desired.
9	Features may not use any materials that contains toxic substances in toxic amounts	Contaminant testing results for dredged materials (sands and fines) will be evaluated by the WDNR. Rip rap will be required to be clean and from a local quarry.
10	Ensure any material used to construct a project is properly contained and stabilized in a manner that will prevent the material from being eroded.	Stabilization features are being incorporated into project features. Temporary stabilization and BMPs will be required during construction.
11	Implement planning and pretreatment of equipment to minimize spread of invasive or noxious species, designated under to ch. 40, Wis. Adm. Code.	This condition will be required as a construction requirement.
12	Whenever an applicant is completing sediment sampling and analysis, monitoring or disposal of materials from any dredging project, proper sampling and quality assurance methods shall be implemented in alignment with ch. NR 347, Wis. Adm. Code.	Contaminant testing results for dredged materials (sands and fines) will be evaluated by the WDNR. Rip rap will be required to be clean and from a local quarry.

Table B-5. Relevant Regional Conditions for NWP 27 from U.S. Army Corps of Engineers, St. Paul District, Regulatory Division

B. Temporary Impacts: All regulated temporary impacts to waters of the U.S. must comply with the following criteria: (1) If the temporary impacts in waters of the U.S., including wetlands, that occur as a result of the regulated activity would remain in place for longer than 90 days between May 15 and November 15, a PCN is required. (2) Any PCN with temporary impacts must specify how long the temporary impact will remain and include a restoration and re-vegetation plan showing how all temporary fills and structures will be removed and the area restored to preconstruction contours and elevations. Native, non-invasive vegetation must be used unless otherwise authorized by a Corps NWP verification.	No temporary fill or structure is anticipated at this time
E. Special Aquatic Resources: A project proponent must notify the District by submitting a PCN if a regulated activity would occur in any of the following aquatic resources: (1) State-designated wild rice waters1,2 ; (2) Bog wetland plant communities1,3; (3) Fens1,3; (4) Coastal plain marshes1,4; (5) Interdunal wetlands1,4; (6) Great Lakes ridge and swale complexes1,4; (7) Aquatic resources within Lake Superior National Estuarine Research Reserve; (8) Ramsar wetland sites, including: the Horicon Marsh, Upper Mississippi River Floodplain Wetland, Kakagon and Bad River Slough, Door Peninsula Coastal Wetlands, Chiwaukee Illinois Beach Lake Plain, and Lower Wisconsin Riverway. The complete up to date Ramsar list is available at https://rsis.ramsar.org.	*See Chapter 6 of the EA.*
H. NWP 27. Aquatic Habitat Restoration, Establishment and Enhancement Activities: NWP 27 does not authorize the permanent conversion of forested, bog, fen, sedge meadow, or shrub-carr wetlands to other plant communities. A project proponent may request, in writing, a waiver from this condition from the District. The waiver will only be issued if it can be demonstrated that the conversion would restore wetland plant communities to the pre-settlement condition or a watershed approach and that the current landscape and hydrologic conditions would sustain the targeted community.	See above and Chapter 6 of the EA

St. Paul District Regional Conditions applicable to use of NWP 27

Table B-6. Wisconsin Section 401 Water Quality Certification for NWP 27 Conditions and Compliance Responses
https://www.mvp.usace.army.mil/Portals/57/docs/regulatory/RGP/WI_DNR_401.pdf?ver=5hkqn4yeUSK0gAVItVfh7A%3d%3d

#	Wisconsin Section 401 Water Quality Certification for NWPs	Compliance Response
1	Allow the WDNR reasonable entry and access to the discharge	Wisconsin and any partner agency will be able to tour the project site during construction. Coordination with the USACE construction representative will be needed to ensure safety.
2	WQ certification is denied without prejudice for activities involving the temporary stockpiling of dredged or fill material in waters of the state, including wetland	Dredged material will not be stockpiled long-term onsite. Material will be placed in areas needed for construction, remaining in place only long enough to practically meet construction logistics and field conditions to complete habitat features.
3	WQ certification is denied without prejudice for activities that have the potential to adversely impact Area of Special Natural Resource Interest (ASNRI) waters designated under to s. NR 1.05, Wis. Adm. Code	The project will not adversely affect special interest waters. The project area is a USFWS Refuge and USFWS and WDNR have actively been involved with planning project features.
4	WQ certification is denied without prejudice for activities that have the potential to adversely impact Public Rights Features (PRFs) designated under to s. NR 1.06, Wis. Adm. Code	The project will not have permanent, adverse effects to Public Rights or use of the area.
5	Fish spawning exclusion March 1st through June 15th	Fish spawning exclusion will be abided during construction.
6	The permittee must install in-water best management practices (BMPs) to minimize total suspended solids (TSS), sedimentation and nutrient loadings for any work conducted below the ordinary high water mark (OHWM). Any visual increase in turbidity outside of the approved impact area shall result in the project operations ceasing until BMPs have been modified to address the issue	BMPs will be required for construction, with the NWP permit conditions, and the WDNR water quality certification conditions also included as construction requirements.
7	Features may not use any materials that contains toxic substances in toxic amounts	Contaminant testing results for dredged materials (sands and fines) will be evaluated by the WDNR. Rip rap will be required to be clean and from a local quarry.
8	Ensure any material used to construct a project is properly contained and stabilized in a manner that will prevent the material from being eroded.	Stabilization features are being incorporated into project features. Temporary stabilization and BMPs will be required during construction.
9	Implement planning and pretreatment of equipment to minimize spread of invasive or noxious species, designated under to ch. 40, Wis. Adm. Code.	This condition will be required as a construction requirement.
10	Whenever an applicant is completing sediment sampling and analysis, monitoring or disposal of materials from any dredging project, proper sampling and quality assurance methods shall be implemented in alignment with ch. NR 347, Wis. Adm. Code.	Contaminant testing results for dredged materials (sands and fines) will be evaluated by the WDNR. Rip rap will be required to be clean and from a local quarry.

5 Conclusion

This Project is in compliance with Section 404 of the CWA and will meet the terms and conditions the 2021 Department of Army NWP 27 for aquatic habitat restoration, establishment and enhancement activities, as described in the December 27, 2021 Federal Register (Vol. 86, No. 245).

The District and USFWS realize NWP 27 may be modified, reissued, or revoked prior to project construction. The PDT will remain informed of changes to the NWPs. If construction activities are not completed prior to 12 months from the date of the modifications or revocation of the NWP, the team will reevaluate the Project's 404 compliance status and will coordinate the Project with the District's Regulatory Branch. The Project will be in full compliance with the current CWA regulations prior to any construction and activities.

Appendix C:
Habitat Benefits Evaluation

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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Appendix C

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1 Introduction

The U.S. Army Corps of Engineers (Corps) is committed to spending the nation's dollars wisely by investing in ecosystem restoration projects that provide the greatest benefits for the investment. As such, a national ecosystem benefits analysis is completed on restoration projects to help determine if projects are warranted and if so, which combination of proposed features provide the greatest benefit for the money.

This appendix describes the methods used to quantify the benefits of various alternatives considered for the Lower Pool 4 Big Lake Upper Mississippi River Restoration (UMRR) Habitat Rehabilitation and Enhancement Project (HREP, hereafter, the Project). Maps of the proposed features can be found in the main report.

Habitat Evaluation Procedures (HEP) were used to evaluate the potential benefits of alternative habitat improvement features (island construction, habitat dredging, shoreline protection, sediment deflection etc.) for the Project. Three habitat suitability index (HSI) models were used to quantify the benefits generated within the study area by the Project: the Upper Mississippi River System Floodplain Forest Habitat Model (USACE 2021; hereafter the Floodplain Forest Model); the Modification of the Habitat Suitability Index Model for the Bluegill (*Lepomis macrochirus*) for Winter Conditions for Upper Mississippi River Backwater Habitats (Palesh & Anderson 1990; hereafter the bluegill overwintering model); and the Migratory Habitat Model for Diving Ducks using the Upper Mississippi River (Devendorf 1995; hereafter the diving duck model). The floodplain forest model was used to assess habitat features targeting floodplain forest improvement; the bluegill overwintering model was used to assess features that would improve backwater aquatic habitat; and the diving duck model was used to assess benefits associated with the proposed sediment deflector.

All model documentation and model spreadsheet templates used to assess benefits of the Project have been certified or approved and are available for download through the Corps – Ecosystem Restoration Planning Center of Expertise (ECO- PCX) Ecosystem Restoration Model Library. The Annualization calculator in IWR Planning Suite II was used to verity average annual habitat units for the different Habitat Suitability Index model results.

2 Methods, Data and General Assumptions

2.1 Habitat Evaluation Procedures

The U.S. Fish and Wildlife Service's 1980 version of Habitat Evaluation Procedures (HEP) was used to quantify and evaluate the potential project effects and benefits. The HEP methodology utilizes a Habitat Suitability Index (HSI) to rate habitat quality on a scale of 0 to 1 (1 being optimum). The HSI is multiplied by the number of acres of available habitat to obtain Habitat Units (HUs). One HU is defined as one acre of optimum habitat. By comparing the projected HUs available without a proposed action to projected HUs with a proposed action or alternative, the benefits of different alternatives can be quantified. HSIs and HUs were calculated for the baseline (existing) conditions and for Future Without Project (FWOP) and Future With-Project (FWP) conditions.

2.2 Habitat Objectives and Model Selection

Selection of habitat models for evaluation of a project is an important component of measuring the potential benefits of a project and comparing benefits among different alternatives. The selected models should reflect the project's objectives and the ecological values of the project area. Project objectives were identified and are listed in Table 1.

Table 1. Big Lake HREP Project Objectives

Habitat Areas	Objectives
Bottomland Forest (Islands and other Forest Features)	Protect, enhance, restore, or create naturally regenerating, resilient, and diverse **bottomland forest habitats**.
Aquatic Side channel	Protect, enhance, restore, or create **flowing channel habitats**.
Aquatic Vegetation	Maintain a balance of coverage and relative abundance of **native emergent, rooted floating leaved, and submersed aquatic vegetation communities**.
Backwater Fisheries	Protect, enhance, restore, or create **backwater habitats**.

The floodplain forest model was selected to evaluate Objective 1, the establishment of new terrestrial island habitat and improvement of the existing floodplain forest community. The diving duck model was selected to evaluate Objective 2. This model is sensitive to the loss of aquatic vegetation communities of value to diving ducks, particular the submersed aquatic vegetation species wild celery, because a large portion of the Project area is used heavily by diving ducks, particularly canvasbacks, during spring and fall migration. The bluegill overwintering model was selected to evaluate Objective 4, it effectively quantifies the benefits of deep aquatic habitats suitable for overwintering by a variety of backwater gamefish; deep backwater habitats are become increasingly rare in the UMRS due to continual sedimentation.

Lastly, as measure identification, alternative formulation and habitat evaluation evolved, it was decided that benefits for flowing channel habitat, Objective 2, would be considered ancillary. Habitat modeling was not done to assess benefits specifically to flowing channel habitat. However, future design of rock features such as the sediment deflector and shoreline stabilization will consider adaptations to benefit fluvial fish such as redhorse, suckers, sturgeon and other fluvial or lotic species. Observations from lower Pool 4 fisheries surveys show that these species, some of which are rare species of management concern (e.g., blue sucker) are relating to in-water rock features designed for erosion protection (Minnesota DNR pers comm). Consideration will be given during design to better adapt these rock features to function even better as aquatic habitat.

2.3 Data Sources

Variables in the models required input from several available sources, as well as the collection, extrapolation and interpretation of additional data and professional judgement. Data inputs and their sources are discussed below.

2.3.1 Aerial Imagery and Light Detection and Ranging (LIDAR)

Aerial imagery from multiple sources and years along with LIDAR data were used to help inputs for habitat modeling. Past aerial images were used to understand land accretion and erosion, and predict land loss into the FWOP.

2.3.2 Bathymetry & Topography

Bathymetry and topography from the project area were used to categorize water depths and land elevations, respectively, within the project area. Topobathy utilizing LIDAR from 2016 of the entire area (a combination of both bathymetry and topography) from the United States Geological Survey, Upper Mississippi Environmental Service Center (USGS UMESC) was used to analyze the entire project area. Additional bathymetry data was collected by the Corps from 2022 and 2023, corrected to Low Control Pool (LCP) elevation, and used to supplement the USGS topobathy information within certain areas of the project area.

2.3.3 Vegetation/Land Cover

Vegetation species and community data collected by the Upper Mississippi River Restoration program's Long-Term Resource Monitoring element (LTRM) since 2000 was reviewed to assess trends and existing conditions in the project area. Additional data collected by USFWS in 2018 and 2019 supplemented the LTRM data. These data were used to estimate existing vegetation dry mass (used as a proxy for vegetation cover in our modelling) and to characterize community types (submergent and emergent) and key food species throughout the project area. Biological specialists from the Minnesota DNR LTRM Station, as well as the Upper Mississippi River National Wildlife and Fish Refuge (Refuge), were engaged to understand vegetation changes over time.

Forestry-related data were collected by U.S. Army Corps of Engineers, St. Paul District foresters from the Natural Resource Project Office. Data on community composition and other key model variables were collected from sites within the project area, as well as adjacent areas, in lower Pool 4 during 2022.

2.3.4 Waterfowl Use

This evaluation took advantage of data from two waterfowl survey efforts performed at Big Lake during 2017–2022. Surveys were conducted by refuge staff from adjacent bluff tops during spring and fall of 2020–2022, whereby the perimeter of waterfowl flocks were drawn on maps and then digitized in a geographic information system. This permitted the visualization of areas within Big Lake with different levels of waterfowl use. Aerial waterfowl surveys were conducted in the fall during 2017-2019. This data permitted the visualization of areas that were differentially used by diving ducks, puddle ducks, and swans. Conversations were held between USACE and Refuge biologists on interpretation of results. Both sets of observations have strengths and limitations. Discussion with Refuge biologists who routinely work this area confirm that waterfowl location can vary based on many different factors with differences in location from year to year. The overriding observation is that Big Lake is a critical area for waterfowl migration during spring and fall, providing vital food resources and resting space that is heavily used every year.

2.3.5 Water Quality

The water quality metrics dissolved oxygen and water temperature were used to assess habitat quality throughout the project area. Water quality data for existing conditions was obtained from the LTRM program for lower Pool 4.

2.3.6 Water Velocity

Multiple data sources were used to understand velocities for existing and potential future conditions. Hydraulic modelling, including water velocity, was used to assess the existing condition, FWP and FWOP throughout the project area. Field measurements for flow velocity and backwater flow input also were collected by Wisconsin DNR (S. Giblin, WIDNR, unpublished data) for specific sidechannels and associated backwater locations assessed through this analysis. Finally, flow velocity measurements are also collected by the LTRM program for lower Pool 4 and were a factor in assessing flow velocity conditions.

2.4 Software

ArcGIS Pro version 2.6.1 used to examine, evaluate, and present the various layers of spatial information used to develop suitability indexes for a variety of habitat variables. Spreadsheets developed in Microsoft Excel were used in data storage and analysis. The IWR Planning Suite Annualization Calculator was used to annualize habitat units. The IWR Planning Suite software to conduct cost effectiveness and incremental cost analysis is discussed and presented in the main report.

2.5 General Assumptions

Predicted FWOP and FWP conditions are used in the planning of all Corps restoration projects. These predictions are used to quantify the expected habitat benefits for use in alternatives evaluation and project justification. Predictions are based on factual information as much as possible; however, by their very nature, predictions require the considerable use of professional expertise and judgment. For this analysis, a number of general assumptions were made as follows:

1. A 50-year planning period is used. Because construction of this project would not begin until at least 2027, the planning period for this project is 2027-2077.
2. The projection of FWOP conditions assumes no habitat restoration measures would occur in the study area and natural forces would continue to change the area in a manner similar to what has occurred since the creation of Pool 4 in 1935 due to the construction of Lock and Dam No. 4.
3. Forestry benefits vary across the 50-year planning horizon as forests are slow growing and take years to respond and reach their full habitat potential.
4. Benefits to diving duck habitat via controlled sediment deflection would occur immediately and have a steady influence (reduction in sedimentation rates resulting in slower habitat decline) over the 50 year planning horizon.
5. Key drivers to changes to diving duck are associated with the loss of depth in Big Lake, and the conversion of deeper water with wild celery, to shallower water with wild rice

vegetation. While wild rice can be a valuable food source, Refuge biologists identify that diving ducks do not prefer the vertical structure of wild rice and avoid these areas, favoring the openness and space further away from shore in Big Lake.

6. Backwater habitat benefits associated with changes in depth and velocity would occur immediately. Benefits associated with changes in depth would last across the 50-year planning horizon as the dredging levels (depths of at least eight feet) account for additional sedimentation that would occur over those 50 years.
7. Water quality benefits for dredged areas under Future With Project are based on observations from many similar projects that have been constructed over more than 30 years of the UMRR program. Experience has shown that increasing depth and limiting inflows will improve backwater overwintering conditions. However, model variables with the project will not be “perfect” or “ideal.” Water quality variable improvements typically include Category B for Dissolved Oxygen; and resulting temperatures of 3°F. This typically results in total model HSI values between 0.6 or 0.7.
8. No major changes would occur in water control operations which affect water surface elevations at the study area.

Habitat modeling was performed in close collaboration with resource biologists from the USFWS, and Wisconsin and Minnesota DNR. The project area is unique in that the LTRM Program includes annual monitoring in lower Pool 4 for many key habitat conditions. Moreover, the area includes heavy management from these three resource agencies. Modeling results were discussed with biologists from the partner agencies, and they concur that the general trends projected by habitat models seem realistic for the differences between with and without project conditions for the alternatives assessed.

3 Habitat Suitability Modeling

The following discusses the models and modeling results of the various measures considered for this study. It’s critical to remember that habitat models are not an absolute measure or prediction of habitat conditions, but rather a relative index of the types of habitat changes that could occur with different measures over time. As such it’s critical to not focus on individual habitat values or suitabilities, but rather the relative differences in habitat conditions that are generally seen among different measures across the 50-year planning horizon under Future Without and Future With Project.

3.1 Forest Habitat Suitability Index Modeling

3.1.1 Model Selection and Variables

The recently approved Upper Mississippi River System Floodplain Forest Habitat Model was the model chosen to assess forest habitat benefits for the project. This model provides a mechanism to assess the intrinsic quality of forest habitats based on standard metrics used in forest inventory and health assessment. This assessment can be further applied to quantify changes in habitat quality from forest management actions.

The model contains five variables.

a. Percent canopy cover: optimized between 70 – 80%.
b. Percent desired forest type: curvilinear relationship, optimized at 100%.

c. Percent invasive species: curvilinear relationship, optimized at 0%.
d. Regeneration (percent of desired stocking): curvilinear relationship, optimized at 100%. "Desired stocking" refers to the number of young trees per acre required for the forest to persist into the future. Desired stocking varies based on the type of forest, the age of the stand, and the desired species. Due to the many variables that influence the desired stocking (i.e. number of trees per acre), the desired stocking must be determined on a case-by-case basis.
e. Structural diversity: index consisting of five components (horizontal structural diversity, vertical structural diversity, size class diversity, standing dead wood, tree species diversity), each scored on a 0-1 scale. Optimized when all components are scored at 1.

The model was specifically designed to assess forest habitat benefits for large forest areas with a wide range of wildlife species, and, due to the large, forested area under evaluation for the Big Lake HREP, coupled with the overarching primary objective of maximizing forest health and resilience, this is the most appropriate model to use for forest habitat benefit evaluation.

3.1.2 Island Restoration

Key assumptions for island restoration included that remaining islands in the footprint areas of proposed island restoration will lose their floodplain forest habitat by TY 10 and remain absent through TY 50. Much of the remaining island habitat within proposed footprints is heavily eroding and remaining trees are stressed, dying and falling over. These changes have become more rapid in recent years as conditions have become more wet, with higher river discharges and water levels during the growing season (June through September). Any of the island areas considered here that remain in 10 years will likely be dominated by reed canary grass and other invasives and likely without tree cover. Loss of forest habitat in the near future, within the proposed island locations, appears likely. HSI values were assumed to be 0 for the FWOP from Target Year 10 and beyond. This assumption was held constant for all comparisons with FWP alternatives.

Photograph 1. Example of island erosion and loss in lower Big Lake at Island I-B-4.

3.1.3 Thin Layer Placement

Key assumptions for evaluating thin layer placement is that these areas currently grade out as 0.0 HSI within the floodplain forest model under existing conditions, and would continue to do so in the future. The areas proposed for Thin Layer Placement are dominated by thick growth of invasive reed canary grass. These areas are stable and do not change over time. Without management action, it's unlikely conditions in these areas will improve.

3.1.4 Forestry Non-Structural Measures

Areas proposed for non-structural measures have a range of existing suitabilities suggesting minimal to marginal habitat. Non-structural measures result in modest improvements according to the model. Modeled improvements are often 20-30%, which is generally in line with the response of non-structural forest improvement measures done elsewhere on the Upper Mississippi River in St. Paul District.

3.1.5 Forest Model Results

Existing Conditions

Current forest conditions within existing island habitat is poor. The habitat model projects a suitability of 0.2 for existing island habitat. Floodplain forest habitat within areas proposed for Thin Layer Placement are non-existent, with an HSI of 0.0. Existing forest conditions within areas considered for non-structural forest management vary from moderate to non-existent (HSI of 0.4 to 0.0; average HSI of about 0.25).

Future without Project

Modeled conditions in the FWOP for are assumed to show significant declines for floodplain forest on island areas. Continued erosion loss, combined with invasive species on areas that remain, will eliminate remaining trees and effectively reduce the HSI score to 0.0 by Target Year 10, and hold that way to Target Year 50. Within areas targeted for non-structural forest management, projected suitabilities will be relatively similar across the 50 year planning horizon.

Table C-2. Floodplain Forest Model Results Summary for Future Without Project and Future With Project conditions. Acres are for the full buildout with Alternative 10. Results are scaled accordingly for the Recommended Plan.

		Future Without Project			Future With Project		
Feature Group	**Acres**	**TY0 HSI**	**TY10 HSI**	**TY50 HSI**	**TY0 HSI**	**TY10 HSI**	**TY50 HSI**
Islands	34.8	0.20	0.00	0.00	0.20	0.56	0.60
Thin Layer Placement	21.3	0.00	0.00	0.00	0.00	0.58	0.54
Underplant.	49.6	0.23	0.23	0.19	0.23	0.28	0.48
TSI+Invasives	47.2	0.38	0.38	0.36	0.38	0.61	0.58
Invasives	52.7	0.39	0.36	0.37	0.39	0.64	0.67
Reed Canary Specific	8.9	0.00	0.00	0.02	0.00	0.58	0.54

Future with Project

The FWP does show higher scores for all measures compared to the FWOP conditions across the 50 year planning horizon. Island forest habitat is projected to have an HSI score slightly below 0.6 for TY 10, and a score of 0.6 for TY50. For Thin Layer Placement, habitat scores increase to 0.58 for TY 10, and end at 0.54 at TY50. For non-structural forest management measures, project scores vary by measure. The general trend is suitabilities increase quickly at TY 10 (average HSI of 0.53) and rise slightly at TY50 (HSI of 0.57).

3.2 Overwintering Habitat Suitability Index Modeling

3.2.1 Model Selection and Variables

The bluegill overwintering habitat model was used to quantify the benefits gained in areas that would be improved for backwater fish habitat. This model has been applied to numerous UMRR Program studies in the past and high model scores have generally been accepted as good indicators of quality backwater overwintering habitat. Even though the model was developed to measure optimal habitat conditions for the bluegill, many other species such as largemouth bass, black crappie, gizzard shad, and other species have been shown to respond favorably to similar conditions. Therefore, the model was chosen not only as a good indicator for quality bluegill winter habitat but also for backwater fish habitat in general. Backwater fish habitat and benefits were directly correlated to areas that would be dredged for the acquisition of fine materials for topsoil. Benefits were also influenced by how various combinations of flow closing structures would reduce inflow during winter months.

A total of four separate areas covering approximately 246 acres were evaluated with the model (Figure C-1). Two areas (D-O-1, 27.3 acres; and D-O-3, 36.9 acres) primarily benefited via dredging activities; two others (Big Lake, 77.2 acres; and Thatchers backwater, 104.3 acres) benefitted by inflow control via closure structures.

Figure C-1. Big Lake aquatic habitat areas evaluated for overwintering habitat benefits.

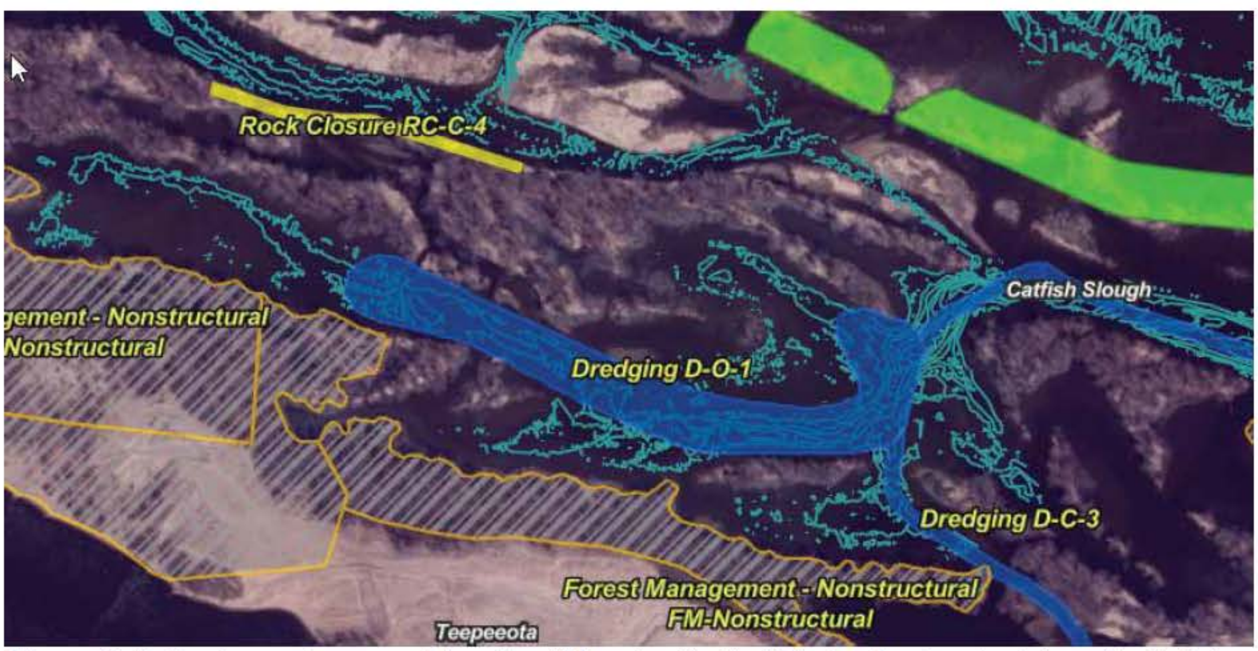

Figure C-2. Dredge cut area and location (blue shading) within backwater dredging site D-O-1 (approximately 7 acres of dredging) of the Tentatively Selected Plan.

The winter portion of the bluegill model was used for this analysis and consists of four variables that assess the habitat value of the water quality and water depth of an area. Optimum conditions described in the model are as follows:

a. Water depth > 4 feet in at least 50-percent of the areas designated as overwintering habitat.
b. Dissolved oxygen levels ≥ 5 mg/l at mid-depth.
c. Winter water temperature ≥ 4ºC.

Winter current velocities of ≤ 0.3 cm/sec.

3.2.2 Overwintering Model Results

Existing and Future without Project Conditions

The bluegill model was applied to areas identified above. In general, all areas are providing moderate to low-quality habitat conditions for bluegills, mostly as a result of the shallow conditions within these evaluation areas. For D-O-1 and D-O-3, the current lack of depth diversity in the evaluation areas results in very little overwintering habitat, as dissolved oxygen is anticipated to be low. Suitabilities for these two areas are low under existing conditions, and would remain so through the 50 year planning horizon. For the Big Lake and Thatchers backwaters, evaluation of existing conditions shows marginal to moderate habitat and would likely hold some fish throughout the winter months. Conditions would deteriorate steadily over the 50 year planning horizon, to where suitabilities would be extremely poor by the end of the period, with few if any fish typically present.

Future with Project

Alternatives included the following assumptions related to the four bluegill overwintering areas. First, the amount of dredging in D-O-1 was generally assumed to be the same amongst alternatives (dredge cut set at 6.9 acres). Although there may be minor differences, these differences weren't significant enough to likely result in meaningful differences in the variables that drive the model. Second, the amount of dredging in D-O-3 was small (dredge cut set at 2.5 acres) and only applied to a couple alternatives (Alternatives 8 and 10). Third, two variations to the number of closing structures for the Big Lake Overwintering were considered amongst alternatives, and forecasted changes in water quality were proportional to the amount of flow diverted via the closing structures. Lastly, the benefits to the Thatcher's backwater were constant across the alternatives that included shoreline stabilization features for that area.

The primary bluegill HSI variables affected by different features include percent winter depths over four feet, dissolved oxygen, winter water temperature and flow velocity. The dredging areas were chosen based on longevity. Dredging these areas to roughly eight feet below LCP would provide depth diversity in the summer and increased depth for critical winter habitat (i.e., benefits dissolved oxygen, temperature and velocities). A target depth of eight feet also helps ensure depths of at least four feet are maintained over the project life. Protection from flows during the winter helps reduce the rate of water exchange, reduces water velocities, and can increase winter water temperatures in the deeper overwintering areas.

Table 2 shows how the overwintering HSI changed over the project planning period of 50 years using the bluegill HSI model. The bluegill model takes the lowest HSI portion of the analysis, and uses it as the limiting factor to present an overall HSI value. In general, higher suitability numbers were observed in all areas under all action alternatives. D-O-1 and D-O-3 do not contain adequate depth and likely freeze to the bottom during winter. Increasing the depth will improve D-O-1 the most as the amount of areas dredged is the greatest. D-O-3 would see marginal improvements as the dredged area is much smaller. Habitat gains in Big Lake and Thatchers would occur as a result of diverting flow. The benefits in these two backwaters would wane over time due to sedimentation that would still occur. But conditions at year 50 should be significantly better with the project than without. The FWP numbers were compared the FWOP to get an incremental gain for the duration of the project.

Table C-3. Bluegill Overwintering HSI Model Results Summary

		Future Without Project HSI				Future With Project HSI			
Aquatic Backwater Areas	**Acres**	**TY 0**	**TY 1**	**TY 25**	**TY 50**	**TY 0**	**TY 1**	**TY 25**	**TY 50**
D-O-1	**27.3**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.66**	**0.66**	**0.66**
D-O-3	**36.9**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.35**	**0.35**	**0.35**
Big Lake RCC2,3&8 FWP	**77.2**	**0.40**	**--**	**--**	**0.10**	**0.40**	**0.63**	**0.40**	**0.20**
Big Lake all features FWP		**0.40**	**--**	**--**	**0.10**	**0.40**	**0.69**	**0.63**	**0.30**
Thatcher's All Features FWP	**104.3**	**0.54**	**--**	**--**	**0.05**	**0.54**	**0.62**	**0.62**	**0.55**

3.3 Diving Duck Habitat Suitability Index Modeling for Aquatic Vegetation

3.3.1 Model Selection and Variables

One of the goals of the project was to decrease sedimentation in the project area. Sand transport through this river reach is very high, and sand deposition is a significant risk in Big Lake. Sedimentation would reduce depth, leading to changes in vegetation types, in areas of Big Lake that are heavily used by canvasbacks and other diving ducks during spring and fall migration. Construction of a sediment deflector at the point where Catfish Slough branches off the main channel should reduce sediment loading in Big Lake, reducing the rate of sedimentation and undesirable changes to the vegetation community in the project area. To evaluate this, the diving duck HSI model was applied to areas of Big Lake with relatively deep water and vegetation used by diving ducks as forage.

The exact pattern of future sedimentation is difficult to predict and would occur broadly through the project area. However, the lower and western portions of Big Lake are particularly vulnerable as Catfish Slough acts as a conduit to transport sediment. These areas are also heavily used by waterfowl during spring and fall migration. Figure C-3 depicts data from two distinct waterfowl survey methodologies. Waterfowl surveys were conducted by refuge staff from adjacent bluff tops during spring and fall of 2020–2022, whereby the perimeter of waterfowl flocks were drawn on maps and then digitized in a geographic information system. Blue ovals in Figure C-3 represent individual flock perimeters and darker shades indicate areas of overlap and greater use by waterfowl. Aerial waterfowl surveys were conducted by the USFWS and the Wisconsin DNR in the fall of 2017-2019, and observations of individual birds and flocks were captured as x, y coordinates with a GPS along with attribute data such as species identity and flock size. This data was added to a GIS, allowing the visualization of areas that were differentially used by diving ducks, dabbling ducks, and swans. In Figure C-3, diving ducks are depicted with red circles, dabbling ducks are depicted with green circles, and swans are depicted with white circles. Discussions with Refuge staff confirmed that each of the two waterfowl datasets provides information that is distinct from the other, and they both have strengths and limitations. Assessed together, the two datasets give an indication of the varying levels of waterfowl use across Big Lake and that some individual waterfowl species/groups use areas that are distinct from what other species/groups use.

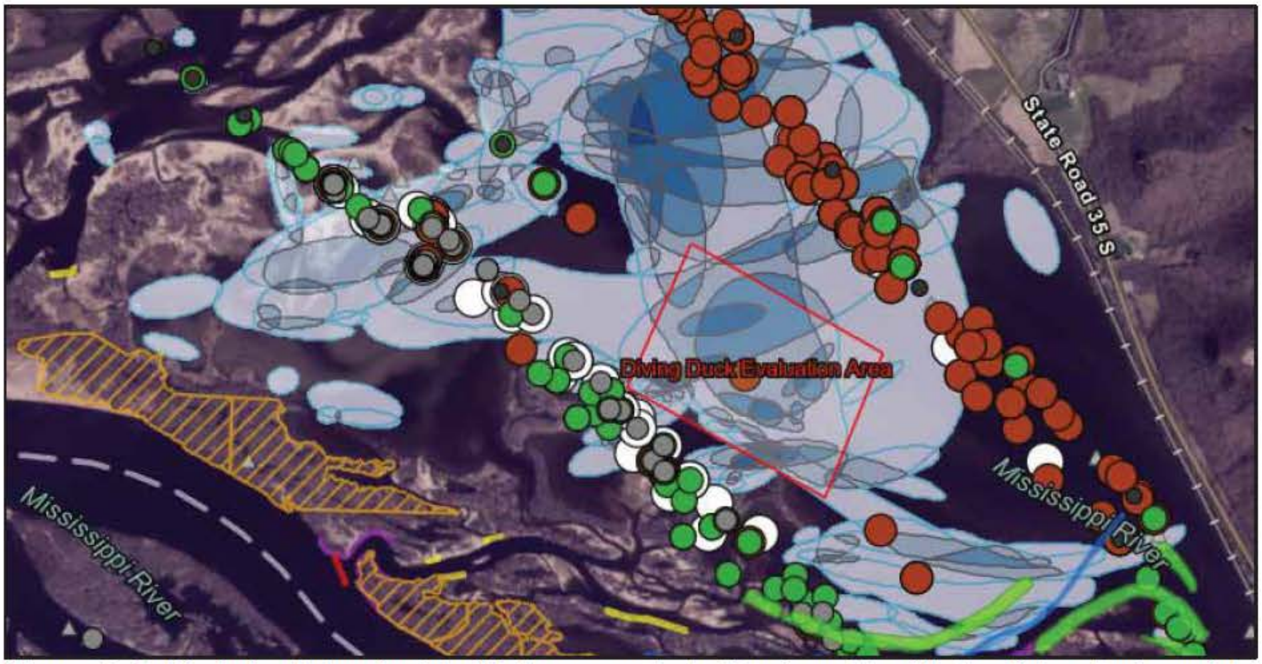

Figure C-3. Big Lake diving duck habitat area evaluated for benefits with the diving duck model. Blue ovals represent individual flock perimeters determined through blufftop surveys in 2020–2022 whereby darker shades indicate areas of overlap and greater use by waterfowl. Colored circles represent observations of waterfowl during aerial waterfowl surveys conducted in 2017–2019. Diving ducks are represented by red circles, dabbling ducks are represented by green circles, and swans are represented by white circles.

This analysis evaluated the potential effects of sediment delivery by Catfish Slough to a 100-acre area in lower Big Lake, the Diving Duck Evaluation Area highlighted in Figure C-3. This assessment doesn't imply that the 100-acre diving duck evaluation area is the only area in Big Lake impacted by sediment transported by Catfish Slough. Instead, this assessment intended to quantify habitat changes in a single, distinct area that is likely impacted by sedimentation at the current time, would likely be impacted to a greater degree in a FWOP scenario, and would likely be impacted to a lesser degree in a FWP scenario. For modelling purposes, it was assumed that without the project, over the 50-yr project life, sedimentation would reduce water depths in the diving duck evaluation area from 18–30 inches to depths of less than 18 inches. This would also likely shift the dominant vegetation type from wild celery (Figure C-4) to other species such as wild rice. It should be noted that wild rice can be a preferred food source for many waterfowl, but canvasbacks greatly prefer wild celery and there is some evidence that canvasbacks avoid the tall vertical structure of wild rice beds. The preference of canvasbacks for vast, open water habitat areas is acknowledged in the diving duck model with two variables: size of water body, and percent emergent vegetation. Water bodies greater than 1,000 acres receive the highest suitability index score, a 10. Areas with percent emergent vegetation cover, such as wild rice, between 20 and 30% are given the highest suitability index score (10) while areas greater than 30% are given progressively lower suitability index scores.

The diving duck model includes two vegetation variables for which suitable data was not immediately available, and can vary from year to year: percent submergent vegetation cover and percent emergent vegetation cover. We utilized LTRM aquatic vegetation data to create proxy variables that are an appropriate substitution for percent cover.

Figure C-4. Estimated wild celery dry mass for the period 1997 thru 2007 for Big Lake (LTRM, unpublished data). Darker green areas indicate greater cumulative wild celery dry mass across 1997–2007. Blue areas in Big Lake are locations that likely contain dense stands of wild rice.

Optimum conditions described in the model are as follows:

a. Size of water body > 1,000 acres
b. > 70% water depth between 18 inches and 6 feet
c. > 50% submerged vegetation cover
d. > 60% of aquatic bed is comprised of key food species
e. 20-30% emergent vegetation cover
f. >60% of emergent vegetation beds contain key food species
g. At least one key taxonomic group of invertebrates (*Shaeriidae, Gastropoda, Hexegina, Amphipoda, Chironomidae*) is present and abundant
h. No human activity occurs or closed to human entry

3.3.2 Diving Duck Modeling Results

Existing and Future without Project Conditions

The diving duck model was applied to the 100-acre Diving Duck Evaluation Area of lower Big Lake. Benefits of the sediment deflector would likely occur beyond this area, but this approach provided a simple, conservative way to assess a reasonably potential benefits within an easily defined and discrete area. The Diving Duck Evaluation Area is situated within a portion of lower Big Lake that already provides high quality habitat for diving ducks under existing conditions as defined by the model; all but one model variable (size of water body) had optimal (maximum) habitat values.

Habitat changes due to sedimentation would occur slowly over time as variables b, c, d, e and g were influenced by continual sedimentation causing the area to become shallower. For this analysis we assumed sedimentation could be six to twelve inches of sediment over 50 years. Variables that would not change in the future included the size of the waterbody (variable a), species of emergent vegetation (variable f), and the level of disturbance (variable h). The model predicted the rate of habitat quality decline in the Diving Duck Evaluation Area would be much less under the FWP scenario than it would be under the FWOP scenario (Table C-4).

Future with Project

Under the Future With Project condition, it was assumed the sediment deflector would greatly reduce the amount of sediment deposition within the Diving Duck Evaluation Area. While it would not stop all sedimentation, we estimated that with the sediment deflector, resulting water depths (variable b) would be at least 18" deep across 40-70% of the Diving Duck Evaluation Area, compared to less than 10% under the FWOP condition. Maintaining depths of at least 18" will help to maintain key vegetation variables, resulting in considerably better modeled habitat conditions with the deflector, compared to without (Table C-4).

Table C-4. Diving Duck HSI Model Results Summary

Diving Duck Summary	Acres	Future Without Project HSI		Future With Project HSI	
		TY 0	TY 50	TY 0	TY 50
SD-1 Benefits	100	0.96	0.40	0.96	0.85

While the level of sedimentation, and the resulting vegetation changes resulting from that sedimentation are somewhat speculative, conversations with technical experts suggested these modelled results are reasonable. Even if water depths didn't change as appreciably as forecasted, subtle losses of water depth would promote further expansion of wild rice. While this plant can be favorable for waterfowl, observations by USFWS suggest that the visual obstruction created by tall, dense stands of wild rice impedes use by canvasbacks of areas where wild rice abundant. Loss of depth and continued of expansion of wild rice would likely result in the loss of existing diving duck habitat in lower Big Lake. The level of changes suggested by the model appear reasonable to capture this risk of habitat loss due to sedimentation and shifts in aquatic vegetation.

3.4 Annualization and Cumulative Habitat Benefits

Annualization was completed for each habitat type using the above HSI values and corresponding acreages, within IWRPlanning Suite. Resulting AAHUs were summed for each alternative. See the main report, Section 4, for a summary of the annualization process. Annualization results are provided below for each alternative for each habitat model.

Alternative	Forest Model AAHUs	Duck Model AAHUs	Bluegill Model AAHUs	Total AAHUs
Alt1	0	0	0	0
Alt2	37.4	56.1	15.4	108.9
Alt3	45.3	56.1	15.4	116.8
Alt4	46.2	56.1	27.5	129.8
Alt5	49.1	56.1	44.6	149.8
Alt6	46.2	56.1	44.6	146.9
Alt7	46.2	56.1	27.5	129.8
Alt8	57	56.1	53.7	166.8
Alt9	48.5	56.1	27.5	132.1
Alt10	59.3	56.1	53.7	169.1

4 References

Devendorf, R.D. 1995 and 2013. A Migratory Habitat Model for Diving Ducks Using the Upper Mississippi River. U.S. Army Corps of Engineers, St. Paul District.

Palesh, G., and D. Anderson. 1990. Modification of the Habitat Suitability Index Model for the Bluegill (Lepomis macrochirus) for Winter Conditions for Upper Mississippi River Backwater Habitats. U.S. Army Corps of Engineers. St. Paul District. St. Paul, Minnesota.

USACE. 2021. UMRS Floodplain Forest Model Documentation and Application Guide. USACE Ecosystem Restoration Planning Center of Expertise Model Library.

USFWS (U.S. Fish and Wildlife Service). 1980. Habitat Evaluation Procedures. Ecological Services Manual 102. Division of Ecological Services, Washington DC.

Appendix D – Geotechnical & Sediment Quality Analysis

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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Appendix D - Geotechnical & Sediment Quality Analysis

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1 Location and Physiography

1.1 Purpose

This appendix provides the geologic and geotechnical data, analysis, and computations for the Recommended Plan for the Big Lake, Habitat Rehabilitation and Enhancement Project. 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. Due to the limited number of geotechnical borings no calculations were completed however this report includes design assumption discussions on shrinkage, settlement and overbuild, and riprap gradations.

Some of the work is acknowledged to be completed during Preconstruction Engineering and Design (PED).

The main purpose of the proposed project, location, and project features of the Recommended Plan is outlined in the main report.

1.2 Project Features

The Recommended Plan includes access and overwintering dredging, four island features, four shoreline stabilization features, and six rock closures.

1.3 Datums

All elevation referred to within this document are referenced to the North American Vertical Datum of 1988 (NAVD88), unless otherwise notated. The units of elevations reported are U.S. Feet.

2 Geology

2.1 Physiography

The most significant geologic event explaining the nature of the Mississippi River within Pool 4 occurred as the Pleistocene glaciation, approximately 10,000 years ago, came to a conclusion. During this time, tremendous volumes of glacial meltwater, primary from the Red River Valley's glacial Lake Agassiz, eroded the pre-glacial Minnesota and Mississippi River valleys. Glacial Lake Duluth also provided a significant amount of meltwater, carving out the St. Croix River that joins the Mississippi River upstream of the project area. As meltwaters diminished, the deeply eroded river valleys aggraded substantially to about the present levels. Prior to construction of the Lock and Dams and impoundment, the broad flood plain of the river contained depressions, sloughs, natural levees, islands, and shallow lakes.

Lower Pool 4 is on the northern edge of a unique region referred to the Driftless Area, which escaped the last glacial epoch ending about 10,000 years ago. Topographic features evident in this area today existed prior to glaciation; the upland area, dominated by ridge and valley terrain, towers 400-500 feet above the river valley. The Mississippi River lies in a bedrock valley about 4 miles wide with a broad terrace on the Minnesota side and narrow bench on the Wisconsin side.

The bluffs of the Upper Mississippi Valley along Lower Pool 4 consist of Ordovician Period dolomite and limestone of the Prairie du Chien Formation cap the bluffs and ridges. Bedrock underlying the Prairie du Chien in descending order include Cambrian Period Jordan Sandstone, St. Lawrence dolomite and siltstone, Franconia Sandstone, Ironton and Galesville Sandstone, and Mt Simon Sandstone.

The principal parent materials of soils in the Lower Pool 4 drainage basin are loess, and alluvium glacial drift. The loess lay either over bedrock or over clay loam till which is the major historic parent material of Pool 4 and associated uplands. The slopes associated with these soil types make them very susceptible to erosion in upland areas, where cover of plants is sparse or where inadequate soil conservation practices are used. The sediment load carried into Pool 4 by the Mississippi River accumulates in backwater areas and in the navigation channel. This project area soil foundation is part of the sandy Chippewa River delta that continues to form at the Mississippi River confluence.

2.2 Site Specific Geology

The Big Lake project is founded on fluvial valley fill in the Chippewa River Delta. Soils are dominated by fluvial sands. Low energy back waters that have formed from both the Chippewa Delta and the lock and dam inundation, now allow fine grained silt and clay sediments to deposit in layers above the Chippewa Delta sands. At the time of feasibility borings collected range to a depth of 7 feet into sediment. Further discussion on soil quality, soil foundation, plasticity and grainsize will occur during PED.

3 Subsurface Exploration

3.1 2022 Exploration

In the summer of 2022, 12 borings were conducted. Borings were conducted via USACE drilling pontoon, USACE geologist, and contracted driller. The machine borings were generally conducted using a continuous sampling method which allowed the soils to be classified in the field by a Saint Paul District Geologist. The sampling was done in 5-foot flights. The first 3 feet were sampled with a modified 2” ID x 2 ½” OD split spoon, followed by the 2-inch standard penetration spoon for the remaining 2 feet. The already sampled 5-foot interval was then cleaned out with the noted drilling method, and sampling continued. The larger spoon above the standard spoon cleaned the hole out large enough to not affect the SPT blow counts of the standard spoon. The Geologist recorded the standard SPT blows in the field and blow counts are presented on the logs. SPT blows were performed dropping a 140-pound hammer 30 inches, with the auto-hammer corresponding to the drill rig performing the boring. The four-drive method was used for SPTs, with the 2 middle drives being used for the stick logs. No corrections were completed for the blow counts to be correlated to parameters.

Borings focused on defining the stratigraphy and characterizing foundation materials at key locations including proposed islands, overwintering dredge areas, and access dredging features. Borings ranged from 10 to 13 ft in depth.

Draft soil boring logs are provided in Attachment D-1. A location map is provided below in Figure 1 and Figure 2.

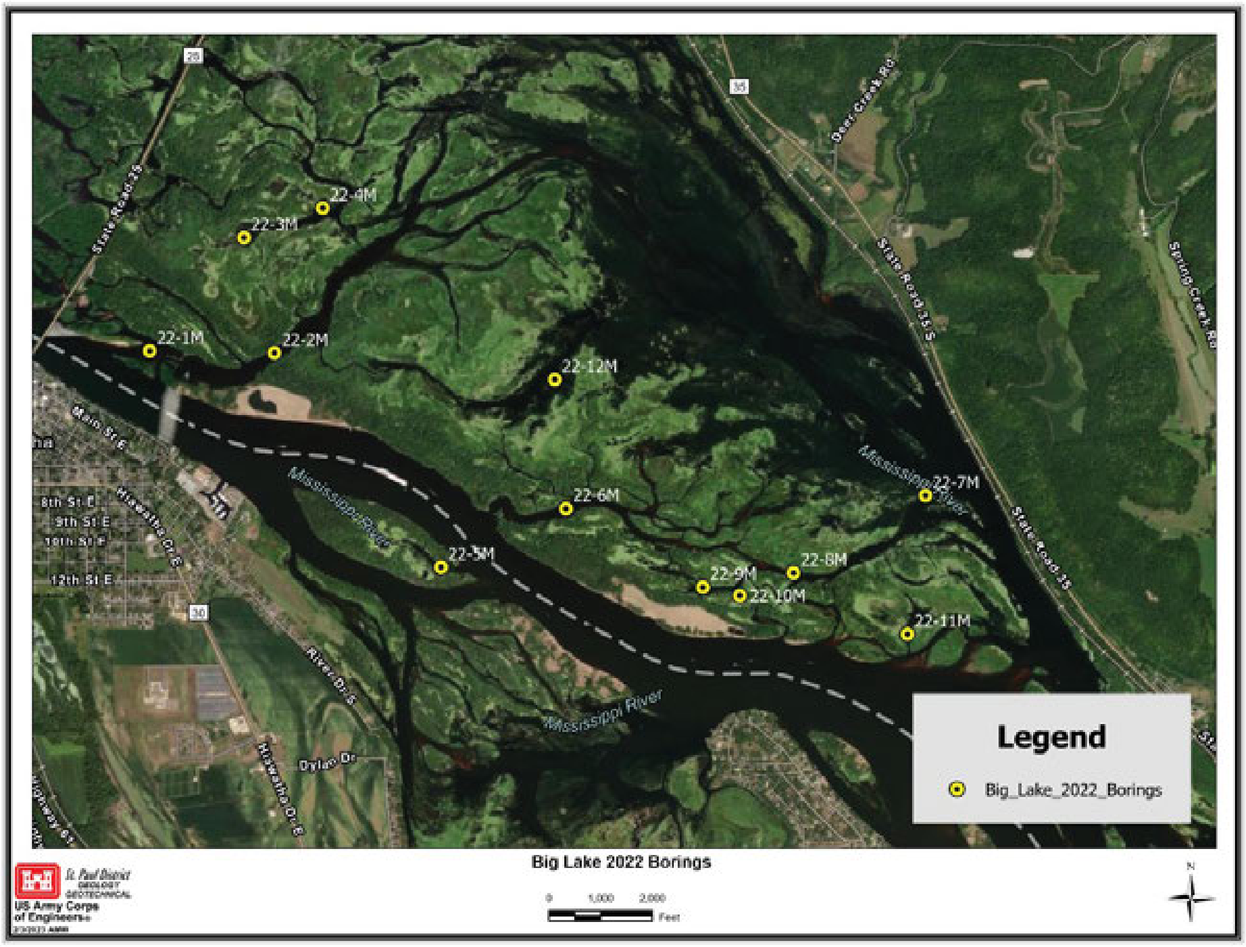


Figure 1: Big Lake 2022 Boring Location Map

3.2 2023 Exploration

The second geotechnical exploration was completed in the summer of 2023 and focused on evaluating the foundation materials for proposed islands, and rock closures. Additionally environmental soil samples for chemical analysis were collected to characterize borrow sites, access dredging, and overwintering dredging sediment quality. Eleven borings were completed, three environmental borings, eight geotechnical borings. No major concerns or findings resulted from the borings in impact the recommended plan. The borings will be used during PED.

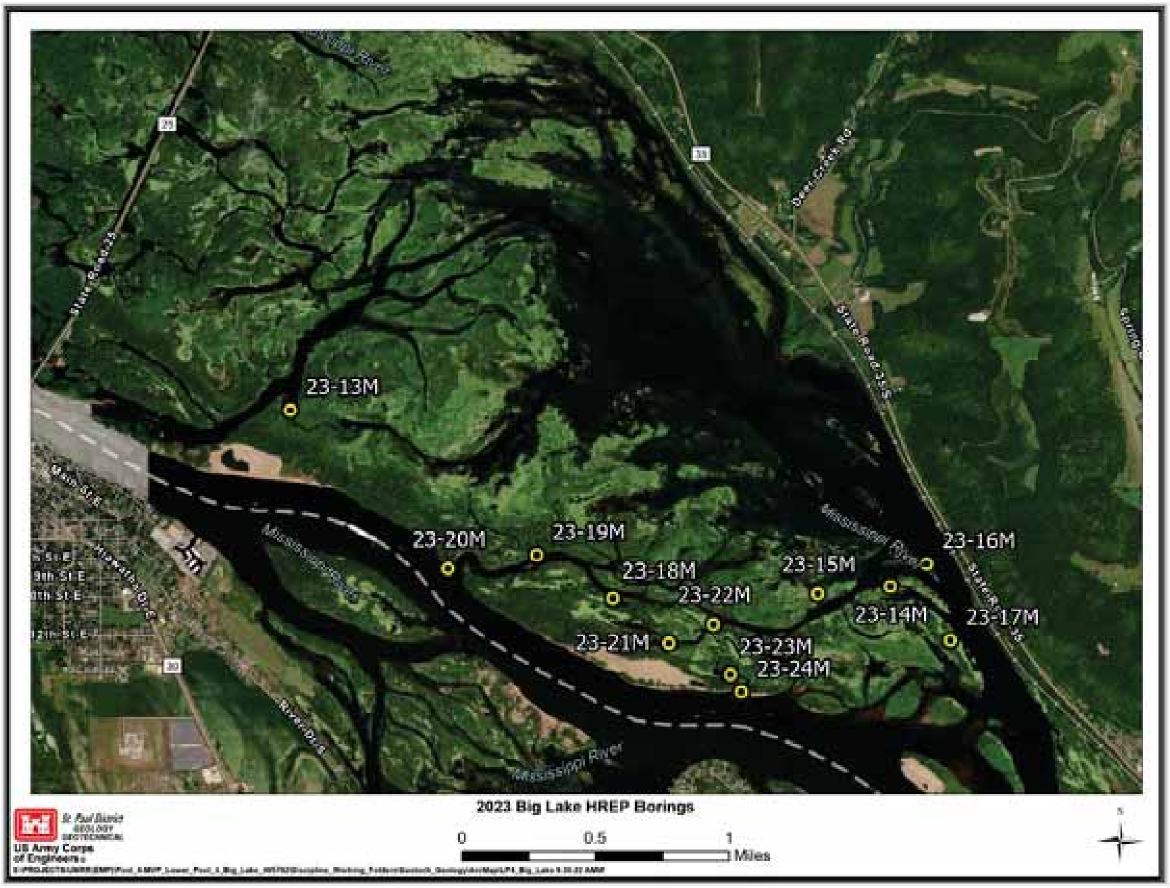


Figure 2: Big Lake 2023 Boring Location Map

3.3 Machine Borings

The St. Paul District completed a total of 24 machine borings and 1 undisturbed boring for the Big Lake project. These subsurface explorations are located in various project feature areas shown in Attachment 1: Soil Exploration. The machine borings were performed to determine the subsurface conditions and stratigraphy.

Table 1 Boring Summary Table

Boring ID	Latitude	Longitude	Top of Boring Elev.(1) (ft, NAVD88)	Boring Depth(2) (ft)	Type
22-1M	44.385869	-92.024283	666.8	10.5	Geotechnical
22-2M	44.385677	-92.01505	666.8	11.5	Geotechnical
22-3M	44.391743	-92.017211	666.8	9.5	Geotechnical
22-4M	44.393261	-92.011353	666.8	9.5	Geotechnical
22-5M	44.374159	-92.00293	666.8	8.5	Geotechnical
22-6M	44.377241	-91.993642	666.8	8.5	Geotechnical

22-7M	44.377697	-91.96704	666.8	8.5	Geotechnical
22-8M	44.373623	-91.97687	666.8	8.5	Geotechnical
22-9M	44.372926	-91.983586	666.8	8.5	Geotechnical
22-10M	44.372464	-91.980862	666.8	9.5	Geotechnical
22-11M	44.370302	-91.968499	666.8	8.5	Geotechnical
22-12M	44.384092	-91.994346	666.8	9.5	Geotechnical
23-13M	44.38586	-92.01165	668.0	30.0	Geotechnical
23-14M	44.375812	-91.966383	668.0	25.0	Geotechnical
23-15M	44.375472	-91.971902	668.1	20.0	Geotechnical
23-16M/MU	44.377016	-91.963609	668.1	35.0	Geotechnical
23-17M	44.372832	-91.961873	668.2	35.0	Geotechnical
23-18M	44.375347	-91.987361	668.2	32.0	Geotechnical
23-19M	44.377757	-91.993090	668.3	35.0	Geotechnical
23-20M	44.377082	-91.999837	668.3	30.0	Geotechnical
23-21M	44.372873	-91.983231	668.3	12.0	Environmental
23-22M	44.373877	-91.979843	668.3	10.0	Environmental
23-23M	44.371129	-91.978597	668.3	8.0	Environmental
23-24M	44.370167	-91.977788	668.1	25.0	Geotechnical

(1) Boring top of elevation is the water surface
(2) Boring depth is distance from water surface to boring termination

4 Soil Testing

4.1 Geotechnical Sample Testing

Laboratory testing was performed on both undisturbed and disturbed soil samples from the 2023 Exploration. No soils testing has been performed on samples from the 2022 Exploration. Laboratory testing performed included moisture contents, Atterberg limits, and grain size analysis.

4.2 Environmental Sample Testing

Soil samples for chemical analysis were collected in summer of 2023. The locations were targeted in areas for access dredging, overwintering, and potential borrow sites.

5 Geotechnical Evaluation and Design

The purpose of the geotechnical evaluation and design was to ensure the Recommended Plan was feasible and to provide input for cost estimates. The source and foundation of the fill features for the constructed islands were evaluated for consolidation settlement, lateral displacement during construction, shrinkage of fine material and compaction. Recommendations are provided based on the evaluations.

5.1 Lateral Displacement

Experience on previous projects has shown that shear stresses resulting from the placement of fill atop very soft clayey strata can result in lateral displacement of the near-surface foundation material. Lateral displacement can occur in a semi-liquid fashion, in which the material is simply "squeezed" outwards from beneath the fill like toothpaste, or in a plastic fashion, in which distinct shear zones or planes develop within the soil mass and wedges of material are displaced outwards along those shear zones. Either mechanism is likely to result in uplift of foundation material directly outside the vicinity of loading. This uplifted material is often referred to colloquially as a "mud wave", as it can protrude above the water surface giving the appearance of a wave.

There is no currently available method to accurately predict the depth and quantity of lateral displacement of soft materials. The approach taken in the geotechnical design is to provide a judgment-based estimate and to provide recommendations for minimizing that displacement during construction.

It is considered likely that a portion of these very soft soils will be displaced laterally, while a portion will remain in place and consolidate below the dredge sand fill. Given the presence of a very soft clayey strata in nearby borings, it is suggested to plan for 1.0 ft of additional fill to compensate for foundation material lost because of lateral displacement. Consolidation of these soils has been incorporated in the consolidation evaluation described below.

Laterally displaced material could be reused in the project design if the material meets project specifications. Care and consideration should be given when excavating this material as to not undermine the island foundation. An excavation plan specifically referencing the removal and reuse of the laterally displaced material shall be prepared by the contractor prior to proceeding.

5.2 Shrinkage

A shrinkage factor will be further defined during the next phase. Shrinkage factors can vary greatly between 10% and 50% based on localized material properties and placement construction methods. For Recommended Plan refinement (spring 2023) and quantity calculations an assumed shrinkage factor of 20% was used for fine material. Dredge sand is considered to have a shrink/swell factor around 0%. The proposed shrinkage factor will be reviewed again during PED after the 2023 soil exploration has been completed.

5.3 Consolidation Settlement

Due to the limited amount of geotechnical information at time of Recommended Plan selection, experience and judgement-based approach was used to estimate settlement. The amount of consolidation depends on the thickness of compressible soils and presence of soft, high plasticity clay material near the surface.

Nearby borings taken in similar backwater locations, as the proposed islands, show very soft ooze-like material at the surface followed by several feet of soft clay. These nearby borings are shallow, less than 10 ft in depth from the water surface, and do not provide any indication to the deeper foundation soils. Conservatively, it is assumed that there is more compressible material at deeper depths. For the Recommended Plan refinement and cost compilation a conservative estimate of 1 to 2 feet of settlement can be expected.

While there is significant uncertainty and variability associated with time rate of consolidation predictions, it is likely that most foundation consolidation will occur within 2-5 years of placement.

5.4 Compaction

Compaction of the proposed islands will need to be further considered during PED. It is thought that over compaction could make it more difficult to plant trees and allow for vegetative growth. Additionally, under compaction could lead to more shrinkage and consolidation well after placement which could lower the island elevations over time. Erosion may also be more suspectable to under compacted soils.

5.5 Dredging Assessment (materials)

An analysis of chemical quality for Big Lake was completed is the summer of 2023 and will be evaluated during PED.

Initial chemical testing results indicate that the material should be able to be used. The results will be coordinate with the state agencies for concurrence during PED, but it is assumed that the material will be able to be used.

5.6 Topsoil Composition

Fines to be used as topsoil are expected to be obtained from the dredging locations. Additional testing to determine the suitability of the fines will be completed during PED.

5.7 Erosion Protection

Riprap is required for erosion protection. Riprap will be placed as rock vanes and groins along the islands. R45 riprap was selected as the recommended gradation.

Bedding and geotextile will not be required underneath the riprap. The thicker layer section and low risk are considered sufficient justification. See Appendix H for additional information regarding the riprap design.

Sources of riprap should be available locally and there are approximately 12 quarries within a 20 mile radius of the city of Wabasha, MN. However, additional investigation will be completed during PED to accurately quantify the amount of stone product available within a reasonable radius of the area.

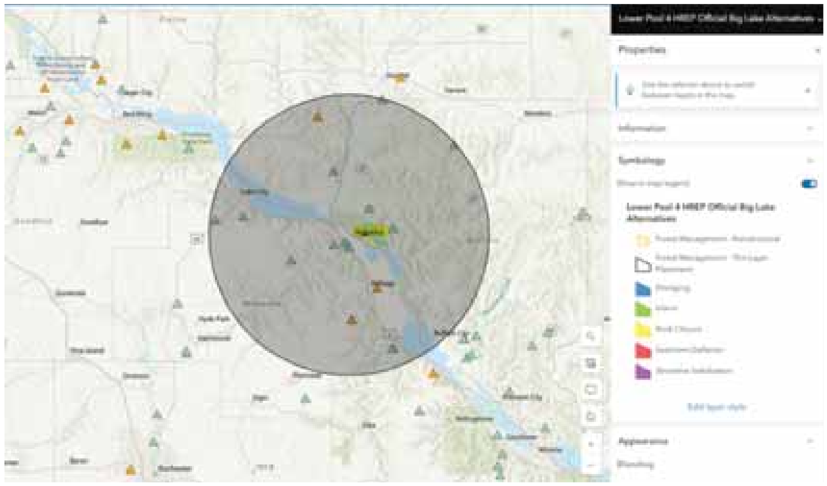


Figure 3: Map showing the nearby quarries. Circle indicates a 20 mile radius.

6 Phase 1 HTRW

A Phase 1 HTRW was conducted in summer of 2022, in accordance with ER-1165-2-132, Water Resource Policies and Authorities HTRW Guidance for Civil Works Projects. At the time the report was written, the subject property was primarily backwaters to the Mississippi River, and used as a recreational area used for hunting, boating, and fishing. During site reconnaissance environmental concerns were not observed on or near the immediate vicinity of the subject property. The full report is available in Attachment 2.

6.1 Dredged Material Quality

A summary of environmental testing results will be added in Plans and Specs.

7 Conclusion

Island overbuild – based on the presence of soft ooze like material and the possibility of compressible foundation soils it can be expected that 2-3 feet of additional fill will be needed for the island construction. For the Recommended Plan selection and quantity calculation 2 feet of overbuild was assumed.

Slopes – As with other similar projects the foundation soils are likely to have very low shear strengths and will be unable to support steep slopes. Slopes constructed steeper than 4H:1V are likely to flatten because of lateral displacement or and/or consolidation. Dredging areas shall be offset from proposed features as much as possible to minimize shear stresses resulting from the fill placement and excavation. Ultimately submerged slopes will be governed by the angle of repose.

8 Attachments

8.1 Attachment 1: Soil Exploration

8.2 Attachment 2: Environmental Site Assessment, HTRW Phase 1 Report

US Army Corps of Engineers®
St. Paul District

Attachment D.1: Boring Logs

Habitat Rehabilitation and Enhancement Project

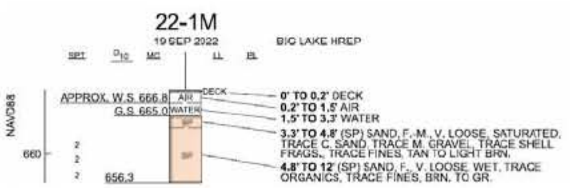
Big Lake

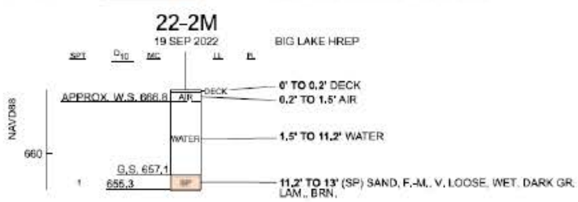
Feasibility Phase

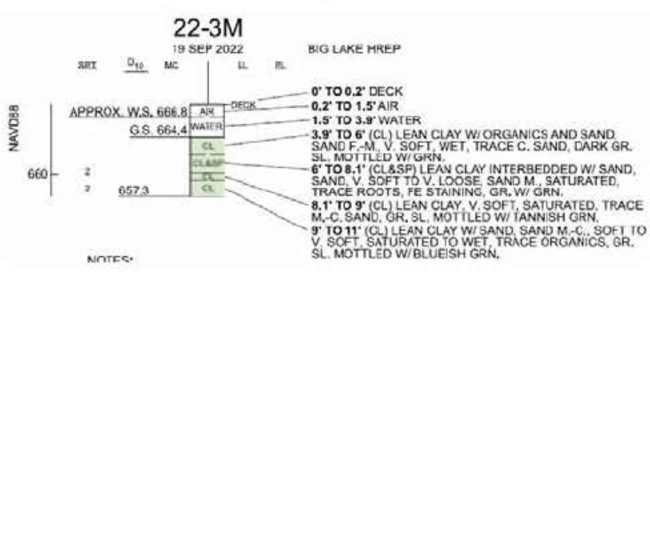
Doc Version: Feasibility Review

May 2024

Indian Slough and Dredging

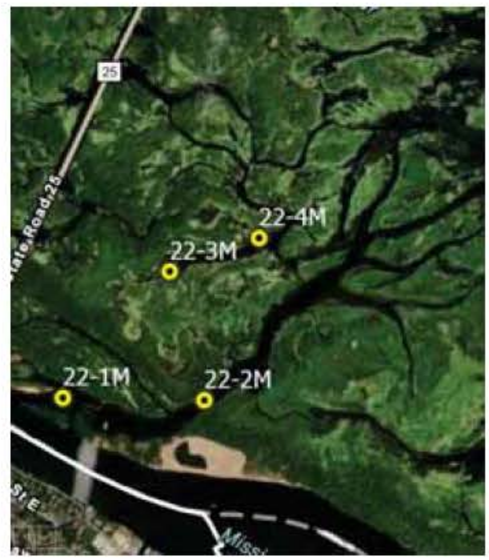


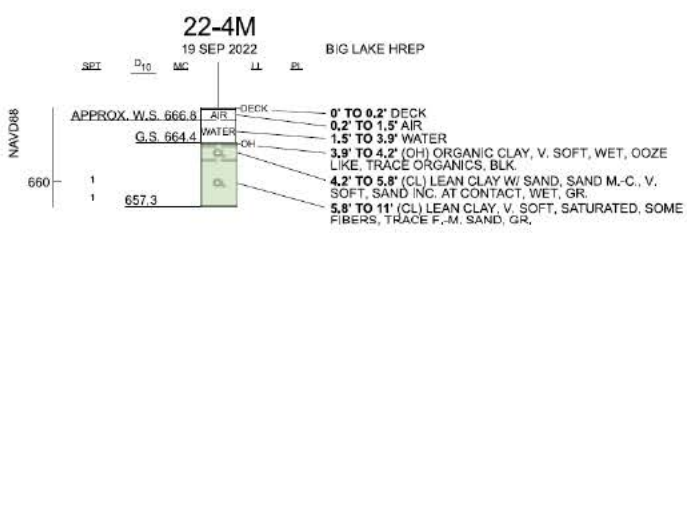




NOTES:

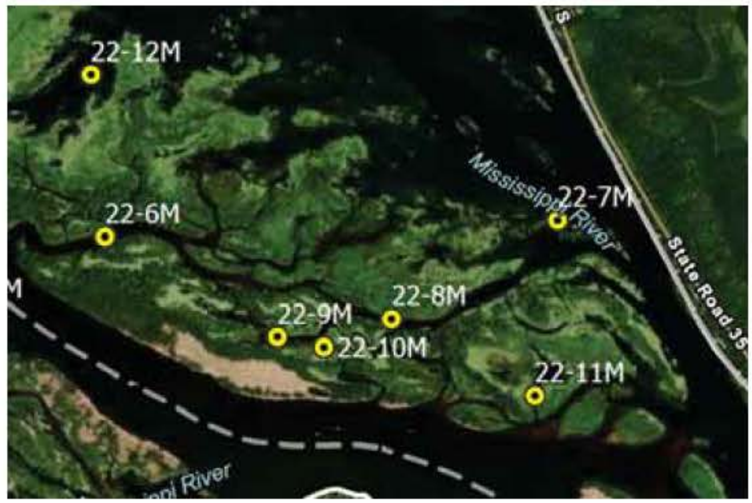
Indian Slough - Sand
Over wintering dredging - Clay





Catfish Slough and Dredging

Catfish Slough – Sand and Silt
Dredging – Clay and Sand
Note ooze like oversaturated clays



22-6M

20 SEP 2022 BIG LAKE HREP

SPT D_{10} MC LL PL

APPROX. W.S. 666.8 AIR DECK
G.S. 664.8 WATER
0 ML
SM
7 658.3 SP

0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 3.5' WATER
3.5' TO 5.7' (ML) SANDY SILT W/ CLAY, SAND F., V. LOOSE, SATURATED, SOME WOOD AT 4, DARK GR.
5.7' TO 6.7' (SM) SILTY SAND, F.-M., V. LOOSE, SATURATED, GR. TO BRN.
6.7' TO 10' (SP) SAND, V. LOOSE, SATURATED, INTERBEDDED W/ ~0.5' THICK LENSES OF F. OR M. SAND, TRACE FINES, BRN.

22-7M

20 SEP 2022 BIG LAKE HREP

SPT D_{10} MC LL PL

APPROX. W.S. 666.8 AIR DECK
WATER
G.S. 661.1 CH
658.3 SM

0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 7.2' WATER
7.2' TO 8.3' (CH) SILTY CLAY, V. SOFT, OOZE LIKE, WET, TRACE SHELL FRAGS., TRACE F. SAND, DARK GR.
8.3' TO 10' (SM) SILTY SAND, V. LOOSE TO LOOSE, SAND F. TO M., SATURATED, TRACE F. GRAVEL, DARK GR. TO BRN.

22-8M

21 SEP 2022 BIG LAKE HREP

SPT D_{10} MC LL PL

APPROX. W.S. 666.8 AIR DECK
WATER
G.S. 661.7
658.3 SP

0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 6.6' WATER
6.6' TO 10' (SP) SAND, F. TO C., LOOSE, SATURATED, TRACE FINES, TRACE F. GRAVEL, BRN.

22-9M

21 SEP 2022 BIG LAKE HREP

SPT D_{10} MC LL PL

APPROX. W.S. 666.8 AIR DECK
G.S. 663.7 WATER
CH
6 658.3 SM

0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 4.6' WATER
4.6' TO 6.5' (CH) SILTY CLAY, V. SOFT, SATURATED, OOZE LIKE, W/F. SAND, SOME ORGANICS, BLK. TO GR.
6.5' TO 10' (SM) SILTY SAND, F., LOOSE, WET, GR. LAM., TRACE ROOTS, TRACE CLAY, FE STAINING, REDDISH BRN. TO BRN.

22-10M

21 SEP 2022 BIG LAKE HREP

SPT D_{10} MC LL PL

APPROX. W.S. 666.8 AIR DECK
G.S. 664.6 WATER
CH
0
8 657.3 SP

0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 3.7' WATER
3.7' TO 8.5' (CH) SILTY CLAY W/ SAND, V. SOFT, SAND F., SATURATED, OOZE LIKE, SOME ORGANICS, DARK GR. TO GR.
8.5' TO 10' (SP) SAND, V. LOOSE TO M. DENSE, SAND F. TO M., SATURATED, TRACE FINES, SP-SM FROM 8.5' TO APPROX. 8.9', GR. TO BRN.

22-12M

21 SEP 2022 BIG LAKE HREP

SPT D_{10} MC LL PL

APPROX. W.S. 666.8 AIR DECK
WATER
G.S. 662.2
1 657.3 CH

0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 6.1' WATER
6.1' TO 11' (CH) SILTY CLAY, V. SOFT, OOZE LIKE, SATURATED, SOME ROOTS AND PLANT FIBERS, TRACE F. SAND, TRACE M.-C. SAND AT APPROX. 9', DARK GR. TO GR.

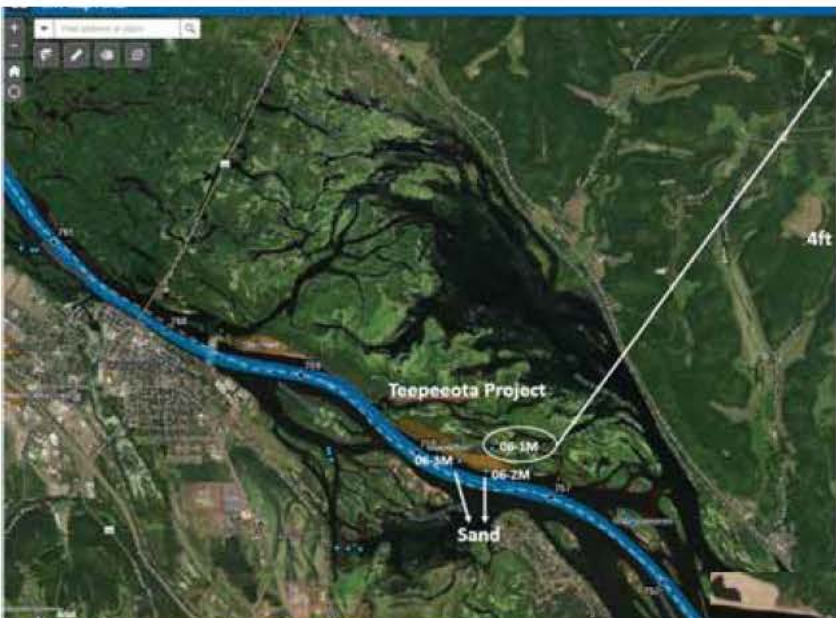
22-11M

21 SEP 2022 BIG LAKE HREP

SPT D_{10} MC LL PL

APPROX. W.S. 666.8 AIR DECK
G.S. 665.6 WATER
2 CL
5 658.3 SP&SM

0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 2.7' WATER
2.7' TO 3.7' (SM) SILTY SAND, M., V. LOOSE, WET, SOME SHELLS AND ORGANICS NEAR G.S., ORGANIC CLAY AT 2.7' TO APPROX. 2.9', BLK. TO BRN.
3.7' TO 4.5' (CH) SILTY CLAY W/ SAND, SAND F., V. SOFT, SATURATED, OOZE LIKE, SOME ORGANICS, DARK GR.
4.5' TO 8.4' (CL) SILTY CLAY, V. SOFT, SATURATED, TRACE F. SAND, GR.
8.4' TO 10' (SP&SM) SAND INTERBEDDED W/ SILTY SAND, F. TO M., LOOSE, WET TO SATURATED, TRACE FINES, GRN. W/ FE STAINING TO BRN.


Teepeeota Project
06-1M
06-3M
06-2M
Sand


4ft
Fines
Sand


22-5M
20 SEP 2022
BIG LAKE HREP
SPT
D_{10}
MC
LL
PL
NAVD88
660
APPROX. W.S. 666.8
G.S. 663.7
5
658.3
DECK
AIR
WATER
SM
CH
SP
SP
0' TO 0.2' DECK
0.2' TO 1.5' AIR
1.5' TO 4.6' WATER
4.6' TO 4.9' (SM) SILTY SAND, M., V. LOOSE, WET, SOME SHELL FRAGS,, SOME ORGANICS, BLK.
4.9' TO 5.2' (CH) SANDY CLAY, SAND F., V. SOFT, WET, BLK.
5.2' TO 7.5' (SP) SAND, M., LOOSE, SATURATED, TRACE FINES, TAN TO LIGHT BRN.
7.5' TO 10' (SP) SAND, F., LOOSE, SATURATED, SOME M. SAND, TRACE FINES, TAN TO LIGHT BRN.
NOTES:
1. BORING OBTAINED FROM A FLOATING PLANT
2. ELEVATION ESTIMATED FROM PRORATED POOL 4 WATER SURFACE
2. PULLED SAMPLER AND ALLOWED HOLE TO COLLAPSE


22-6M
22-5M
Mississippi River

2023 Big Lake HREP Borings

St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers®

0 0.5 1 Miles

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Hole No. 22-12M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 2 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT —
2. LOCATION (Coordinates or Station) See Map	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD88
3. DRILLING AGENCY Interstate Drilling Services	12. MANUFACTURER'S DESIGNATION OF DRILL Jenkins Rig w/ Cathead
4. HOLE NO. (as shown on drawing and file number) PB-Geo-08	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: 1 Jar — UNDISTURBED: —
5. NAME OF DRILLER Dave Tokar	14. TOTAL NUMBER CORE BOXES —
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER surface: 666.8'
	16. DATE HOLE — STARTED: 21 SEPT 22 — COMPLETED: 21 SEPT 22
7. THICKNESS OF OVERBURDEN —	17. ELEVATION TOP OF HOLE 668.3'
8. DEPTH DRILLED INTO ROCK —	18. TOTAL CORE RECOVERY FOR BORING —
9. TOTAL DEPTH OF HOLE 11.0'	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Top of Deck			
	0.2	Deck / AIR	AIR (O_2)			1) Location Lat: 44.384092 Long: -91.994346 NAD83 2) Elev. Pro-rated from Pool 4 elev. 3) 140 lb hammer w/ cathead used for SPT @ 30" drop. 4) 2x2½ = 2" I.D. x 2½" O.D. split spoon sampler.
	1.0					
666.8	1.5		(Water Surface)			
		WATER WATER	Water (H_2O)			
	2.0					
	3.0					
	4.0					
	5.0					
662.2	6.0 6.1		(Ground Surface)			
		CH	Silty Clay (CH) - ooze like to soft - High Plast. - ~~wet to~~ Saturated - Dark Grey to gray - Roots & Plant fibers - 95% Fines - 5% f. Sand - Trace m.-c. sand @ ~9.0'	2x2½ Pound		
	7.0					
	8.0				SN 1	
				R: 2.0 T: 4.0	7.0 8.0	
	9.0			SPT 0		
				0		
658.3	10.0		(Cont'd)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP — HOLE NO. 22-12M

Hole No. 22-12M

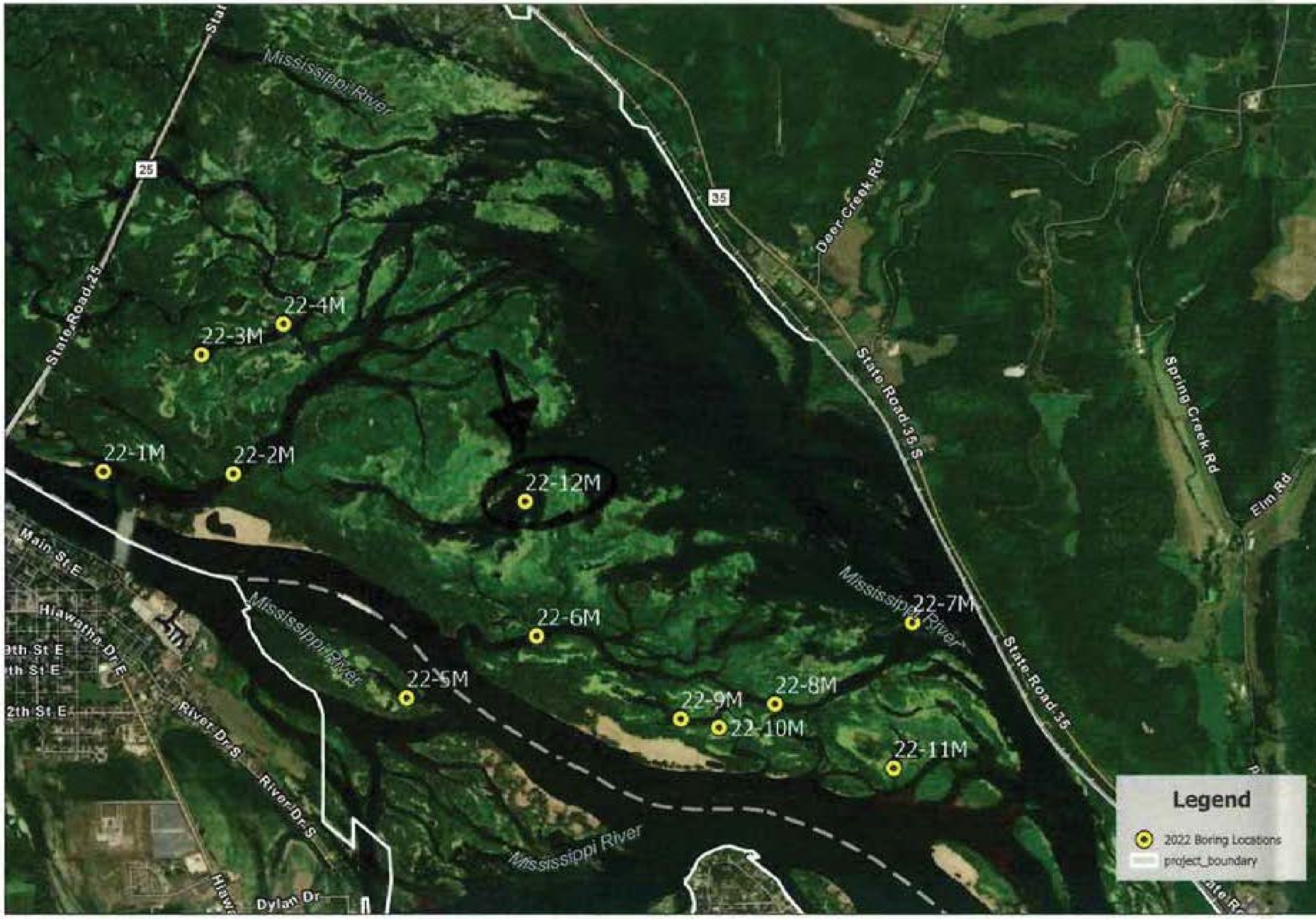
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 2 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE
☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION	DEPTH	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
[illegible]	[illegible]		(cont'd)			
		CH	Silty Clay (CH) - See previous description Ooze like H plasticity, [illegible]	1 1 R:1.2 T:11.0		5) Pull sampler & allow hole to collapse
157.7	11.0		End of Boring Dark grey to gray Roots & Plant [illegible] 95% Fines 5% F. Sand			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-12M



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers

2022 Big Lake HREP Borings

Base Image:

2,000 1,000 0 2,000

Feet

N

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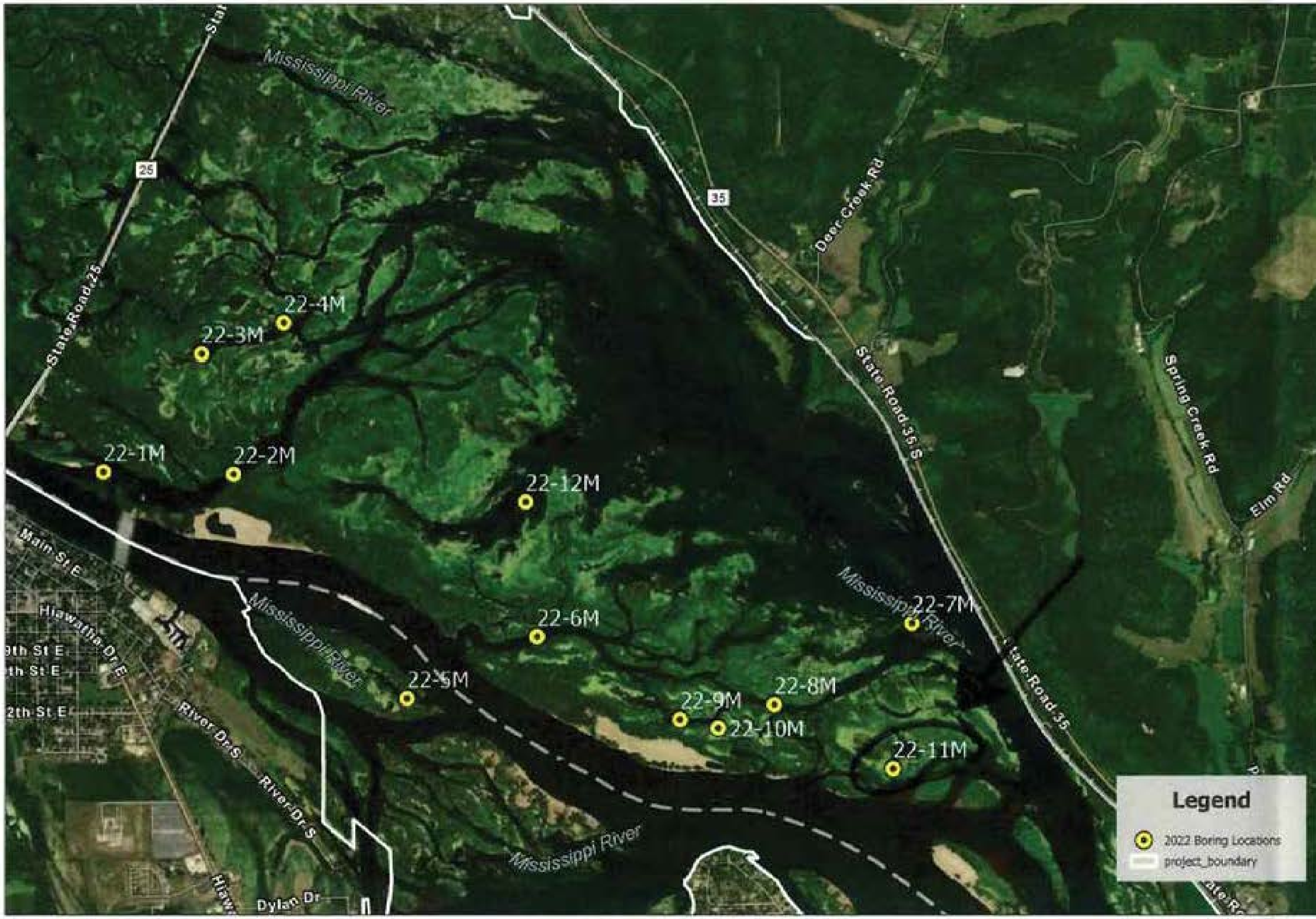
Hole No. 22-11M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 1 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): See Map
3. DRILLING AGENCY: Interstate Drilling Services
4. HOLE NO. (as shown on drawing and file number): PB-Geo-01
5. NAME OF DRILLER: Dave Tokar
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 10.0'
10. SIZE AND TYPE OF BIT: —
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline Rig w/ cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 4 Jars; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: Surface 666.8'
16. DATE HOLE: STARTED 21 Sept 22; COMPLETED 21 Sept 22
17. ELEVATION TOP OF HOLE: 668.3'
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		TOP OF DECK			
	0.2	Deck	AIR (O2)			1) Location Lat: 44.370302 Long: -91.968499 NAD 83
	1.0	AIR				2) Elev. Pro-rated from Pool 4 elev.
666.8	1.5		(Water Surface)			
	2.0	WATER	H_2O (H_2O)			3) 140 lb hammer w/ Cathead used for SPT @ 30" drop.
665.6	2.7		(Ground Surface			4) 2x2½ = 2" I.D. x 2½" O.D. Split Spoon Sampler.
665.4	2.9 / 3.0	OR / SM	Silty Sand (~~OL~~ SM) - V. loose - wet - Black to brown - 85% M. Sand - Shells at ground surface - 15% fines - Organics & Fines at ground surface	2X2½ Pound	S.N. 1 3.0/3.7	
664.6	3.7 / 4.0	CH				
663.8	4.5 / 5.0		Silty Clay (CH) - V. soft to ooze like - ~~wet~~ saturated - roots - M. to H. Plast. - organics - Dark grey - 90% fines - 10% f. sand		S.N. 2 2.8/4.5	
	6.0	CL	Silty Clay (CL) - v soft - H. Plast. - Saturated - grey - 95% fines - 5% f. sand	R: 2.0 T: 6.0 SPT 1 1 1	S.N. 3 6.0/7.0	
	7.0					
	8.0			R: 1.0 T: 8.0 SPT 1		
659.9	8.4	SM	Silty Sand & Sand (SM/SP) - Loose - interbedded - Wet to saturated SM & SP - Green w/ Fe staining to brown - 70% M. sand w/ 30% fines to 85% f. sand w/ 15% fines to 95% M. Sand w/ 5% fines	2	S.N. 4 8.5/8.8	
659.5	8.8	SP-SM		3		
659.2	9.0	SP		5 R: 1.4 T: 10.0		5) Pulled Sampler & allowed hole to collapse
658.3	10.0		End of Boring			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT Big Lake HREP HOLE NO. 22-11M



2022 Big Lake HREP Borings

Base Image

2,000 1,000 0 2,000 Feet

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Hole No. 22-104

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 2 SHEETS
1. PROJECT Big Lake HREP		10. SIZE AND TYPE OF BIT —	
2. LOCATION (Coordinates or Station) See Map		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88	
3. DRILLING AGENCY Interstate Drilling Services		12. MANUFACTURER'S DESIGNATION OF DRILL Jerkline Rig w/ Cathead	
4. HOLE NO. (as shown on drawing and file number) PB-Geo-04		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED 2 Jars / UNDISTURBED —
5. NAME OF DRILLER Dave Tolkar		14. TOTAL NUMBER CORE BOXES —	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED — DEG. FROM VERT.		15. ELEVATION GROUND WATER Surface: 666.8'	
		16. DATE HOLE	STARTED 21 Sept 22 / COMPLETED 21 Sept 22
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE 668.3'	
8. DEPTH DRILLED INTO ROCK —		18. TOTAL CORE RECOVERY FOR BORING — %	
9. TOTAL DEPTH OF HOLE 11.0'		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Top of Deck			
	0.2	Deck	AIR (O_2)			1) Location Lat: 44.372464 Long: -91.980862 NAD 83
	1.0	AIR	↓			
666.8	1.5		(water surface)			2) Elev. Pro-rated from Pool 4 elev.
	2.0	H_2O	Water (H_2O) ↓			3) 140 lb hammer w/ cathead used for SPT @ 30" drop.
	3.0					4) 2x2½ = 2" I.D. x 2½" O.D. split spoon sampler.
			(Ground Surface)			
664.6	3.7		Silty Clay w/ Sand (CH)	2x2½		
	4.0	CH	- V. soft to ooze like - M. to H. Plast - ~~Wet~~ Saturated - Dark grey to grey - organics - Sl. organic odor - 50% Clay - 35% Silt - 15% F. Sand	Pound		
	5.0				S.N. 1 4.2/5.2	
	6.0		↓			
				R: 2.0 T: 2.0 SPT		
	7.0	CH		0		
				0		
	8.0			0		
659.8	8.5	SP-SM	Silty Sand (SP-SM)	2 R: 1.8 T: 1.0		
659.4	8.9					
	9.0	SP	- V. loose to M. dense - wet to saturated - Grey to brown - 95% F. to M. Sand - 5% fines	SPT 4	S.N. 2	
658.3	10.0			4	9.3/10.3	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP

HOLE NO. 22-104

Hole No. 22-10M

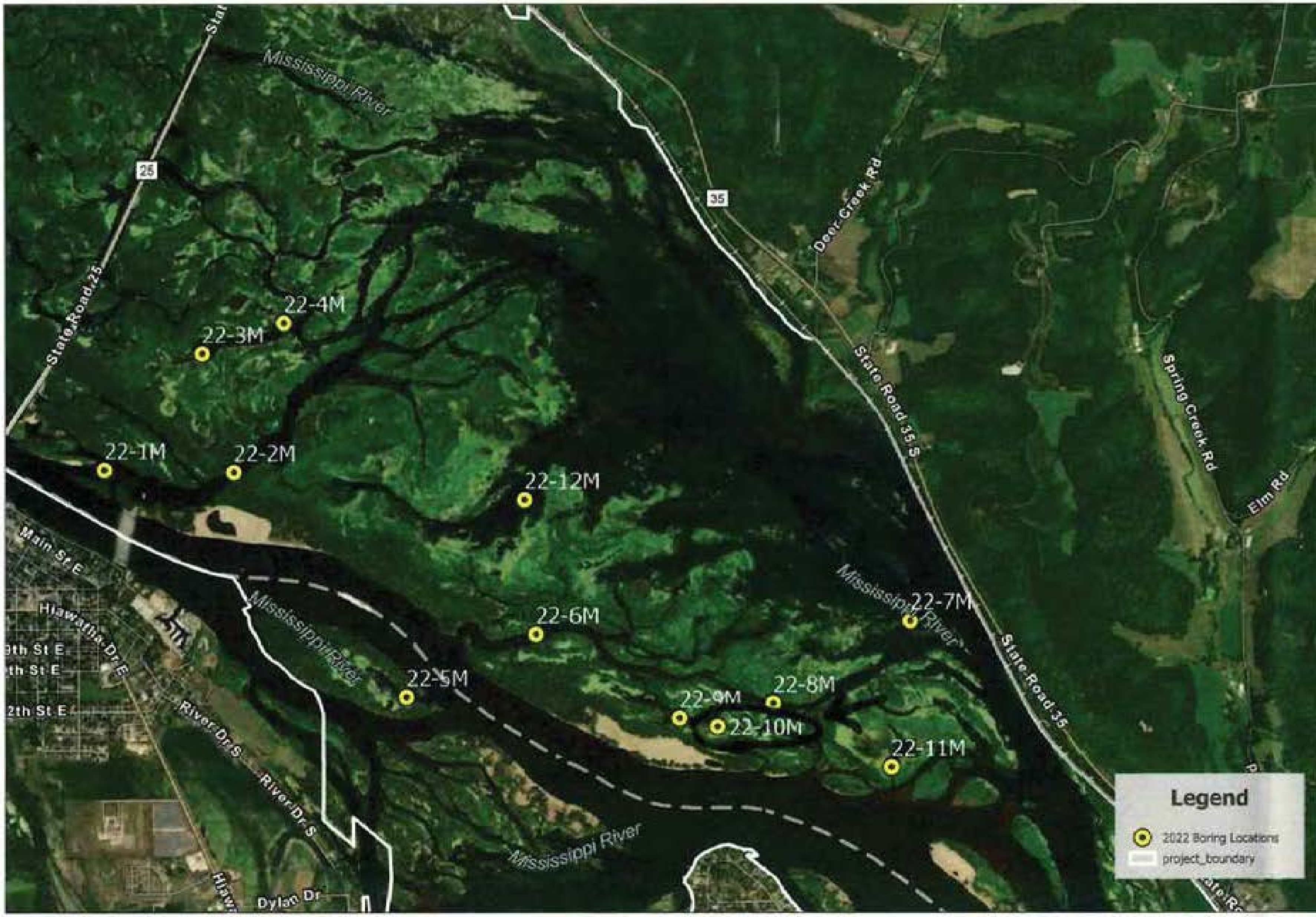
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 2 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.3	10.0	SP	Sand (SP) (continued) ~~- see previous description~~ Missing description	4		
657.3	11.0		End of Boring	7 R: 10.0 T: 11.0		5) Pulled sample and allowed hole to collapse

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-10M



2022 Big Lake HREP Borings

Base Image

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Feet

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Hole No. 22-9M

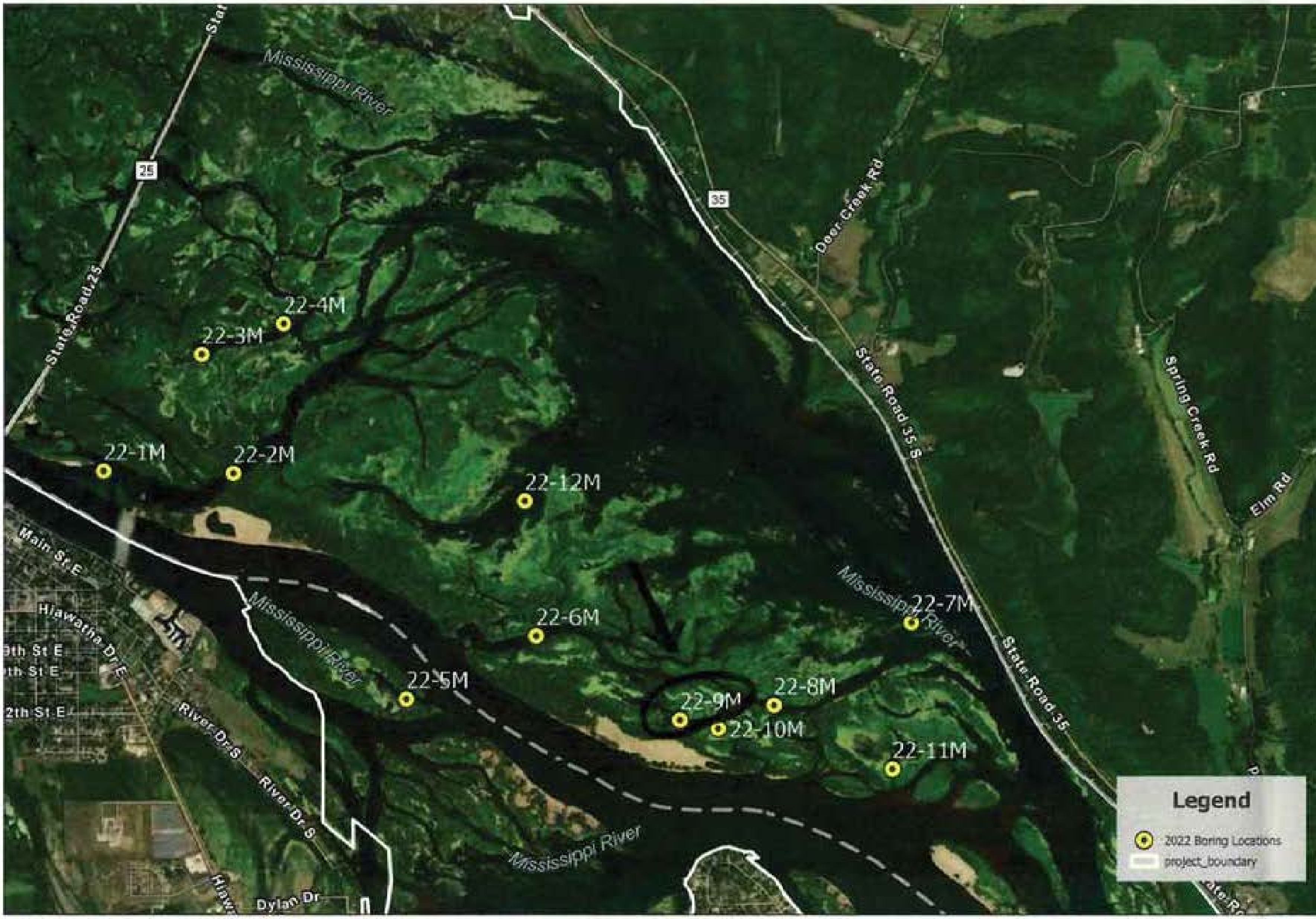
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 1 SHEETS

1. PROJECT: Big Lake HREP	10. SIZE AND TYPE OF BIT: —
2. LOCATION (Coordinates or Station): See Map	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88
3. DRILLING AGENCY: Interstate Drilling Services	12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline Rig w/ Cathead
4. HOLE NO. (as shown on drawing and file number): PB_Geo_05	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 2 Jars; UNDISTURBED —
5. NAME OF DRILLER: Dale Tokar	14. TOTAL NUMBER CORE BOXES: —
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER: Surface: 666.8'
7. THICKNESS OF OVERBURDEN: —	16. DATE HOLE: STARTED 21 Sept 22; COMPLETED 21 Sept 22
8. DEPTH DRILLED INTO ROCK: —	17. ELEVATION TOP OF HOLE: 668.3'
9. TOTAL DEPTH OF HOLE: 10.0'	18. TOTAL CORE RECOVERY FOR BORING: — %
	19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		TOP OF Deck			
	0.2	Deck	AIR (O_2)			1) Location Lat: 44.372906 Long: -91.983586 NAD83
	1.0	AIR				2) Elev. Pro-rated from Pool 4 elev.
666.8	1.5		(Water Surface)			
	2.0	WATER	Water (H_2O)			3) 140 lb hammer w/ cathead used for SPT @ 30" drop. 4) 2x2½ = 2" I.D. x 2½ O.D. Split Spoon Sampler.
	3.0					
	4.0		(Ground Surface)			
663.7	4.6		Silty Clay (CH)	2x2½		
	5.0	CH	- V. soft to ooz like - M. to high Plast - ~~wet~~ Saturated - Black to grey - 90% Fines - 10% F. sand - Organics (wood, Plant) - organic odor	Pound	S. #1 5.0 / 6.5	
	6.0					
661.8	6.5		Silty Sand (~~SP~~-SM)			
	7.0	~~SP~~	- Loose - Wet - Reddish brown to brown w/ grey laminations			
	8.0	SM	- 75% F. Sand - 20% silt - 5% Clay - Tr. roots - Fe staining	R: 2.5 T: 8.0 SPT 2	S. #2 8.0 / 9.1	
				3		
	9.0			3		5) Pulled Sampler & allowed hole to collapse
658.3	10.0		End of Boring	3 R: 1.1 T: 10.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP HOLE NO. 22-9M



St. Paul District
GEOLOGY
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US Army Corps of Engineers

2022 Big Lake HREP Borings

Base Image

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Hole No PZ-8M

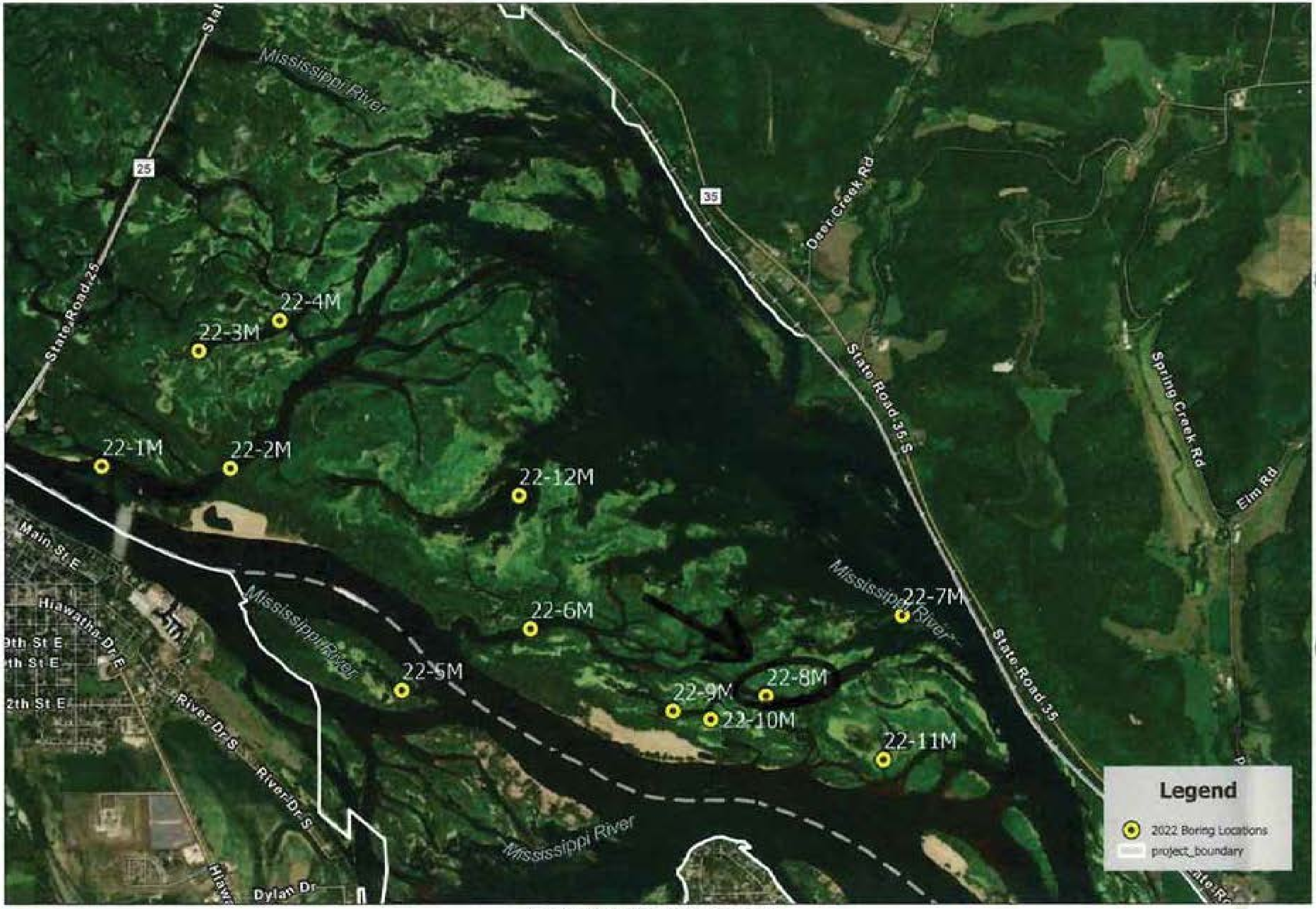
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 1 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): See Map
3. DRILLING AGENCY: Interstate Drilling Services
4. HOLE NO. (as shown on drawing and file number): PB_Geo_03
5. NAME OF DRILLER: Dave Tokar
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED — DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 10.0'
10. SIZE AND TYPE OF BIT: —
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline Rig w/ cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 1 Jar; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: Surface: 666.8'
16. DATE HOLE: STARTED 21 Sept 22; COMPLETED 21 Sept 22
17. ELEVATION TOP OF HOLE: 668.3'
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Top of Deck			
	0.2	Rock				
		AIR	AIR (O_2)			1) location Lat: 44.373623 Long: -91.976870 NAD83
	1.0					2) Elev. Pro-rated from Pool 4 elev.
666.8	1.5		(Water Surface)			
	2.0	WATER	Water (H_2O)			3) 140 lb hammer w/ cathead used for SPT @ 30" drop.
	3.0					4) 2x2½ = 2" O.D. x 2½ I.D. Split Spoon Sampler.
	4.0	WATER				
	5.0					
	6.0		(Ground Surface)			
661.7	6.6					
	7.0		Sand (SP) -Loose -Saturated -Brown -95% F.-M. Sand -5% Fines -Tr. C. Sand -Tr. F. Gravel	2x2½ Pound	SS1 6.6/8.0	
	8.0	SP				
	9.0					5) Pulled Sampler & allowed hole to collapse
658.3	10.0		End of Boring	R 1/3 T. 10.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP HOLE NO. 22-8M



St. Paul District
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US Army Corps
of Engineers®

2022 Big Lake HREP Borings

Base Image:

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Feet

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Hole No. 22-7M

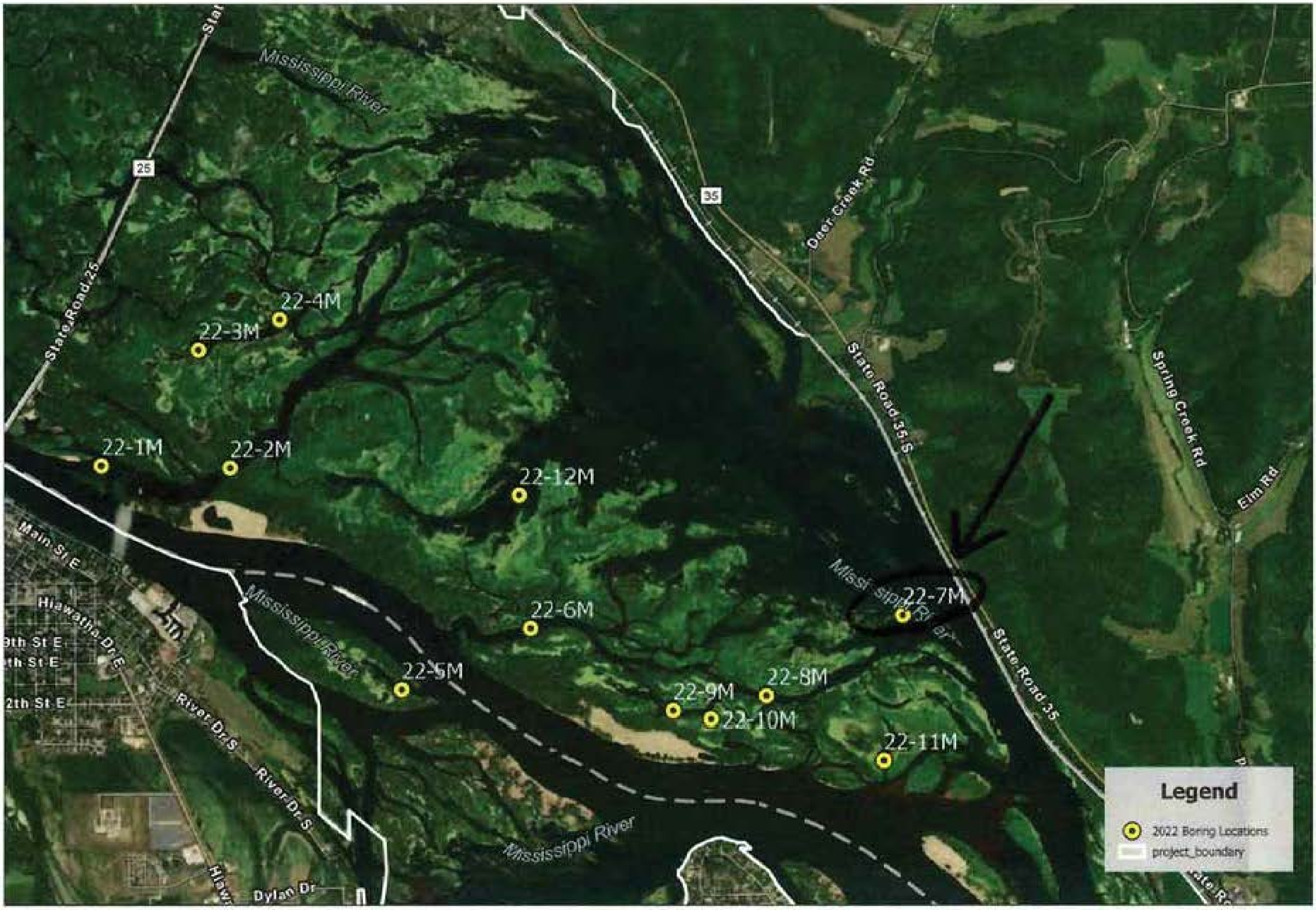
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 1 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) See Map	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88
3. DRILLING AGENCY Interstate Drilling Services	12. MANUFACTURER'S DESIGNATION OF DRILL Jack Line Rig w/ Cathead
4. HOLE NO. (as shown on drawing and file number) PB_Geo_02	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED: 2 Jars; UNDISTURBED: —
5. NAME OF DRILLER Dave Tokar	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER Surface: 666.8'
7. THICKNESS OF OVERBURDEN —	16. DATE HOLE — STARTED 20 Sept 22; COMPLETED 20 Sept 22
8. DEPTH DRILLED INTO ROCK —	17. ELEVATION TOP OF HOLE 668.3'
9. TOTAL DEPTH OF HOLE 10.0'	18. TOTAL CORE RECOVERY FOR BORING — %
	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Top of Deck			
	0.2	Deck / AIR	AIR (O_2)			1) Location: Lat 44.377697 Long -91.967040 NAD 83
	1.0					2) Elev. Pro-rated from Pool 4 elev.
666.8	1.5		(Water Surface)			3) 140lb hammer w/ cathead used for SPT @ 30" drop.
	2.0	WATER	Water (H_2O)			4) 2x2½ = 2" I.D. x 2½ O.D. Split spoon sampler.
	3.0					5) Sampler pulled & allowed hole to collapse
	4.0					
	5.0	WATER				
	6.0					
	7.0		(Ground Surface)			
661.1	7.2	CH	Silty Clay (CH) - V. soft to ooze like - ~~Wet~~ Saturated organic odor - High Plast. - Dark grey - Tr. Shell fragments - 95% fines - 5% f. Sand	2x2½ Pound	S.N. 1 7.2/8.3	
	8.0					
660.0	8.3	~~SP~~ SM	Silty Sand (~~SP-SM~~) - V. loose to loose - Wet to Saturated - Dark grey to brown - 85% M to C. Sand - Tr. f. Gravel - 15% fines		S.N. 2 8.3/9.2	
	9.0					
658.3	10.0		End of Boring	X:20 T:100		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-7M



2022 Big Lake HREP Borings

Base Image:

2,000 1,000 0 2,000 Feet

St. Paul District
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Hole No. 22-6M

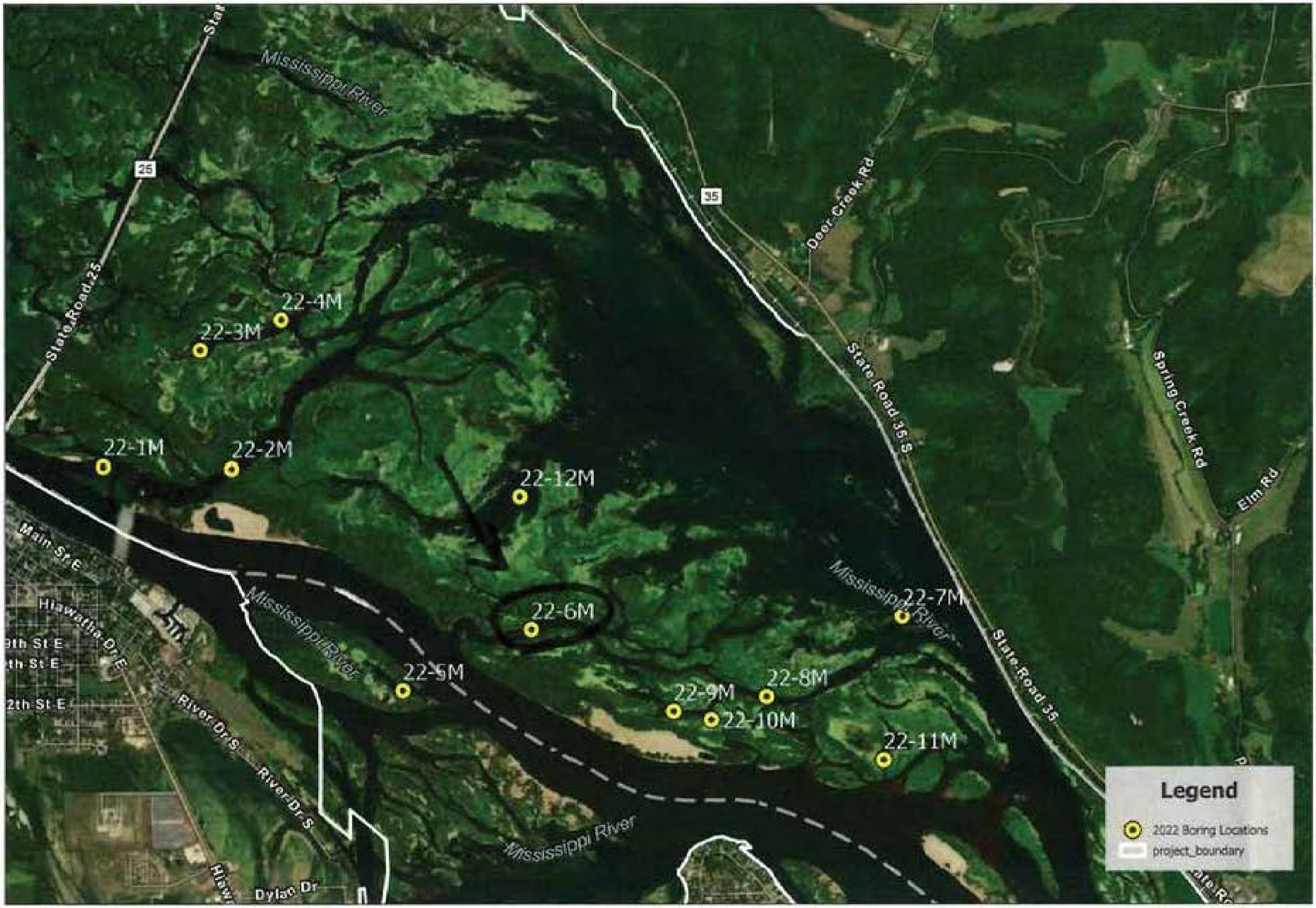
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 1 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): See Map
3. DRILLING AGENCY: Interstate Drilling Services
4. HOLE NO. (as shown on drawing and file number): PB-Geo_7
5. NAME OF DRILLER: Dave Tokar
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED — DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 10.0'
10. SIZE AND TYPE OF BIT: 4" Chopper Bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD88
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline Rig w/ Cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 3 Jars; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: Surface 666.8'
16. DATE HOLE: STARTED 20 Sept 22; COMPLETED 20 Sept 22
17. ELEVATION TOP OF HOLE: 668.3'
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Top of Deck			
	0.2	Deck / AIR	AIR (O2) ↓			1) Location: Lat: 44.377241 Long: -91.993642 NAD83
666.8	1.5	WATER	(Water Surface) Water (H2O) ↓			2) Elev. Pro-rated from Pool 4 elev. 3) 140 lb hammer w/ cathead used for SPT @ 30" drop. 4) 2x2½ = 2" I.D. x 2½" O.D. Split Spoon Sampler.
664.8	3.5		(Ground Surface)			
664.3 / 664.2	4.0 / 4.1	ML / WP / ML	Sandy Silt w/ clay (ML) - V. loose - Wet to Saturated - No Plast. - Dark grey - Wood @ 4.0' - Sl. dilatation - 60% silt - 10% clay - 30% f. sand	SPT 0, 0, 0; R: 0.7 T: 5.4; 2x2½	S.N. 1; 5.0/5.4	
662.6	5.7	~~SP~~ SM	Silty sand (~~SP-SM~~ SM) - V. loose - Wet to Saturated - Grey to brown - 70% F.-M. ~~SP~~ Sand - 30% Fines	Pound	S.N. 2; 5.7/6.7	
661.6	6.7	SP	Sand (SP) - V. loose - Saturated - Brown - 95% M. or F. gr. Sand - 5% Fines - Inter bedded - ~0.5' thick lenses of Fine & M. Sands	R: 2.3 T: 8.0; SPT 2, 3, 4, 5; R: 1.0 T: 10.0	S.N. 3; 8.0/9.0	5) - Set 4" Alluminum Pipe casing to 8.0' & clean hole w/ H2O & Chopper bit. 6) - Pulled all casing & allowed hole to collapse to ground surface
658.3	10.0		End of Boring			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP | HOLE NO. 22-6M



2022 Big Lake HREP Borings

Base Image:

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St. Paul District GEOLOGY GEOTECHNICAL

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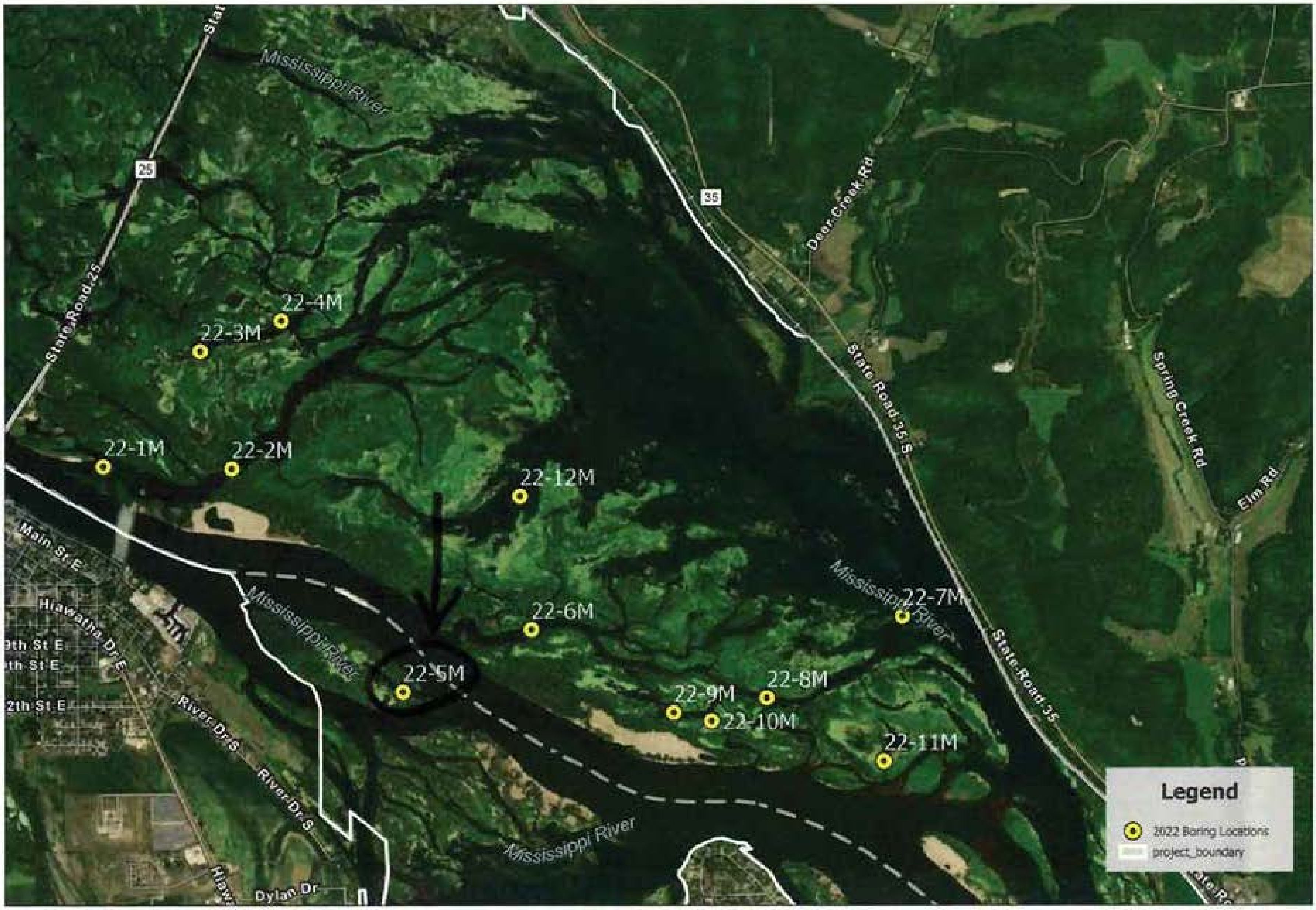
Hole No. 22-5M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 1 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT —
2. LOCATION (Coordinates or Station) See Map	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88
3. DRILLING AGENCY Interstate Drilling Services	12. MANUFACTURER'S DESIGNATION OF DRILL Jerkline w/ Cathead
4. HOLE NO. (as shown on drawing and file number) PB-Gen-9	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED 4 Jars — UNDISTURBED —
5. NAME OF DRILLER Dave Tokar	14. TOTAL NUMBER CORE BOXES —
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER Surface: 666.8'
	16. DATE HOLE STARTED 20SEP22 COMPLETED 20SEP22
7. THICKNESS OF OVERBURDEN —	17. ELEVATION TOP OF HOLE 668.3'
8. DEPTH DRILLED INTO ROCK —	18. TOTAL CORE RECOVERY FOR BORING — %
9. TOTAL DEPTH OF HOLE 10.0'	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		TOP of Dock			
	0.2	Dock	AIR (O_2)			1) Location: Lat: 44.378159 Long: -92.002930 NAD 83'
	1.0	AIR	(Water Surface)			2) Elev. Pro-rated from Pool 4 elev.
666.8	1.5	WATER	Water (H_2O) ↓			3) 140 lb hammer w/ cathead used for SPT @ 30" drop.
	2.0					4) 2X2½ = 2" I.D. x 2½ O.D. Split Spoon Sampler.
	3.0					
	4.0		(Ground Surface)			
663.7	4.6	SM	Silty Sand (SM) - V. Loose - Wet - Black - Some Shell Fragments - 70% M. Sand - 30% Fines - Some organics	2X2½ Pound		
663.4	4.9					
	5.0	CH				
663.1	5.2		Sandy Clay (CH) - V. Soft - M. Plast. - Wet - Black - 70% Fines - 30% F. Sand		S.N. 1 4.6/4.9	
	6.0	SP	Sand (SP) - Loose - Saturated - Tan to Light brown - 98% M. Sand - 2% Fines		S.N. 2 4.9/5.2	
	7.0					
660.8	7.5			R: 7.0 T: 8.0		
	8.0		Sand (SP) - Loose - Saturated - Tan to Light Brown - 98% F. Sand - 2% Fines - Some M. Sand	SPT 1	S.N. 3 6.6/6.6	5) Pulled Casing & allowed hole to collapse
	9.0	SP		2 3	S.N. 4 8.9/9.0	
658.3	10.0		End of Boring	4 R: 11.0 T: 9.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT Big Lake HREP HOLE NO. 22-5M



2022 Big Lake HREP Borings

Base Image:

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Hole No. 22-4M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 2 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): See Map
3. DRILLING AGENCY: Interstate Drilling Services
4. HOLE NO. (as shown on drawing and file number): PB_Geo_10
5. NAME OF DRILLER: Dave To Kar
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED — DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 11.0'
10. SIZE AND TYPE OF BIT: —
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline Rig w/ Cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 2 Jars; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: Surface: 666.8'
16. DATE HOLE: STARTED 19 Sept 22; COMPLETED 19 Sept 22
17. ELEVATION TOP OF HOLE: 668.3'
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
668.3	0.0		Top of Deck			
	0.2	Deck / AIR	Air (O_2) ↓ (water surface)			1) Location Lat: 44.393261 Long: -92.011353 NAD 83
666.8	1.5	WATER	Water (H_2O) ↓ (Ground Surface)			2) Elev. Pro-rated from Pool 4 elev. 3) 140 lb hammer w/ cathead used for SPT @ 30" drop. 4) 2X2¼ = 2" I.D X 2½ O.D. Split Spoon sampler.
664.4	3.9					
664.1	4.0–4.2	OH	Organic Ooze (OH) - V. soft (ooze like) - ~~Wet~~ Saturated - Vegetation - Black - Roots	2X2½ Pound		
	5.0	CL	Lean Clay w/ sand (CL) - V. soft - Low to no Plast. - wet - 80% Fines - grey - 20% M-C Sand - incr. sand at contact		SM 1 4.2/5.8	
662.5	5.8 / 6.0	CL	Lean Clay (CL) - V. soft - Saturated - Low to M. Plast. - grey - Plant fibers - 95% Fines - 5% F-M ~~C~~ Sand ↓	R: 2.0 T: 7.0 SPT 0 0 1	SM 2 7.0/8.2	
	9.0	CL	↓	R: 1.2 T: 9.0 SPT 0 0		
658.3	10.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP | HOLE NO. 22-4M

Hole No. 22-4M

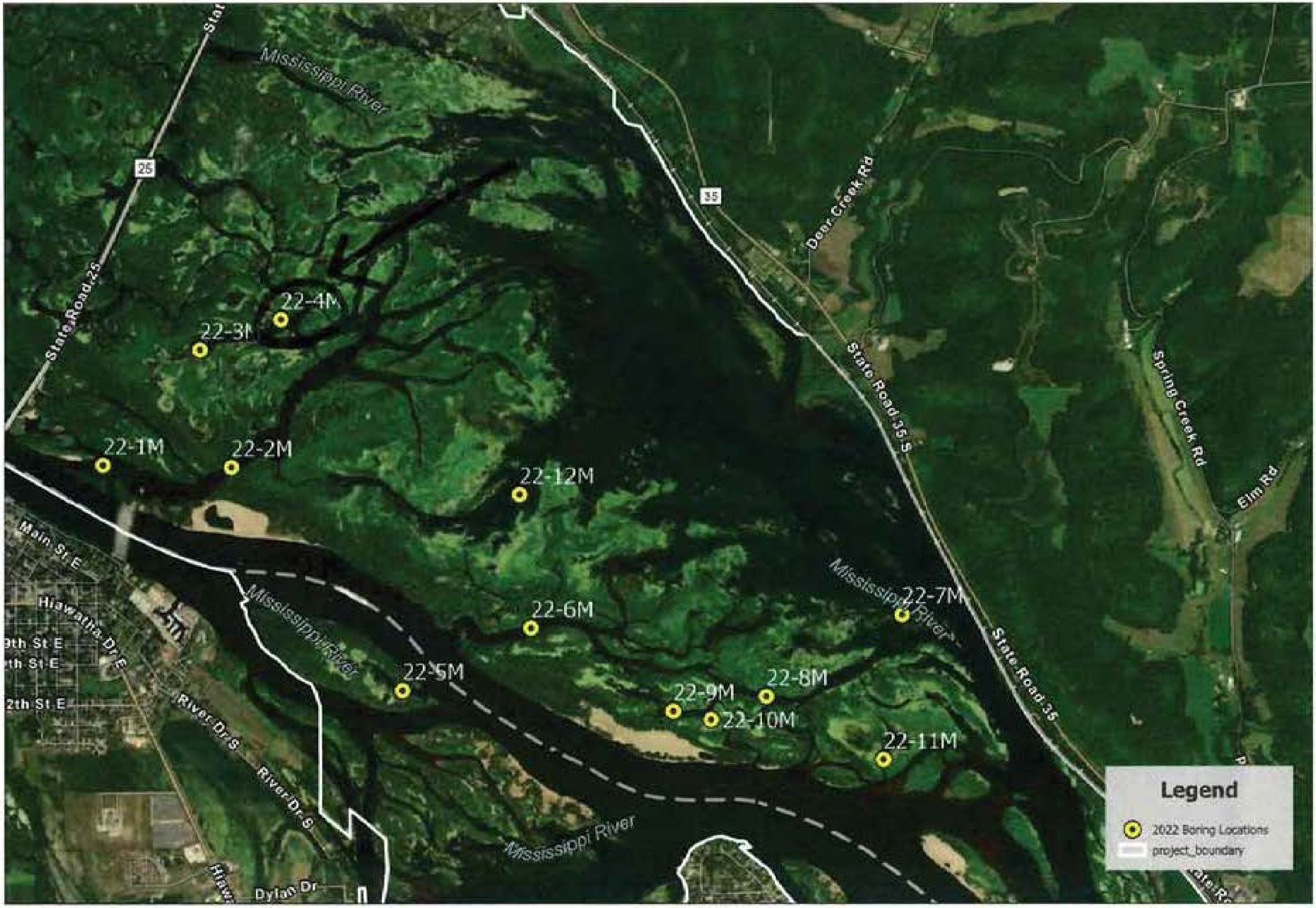
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 2 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR [signature]
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.3	10.0		(Cont'd)			
		CL	Lean Clay (CL) ~~See previous description~~ V. Soft Saturated L to M plasticity Gray Plant Fibers 95% fines 5% F-M Sand	1	1 T: 0.8 B: 11.0	5) Pulled casing & allowed hole to collapse
657.3	11.0		End of Boring			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-4M



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2022 Big Lake HREP Borings

Base Image:

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Feet

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Hole No. 22-3M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 2 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT —
2. LOCATION (Coordinates or Station) See Map	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88
3. DRILLING AGENCY Interstate Drilling Services	12. MANUFACTURER'S DESIGNATION OF DRILL Jon Kline Rig w/ Cathead
4. HOLE NO. (as shown on drawing and file number) PB-Geo_12	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED 4 Jars — UNDISTURBED —
5. NAME OF DRILLER Dave Tokar	14. TOTAL NUMBER CORE BOXES —
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER Surface: 666.8'
	16. DATE HOLE STARTED 19 Sept 22 COMPLETED 19 Sept 22
7. THICKNESS OF OVERBURDEN —	17. ELEVATION TOP OF HOLE 668.3'
8. DEPTH DRILLED INTO ROCK —	18. TOTAL CORE RECOVERY FOR BORING — %
9. TOTAL DEPTH OF HOLE 11.0'	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Top of Deck			
	0.2	Deck / AIR	AIR (O_2)			1) Location Lat: 44.391743 Long: -92.017244 NAD83
	1.0					2) Elev. Pro-rated from Post 4 elev.
666.8	1.5		(Water Surface) WATER (H_2O)			3) 140 lb hammer w/ cathead used for SPT @ 30" drop.
	2.0	WATER				4) 2 X 2½ = 2" I.D. x 2½" O.D. Split Spoon Sampler.
	3.0					
664.4	3.9		(Ground Surface)			
	4.0	CL	Lean Clay w/ organics (CL) - V. soft - wet - Low to M. Plast - Dark grey w/ green mottle (slight) - 90% fines - 10% F.-M. Sand - Tr. C. Sand (transitional)	2X2½ Pound	S.N. 1 3.9/5.0	
	5.0					
662.3	6.0	Lean clay interbedded w/ sand	~~Clay w/ Sand (CL)~~ (CL/SP) - V. soft to loose - Low to M. Plast - saturated - Grey w/ green - Fe stained roots - Interbedded - 70% Fines - 30% M. gr. Sand (transitional)	R: 2.1 T: 7.0 SPT 0 1	S.N. 2 6.0/7.2	
	7.0	CL/SP				
660.2	8.0 8.1	CL	Lean Clay (CL) - V. Soft - Low plast. - Saturated - Grey w/ Sl. green/tan mottle - 95% fines - 5% M. Sand - Tr. C. Sand	1 1 R: 1.7 T: 9.0		
659.2	9.0	CL		SPT 1 1	S.N. 3 9.0/9.0	
658.3	10.0		See description, next page			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-3M

Hole No. 22-3M

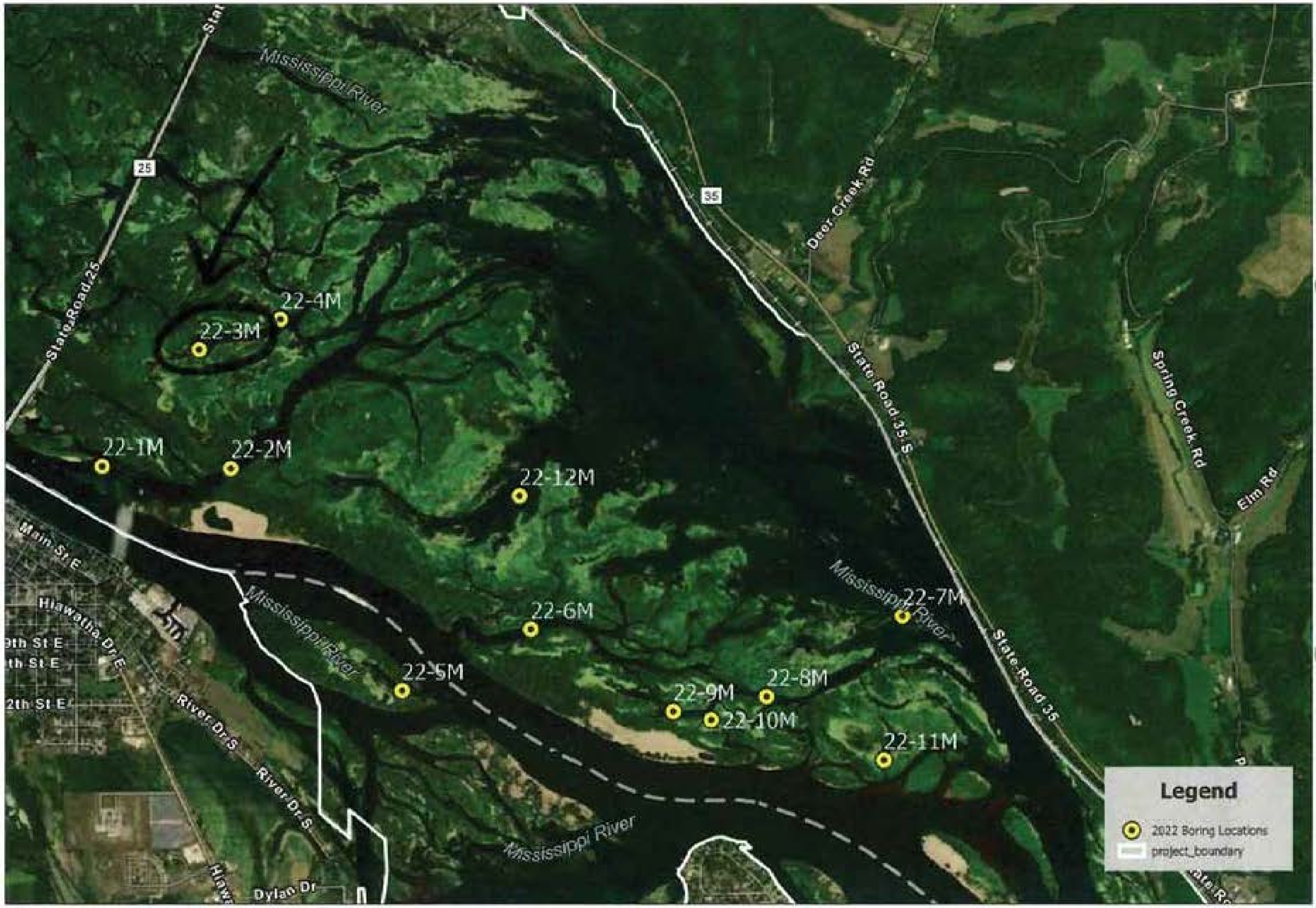
DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 2 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION	DEPTH	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.03	10.0		(Cont'd)			
		CL	Lean clay w/ sand (CL) - Soft to v. soft - low to M. plast - Saturated to wet - Grey - Sl. Brown to tan nodules - 80% fines - 20% M. to C. sand - Tr. vegetation - Blue-green mottle (Q.)	1 2 R: 1.5 T: 11.0	S/N 4 9.6/10.5	S) Pulled Sampler & allowed hole to Collapse
657.3	11.0		End of Boring			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-3M



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps
of Engineers

2022 Big Lake HREP Borings

Base Image:

2,000 1,000 0 2,000
Feet

K:\PROJECTS\UMRR(EMP)\Pool_4-MVP_Lower_Pool_4_Big_Lake_456702\Discipline_Working_Folders\Geotech_Geology\ArcMap\LP4_Big_Lake 5.30.22 AMW

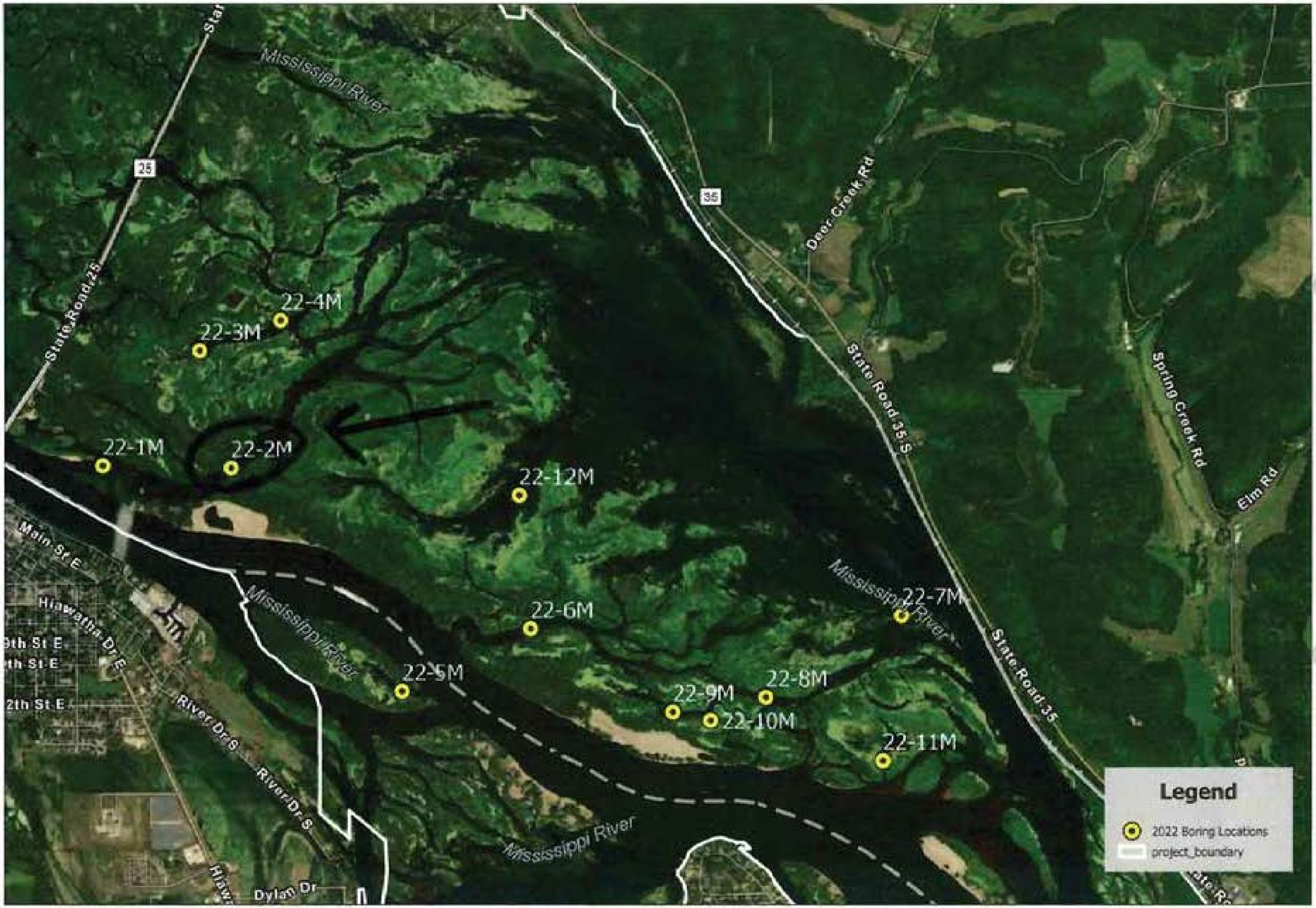
Hole No. 22-2M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 1 SHEETS
1. PROJECT Big Lake HREP		10. SIZE AND TYPE OF BIT —	
2. LOCATION (Coordinates or Station) See Map		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88	
3. DRILLING AGENCY Interstate Drilling Services		12. MANUFACTURER'S DESIGNATION OF DRILL Jerk line Rig w/ Cathead	
4. HOLE NO. (as shown on drawing and file number) PB-Geo-15		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED 1 Jar / UNDISTURBED —
5. NAME OF DRILLER Dave Tokar		14. TOTAL NUMBER CORE BOXES —	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED — DEG. FROM VERT.		15. ELEVATION GROUND WATER Surface: 666.8'	
		16. DATE HOLE	STARTED 19 Sept 22 / COMPLETED 19 Sept 22
7. THICKNESS OF OVERBURDEN —		17. ELEVATION TOP OF HOLE 668.3'	
8. DEPTH DRILLED INTO ROCK —		18. TOTAL CORE RECOVERY FOR BORING — %	
9. TOTAL DEPTH OF HOLE 13.0'		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Top of deck			
	0.2	Deck / AIR	Air (Air)			1) Location Lat: 44.385677 Long: -92.015050 NAD83
	1.0					
666.8	1.5		(Water Surface)			2) Elev. pro-rated from Pool 4 elev.
		WATER	Water (H₂O)			3) 140 lb hammer w/ cathead used for SPT @ 30" drop
	11.0					
657.1	11.2		(Ground Surface)			
			Sand (SP) - V. loose - Wet - Brown - Tr. dark grey laminations - 100% F-M. gr sand - Organic odor	SPT 0 / 1 / 0 / 0		
	12.0	S			S.N. 1 11.2/12.0	
655.3	13.0			R: 0.8 T: 13.0		4) Pulled sampler & allowed hole to collapse
			End of Boring			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-2M



St. Paul District
GEOLOGY
GEOTECHNICAL
US Army Corps of Engineers

2022 Big Lake HREP Borings

Base Image

2,000 1,000 0 2,000
Feet

N

X:\PROJECTS\UMRR(EMP)\Pool_4-MVP_Lower_Pool_4_Big_Lake_498792\Discipline_Working_Folders\Geotech_Geology\ArcMap\LP4_Big_Lake 9.29.22 AMW

Hole No. 22-1M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 2 SHEETS
1. PROJECT Big Lake HREP		10. SIZE AND TYPE OF BIT 4" Chopper Bit	
2. LOCATION (Coordinates or Station) See Map		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) NAVD 88	
3. DRILLING AGENCY Interstate Drilling Services		12. MANUFACTURER'S DESIGNATION OF DRILL Jerkline w/ Cathead	
4. HOLE NO. (as shown on drawing and file number) PB_Geo_M		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED 3 Jars / UNDISTURBED —
5. NAME OF DRILLER Dave Tokar		14. TOTAL NUMBER CORE BOXES —	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.		15. ELEVATION GROUND WATER Surface: 666.8'	
		16. DATE HOLE	STARTED 19 Sept 22 / COMPLETED 19 Sept 22
7. THICKNESS OF OVERBURDEN —		17. ELEVATION TOP OF HOLE 668.3'	
8. DEPTH DRILLED INTO ROCK —		18. TOTAL CORE RECOVERY FOR BORING — %	
9. TOTAL DEPTH OF HOLE 12.0'		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0	Deck	Top of Deck			
	0.2	AIR	Air (O2)			1) Location Lat: 44.385869 Long: -92.029283 NAD 83
	1.0					2) Elev. Pro-rated from Pool 4 elev.
666.8	1.5		(Water Surface)			
	2.0	WATER	Water (H2O)			3) 140 lb hammer w/ cathead used for SPT @ 30" drop.
	3.0					4) 2x2¼ = 2" I.D. x 2½" O.D. Split Spoon Sampler.
665.0	3.3		(Ground Surface)			
	4.0	SP	Sand (SP) V. loose - Wet to saturated - Tan to light brown - 98% F.-M. ~~gr~~ Sand - 2% fines - Tr. C. Sand - Tr. M. ~~gr~~ gravel - Tr. Shell fragments	2x2¼ P O 4 n d	S.N. 1 3.3/4.3	
663.5	4.8					
	5.0					
	6.0	SP	Sand (SP) - V. loose - saturated - Brown to gray - 95% F. Sand - 5% fines - Tr. organics	R: 2.0 T: 6.0 SPT 1 1 1	S.N. 2 4.8/5.3	
	7.0					5) - Set casing to 7.0' & clean w/ H2O & chopper bit.
	8.0			2 R: 0.9 T: 8.0 SPT 0 1 1 2		6) Cave in from Site No. 6 Sampled.
	9.0					7) Clean out to 10.0' w/ H2O & chopper bit.
658.3	10.0			R: 0.0 T: 10.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP | HOLE NO. 22-1M

Hole No. 22-1M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 2 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE

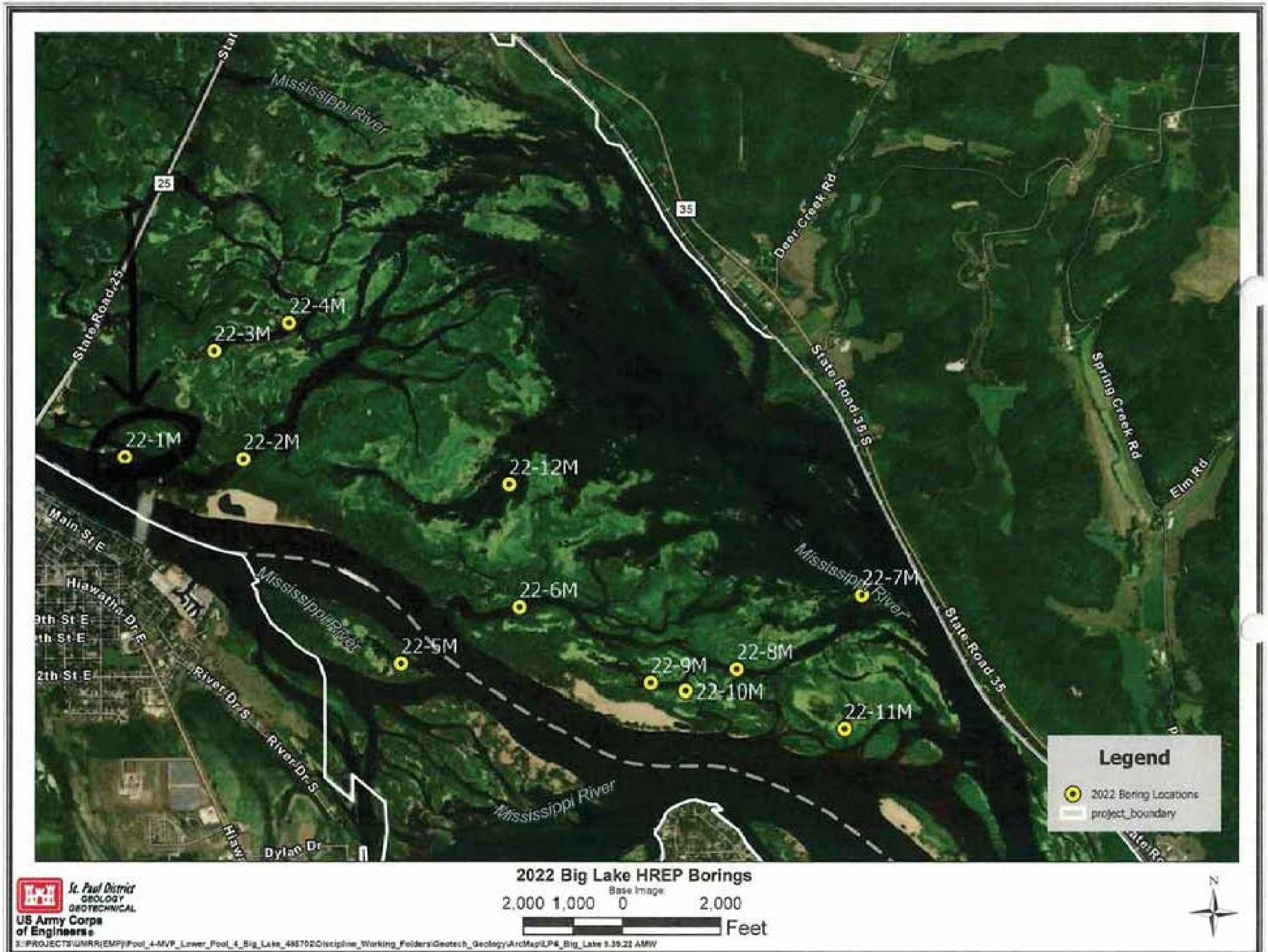
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.3	10.8		Cont.			
	11.0	SP	Sand (SP) - V. Loose - Saturated - Brown ~~V.~~F. to M. Sand - 2% Fines - Trace C. ~~Gr.~~ Sand	SPT 1 1 1 1 R: 11.0 T: 12.0	S.N. 3 10.0/11.0	8) - Pulled all casing & allowed hole to cave to ground surface.
656.3	12.0		End of Boring			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP

HOLE NO. 22-1M


Mississippi River
Mississippi River
Mississippi River
Mississippi River
State Road 25
25
35
Deer Creek Rd
State Road 35 S
State Road 35
Spring Creek Rd
Elm Rd
Main St E
Hiawatha Dr E
9th St E
2th St E
River Dr S
River Dr S
Dylan Dr
22-1M
22-2M
22-3M
22-4M
22-5M
22-6M
22-7M
22-8M
22-9M
22-10M
22-11M
22-12M
Legend
2022 Boring Locations
project_boundary
St. Paul District
GEOLOGY
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US Army Corps of Engineers
2022 Big Lake HREP Borings
Base Image:
2,000 1,000 0 2,000
Feet
N

Hole No. 23-13M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 4 SHEETS

1. PROJECT Big Lake HREP (Pool 4)	10. SIZE AND TYPE OF BIT 3" Chopper Bit
2. LOCATION (Coordinates or Station) Boring GEO-10 44.38586, -92.01165	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) W.S. 1712 - 0.41 NAVD 88 = 666.5 @ Wabasha 666.9 - .41
3. DRILLING AGENCY MVP USACE	12. MANUFACTURER'S DESIGNATION OF DRILL Jerkline Rig w/ Cathead
4. HOLE NO. (as shown on drawing and file number) GEO-10	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED 8 Jars — UNDISTURBED
5. NAME OF DRILLER Mike Davis, Aaron Nelson	14. TOTAL NUMBER CORE BOXES —
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE STARTED 8/21/23 COMPLETED 8/21/23
7. THICKNESS OF OVERBURDEN —	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK — 0 —	18. TOTAL CORE RECOVERY FOR BORING — %
9. TOTAL DEPTH OF HOLE 30.0'	19. SIGNATURE OF INSPECTOR B. Anderson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.0	0.0					Location
	0.3		Deck			Lat 44.38586 Long -92.01165 NAD83
	1.0	AIR	Air			
666.5	1.5		Water Surface			2) Boring conducted from floating plant
	2.0		Water (H_2O)			3) 2x2½ = 2" ID by 2½" O.D. split spoon.
			Mississippi River			4) 140# hammer used w/Cathead for SPT 30" drop.
	3.0	H_2O				
	4.0					5) Elevation from Pool 4 Wabasha gage.
			Bottom Boring when sounded w/ metal pole			WH = weight of Rods + 140# hammer. WR = weight of Rods
	5.0		SANDY (OL) V. Soft Alluv. Black Saturated L plasticity			
662.0	6.0	OL	40% silt, clay organic 60% f-c sand	2x4½		
661.7	6.3		SANDY CLAY (CL) Alluv.			
	7.0		V. Soft Rusty oxidation mottles Saturated	4	S#1 6.7 7.7	LL = 47 PL = 20 WC = 33%
			M Plastic 10±% f-c sand 90% silt & clay Brown-grey	02.0 R1.7 SPT		Set 4" casing to 8.0' cleaned hole to 8.0' w chopper bit & H_2O.
	8.0	CL		1		
			Scattered roots & grassy organics	0		
	9.0			1		
				0	S#2 9.0 10.0	LL = 34 PL = 17 WC = 31%
658.0	10.0		Grey	D2.0 R2.0		

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PROJECT BIG LAKE HREP — HOLE NO. 23-13M

Hole No. 23-13M

DRILLING LOG	DIV. MVD	INSTALLATION St. Paul District	SHEET 2 OF 4 SHEETS

1. PROJECT BIG LAKE HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number) GEO 10	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.0	10.0		continued Sandy Clay (CL) Allav soft Saturated Grey 10% f-m Sand Dispersed & in irregular pockets	2x2½ WH		4" Casing pounded To 7.0' Clean hole to 10.0' w/ Chopper bit & H_2O.
	11.0	CL				
	12.0					
		SM	SM Seam	3 D3.0 R2.1	SH 3 11.5 12.5	LL = 35 PL = 17 WC = 34%
		CL				
655.2	12.8					
	13.0		Med-Fine SAND (SP) Alluvial Loose-M Dense Saturated Grey Brown <5% SILT 60% f Sand 35+% M Sand ↓ <2% Silt w/ Depth	SPT 2 5 14 20 D2.0 R2.0 2x2½ 22 24	SH 4 14.0 15.0	- Clean hole to 13.0 w/ Chopper bit & Water - Mix Mud 10# bentonite 50 gal H_2O. Clean hole to 15.0' w/ Mud & Chopper bit
	14.0					
	15.0	SP				
	16.0					
	17.0			23 D3.0 R2.4 SPT 3 4	SH 5 16.5 17.5	- Clean hole to 18.0 w/ Mud & chopper bit
	18.0					
647.0	19.0					
		SP	Fine Medium (SP) M. Dense Allav. Scattered silt (Tan) Sat. Grey-Brown	5 6 D2.0 R2.0		
645.0	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT BIG LAKE HREP | HOLE NO. 23-13M

Hole No. 23-13M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 3 OF 4 SHEETS
1. PROJECT BIG LAKE HREP		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (as shown on drawing and file number)		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
648.0	20.0		Continued. Fine-Med SAND Alluvial (SP)	2x2½		Clean hole to 20.0' w/ mud & chopping bit
			M. Dense Saturated Gray-Brown	17		
	21.0	SP	Subrounded fine gravel & coarse sand		SA6	
				21	21.0	
	22.0		<2% silt 55% med 42% fine SAND	22.0 / 22.0	22.0	Drill out 22.0-23.0'
	23.0					Clean hole to 23.0' w/ mud
				SPT 9		
				4		
	24.0					
643.7	24.5	GP	Sandy Gravel Sand fine/ sub-rounded	15	SA7	
		Fine SP	M. Fine Sand SP Alluv. M. Dense Gray Brown Saturated	6 / 22.0 / 22.0	24.3 - 25.0	
	25.0			2x2½		- Add 20 gal H2O to the remaining 30 gal Mud Mix. Added ≈ 10# Bentonite -
642.0	26.0		Approx.			Cleaned out to 28.0'
	27.0		Silty Fine Sand Alluv. (SM) M. Dense			Drill out firm & consistent with sandy soils.
		SM	Saturated Gray Brown			
	28.0		15-20% Silt 50% f sand 50% M sand	SPT 6		
				3	SA8 28.0-29.0	
	29.0			8		BOH 30.0' 8/22/23
				3 / 22.0 / 22.0		/
638.0	30.0		BOH			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

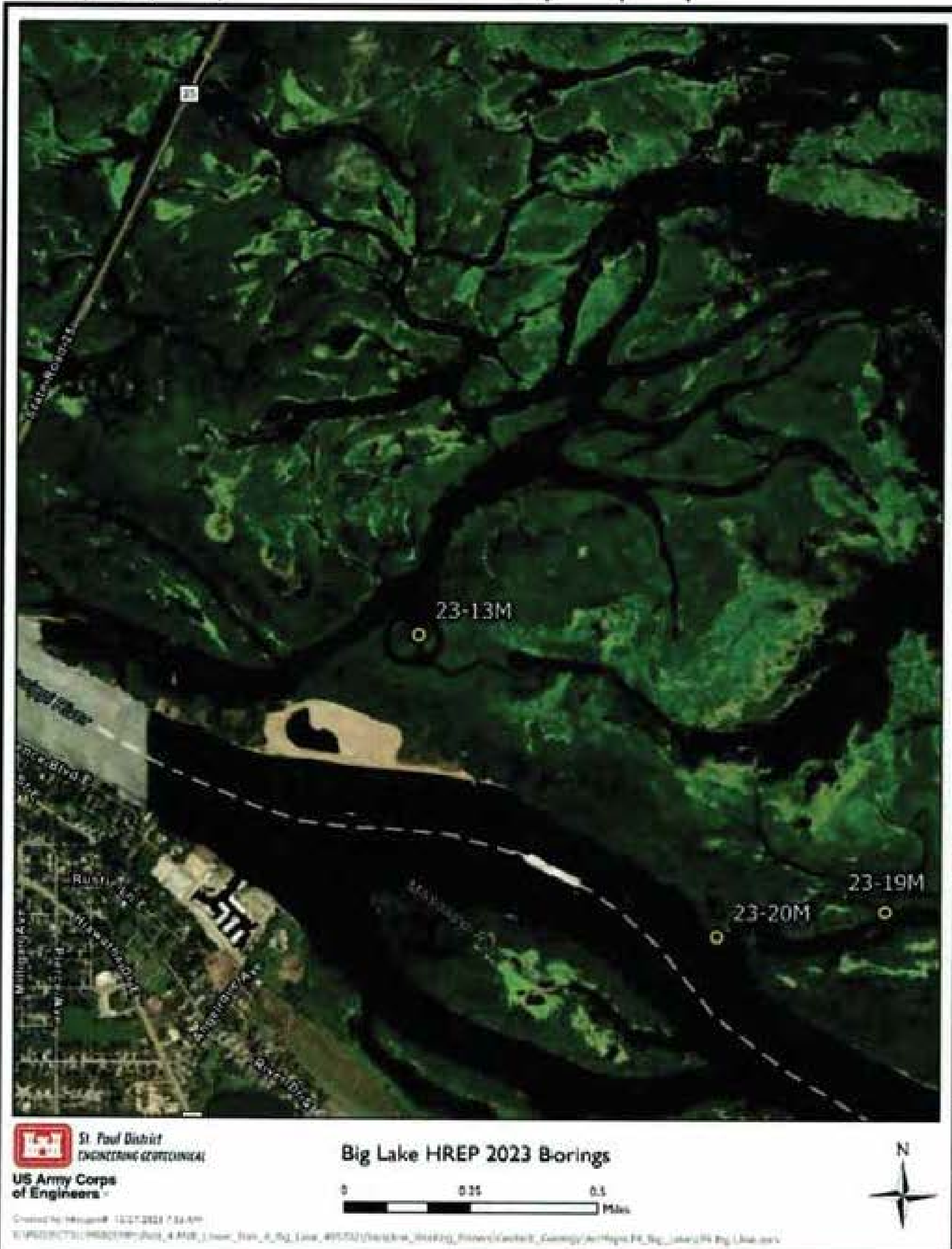
PROJECT BIG LAKE HREP | HOLE NO. 23-13M

Hole No. 23-13M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 4 OF 4 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Awood

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: Unmaped T&R



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-13M

Hole No. 23-14M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 4 SHEETS

1. PROJECT: Big Lake HREP (Pool 4)
2. LOCATION (Coordinates or Station): See Page 4 LAT 44.275812N Long -91.966383W NAD83
3. DRILLING AGENCY: USACE
4. HOLE NO. (as shown on drawing and file number): GEO-2
5. NAME OF DRILLER: Mike Dow, K. Nelson
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 25.0'
10. SIZE AND TYPE OF BIT: 3" chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD88 = 668.49 W.S. 1912 Datum 664.9 -.41
12. MANUFACTURER'S DESIGNATION OF DRILL: Skid rig / Catfood
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 7 JAR; UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER: 664.5 ≈ River Bottom
16. DATE HOLE: STARTED 6/22/23; COMPLETED 6/23/23
17. ELEVATION TOP OF HOLE: 668.0
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.0	0.0					1) Location Lat 44.27581 N Long -91.966383W NAD83
	0.3		Deck			
	1.0	Air	Air			2) Boring conducted from floating plant
666.5	1.5		(H_2O) Water Surface Ms. River			3) Sampler = Split spoon 2" ID, 2½" OD sampler.
	2.0					4) SPT, 140# hammer 30" drop, using rope & cathead
	3.0	H_2O	H_2O & Lily Pads			5) El. converted from 1912 datum to NAVD88 1912 -.41 = NAVD88
664.5	3.5		River Bottom	SPT		
	4.0	OL	Silty Organic Alluv. OL v. soft (mucky) Saturated 20-30% organics 70% silt & clay w/ some v.f. sand Grey	WR		
				WR	S#1	
				WR	3.5	
	5.0			DIS R1.0 2x ey		4" casing to 5.0' Driven
662.7	5.3	CL				
662.4	5.6		organics (wood, roots) & vegetation	WR		S#1 LL 20 PL N/A Wc = 38%
	6.0		Silty Clay Grey CL	9	S#2 5.6 6.6	
	7.0	SP	Fine Med. SAND Alluv. (SP) Loose Grey-Brown Saturated 45% F Sand 55% M	14		
				DIS R2.0		
	8.0			SPT 2		4" Casing to 8.0' driven
						S#3 Mix 50 gal H₂O & Bentonite
	9.0		Fe Staining throughout	3	8.0 9.0	
				5		
658.5	9.5		Fine SAND (SP) Loose Alluv. Saturated Grey-Brn	6		
658.0	10.0	SP		DIS R1.8		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: BIG Lake HREP HOLE NO. 23-14M

Hole No. 23-14M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET OF 4 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: USACE
4. HOLE NO. (as shown on drawing and file number):
5. NAME OF DRILLER: M Davis Kuehn
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 25.0
10. SIZE AND TYPE OF BIT: 3" Chopper
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88 = 666.4 TBM? 666.8
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkins
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 7 Jar; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 8/22/23; COMPLETED 8/23/23
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Hoffman

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.0	10.0		Continued			
	11.0	SP	Fine SAND (SP) Alluv. Loose - M. Dense Saturated Grey Brown Scattered f gravel & c sand 80% f sand 20% m sand	2x2 ½ 16 / 24 / 24	S#4 11.0 12.0	8/22/23 END of Drill Day 8/23/23 Start Drill out to 10.0 w/ mud & chopper bit. Pool came up SAN 666.99 + .41 = 666.58 up .1 from yesterday but did not adjust
655.7	12.0 12.3					
	13.0	SP	F-Med SAND Alluv (SP) Interbeds of fine SP Loose - M Dense Grey Brn 80% Med 20% fine sand	D3.0 R3.0 SPT 3 / 4 / 6	S#5 13.0 14.0	- Clean out to 13.0' w/ Chopper bit & mud
653.7	14.0 14.3	SP	Fine Sand (SP) Alluv. Loose M dense 60% f, 40% Med S	6 / D2.0 R1.5 2x2 ½		- Clean hole to 15.0'
652.7	15.0 15.3					
	16.0		Med SAND (SP) Alluv. L - med dense Brown Grey Saturated 20% f, 80% m SAND Scattered f. grav. & C. sand	13 / 19 / 15 D2.5 R2.0		
	17.0	SP	80 f. gravel			
	18.0			SPT 4 / 5	S#6 18.0 19.0	clean out to 18.0' Drill out from ! consistent w/ Sand
	19.0	SP	- Fine Seam	5		
648.0	20.0	SP	Med Sand (SP) Continued Brown-Grey	D R1.5		Clean hole to 20.0 w/ Mud & Chopper Bit

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: BIG Lake HREP | HOLE NO. 23-14M

Hole No. 23-14M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 3 OF 4 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number) CEO 2
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
648.0	20.0	SP	Continued Medium SAND (SP) Alluv.	SPT 4		
		ESP	Loose - Med Dense	3		
	21.0	SP	Saturated Gray	4		
			80±% m. SAND 20±% f.	5 DZ.0 R1.7		
	22.0		Scattered c. Sand & thin fine sand seams < 0.1'.			- Clean hole to 23.0 w/ mud & chopper bit. Drill out firm & w/ early cuttings
	23.0			SPT 7		
				4	S#7	
	24.0			7	23.9 24.0	
				5 DZ.0 R1.5		
643.0	25.0		BOH			- BOH 25.0' Pulled casing, Allowed boring to heave. Hole ended @ 25' vs. 35' due to Sandy & m. Dense.
			Location: See Attached Map.			
638.0						

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

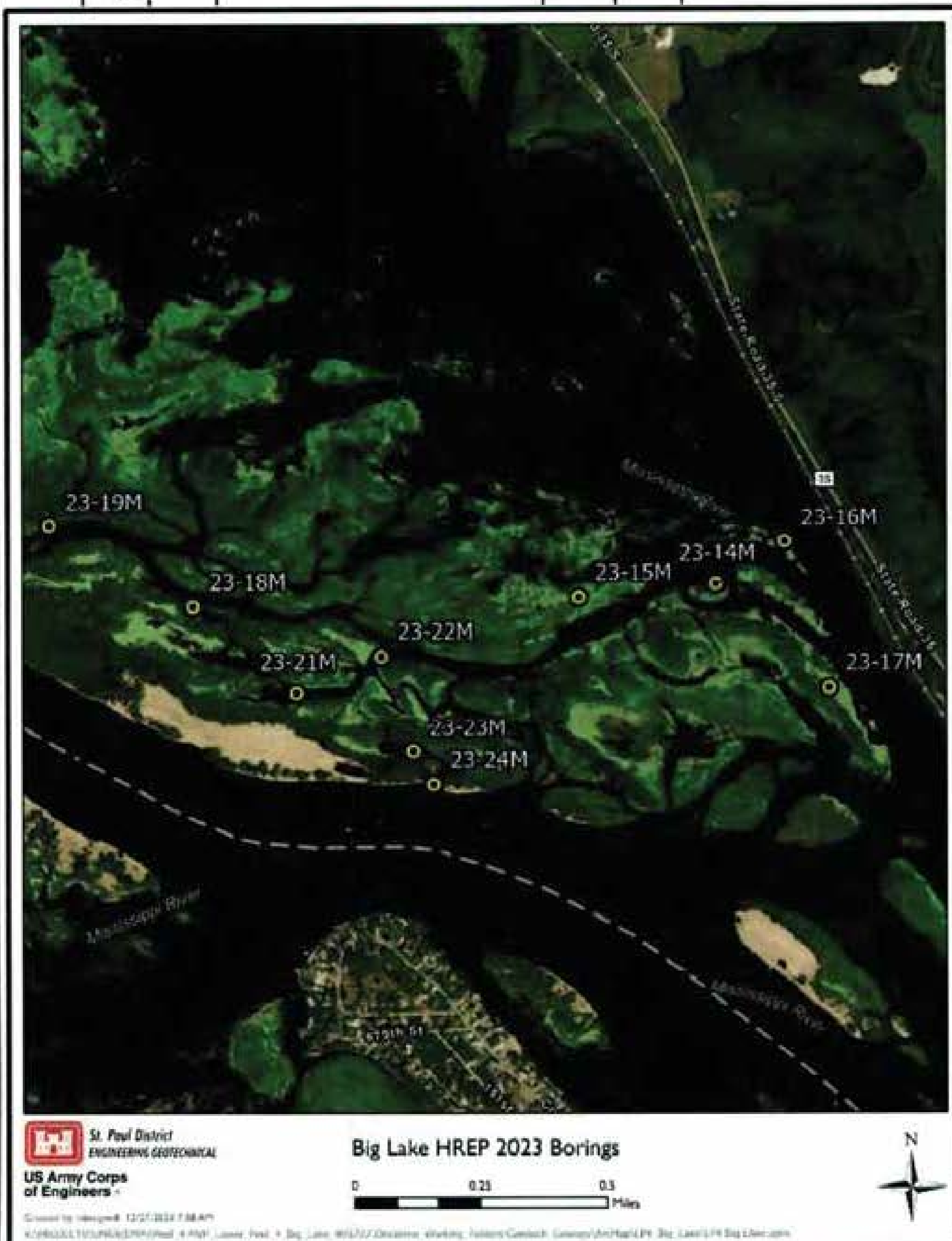
PROJECT Big Lake HREP | HOLE NO. 23-14 M

Hole No. 23-14M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 4 OF 4 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR A. Wood

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W NW¼ Sec. 21



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-14M

Hole No. 23-15M

DRILLING LOG

DIVISION	MVD
INSTALLATION	St. Paul District
SHEET 1 OF 3 SHEETS	
1. PROJECT	Big Lake HREP (Pool 4)
2. LOCATION (Coordinates or Station)	Lat/Long 44.375471 N -91.971902 W
3. DRILLING AGENCY	USACE MVP
4. HOLE NO. (as shown on drawing and file number)	GEO 04
5. NAME OF DRILLER	Mike Davis K Nelson
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	—
9. TOTAL DEPTH OF HOLE	20.0'
10. SIZE AND TYPE OF BIT	3" Chopp. Bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	NAVD 88 1912 -.41 = NGVD 88; W.S. = 666.99 -.41
12. MANUFACTURER'S DESIGNATION OF DRILL	Jackline Cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED: 6 Jar; UNDISTURBED: —
14. TOTAL NUMBER CORE BOXES	—
15. ELEVATION GROUND WATER	= River Bot. = 664.1
16. DATE HOLE	STARTED 8/23/23; COMPLETED 8/23/23
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	— %
19. SIGNATURE OF INSPECTOR	[illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.1	0.0	Air	Deck			1) Location 23-15M Lat. 44.375471 N Long -91.971902 W NAD83 W.S. 666.99 -.41 = 666.6
666.6	1.5		Water Surface			2) Borings conducted from floating plant
	2.0	H2O	H_2O			3) 2 x 2½ = 2" ID by 2½" O.D. Split Spoon.
	3.0					4) 140# hammer used w/cathead for SPT, 30" drop.
664.1	4.0	SM	River Bottom; Organic Fine SAND SM V. Loose	23%		5) Elevation from Pool 4 Wabasha gage. (same as L/D4)
	4.6		5% Plant roots	P		
	5.0	SP-SM	& Dark grey organic silt; Saturated	U	SS1 5-5.6	
662.3	5.8	Gry Brn	Grey 15% Fines 65% f. sand	S H		
	6.0	SP-SM	Silty Fine SAND Alluv. (SP-SM) V. Loose 10-12% Fines Saturated Grey Faint & thin laminations	10	SS2 5.8-6.5	[illegible] 10' [illegible] Clean hole to 8.0' w/ [illegible]
	7.0	ML		44.0 / 47.5		
	8.0	SP-SM		2		
659.4	8.7	Brn Grey	Silty Fine SAND Alluv. SP-SM V. Loose Brown	5		
	9.0	Silty SM / SP	Laminated w/ Scattered < 1 cms. seams	6	SS3 8.7-9.5	
658.1	10.0		Fine SAND SP Grey	6		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP

HOLE NO. 23-15M

Hole No. 23-15M

DRILLING LOG	DIVISION MVD	INSTALLATION St Paul District	SHEET 1 OF 3 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: USACE
4. HOLE NO. (as shown on drawing and file number):
5. NAME OF DRILLER: Mike Davis, K Nelson
6. DIRECTION OF HOLE: VERTICAL / INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE:
10. SIZE AND TYPE OF BIT: 3" Chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD88
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED / COMPLETED
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.1	10.0		Continued			
		SP	M-Fine SAND (SP) Alluv. Med Dense Saturated Gray 80% F, 20% M SAND	SPT 3, 8, 7	S#4 10.5-11.5	Clean hole to 10.0' w/ mud & chopper bit
	11.0					
		SP	med. Scattered med beds	7 D2.0 R2.0		
	12.0	SP				
	13.0			SPT 3		Clean to 13.0' w/ mud & chopper bit.
	13.6		M,C sand seam			
	14.0	SP	60% F, 40% M SAND Gray Saturated Faint Laminations evident Med Dense	6, 7, 8 D2.0 R1.5		
	15.0			SPT 3, 5, 7, 8 D2.0 R2.0	S#5 18.0-19.0	
	16.0					
	17.0					
	18.0	SP	Continued M-F SAND (SP) Alluv. Med Dense Gray Med. Dense	SPT 6, 8, 7, 8 D2.0 R2.0	S#6 18.5-19.5	Drill out to 18.0' w/ mud & chopper bit
	19.0					8/23/23 BOH 20.0' End of day. Excessive heat >100°. 8/24/23 19' of M. Dense SP
648.1	20.0		B.O.H.			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

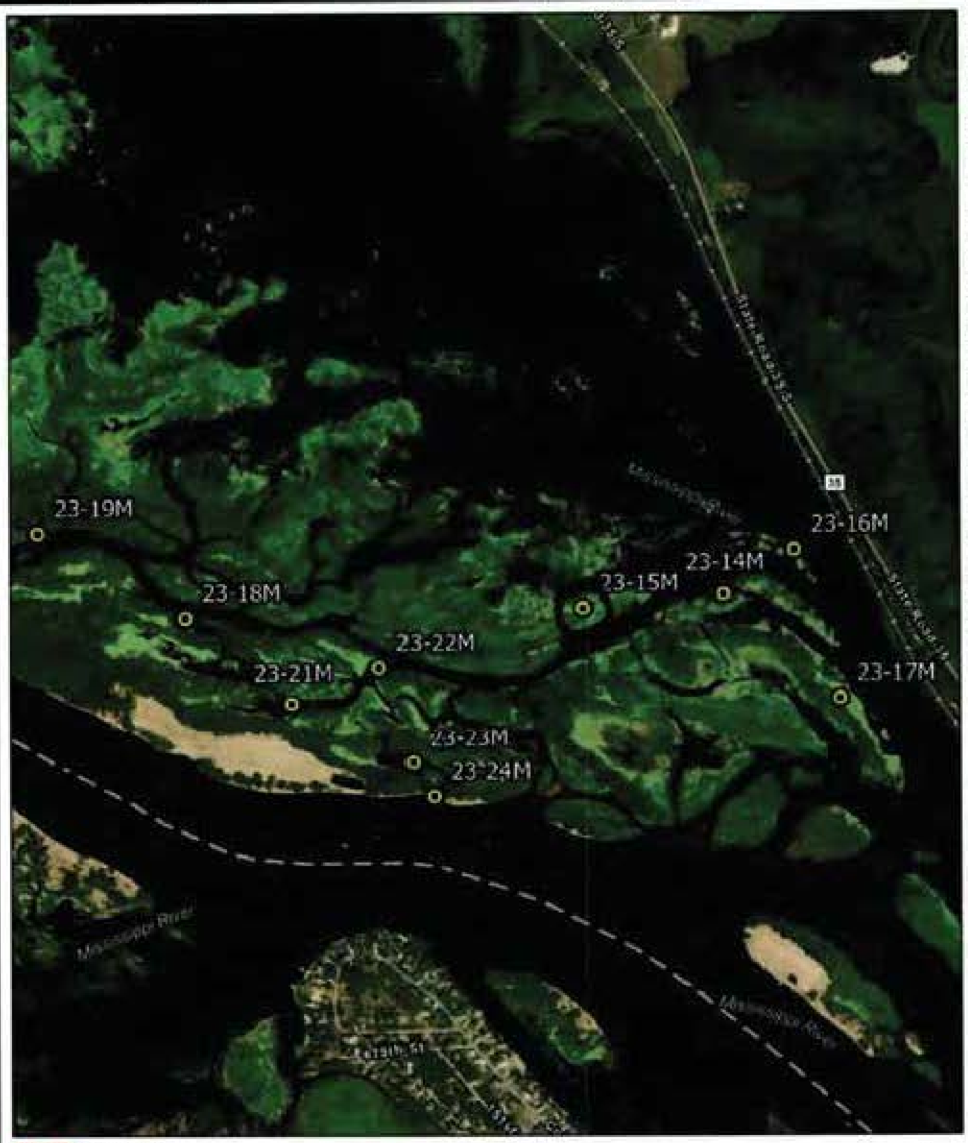
PROJECT: Big Lake HREP | HOLE NO. 23-15M

Hole No. 23-15M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 3 OF 3 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W NW 1/4 Sec. 21



St. Paul District ENGINEERING GEOTECHNICAL
US Army Corps of Engineers

Big Lake HREP 2023 Borings

0 0.25 0.5 Miles

N

Hole No. 23-16M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET of 6 SHEETS

1. PROJECT: Big Lake HREP (Pool 4)
2. LOCATION (Coordinates or Station): MVP USACE, See Drawing pg 6
3. DRILLING AGENCY: USACE MVP
4. HOLE NO. (as shown on drawing and file number): GEO-03
5. NAME OF DRILLER: Mike Dwyer & Nelson
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 25.0'
10. SIZE AND TYPE OF BIT: 3" Chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88; WS = 666.57
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline & Cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 11 Jar; UNDISTURBED 1 tube - 3" Shelby
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: = River Bottom
16. DATE HOLE: STARTED 8/24/23; COMPLETED 8/24/23
17. ELEVATION TOP OF HOLE: 669.1 - Deck
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
669.1	0.0					
	0.3		Deck			1) Lat 44.377416N Long -91.963609 Approx 25' from GEO-03
	1.0	O2	Air			2) Boring from Floating Plant.
666.6	1.5		Water surface			3) 2x2½ = 2" inner diameter by 2½" outer diam. split spoons
	2.0	H_2O	MS River			4) SPT = 140# hammer dropped 30" with standard split spoon.
665.1	3.0		River Bottom			5) Elevated from Webasha gage < 0.1' different than Alma Pool.
		OL	Silty Organics (OL) Alive Med Plastic Black, Saturated Plant roots	WR	S#1	
	4.0	SP-SM		WH	3.0 4.0	WR = weight of rod; WH = weight of 140# hammer
		OL	amorphous silty organics w/ some clay & fine sand; 10-15% f sand; 85% silty organics	WH	S#2	LL = 31; PL = 26; WC = 45%
	5.0			WH; 2x2½	4.1 5.0	4" casing to 5.0'; clean hole to 5.0' w/ mud
				WR		
	6.0		V.V. Soft silty Mucky			Sample barely
		SM	f. sandy Seam 70% f sand 10% silt	WH	S#3 5.5 6.5	
	7.0	OL				— See offset boring 23-16MU for 3" Shelby
				WH		4" casing to 7.5'
	8.0			D.O. 8.5 SPT		S#3 LL = 28; PL = 22; WC = 52%
659.9	8.2		Organic Silty Clay v. soft OL/CL Holds its shape 25-35% organics 75-80% silty clay 5% f sand; Mucky amorphous organic roots	1		
		OL/CL		0	S#4 8.5-9.5	
	9.0			1		
658.4	9.7			1		
658.1	10.0	SP-SM	~~Silty fine SAND~~ SP-SM			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. Small f SM (TRANSLUCENT) | PROJECT Big Lake HREP | HOLE NO. 23-16MU

Hole No. 23-16M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 6 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): MVP WACE
3. DRILLING AGENCY: USACE MVP
4. HOLE NO. (as shown on drawing and file number): GEO -03
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: TJ Bergman

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.1	10.0		Continued From Grab Sample			
		SP-SM	~~Silty fine SAND~~ Alluv (SP-SM) v Loose	2x2½		Clean hole to 10.0' w/ mud & 3" chopper bit
657.6	10.5		Saturated Grey 6-10% Silt	4		
	11.0	SP			5# 5	
				10	10.5 11.5	
		ML				
	12.0		Fine SAND SP Alluv.			
		SP	V. Loose - Loose Grey Saturated	10		
				DS0 RZ.0 SPT		
	13.0		60-70% f, 30-40% m : SAND	2	S#	Clear hole to 13.0' w/ mud & chopper bit
	13.5	SP	Med SAND Bed	1		
	14.0	SP	fine SP	3		
653.6	14.5	SP	m f- Medium SAND Alluvial (SP)	3 D2.0 R2.0 2x2½	S# 6 15.0 16.0	clean hole w/mud & chopper bit to 15.0'
	15.0		Loose Grey Saturated	12		
	16.0	SP	m. Beds of f & m sand alternating			
651.7	16.4	SP	f. Interbedded Fine-Med & M-F. (SP) SAND	13		
	17.0		MLSSee	15		
		SP	m. Scattered silty Seams << 1 cm			
	18.0		40-60% f : SAND 40-60% m	DS0 R2.5 SPT 4		clean hole to 18.0' w/ mud & chopper bit
		SP	f.		SP7 18.1 19.0	
				4		
	19.4	SP		3		
			M	3 D2.0 R1.7		
648.1	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP | HOLE NO. 23-16M

Hole No. 23-16M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 3 OF 6 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Johnson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
648.1	20.0	SP	Medium SAND (SP) Alluv; c. SP; Loose; Grey; Saturated; 60-70% m sand; 40-30 f sand; Scattered seams of coarse sand & sparse f gravel dispersed	SPT 4, 4, 4, 2; D2.0 R2.0		Clean hole to 20' w/ mud & chopper bit
	21.0	SP				
	22.0					
	23.0					Drill out to 23.0' w/ mud & Roller bit drill out firm as the overlying sand
644.9	23.2	~~CL~~ ML	Silty ~~Clay~~ (~~CL~~) ML Alluv; Dk Grey; Soft - M. Stiff; Saturated	SPT 3, 5	SH8 23.2 23.5	SWT LL = 40 PL = 26 WC = 60%
	23.5	SP	Fine SAND (SP) Alluv; M. dense; Grey; Saturated; 60-70% f fine SAND; 30-40% m.; interbedded fining and coarsening beds; m. SP	7, 9; D2.0 R2.0	SH9 23.9 25.0	
	24.0					
	25.0			SPT 5, 5, 6		— Mixed more mud Added 40 gal & 5# bentonite to last mix.
	26.0					
641.9	26.2	SP	c. SP	9; D2.0 R1.6		
	27.0		F. Med. SAND (SP) Alluv; Med Dense; Grey; Saturated; 60-70% m sand; 30-40% f sand; Scattered coarse			
	28.0	SP		SPT 6, 5, E, 6; D2.0 R2.0	SH 10 28.0 29.0	Cleaned hole to 28.0 w/ mud & chopper bit, sandy firm drill out.
	29.0					
638.1	30.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP

HOLE NO. 23-16M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	Hole No. 23-16M SHEET 4 OF 5 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
638.1	30.0		continued			
		SP	Fine & Med um Sand Alluv. (SP)	SPT 4		Clean hole to 30.0 w/mud and chopper bit
			M. Loose-M Dense	4		
	31		Saturated Grey	6		
		SP	F. Interbedded fine and M-F SAND beds	9		
	32		Contacts gradational	Dr. 2.0 R. 2.0		
635.6	32.5		Approx.			
	33.0	SM	Silty fine SAND Alluv. (SM)	SPT 3		Clean hole to 33.0' w/ mud & Chopper bit. Drill out softer @ at 32.5.
		SP	F. Loose	2	SH 11	
		SM				
634.1	34.0		Tan 1 mm dense laminations Clayey, Grey	5	34.0 35.0	
		SM		6		
633.1	35.0		BOH 35.0'	Dr. 2.0 R. 2.0		Hole ended 35.0' Pulled casing & allowed to heave 8/24/23
			Location: See Attached Drawing.			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) | PROJECT Big Lake HREP | HOLE NO. 23-16M

Hole No. 23-16MU

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 5 OF 6 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): See Sketch / Map attached
3. DRILLING AGENCY: USACE MVP
4. HOLE NO. (as shown on drawing and file number): GEO3
5. NAME OF DRILLER: Mike Davis K. Nelson
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 9.8'
10. SIZE AND TYPE OF BIT: 4" Chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD88; 1912 - 0.41 Wab. Gage; WS = 666.6
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline w/ Cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED: See pilot; UNDISTURBED: 1 Shelby 3"
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: 665.1
16. DATE HOLE: STARTED 8/24/23; COMPLETED 8/24/23
17. ELEVATION TOP OF HOLE: 668.1 = Top of Deck
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.1	0.0					Offset Boring 5' North of pilot Boring, pivoting pontoon. Use Lat. & Long from pilot Boring —
	0.3	AIR	Deck			
	1.0		Air			
666.6	1.5					
	2.0	H_2O	H_2O Ms. River			
665.1	3.0		River bottom			
	4.0	OL	Silty Organic OL See pilot hole 23-16M. Mucky, too soft to tube sample v.v. soft.			
	5.0					
	6.0					Set 4" casing to 7.0'
	7.0					Drill out to 7.5' w/ 4" roller bit used as chopper bit
660.6	7.5		Silty Sand (SM) ~~Organic Clay~~ ~~OL/CL~~		UND #1 3" Shelby	Pushed with weight of 2 men w/ wrenches. 1.8' recovery 2.2' push
	8.0	SM ~~OL/CL~~	Black v. soft @ Top, soft - med stiff @ bottom. Scattered sand	PUSH		Tube of soil from Photos - NO Attending
	9.0					
	9.3			D2.2 R1.8		- firm Bottom of push, refusal,
	9.8		BOH 9.8'			
658.1	10.0					

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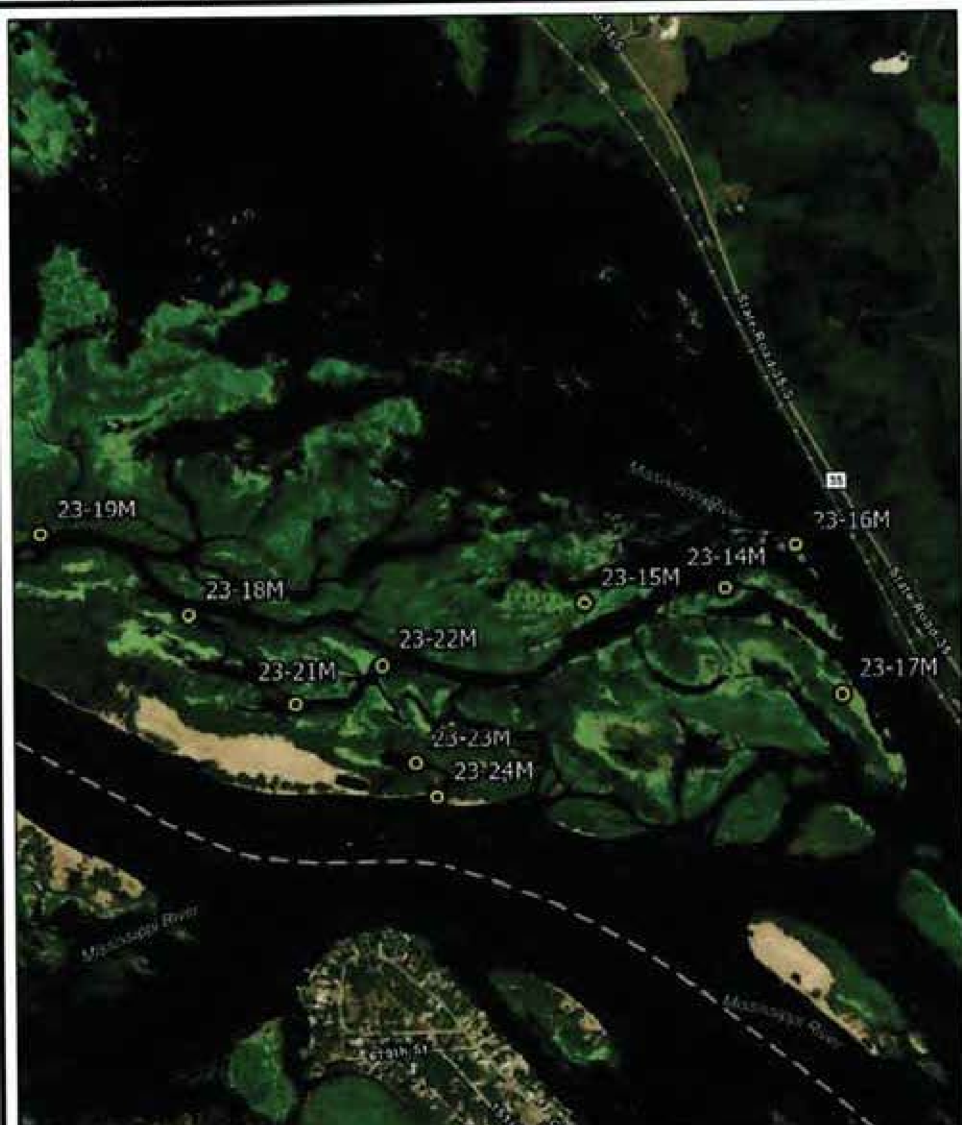
PROJECT: Big Lake HREP — HOLE NO. 23-16MU

Hole No. 23-16M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 6 OF 6 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W NW 1/4 Sec. 21



St. Paul District ENGINEERING GEOTECHNICAL
US Army Corps of Engineers

Big Lake HREP 2023 Borings

0 0.25 0.5 Miles

N

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-16M

Hole No. 23-17M

DRILLING LOG	DIVISION MVD	INSTALLATION St Paul District	SHEET 1 OF 5 SHEETS

1. PROJECT: Big Lake HREP (Pool 4)
2. LOCATION (Coordinates or Station): 44.372832 N, -91.961893 W — See Att. Sketch
3. DRILLING AGENCY: USACE MVP
4. HOLE NO. (as shown on drawing and file number): GES 01
5. NAME OF DRILLER: Mike Davis, K. Nelson
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 35.0'
10. SIZE AND TYPE OF BIT: 3" Chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88 — WS 667.13 - .41 = 666.72
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 13 Jar; UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 8/24/23; COMPLETED 8/25/23
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Tammie Johnson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.2	0.3		Deck			1) Lat. 44.372832 Long -91.961893
	1.0	AIR	Air			2) Boring drilled from Floating Plant.
666.7	1.5					3) 2x2½ = 2' inner diameter by 2½" outer diameter split spoon
	2	H_2O	H_2O Ms. River			4) SPT = 140# hammer dropped 30" using cathead & standard split spoon
655.5	2.7		River Bottom			
665.2	3.0	OL	SANDY Organics Black OL	SPT 1		5) Elevations from Water gage, Same as pool 4 Lock 4 Alma
			Black gray F sand 5-10% Plant roots	WH		WH = weight of hammer & drill rods
	4.0		Fine SAND Allum SP V. Loose Saturated 90% f. sand 10% m sand	1	S#1 3.5 4.5	WR = wt. of Rods. Drive 4" casing to 5.0'
	5.0	Grey / Rusty Brown		WH D2.3 R1.7 2x2½		Drill out to 5.0 w/ water.
	6.0		F. SAND continued Fe staining V. fine sand	6		
				8		Mixed Mud 50 gal, 10# Bent.
	7.0	SP		9	S#2 6.5	
	8.0		Fe stained to 8.4	D3.0 R2.2 SPT 1	7.2	Clean hole to 8.0' w/ Mud & Chopper Bit.
659.6	8.6	TBL	Medium SAND SP	5		
	9.0	SP	Loose - M. Dense Saturated Gray 65% M, 33% F. SAND	5	S#3	END Day 8/24/23 10.0'
658.2	10.0			4 D2.0 R2.0	9.0 10.0	Start 8/25/23 No W.S. adjustments

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PROJECT: Big Lake HREP — HOLE NO. 23-17M

Hole No. 33-17M

DRILLING LOG	DIVISION MVD	INSTALLATION St Paul District	SHEET OF 5 SHEETS

1. PROJECT Birch Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR [illegible signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.2	10.0		Medium SAND Alluv. (SP)	SPT		Clean hole to 10.0' w/ mud & 3" chopper bit
			Loose	7		
	11.0	SP	Saturated			
			Gray	10		
			55% M - SAND 45% f -			
	12.0		Scattered c sand dispersed	15		
				D&D R		Clean out to 13.0' w/ mud & 3" chopper bit
	13.0			SPT		
				2	S#4 13.0 14.0	
				2		
	14.0			3		
				3 R1.4		
653.0	15			SPT		Clean hole to 15.0' w/ mud & 3" chopper bit.
	15.2		Fine SAND (SP)	10		
			Loose			
	16.0		Saturated			
			Gray	10		
		SP F	60-70% f SAND 30-40% m			
	17.0		Scattered c. sand	16	17.0 T.d.	
			Subtle changes in fine & medium sand amounts			
	18.0			D&D R5.0 SPT		Clean hole to 18.0 w/ mud & 3" chopper bit.
		CL	clayey silt pocket	3		
				3		
	19.0	SP	M-F in SP	1		
648.8	19.4					
		SP SM	Silty SAND (SM) Loose, Gray, Alluv. Saturated 25% silt 75% f SAND	3		Clean hole to 20.0' w/ mud & 3" chopper bit
648.2	20.0			R2.0		

Hole No. 23-17M

DRILLING LOG	DIVISION MVD	INSTALLATION St Paul District	SHEET 3 OF 5 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: T Johnson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
~~648.2~~	20.0	ML	Clayey Silt (ML) Dk Grey Soft-med stiff	2X2Y; 5	S#6 20.0 20.7	LL = 30 PL = 24 WC = 38%
		CL				
		SP-SM	- f. sand, seam			
	21.0	ML	Soft-m. stiff fines			
646.9	21.3	CH ~~CL~~	(CH) Fat Clay (CH) Mod. organic Gravelly Shell seam	4	S#7 21.3 22.5	LL = 62 PL = 30 WC = 56%
	22.0	SP-SM	in SAND SP-SM	12		
	23.0		Silty Clay CH ~~CL~~ Alluv Med Plastic Med stiff Dk Grey	D3.0 R2.6 SPT 7; 4; 2	S#8 23.4 24.0	Sampler struck difficult to pull due to cohesion in clayey bed, Any tubes
	24.0	SP	Fine sand SP Loose Grey 2-4% silt Saturated 90+% f sand 10% m. sand	3 D2.0 R2.0		Clean hole to 25.0
643.1	25.1	OL Woody		2X3Y; 6	S#9 25.1 25.7	
	25.7	SM				
	26.0	ML				
		SP F		7	ST 10	26.6 27.2 LL = 33 PL = 24 WC = 34%
		ML				
	27.0	ML ~~CL~~	Woody Organics w/ silt & clay Wood fragments Black			
641.0	27.2	SP M	Interbedded SAND, silt & clay Grey loose, med stiff	21; D2.0 R2.0		
	28.0			12		Clean hole to 28.0 w/ mud & 3" chopper bit Bo depending of rods needed
			Gray Med SAND (SP) Loose-Med Dense Alluv. Grey Saturated 60-70% med, 30-40% f. SAND 3% f. grvl, Dispersed	4	S#11	
	29.0			5	28.0 27.0	
638.2	30.0			4; D2.0 R2.0		Clean hole to 30.0' w/ mud & chopper bit

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PROJECT: Big Lake HREP | HOLE NO. 23-17M

Hole No. 23-17M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 4 OF 5 SHEETS

1. PROJECT: Big Lake HREP Pool 4
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 8/24/23 COMPLETED 8/25/23
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
638.2	30.0	SP	saturated; Med Sand SP Loose Alluv. Grey saturated Swt. f. Gravel	2 3 5	S#12 30.0–31.0	
637.1	31.1		Coarse SAND (SP) AllUv. Med. Dense Grey saturated 80% c. Sand 20% f-med. Sand	6	02.0 R1.6	
	32.0	SP	M. Fine SAND Allu. (SP) Med. Dense Grey saturated 70% f. Sand 30% m Sand	6 6	S#13 34.0–35.0	Cleaned hole to 33.0' w/ mud & 3" chopper bit. Firm & drills smooth-like sand
	33.0					
	34.0			6 7	02.0 R2.0	
635.2	35.0		BOH 35.0'			BOH 35.0' pulled casing & allowed hole to heave

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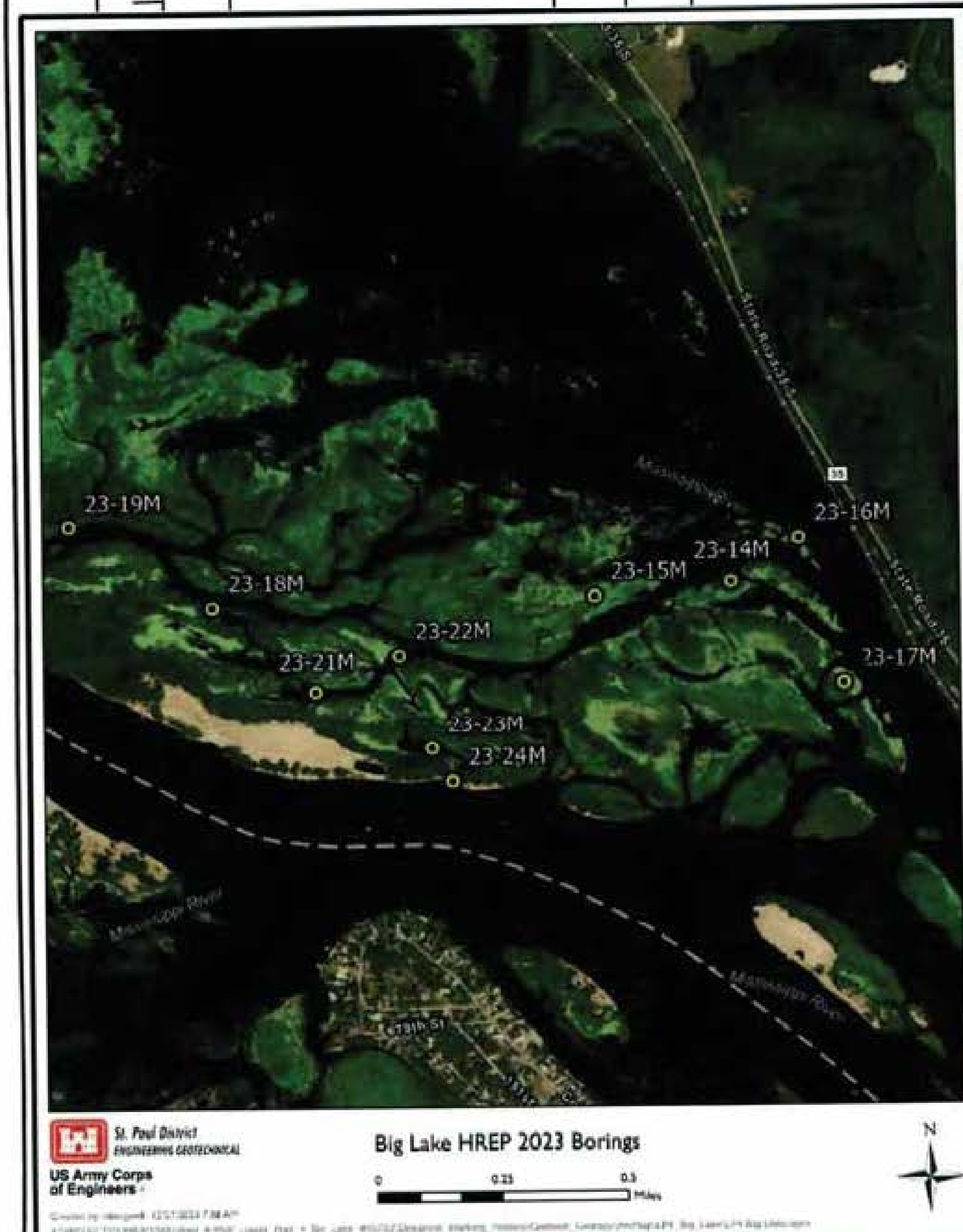
PROJECT: Big Lake HR | HOLE NO. 23-17M

Hole No. 23-17M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 5 OF 5 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR Atwood

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R8W NE 1/4 Sec. 21



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PROJECT Big Lake HREP | HOLE NO. 23-17M

Hole No. 23-18M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 5 SHEETS

1. PROJECT: BIG Lake HREP Pool 4
2. LOCATION (Coordinates or Station): See Drawing pg. 5
3. DRILLING AGENCY: USACE MVP crew
4. HOLE NO. (as shown on drawing and file number): GEO 7
5. NAME OF DRILLER: Mike Davis w/ K. Olson
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 32.0
10. SIZE AND TYPE OF BIT: 3" chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 88 — WS = 667.1
12. MANUFACTURER'S DESIGNATION OF DRILL: Jenkins Central
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 8 Jar; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION ~~GROUND~~ WATER: Surface
16. DATE HOLE: STARTED 8/25/23; COMPLETED 8/26/23
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.2	0.0		Deck			1) Lat. 44.375347N Long. -91.987361W
	1.0	AIR	Air			
666.7	1.5	WATER	Water Ms. River			2) Boring conducted from Floating Plant
	2.0					3) 2x2½ = 2" ID by 2½" OD split spoon sampler
	3.0					4) SPT - 140# hammer drop 30" using cathead
	4.0					5) Elevations from gage 14 Wabasha 667 due to flat pool 4. WH = Weight of drill rods (AW) and 140# hammer. WR = wt. of drill rods
663.2	5.0	SM / ML / SM / SP-SM / SM	River Bottom (Firm). Interbedded (Alluv.) Sand w/ Silt (SM, SP-SM) Loose Saturated Grey 5-20% Silt Laminated w/ <1 mm to 1 cm	2x2½ 3		
	6.0			3		
661.6	6.6	SP			SS-1 6.6-7.2	
	7.0		Fine Sand (SP) Brown Alluv. Loose Saturated 90% f 6% m SAND 4% Silt	6		Set 4" casing to 7.5!
	8.0			D3b 2,2 SPT 3		Clean hole to 8.0' w/ mud & chopper bit
				4		
	9.0			3		
				5 D2b 1,5		
658.2	10.0					Clean hole to 10.0'

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PROJECT: BIG LAKE HREP | HOLE NO. 23-18M

Hole No. 23-18M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 5 SHEETS

1. PROJECT: BIG Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number): GEO 7
5. NAME OF DRILLER
6. DIRECTION OF HOLE: VERTICAL / INCLINED / DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED / COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.2	10.0		Med - Fine SAND (SP) Alluv. Med Dense Saturated Gray Brown 60% F 40% M - SAND	2x2½ 8 16		
	11.0	SP				
	12.0	F.M.		25	SA 2 11.0 12.0	
		SP	V. Fine Seam, 28% silt	Δ3.0 R3.0		Clean hole to 13.0' w/ mud & 3" chopper bit
655.0	13.2		Fine Medium (SP) (Alluv) Loose Saturated Gray 55% M - SAND 45% Fine	SPT 1 2 4	SS 3 14.0 15.0	
	14.0	SP		7 D2.0 R2.0		
	15.0			SPT 4 4		Clean hole to 15.0' w/ mud, chopper bit.
		SP	Fine - 15% brown Silt ML			
	16.0	SP	m. Scattered fine gravel & seams & 80% f sand.	4 7 D2.0 R1.5		
	17.0					- Drill out - consistent w/ sandy soils. Clean hole to 18.0' w/ mud & 3" chopper bit.
	18.0		Continued	SPT 3		
		SP	Fine SP F Medium SAND (continued) SP scattered f. gravel	3 4	SS 4 19.0 20.0	
	19.0	SP		6 D2.0 R2.0		
648.2	20.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: BIG Lake HREP | HOLE NO. 23-18M

Hole No. 23-18M

DRILLING LOG	DIVISION MVD	INSTALLATION S. Paul District	SHEET 3 OF 5 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number) 6Ec 7	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE	18. TOTAL CORE RECOVERY FOR BORING %
	19. SIGNATURE OF INSPECTOR [illegible signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
648.2	20.0	SP	Fine Medium SAND Alluvium (SP)	SPT 3		Clean hole to 20.0' w/ mud & 3" chopper bit
		SP	Fine Grey Saturated	3		
	21.0		some f. Gravel Loose	6		
			Scattered f gravel in spots & dispersed	5 BZ 0 R2.0		
	22.0	SP	Fine-Med SAND continued			
	23.0		60-70% M SAND 30-40% F SAND	4		Clean out to 23.0' w/ mud & chopper bit firm drilling but consistent w/ sand as sampled
				5		
	24.0			4	S#5 23.5 24.5	
		SP	Fine SP seam	4 BZ 4 R2.0		
	25.0			SPT 2		moved North 4 ft of mud, to move grab w/ 8" bent. Cleaned out to 25.0 w/ mud & 3" chopper bit.
			Fine-Medium (SP) SAND continued	4		
	26.0		Loose-Med Dense Grey	6	S#6 25.5 26.4	Sand lost in casing so pounded casing to 25.5'.
		SP	Scattered f gravel	5 BZ 0 R1.5		Clean hole to 25.0'
	27.0	Drill out		Drill out		End shift 8-25-23 @ 27.0'
	28.0		(SP) Sand	SPT 3		Clean hole to 28.0' w/ 3" chopper Bit.
			M. Dense to Loose saturated	4	S#7 28.5	
	29.0	SP	Grey	5	29.0	
			100% m. Sand			
638.2	30.0			0 2.0 R1.7		

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PROJECT Big LAKE HREP — HOLE NO. 23-18M

Hole No. 23-14M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 4 OF 5 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
638.2	30.0		(SP)			
		SP	Sand m. Dense saturated Grey 100% f.m. sand	SPT 4 6 6 8 B 1.6 / 32.0	S#8 30.5 / 31.0	Cleaned hole to 30.0' w/ 3" chopper bit
	31					
636.2	32		END OF BORING			Pull all casing allow hole to cave to G.S.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

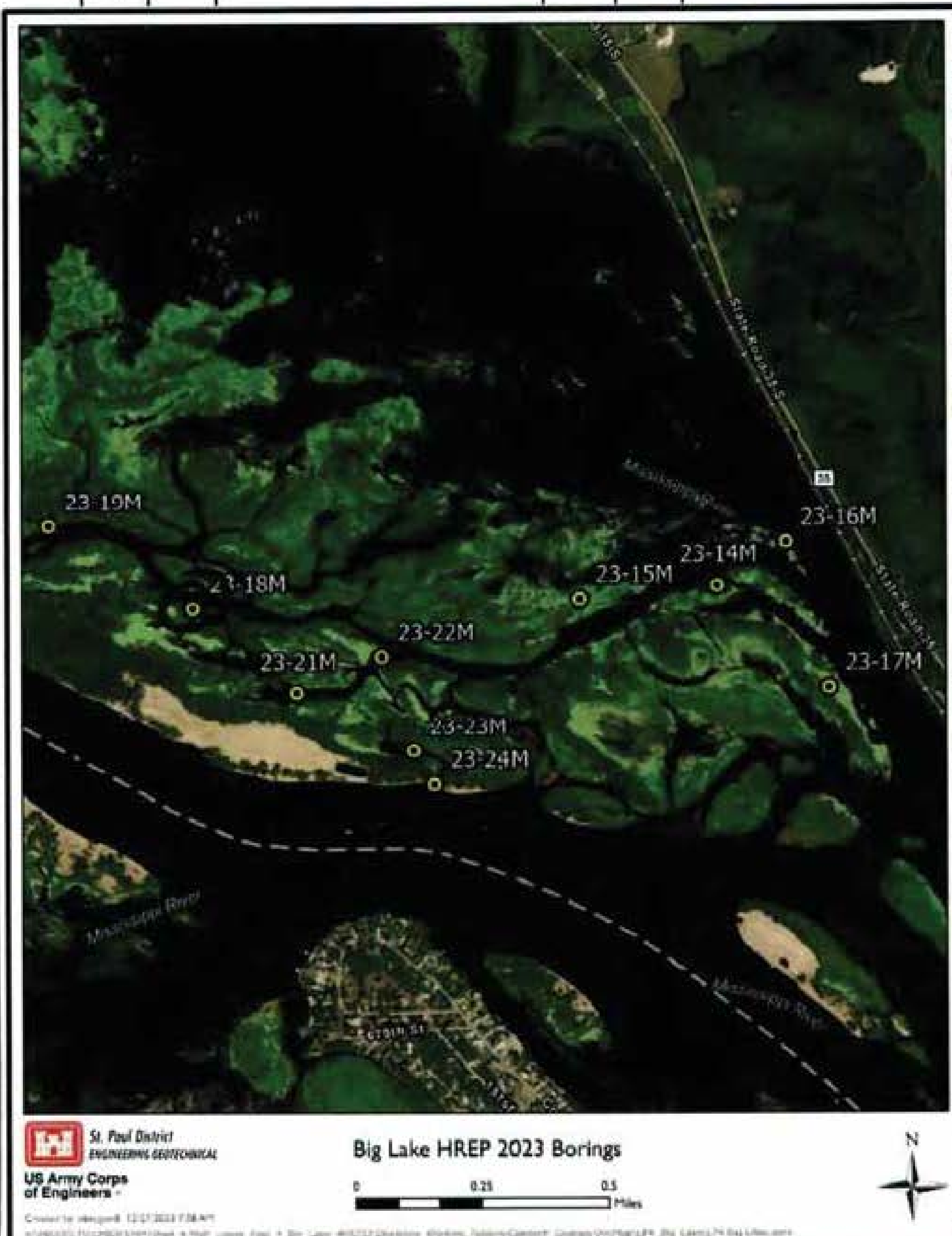
PROJECT Big Lake HREP | HOLE NO. 23-15M

Hole No. 23-18M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 5 OF 5 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR A. Sweet

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W NW1/4 Sec. 20



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-18M

Hole No. 23-19 M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 5 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): See drawing pg. 5
3. DRILLING AGENCY: US-CE-C
4. HOLE NO. (as shown on drawing and file number): Geo 08
5. NAME OF DRILLER: Mike Davis
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: 0.0
9. TOTAL DEPTH OF HOLE: 35.0'
10. SIZE AND TYPE OF BIT: 3" chopper Bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 1988 Adj; Webster Gage WS = 667.18 - .48 = 666.5
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline Rig
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 6 Jars; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: Surface
16. DATE HOLE: STARTED 8/26/23; COMPLETED 8/26/23
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0-8		Top Barge Deck			
		Air	Air			1) SPT = 140 # @ 30" Drop. Cat-Head Driven
	1.0					
666.8	1.5		Water			2) Boring Located @ N 44.377757 W -91.943090 Lat/Long
	2.0	H2O				
	3.0					3) Set 4" Alum. casing to 8.0'. Clean hole to 8.0' w/ 3" chopper Bit and Bent drilling mud
	4.0					
663.4	4.9		River Bottom			
	5.0	ML & SP	(ML & SP) Sandy Silt interbedded w/ Sand. Loose, wet, med Bedded, Brown to Grey, Occ. organic frag.	2x2½ POUND		4) Reset casing to 10.0'. Clean hole to 10.0' w/ 3" chopper Bit
	6.0					
	7.0		(Approx. Contact)			
660.3	8.0	SP	(SP) Sand. Loose, saturated, Grey	R0.3 T8.0 SPT 5	S#1 8.0 / 9.5	
				4		
	9.0	SP	100% f-m. Sand	4		
				4		
658.3	10.0			R1.7 T10.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP | HOLE NO. 23-19M

Hole No. 23-19M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 5 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Grant Riddle

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.3	10.0		Continued (SP)			
			Sand / Loose / Saturated / Grey / 100% fine sand	2x2½ POUND		5) Clean hole to 13.0' w/3" Chopper Bit.
	11.0	SP			S#2 13.0 / 13.5	
	12.0		- V. rare clay inclusion... ≈ ½" diameter -			6) Clean hole to 15.0' w/3" Chopper Bit.
	13.0	SP		R2.0 T13.0 SPT 2		
				3		
	14.0			5		7) clean hole to 18.0' w/3" Chopper Bit.
				4 R1.8 T15.0		
	15.0			2x2½ POUND	S#3 18.5 / 19.0	
	16.0	SP				
	17.0					8) Clean hole to 20.0' w/3" Chopper Bit.
			☆Note: Rare f. gravel below ≈ 18.0' ☆			
	18.0			R2.0 T18.0 SPT 2		
				3		
	19.0			3		
648.3	20.0			6 R1.5 T20.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) | PROJECT Big Lake HREP | HOLE NO. 23-19M

Hole No. 23-19M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 3 OF 5 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR [illegible signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
648.3	20.0		Continued (SP)			
			Sand	SPT 3		9) Clean hole to 22.0' w/3" chopper Bit. Drillout to 23.0'
			M. Dense	5	S#4	
	21.0	SP	Saturated		20.5	
			Grey	6	21.0	
			100% f-m. sand	9		
			v. rare fine gravel	R1.2 T22.0		
	22.0	Drill		Drill		10) Clean hole to 25.0' w/3" chopper Bit.
	23.0	Out		Out		
				SPT 8		Reset casing to 11.0'
				8		
	24.0	SP		11		
				7 R1.3 T25.0		* Anomolus blow counts. Sample disturbed by casing reset
	25.0			SPT 1		
				2		
	26.0			1		11) Clean hole to 27.0' w/3" chopper Bit. Drillout to 28.0'
			(Approx. Contact)	4 R1.0 T27.0		
	27.0	Drill	(SP)	Drill		
640.8	27.5		Sand w/ Gravel			
			M. Dense		#5	
	28.0	Out	Wet to Sat.	Out	28.5	
			Grey	SPT 5	29.0	
			95% m. sand	4		
	29.0	SP	5% fine gravel	6		12) Clean hole to 30.0' w/3" chopper Bit.
				5		
638.3	30.0			R1.3 T30.0		

Hole No. 23-19M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 4 OF 5 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE: VERTICAL / INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED / COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Grant Bulld

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
~~638.3~~	30.0		(SP) Sand; M. Dense; Wet to Sat.; Grey; 99% f-m. sorted; TR. fine gravel	SPT 4		13) Clean hole to 32.0' w/ 3" chopper Bit. Drill-out to 33.0'
				5		
	31.0	SP		7	S#6 31.0 31.5	
				10 R1.4 T32.0		
	32.0	Drill Out		Drill Out		
	33.0			SPT 5		
				7		
	34.0	SP		6		
633.3	35.0			7 R2.0 T35.0		
			END OF BORING			14) Pull all casing. Allow hole to cave to G.S.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP | HOLE NO. 23-19M

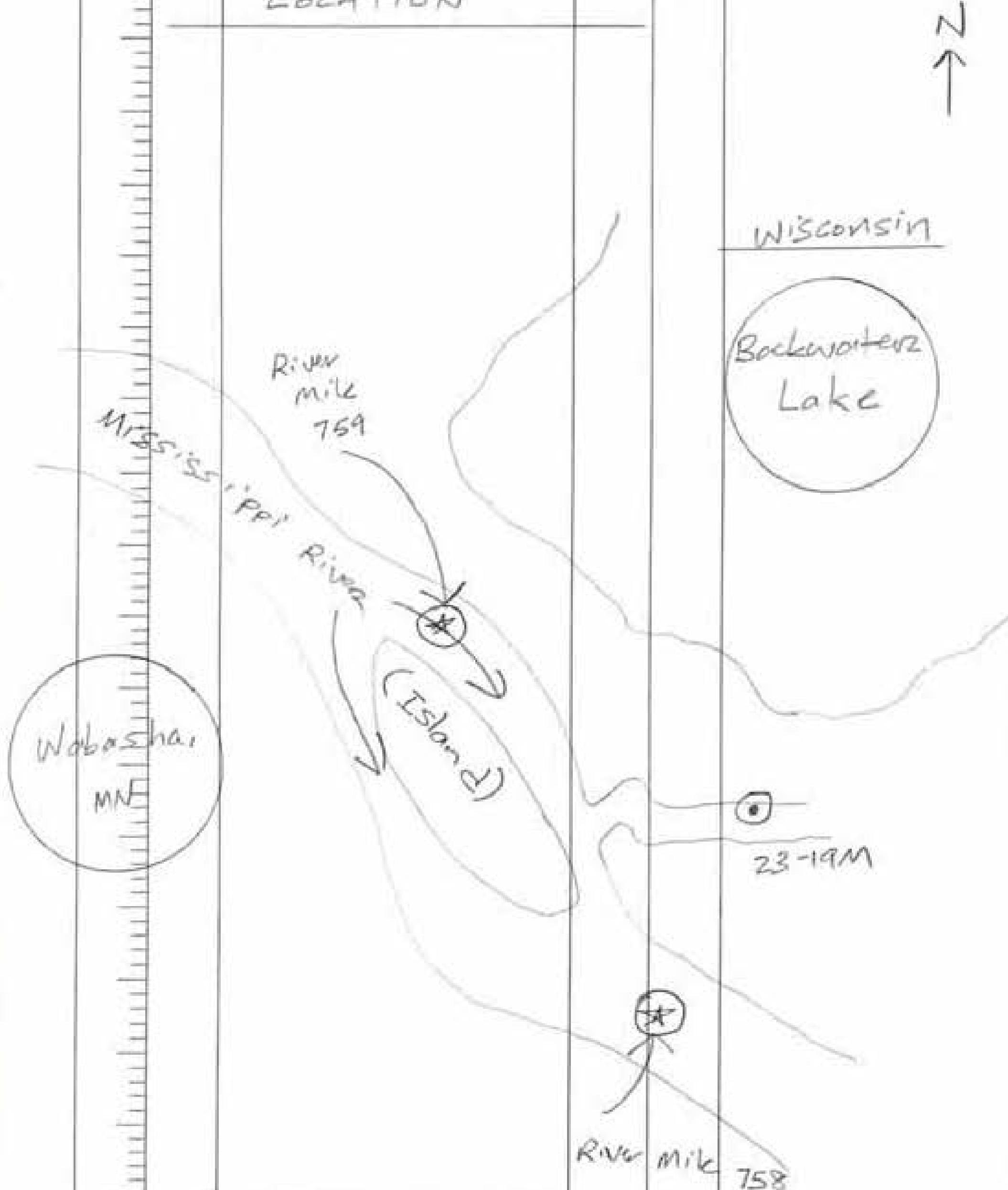
Hole No. 23 - 19M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 5 OF 5 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Grant Thibault

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g

LOCATION



Boring Located at:
T22 N, R13W
NW1/4 Sec. 20

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT Big Lake HREP | HOLE NO. 23-19M

Hole No. 23-20M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 4 SHEETS

1. PROJECT: Big Lake HREP Pool 4	10. SIZE AND TYPE OF BIT: 3" Chopper bit
2. LOCATION (Coordinates or Station): See Location Sheet Pool 4	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD88 (312-.4) = 88; W.S. = 667.2-.4 = 666.79
3. DRILLING AGENCY: USACE MVP	12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline & Cathead
4. HOLE NO. (as shown on drawing and file number): GEO 6	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5 Jar; UNDISTURBED —
5. NAME OF DRILLER: Mike Davis, K. Nelson	14. TOTAL NUMBER CORE BOXES —
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER = River Bottom 656.3
	16. DATE HOLE: STARTED 8/28/23; COMPLETED 8/28/23
7. THICKNESS OF OVERBURDEN —	17. ELEVATION TOP OF HOLE 668.3
8. DEPTH DRILLED INTO ROCK —	18. TOTAL CORE RECOVERY FOR BORING — %
9. TOTAL DEPTH OF HOLE 30.0	19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Deck			1) Lat. 44.317082°N Long -91.999837°W NAD83
		AIR	Air			
	1.0					Rocky Bottom = Moved hole to avoid rocks, River bottom at 0.5 ft deeper
666.8	1.5	H_2O	Water			
656.3	12.0		River Bottom			
		SP	Firm Sandy Bottom	2x2 ½		2) Boring Conducted from Floating Plant
		ML	Silty M.Fine SAND (SP)	6		
	13.0	SP	Loose, saturated, gray - dk gray, 4% silt 60% f. SAND 36% m	6	S#1 12.5 13.2	3) 2x2 ½ = 2 inch inner diameter (ID) by 2½ inch OD split spoon sampler
		CL	c. gravel			
	14.0	SM / OL	Lmst. Shell frag. Black organics	4		4) SPT = 140# hammer 30" drop using cathead
	15.0	SP	Black woody organics w/ shells, Sandy, Silty	DS 0 / R 2.0 SPT		5) Elevation approximate from Pool 4, Wabasha
				1		4" Casing to 14.0 Pounded
				1		Cleaned hole to 15.0 w/ chopper bit & mud from 23-19M
	16.0	SP / ML	Gravelly Sand 4% silt 30% f gravel 66% f-m sand; Seam	1		
		SP	M-Fine SAND (SP) Continued Alluv. V. Loose	1		
	17.0		Saturated Grey 1-2% silt, 60-70% fine 30-40% m	DR 0 R 1.5 / 2x2 ½ / 4		4) Add 25 gal 5% bent to the river mud, Clean to 17.0'
		GP				
	18.0	SP	Coarse SAND Gravel	9	SP 2 18.0 19.5	
	19.0	SP	F-M (SP) Continued Loose	12		
648.3	20.0		scattered f. gravel	DS 0 R 2.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP | HOLE NO. 23-

Hole No. 23-20M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 4 SHEETS

1. PROJECT: Big Lake HREP
2. LOCATION (Coordinates or Station): Pool 4
3. DRILLING AGENCY:
4. HOLE NO. (as shown on drawing and file number): GEO 6
5. NAME OF DRILLER: Michael Davis & Nelson
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE: 30.0
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5 Jar; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 8/28/23; COMPLETED 8/29/23
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
648.3	20.0			2x2½		7) Clean hole to 20.0' w/ chopper bit & mud
646.0	20.5	SP	M Fine SAND SP Loose Alluv. Grey Saturated 65% f, 45 M SAND	8		
	21.0			6		
	22.0		F. Medium SAND Alluv. (SP) Loose Grey Saturated 30-40% f SAND 60-70% M f. gravel dispersed	9	SH3 21.0 22.0	
	23.0	SP		D3.0 R2.2 SPT 2		8) Lost seal - 4" casing set to 16.0' Remix new bentonite mud, cleaned out 5' of heaved sand
	24.0			1		
				2		
	25.0			4 D2.0 R1.5 2x2½		
642.8	25.5			10		
	26.0		M Fine SAND (SP) Alluvi Loose-Med Dense Grey, Saturated 60-75 Fine SAND 25-40% Med f gravel & Coarse sand dispersed		SH4 26.0 27.0	
				15		
	27.0	SP		30		
	28.0			D3.0 R2.5 SPT 9		9) Clean hole to 28.0
				11		
639.3	29.0	SP	Coarse med. Sand (SP) med Dense Alluv. Grey, Saturated 10% fine Gravel 70% M & C. SAND 20% f. Sand	9	SH5 29.0 30.0	
				10 D2.0 R2.0		10) Lost hole due to heave and waves.
638.3	30.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: Big Lake HREP | HOLE NO. 23-20

Hole No. 23-20M

DRILLING LOG	DIVISION MVD	INSTALLATION St. aul District	SHEET 3 OF 4 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			Boh 30.0'			11) Lost circulation - mix new mud. Drill out to 30.0' hole heaved. Lost mud. Pulled casing allowed hole to heave. End of day 8/28/23, Moved pontoon & equip from wavy channel area.

ENG FORM 1836 MAR 71 — PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

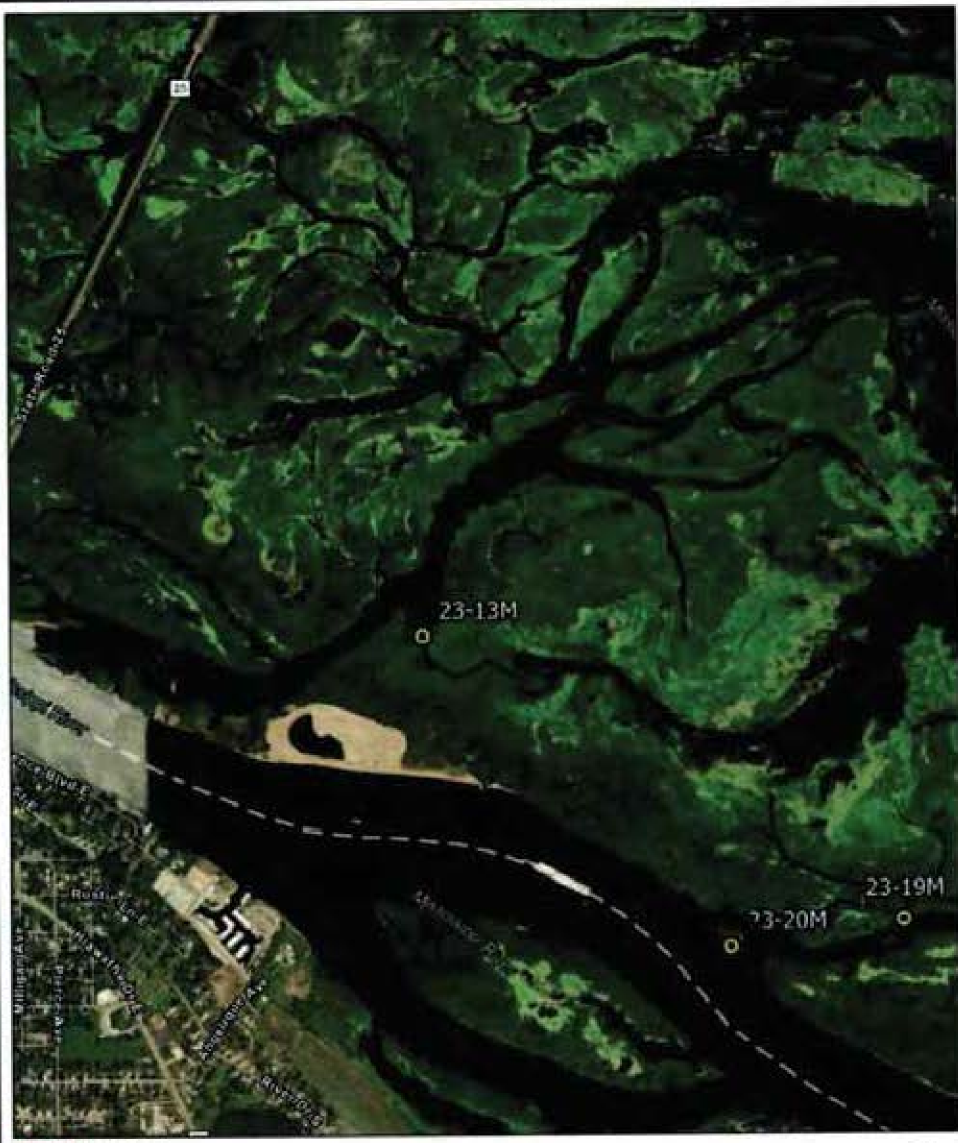
PROJECT Big Lake HREP — HOLE NO. 23-20M

Hole No. 23-20M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 4 OF 4 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR A Wood

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: Unmaped T&R



St. Paul District ENGINEERING GEOTECHNICAL

US Army Corps of Engineers

Big Lake HREP 2023 Borings

0 0.25 0.5 Miles

N

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-20M

Hole No. 23-21M

DRILLING LOG	DIVISION MVD	INSTALLATION S. Paul District	SHEET 1 OF 3 SHEETS

1. PROJECT: Big Lake HREP Pool 4
2. LOCATION (Coordinates or Station): See page 2 Lat. 44.372873 N, Long -91.983231 W
3. DRILLING AGENCY: USACE MVP
4. HOLE NO. (as shown on drawing and file number): ENV 02
5. NAME OF DRILLER: Mike Davis K. Nelson
6. DIRECTION OF HOLE: ☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 12.0'
10. SIZE AND TYPE OF BIT: 3" Chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD 1988 Wab. Gage 667.22
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline w/ Cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 8 Jar/Bag; UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 8/29/23; COMPLETED 8/29/23
17. ELEVATION TOP OF HOLE: 668.3
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
~~668.3~~	0.0					
	0.3		Deck			1) Location Lat: 44.372873 N Long: -91.983231 W
	1.0	AIR	Air			2) Location Offset ~100' east of marked location along dredge cut due to excessive vegetation & lack of water
666.8	1.5		H_2O, Ms. River			
	2.0		Water			
	3.0	H_2O				
	4.0					3) Stainless Samplers cleaned w/ Alconox between samples - River Rinse
663.8	4.5		Organics (OL) Black Alluv. v.v. Soft (mucky) saturated Sandy, 10-20%	2.5/4.5 PUSH		4) ENV. S#1 0930AM 4.5-7.5, 7.5-10 Composite, mixed in stainless bowl
	5.0					
	6.0					
	7.0	OL		D2.5 R2.5 SAT PUSH	ENV. S#1 4.5-7.5 & 7.5-10.0	5) Composite 4.5-10.0'
	8.0		Soft (OL)			6) ENV Sample to Lab 1 plastic 2 Amber 1 Baggy Sample
	9.0			D2.5 R2.5		Casing to 10' Clean out/water to 10'.
658.3	10.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT Big Lake HREP HOLE NO. 23-21M

Hole No. 23-21M

DRILLING LOG	DIVISION MVD	INSTALLATION S. Paul District	SHEET 2 OF 3 SHEETS

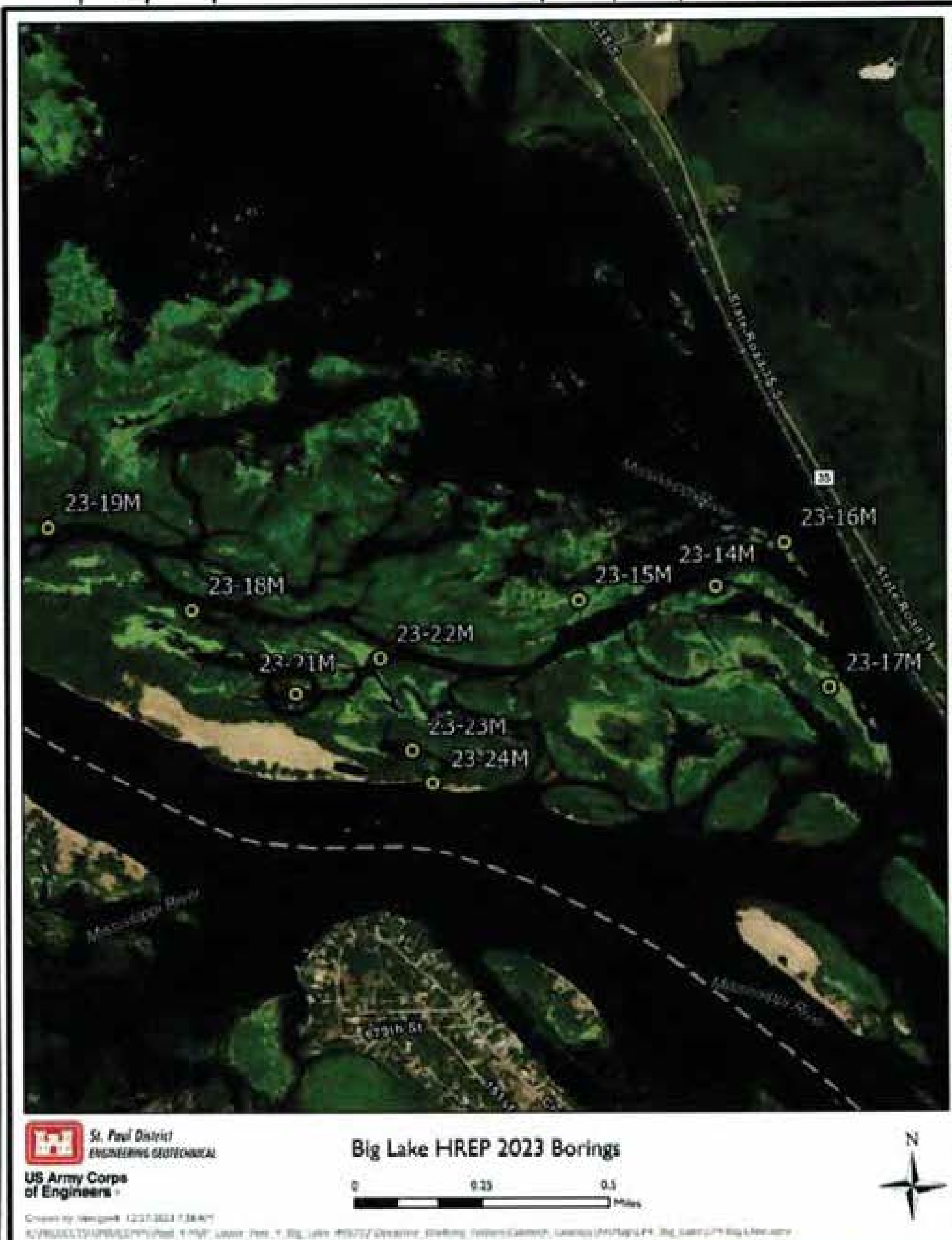
1. PROJECT Big Lake HREP Pool 4	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number) ENV 3	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.3	10.0	OL	Continued Organics (OL) Black Alluv. V. Soft SANDY, Silts & Clay	2YCR3 Pour PUSH 12.0 REC	ENV S# 2	1) Environmental Samples Tak & delivered to lab 8/31/23
	11.0	SP	SAND (SP) Gray Saturated Loose Sl. Silty < 4% Med-Fine SAND		10.0 12.0	2) ENV 0955 S# 2 AM Composite < 1 plastic, 2 Amber jar, 1 Baggy pulled casing & allowed hole to heave.
656.3	12.0		Boh. 12.0'			

Hole No. 23-21M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 3 OF 3 SHEETS
1. PROJECT Big Lake HREP		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number)		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR	Arooost

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W SW/4 Sec. 20



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-21M

Hole No. 23-22M

DRILLING LOG	DIVIS MVD	INSTALLATION St. Paul District	SHEET 1 OF 2 SHEETS

1. PROJECT: Big Lake HREP Environmental
2. LOCATION (Coordinates or Station): See Pg 2 Map
3. DRILLING AGENCY: USACE MVP crew
4. HOLE NO. (as shown on drawing and file number): ENV 2
5. NAME OF DRILLER: Mike Davis K Nelson
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 10.0'
10. SIZE AND TYPE OF BIT: 4" Chopper bit
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD88 664.22 -.41 666.8 = WS Wabasha Gage
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerk line & cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED: 6 Jar 2 Bag 4 ier; UNDISTURBED: —
14. TOTAL NUMBER CORE BOXES: — To ENV Lab
15. ELEVATION GROUND WATER: 662.8
16. DATE HOLE: STARTED 8/29/23; COMPLETED 8/29/23
17. ELEVATION TOP OF HOLE: 667.3
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3			Deck			1) Lat 44.373877 N Long -91.979843 W
	1	O_2	Air			2) WS = 666.8, Wab. gage - Pool 4 Alma gage < 0.03. No Adjustments made to Wab. Gage
666.8	1.5		Ms. River			
	2	H_2O	water		S#1 5.5 8.0	3) Stainless Split Spoons used to sample, Alconox rinse between Samples w/ River wash.
	3					
	4					
	5					
662.8	5.5		Organics OL	3x3½ PUSH	3x3½ PUSH	4) offset & pushed 2nd sampler 11 AM
	6	OL	woody, & v soft Mucky Black vegetative & Amorphous organics			5) S#1 5.5/8.0 (11AM) 5.5/8.0 4 Samples To ENV. Lab 1 small jar plastic 2 amber glass 1 Bag for Hydrometer
661.4	6.9 7.0					
		SM	Silty SAND SM 40-% silt trace f sand Silt, organics	D2.5 R2.0	D2.5 R1.5	6)
	8.0			SPT	SPT	- 4" casing driven to 8.0 offset & pushed piston 8.0-10
		OL	organic seam sl. woody	POUND	POUND	
	9.0	SM	Grey Loose			7) S# 2 9.0-10.0 Composite 8) 4 Samples to Lab for ENV. Testing 1 Small, 2 Amber 1 Bag, Hydrometer
658.3	10.0		Bot 10.0'	D2.0 R1.5	D2.0 R1.5	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) | PROJECT Big Lake HREP | HOLE NO. 23-22M

Hole No. 23-22M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 2 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W NE¼ Sec. 20

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-22M

Hole No. 23-23M

DRILLING LOG	DIVISION MVD	INSTALLATION St Paul District	SHEET 1 OF 2 SHEETS

1. PROJECT: Big Lake HREP Environmental
2. LOCATION (Coordinates or Station): 44.371124N -91.978597W - See Attached Map
3. DRILLING AGENCY: USACE MVP
4. HOLE NO. (as shown on drawing and file number): ENV. 1
5. NAME OF DRILLER: Mike Davis, K. Nelson
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: —
9. TOTAL DEPTH OF HOLE: 8.0'
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): NAVD88 Wsh. Gage 667.22-.41
12. MANUFACTURER'S DESIGNATION OF DRILL: Jerkline w/ cathead
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED — No Recovery; UNDISTURBED
14. TOTAL NUMBER CORE BOXES: —
15. ELEVATION GROUND WATER: River Bot 665.6
16. DATE HOLE: STARTED 8/29/23; COMPLETED 8/29/23
17. ELEVATION TOP OF HOLE: 668.3
18. TOTAL CORE RECOVERY FOR BORING: — %
19. SIGNATURE OF INSPECTOR: [signature]

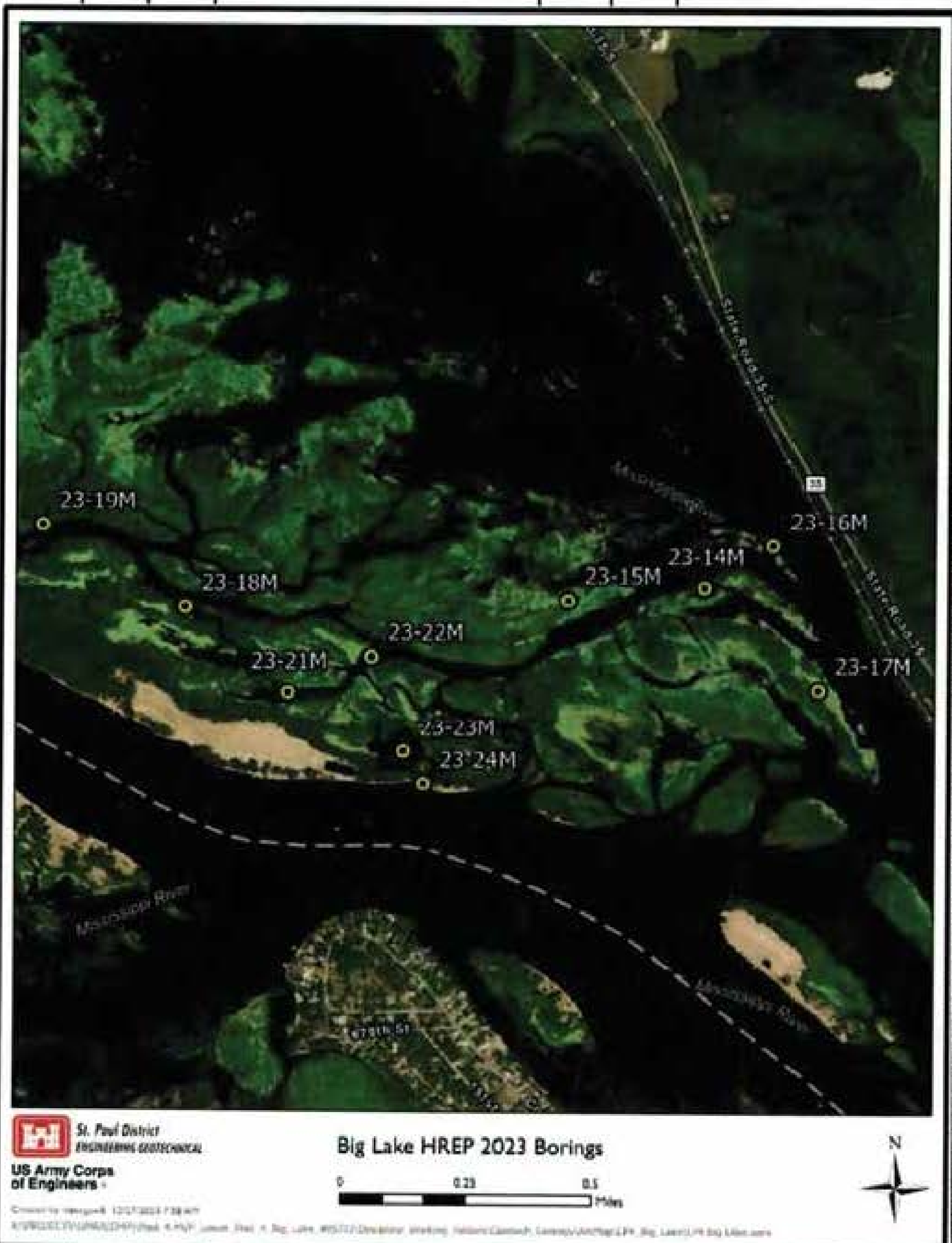
ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
668.3	0.0		Deck			1) Lat 44.371124N Long -91.978597W
		O_2	Air			
	1.0					2) 5 Try's along Channel Cut, All F Sand poor recovery
666.8	1.5		Water, Mr River			
	2.0	H_2O				3) Abandoned ENV. sampling. 3x3½ and 1½x2"
665.6	2.7		River Bottom			
	3.0		Fine Sand (SP) V.V. Loose will not retain in sampler 80% f sand 20% m sand Gray Brown	3x3½ Push		4) Stainless samplers used w/ alconox wash & river water rinse.
	4.0	SP		Pound		5) Attempt SA 1, composite Move 5' East No Recovery
	5.0			D2.5 R0.2		6) Move 50' North No Recovery.
	5.2			2x2½ Push		7) Set sampler down multiple times 5-8' to try to recover stiff barrel - Not successful.
	6.0					
	7.0			Pound		8) changed out baskets - No recovery.
660.3	8.0		B.H 8.0'	D2.5 R0.3		9) Pulled casing, allowed to heave up. 10) Abandoned efforts to Move on to Robinson Lake Environmental Sample.

Hole No. 23-23M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 2 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Alsmock

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W SE1/4 Sec. 20



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Big Lake HREP | HOLE NO. 23-23M

Hole No. 23-24M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 1 OF 4 SHEETS

1. PROJECT	Big Lake HREP
2. LOCATION (Coordinates or Station)	See map pg 4
3. DRILLING AGENCY	USCEC
4. HOLE NO. (as shown on drawing and file number)	Geo_11
5. NAME OF DRILLER	Mike Davis
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	—
8. DEPTH DRILLED INTO ROCK	0.0
9. TOTAL DEPTH OF HOLE	25'
10. SIZE AND TYPE OF BIT	2x2½ SPT, 3" Chopper
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	NGVD 88
12. MANUFACTURER'S DESIGNATION OF DRILL	Jerk Line
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED: 5 Jars; UNDISTURBED: —
14. TOTAL NUMBER CORE BOXES	—
15. ELEVATION GROUND WATER	Surface 666.6'
16. DATE HOLE	STARTED 9/11/23; COMPLETED 9/11/23
17. ELEVATION TOP OF HOLE	669.1
18. TOTAL CORE RECOVERY FOR BORING	— %
19. SIGNATURE OF INSPECTOR	K. Nelson

ELEVATION a (668.1)	DEPTH b (0)	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0	Air	Top of Deck			SPT = 140 lbs @ 30" Drop; 2x2½ = 2" ID x 2½ OD split spoon sampler
	1					
666.6	1.5		Water Surface			Boring located at N 44.370167 E -91.977788 E
	2	H_2O				
	3					
664.4	3.7		Top de Sed 2			- Set 4" csg to 5'
	4	SP	Sand F-M Grades into Sand F-C w/ trace Gravel at 4.5 - Loose - Saturated - Tan to Lt. Gray	SPT WT 2 / 1 / D 1.3 R 1.3 2x2½	SN1 5' 6'	- Mix Bentonite Drilling Fluid - Clean Hole to 5'
	5			Pound		
662.1	6	Mix Gravel	90% Sand F-C 3% Fines Some gravel			- Set csg to 8' - Clean
661.8	6.3	SP	Sharp Contact			
	7		Sand Silty SP w/ Bark Loose saturated Brown 97% F-M Sand 3% Fines Trace Bark			
	8			D R / SPT 15 / 7 / 2 / 3 / D 3 R 1.2	SN2 8' 9'	- material in casing causing High Blows / - Set csg to 9 & Clean to 10'
	9					
658.1	10					

Hole No. 23-24M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 2 OF 4 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (as shown on drawing and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR K. Nelson

ELEVATION a 658.1	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		SP	Sand Cont. (SP)	2x2½		
			– Loose	P		
			– Sat	o		
			– Tan Gray	u		
	11		96% F-M Sand	n		
			4% Fines	d		
	12					
			occ Bark	D 3		– Clean Hole to
	13	SP		R 1.8		13'
				SPT		
				3	SN3	
				2	14' / 14.5'	
	14			3		
			Sand w/ Gravel F-M (SP)	3 D 2.0		– Clean Hole
	15			R 1.5		To 15'
			– Loose / M Dense	2x2½		
			– Saturated	P		
			– Tan Brown	o		
	16		90% F-M Sand	u		
			7% Gravel F-M	n		
			3% Fines	d		
	17					
				D 3.0		
650.5	17.6			R 1.8		– Cle
	18	SP		SPT 2	SN4	
				3	18' / 19'	
	19			4		
	20			4 D 3.0 R 1.3		

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PROJECT Big Lake HREP | HOLE NO. 23-24M

Hole No. 23-24 M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 3 OF 4 SHEETS

1. PROJECT Big Lake HREP	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (as shown on drawing and file number)	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR K. Nelson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
648.1	20	SP	Sand w/ Gravel cont. M. Dense/Loose Saturated Gray Brown Gravel is in seams of Gravelly Sand some sand in clean of Gravel	SPT 3, 5, 5, 7; 0 2 R 1.4		
646.1	22	Drill out	90% F-C Sand 7% F-M Gravel 3% Fines	Drill out		- Clean Hole to 22' & Drill out To 23'
645.1	23	SP	Less gravel 23-25 Trace	SPT 4, 2, 3, 4; D 2 R 1	SN5 23/24	
643.1	25		[END of Boring]			- Pull casing & allow Hole to cave

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

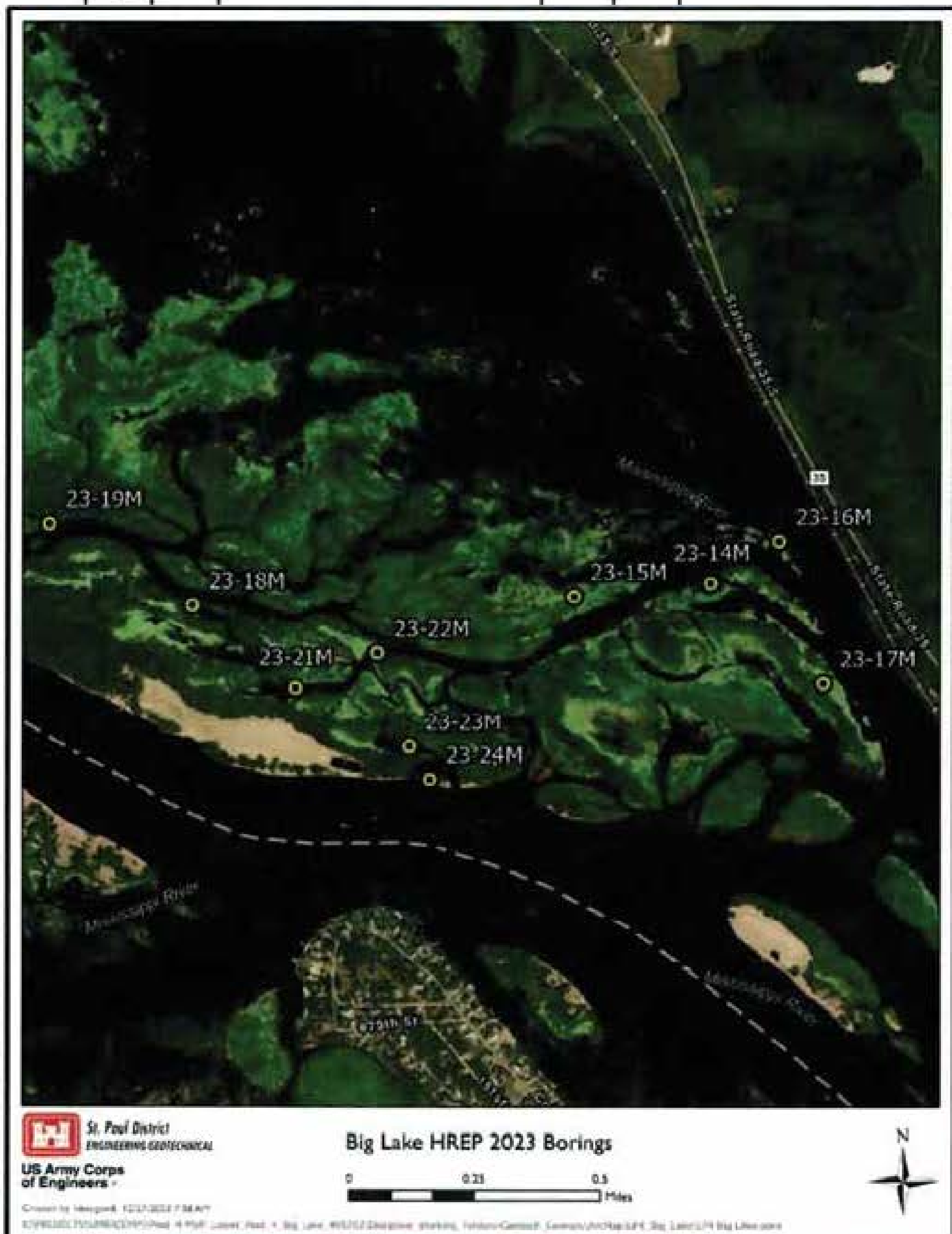
PROJECT Big Lake HREP — HOLE NO. 23-24 M

Hole No. 23-24M

DRILLING LOG	DIVISION MVD	INSTALLATION St. Paul District	SHEET 4 OF 4 SHEETS

1. PROJECT Big Lake HREP
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR A Woods

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						Boring Located At: T22N, R13W SE¼ Sec. 20



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT Big Lake HREP

HOLE NO. 23-24M

Laboratory Test Summary

Project: Big Lake HREP 2023 Job: 14648

Client: USACE -Geotech. & Geology Section Date: 10/12/2023

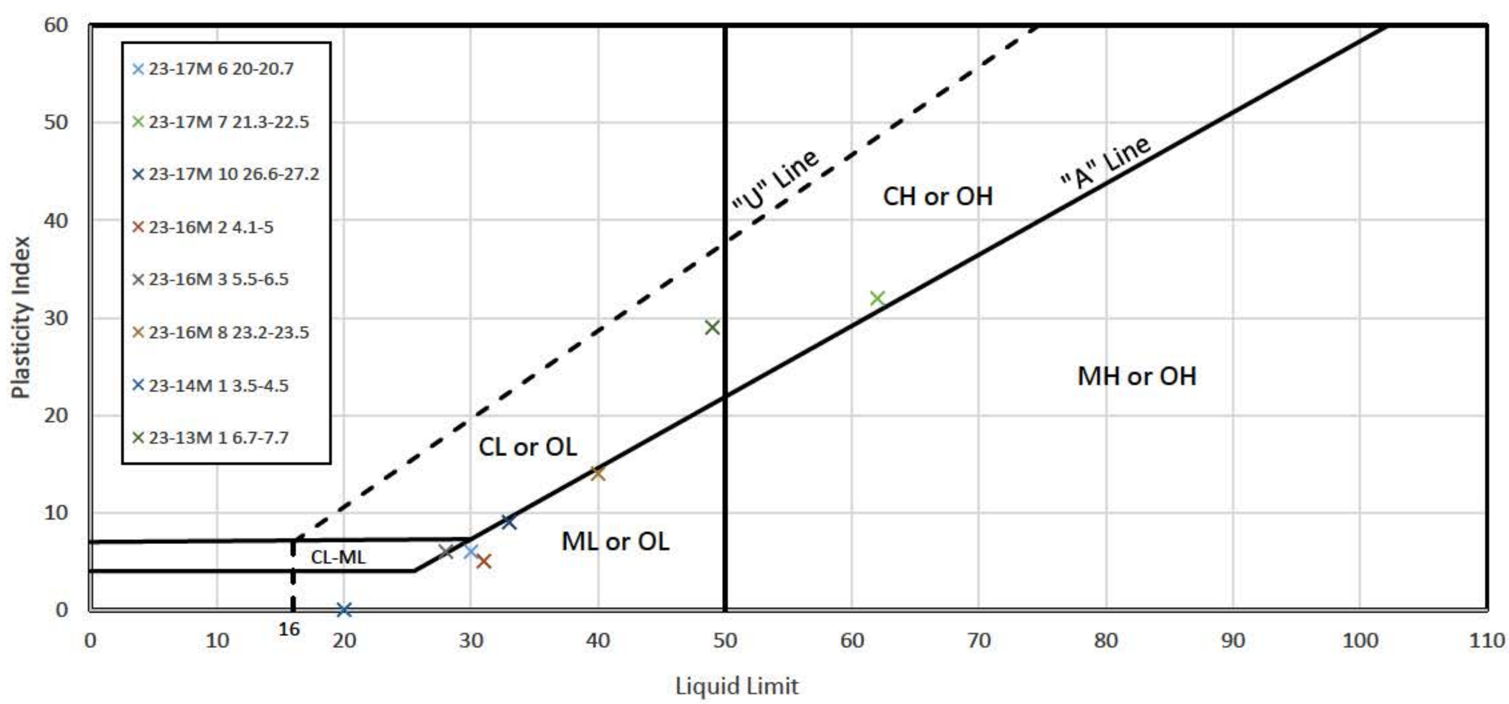
Sample Information & Classification

Boring #	23-17M	23-17M	23-17M	23-16M	23-16M	23-16M	23-14M	23-13M
Sample #	6	7	10	2	3	8	1	1
Depth (ft)	20-20.7	21.3-22.5	26.6-27.2	4.1-5	5.5-6.5	23.2-23.5	3.5-4.5	6.7-7.7
Sample Type	Jar	Jar	Jar	Jar	Jar	Jar	Jar	Jar
Material Classification	Sandy Silt, slightly organic (ML)	Fat Clay, moderately organic (CH/OH)	Sandy Silt w/a little gravel, slightly organic (ML)	Sandy Silt, moderately organic (ML)	Sandy Silty Clay, moderately organic (CL-ML)	Sandy Silt, moderately organic (ML)	Silt w/sand, slightly organic (ML)	Lean Clay w/sand (CL)

Atterberg Limits (ASTM:D4318)

Liquid Limit	30	62	33	31	28	40	20	49
Plastic Limit	24	30	24	26	22	26	N/A	20
Plasticity Index	6	32	9	5	6	14	NP	29

Plasticity Chart (ASTM:D2487)



Laboratory Test Summary

Project:	Big Lake HREP 2023	Job:	14648
Client:	USACE -Geotech. & Geology Section	Date:	10/12/2023

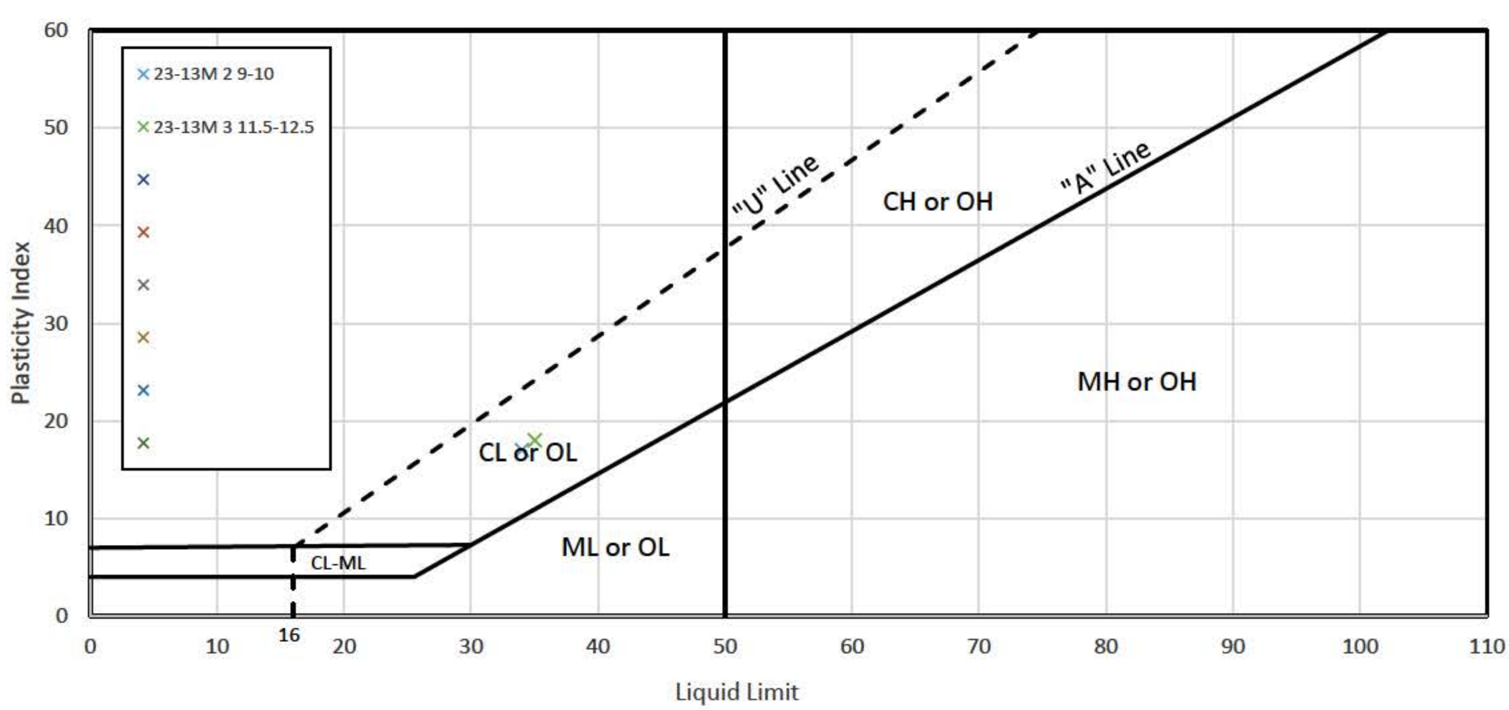
Sample Information & Classification

Boring #	23-13M	23-13M							
Sample #	2	3							
Depth (ft)	9-10	11.5-12.5							
Sample Type	Jar	Jar							
Material Classification	Sandy Lean Clay (CL)	Lean Clay w/sand (CL)							

Atterberg Limits (ASTM:D4318)

Liquid Limit	34	35							
Plastic Limit	17	17							
Plasticity Index	17	18							

Plasticity Chart (ASTM:D2487)

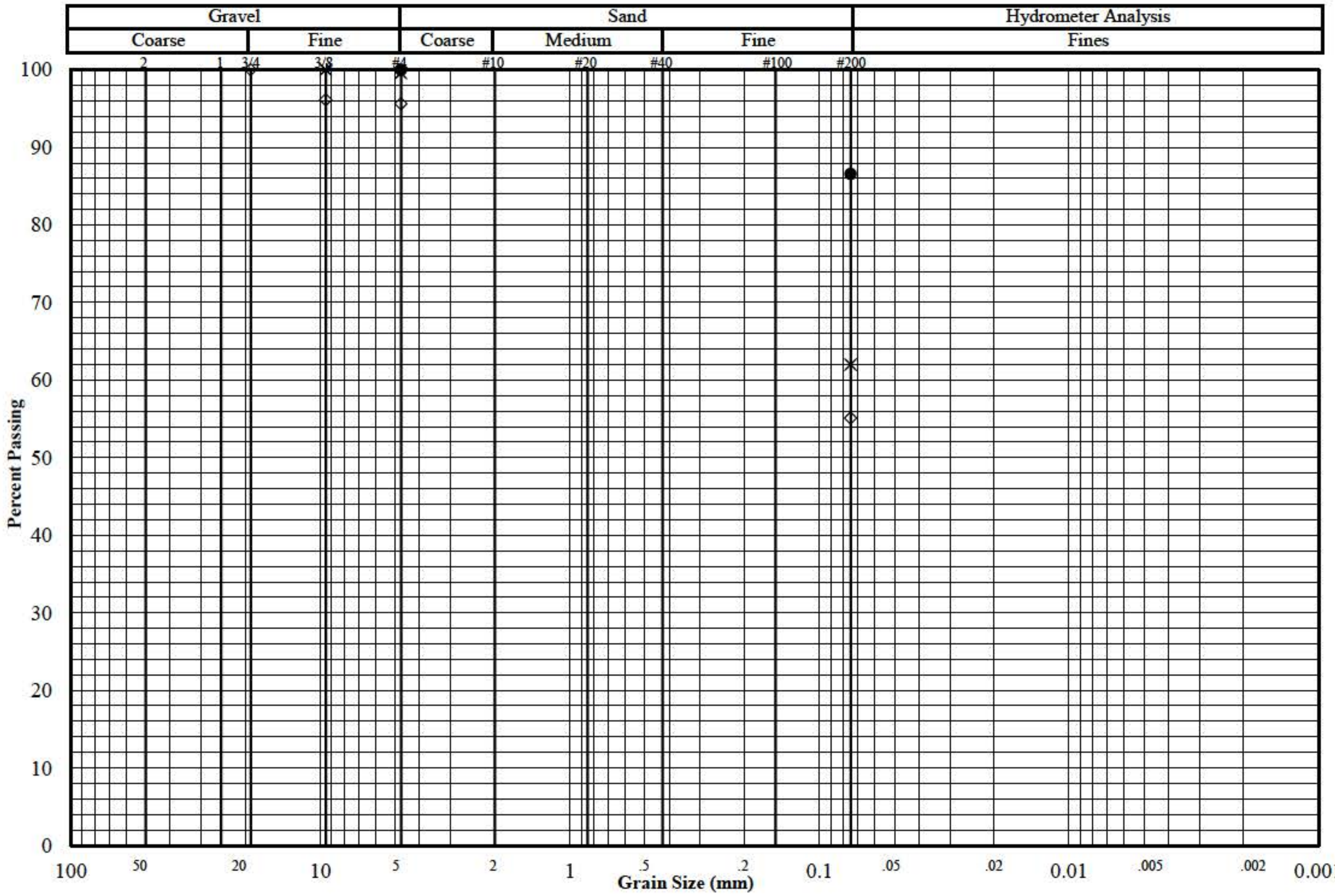


Grain Size Distribution ASTM D1140

Job No.: **14648**

Project:	Big Lake HREP 2023	Test Date:	9/25/23
Reported To:	USACE -Geotech. & Geology Section	Report Date:	10/2/23

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
✱	23-17M	6	20-20.7	Jar	Sandy Silt, slightly organic (ML)
●	23-17M	7	21.3-22.5	Jar	Fat Clay, moderately organic (CH/OH)
◇	23-17M	10	26.6-27.2	Jar	Sandy Silt w/a little gravel, slightly organic (ML)



Additional Results	✱	●	◇
Liquid Limit	30	45	33
Plastic Limit	24	30	24
Plasticity Index ASTM:D4318	6	15	9
Water Content ASTM:D2216	37.6	56.1	36.8
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854			
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

Percent Passing

	✱	●	◇
Mass (g)	110.7	110.5	156.4
2"			
1.5"			
1"			
3/4"			100.0
3/8"	100.0		96.2
#4	99.6	100.0	95.6
#10			
#20			
#40			
#100			
#200	62.0	86.6	55.1

	✱	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

(* = assumed)

9530 James Ave South

SOIL ENGINEERING TESTING, INC.

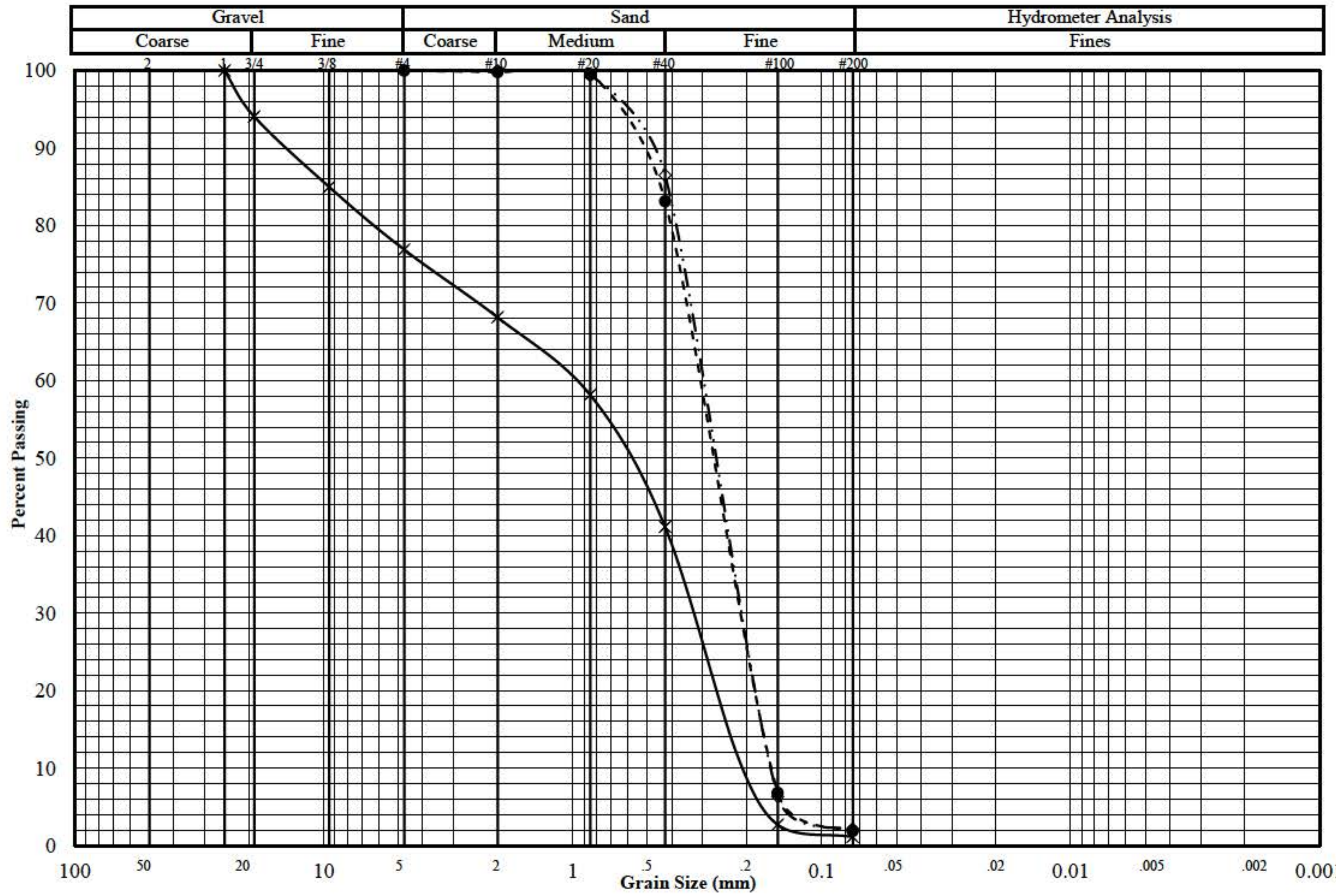
Bloomington, MN 55431

Grain Size Distribution ASTM D422 16

Job No.: 14648

Project:	Big Lake HREP 2023	Test Date:	9/25/23
Reported To:	USACE -Geotech. & Geology Section	Report Date:	10/2/23

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
✱	23-24M	1	5-6	Jar	Sand w/gravel, fine to medium grained (SP)
●	23-20M	1	12.5-13.5	Jar	Sand, fine grained (SP)
◇	23-19M	1	8-8.5	Jar	Sand, fine grained (SP)



Additional Results	✱	●	◇
Liquid Limit			
Plastic Limit			
Plasticity Index ASTM:D4318			
Water Content ASTM:D2216			
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854			
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

(* = assumed)

Percent Passing

	✱	●	◇
Mass (g)	315.6	216.4	188.6
2"			
1.5"			
1"	100.0		
3/4"	94.1		
3/8"	85.0		
#4	76.9	100.0	100.0
#10	68.2	99.8	100.0
#20	58.1	99.5	99.4
#40	41.1	83.1	86.5
#100	2.7	6.8	6.3
#200	1.1	1.9	2.1

	✱	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

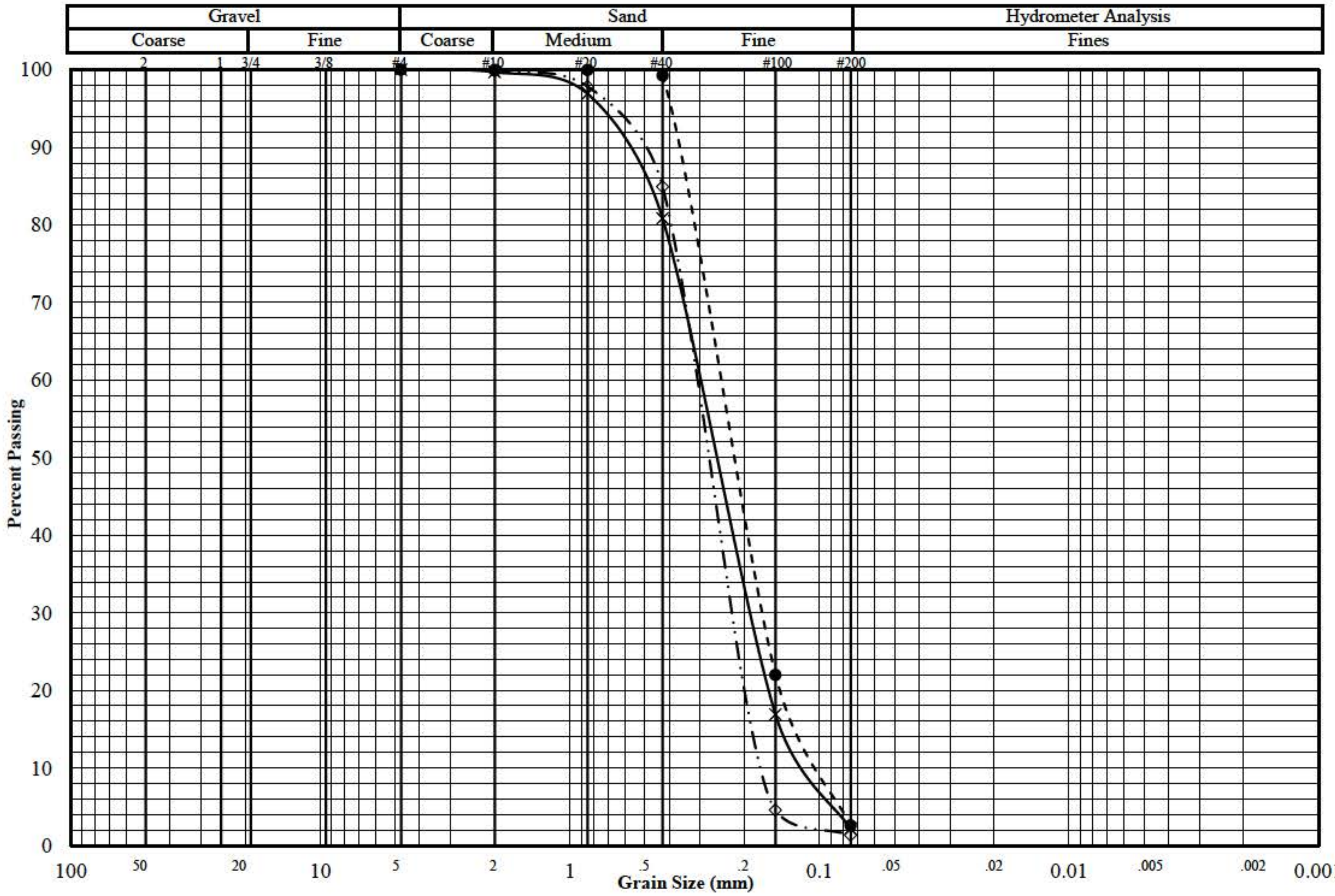
23-20M, #1 at 12.5-13.5' contained a large piece of 1.5" gravel that was omitted from results.

Grain Size Distribution ASTM D422 16

Project:	Big Lake HREP 2023	Test Date:	9/25/23
Reported To:	USACE -Geotech. & Geology Section	Report Date:	10/2/23

Job No. : 14648

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
✱	23-18M	1	6.6-7.2	Jar	Sand, fine grained (SP)
●	23-17M	1	3.5-4.5	Jar	Sand, fine grained (SP)
◇	23-17M	5	17-18	Jar	Sand, fine grained (SP)



Additional Results	✱	●	◇
Liquid Limit			
Plastic Limit			
Plasticity Index ASTM:D4318			
Water Content ASTM:D2216			
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854			
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

Percent Passing

	✱	●	◇
Mass (g)	158.7	148.2	223.6
2"			
1.5"			
1"			
3/4"			
3/8"			
#4	100.0	100.0	100.0
#10	99.7	100.0	99.9
#20	96.9	100.0	97.8
#40	80.9	99.3	84.9
#100	16.9	22.0	4.6
#200	2.2	2.6	1.3

	✱	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

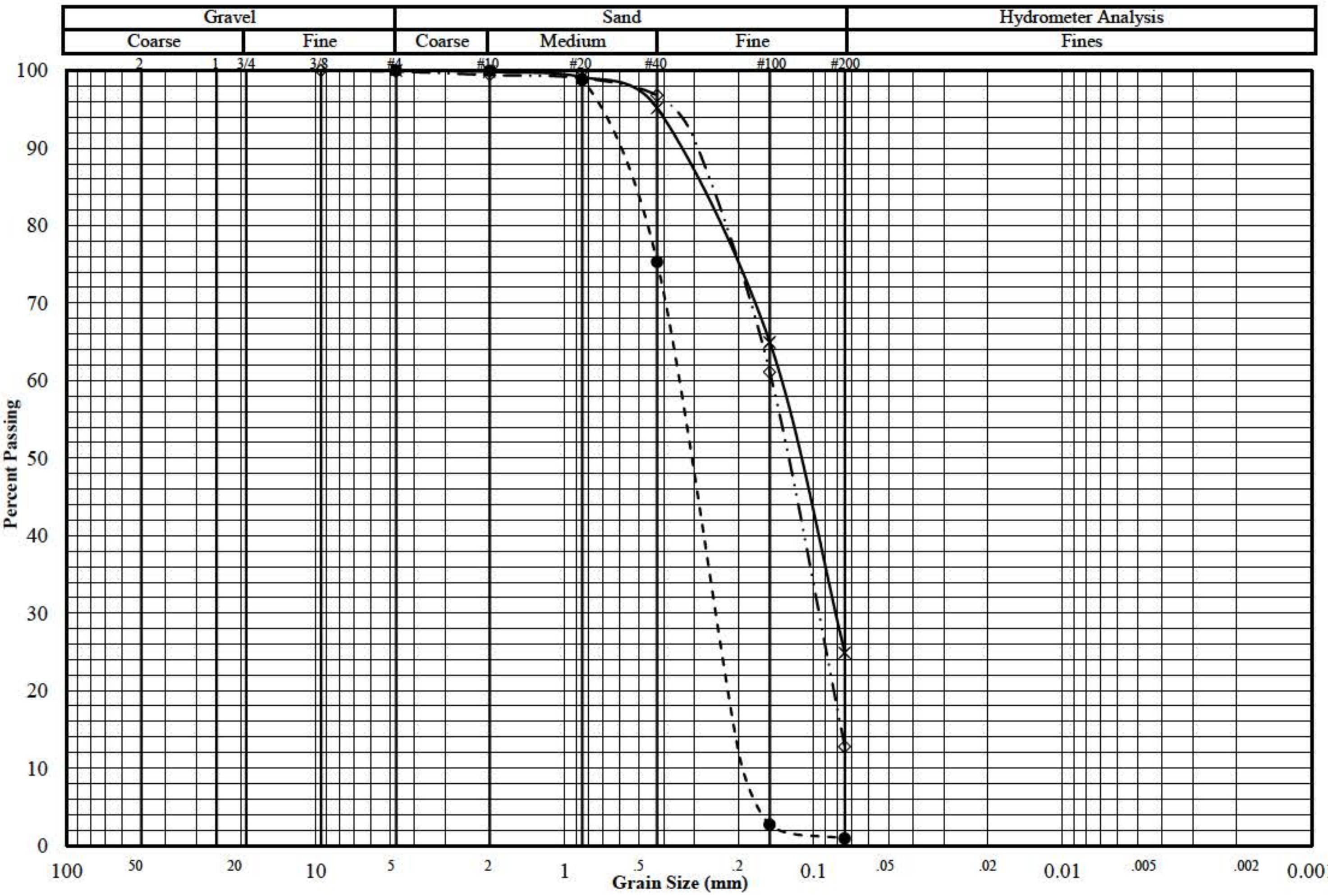
(* = assumed)

Grain Size Distribution ASTM D422 16

Job No.: 14648

Project:	Big Lake HREP 2023	Test Date:	9/25/23
Reported To:	USACE -Geotech. & Geology Section	Report Date:	10/2/23

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
✱	23-16MU	1	7.5-9.3	TWT	Silty Sand w/a trace of organic material (SM)
●	23-16M	5	10.5-11.5	Jar	Sand, fine grained (SP)
◇	23-15M	1	5-5.6	Jar	Silty Sand (SM/SP-SM)



Additional Results	✱	●	◇
Liquid Limit			
Plastic Limit			
Plasticity Index ASTM:D4318			
Water Content ASTM:D2216			
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854			
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

Percent Passing

	✱	●	◇
Mass (g)	134.4	202.2	181.5
2"			
1.5"			
1"			
3/4"			
3/8"			100.0
#4	100.0	100.0	99.9
#10	99.9	100.0	99.4
#20	99.2	98.8	99.0
#40	95.2	75.3	96.8
#100	64.9	2.7	61.1
#200	24.9	0.9	12.7

	✱	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

(* = assumed)

9530 James Ave South

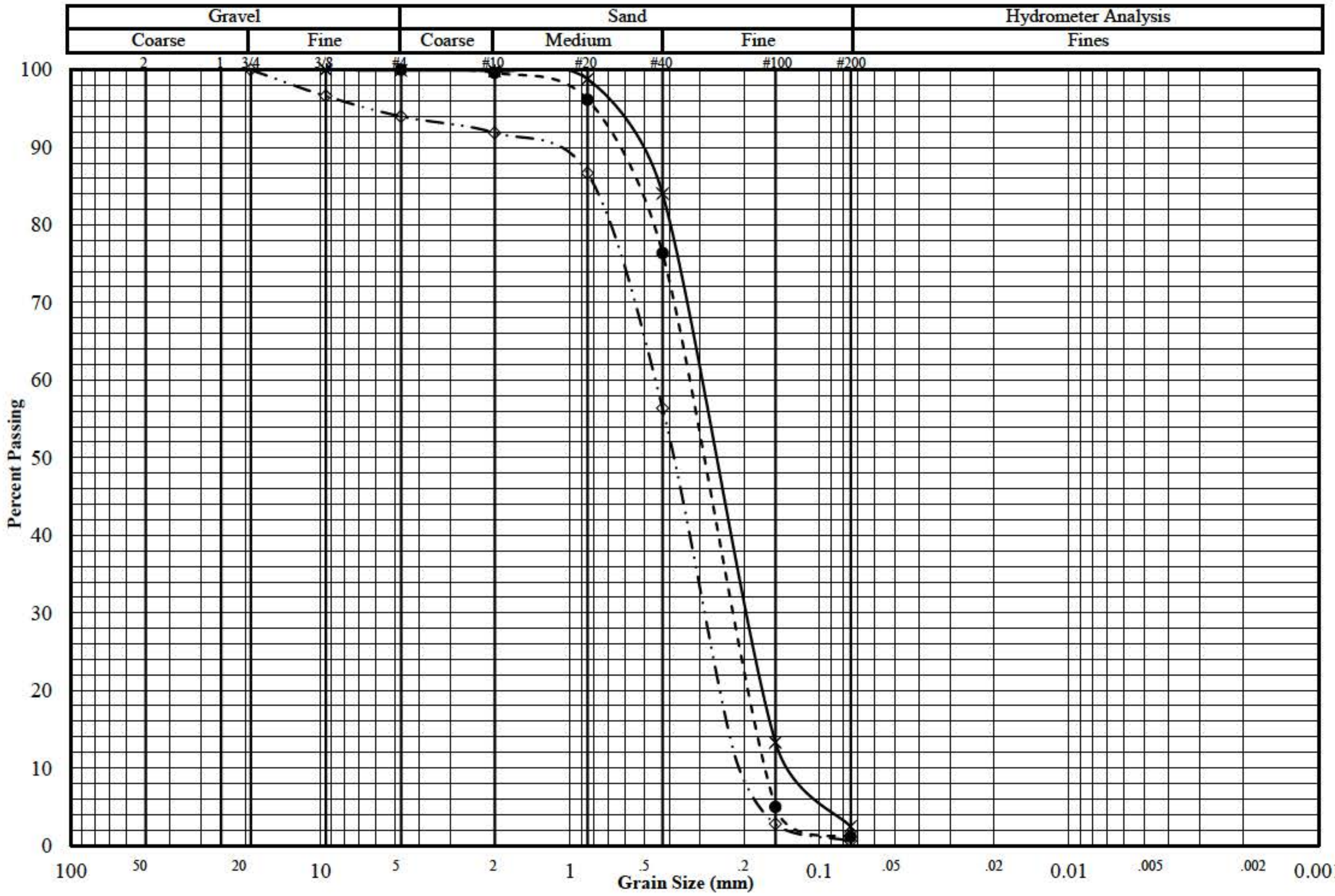
SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

Grain Size Distribution ASTM D422 16

Project:	Big Lake HREP 2023	Job No.:	14648
		Test Date:	9/25/23
Reported To:	USACE -Geotech. & Geology Section	Report Date:	10/2/23

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
✱	23-15M	3	8.7-9.5	Jar	Sand, fine grained (SP)
●	23-14M	2	5.6-6.6	Jar	Sand, fine grained (SP)
◇	23-14M	5	13-14	Jar	Sand w/a little gravel, fine to medium grained (SP)



Additional Results	✱	●	◇
Liquid Limit			
Plastic Limit			
Plasticity Index ASTM:D4318			
Water Content ASTM:D2216			
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854			
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

(* = assumed)

Percent Passing

	✱	●	◇
Mass (g)	176.6	175.3	192.9
2"			
1.5"			
1"			
3/4"			100.0
3/8"	100.0		96.6
#4	99.9	100.0	94.0
#10	99.8	99.6	91.9
#20	98.8	96.2	86.7
#40	84.0	76.4	56.4
#100	13.3	5.0	2.8
#200	2.4	1.1	0.6

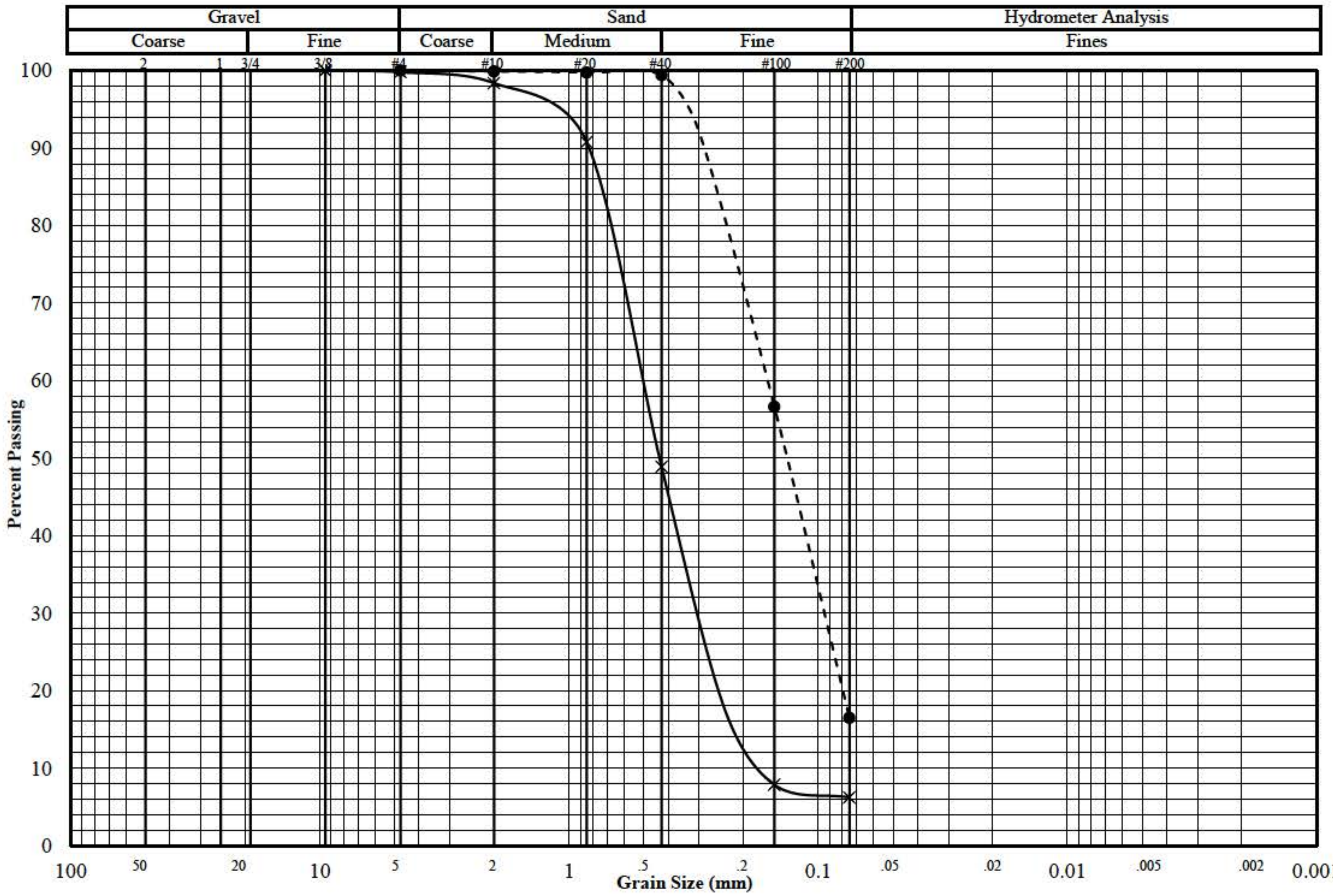
	✱	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

Grain Size Distribution ASTM D422 16

Project:	Big Lake HREP 2023	Job No.:	14648
		Test Date:	9/25/23
Reported To:	USACE -Geotech. & Geology Section	Report Date:	10/2/23

	Location / Boring No.	Sample No.	Depth (ft)	Sample Type	Soil Classification
✱	23-13M	4	14-15	Jar	Sand w/silt, medium to fine grained (SP-SM)
●	23-13M	8	28-29	Jar	Silty Sand (SM)
◇					



Additional Results	✱	●	◇
Liquid Limit			
Plastic Limit			
Plasticity Index ASTM:D4318			
Water Content ASTM:D2216			
Dry Density (pcf) ASTM:D7263			
Specific Gravity ASTM:D854			
Porosity			
Organic Content ASTM:D2974			
pH ASTM:D4972 Method B			

Percent Passing

	✱	●	◇
Mass (g)	230.1	184.8	
2"			
1.5"			
1"			
3/4"			
3/8"	100.0		
#4	99.8	100.0	
#10	98.4	99.9	
#20	90.8	99.8	
#40	48.9	99.4	
#100	7.9	56.6	
#200	6.2	16.5	

	✱	●	◇
D_{60}			
D_{30}			
D_{10}			
C_U			
C_C			

Remarks:

(* = assumed)

9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

Project:	Big La e HR P 2023	Job:	14648
Client	USAC Geotech. Geology Section	Date:	10/12/2023

Sample Information Classification

Boring #	23 17M	23 17M	23 17M	23 16M	23 16M	23 16M	23 14M	23 13M
Sample #	6	7	10	2	3	8	1	1
Depth (ft)	20 20.7	21.3 22.5	26.6 27.2	4.1 5	5.5 6.5	23.2 23.5	3.5 4.5	6.7 7.7
Type	Jar	Jar	Jar	Jar	Jar	Jar	Jar	Jar
Material Classification	Sandy Silt, slightly organic (ML)	at Clay, moderately organic (CH/OH)	Sandy Silt /a little gravel, slightly organic (ML)	Sandy Silt, moderately organic (ML)	Sandy Silty Clay, moderately organic (CL ML)	Sandy Silt, moderately organic (ML)	Silt /sand, slightly organic (ML)	Lean Clay /sand (CL)
Water Content ( )	37.6	56.1	36.8	45.3	52.3	60.1	37.5	33.3

Sample Information Classification

Boring #	23 13M	23 13M						
Sample #	2	3						
Depth (ft)	9 10	11.5 12.5						
Type	Jar	Jar						
Material Classification	Sandy Lean Clay (CL)	Lean Clay /sand (CL)						
Water Content ( )	31.2	33.7						

Sample Information Classification

Boring #								
Sample #								
Depth (ft)								
Type								
Material Classification								
Water Content ( )								

Sample Information Classification

Boring #								
Sample #								
Depth (ft)								
Type								
Material Classification								
Water Content ( )								

US Army Corps of Engineers®
St. Paul District

Attachment D.2: Environmental Site Assessment, HTRW Phase 1 Report

Habitat Rehabilitation and Enhancement Project

Big Lake

Feasibility Phase

Doc Version: Feasibility Review

May 2024

US Army Corps of Engineers
St. Paul District

GEOTECHNICAL & GEOLOGY BRANCH
332 Minnesota St N
St. Paul, MN 55101

PHASE I ENVIRONMENTAL SITE ASSESSMENT REPORT – Lower Pool 4 Big Lake HREP

Habitat Rehabilitation and Enhancement Project (HREP)
Lower Pool 4, Big Lake
Buffalo County, Wisconsin

6/23/2023

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Table of Contents

Table of Contents

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
CESQG	Conditionally-Exempt Small Quantity Generators
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
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 1527-21; 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:	Big Lake Habitat Rehabilitation and Enhancement Project
Site Information:	Mississippi River, Pool 4, River Miles 760.2 to 756.6
County:	Buffalo County, WI
Latitude, Longitude:	Approx. 43.39132N, -91.99014W

Senior Reviewer: Terrance Jorgenson 8/16/23

Terrance Jorgenson,
Senior 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.

8/16/23

Ashley M. Woods, P.G.

4.0 Executive Summary

4.1 Subject Property Description

The 4,115 acre Big Lake area is located within the Upper Mississippi River National Wildlife and Fish Refuge (Refuge) in Buffalo County, Wisconsin and is in Pool 4 between river miles 760.2 to 756.6 (Figure 1). The area is bounded on the west by the Mississippi River Navigation Channel, on the east by the uplands, and to the north by Highway 25. The closest communities to the project area are Wabasha, Minnesota and Nelson, Wisconsin.

The proposed project is approximately 4 miles long and 1.5 miles wide, encompassing approximately 4,115 acres. This US Fish and Wildlife property is primarily Mississippi River back waters and floodplain forest.

4.2 *Environmental Report Summary*

Currently, the subject property are backwaters to the Mississippi River, and used as a recreational area for hunting, boating, and fishing. The land is predominately vegetated with riverine vegetation, and floodplain forest with several sloughs. During site reconnaissance and through document review, no environmental concerns were observed on or near the immediate vicinity of the subject property.

4.3 *Recommendations*

Based on the information obtained during the site reconnaissance and document review, ***a Phase II ESA is currently not necessary***. It should be noted that the complete report must be read in order to fully understand the findings associated with the subject property.

5.0 Introduction

5.1 Purpose

The purpose of the Phase I ESA was to evaluate the current and historic 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 (REC)* is defined by ASTM E 1527-21 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 1527-21 and further defined below:

- USACE has gathered and reviewed available historic data, including fire insurance maps, survey plat maps, aerial photography, topographic maps from the United States Geological Survey (USGS), hydrogeology and geologic maps from the Minnesota Geologic Survey (MNGS), 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 and boating 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: Approx. S1300 WI-35
Nelson, WI 54756

Legal Description: Fourth Principal Meridian, Wisconsin
Township 22 North, Range 13 West
Section 7, 17, 20, and 21
Section 6, South ½
Section 5, SW 1/8
Section 8, S + W ½
Section 16, W ½

Township 22 North, Range 14 West
Section 1, SE 1/8
Section 12, E ½

The area described contains 4,115 acres of land, more or less.

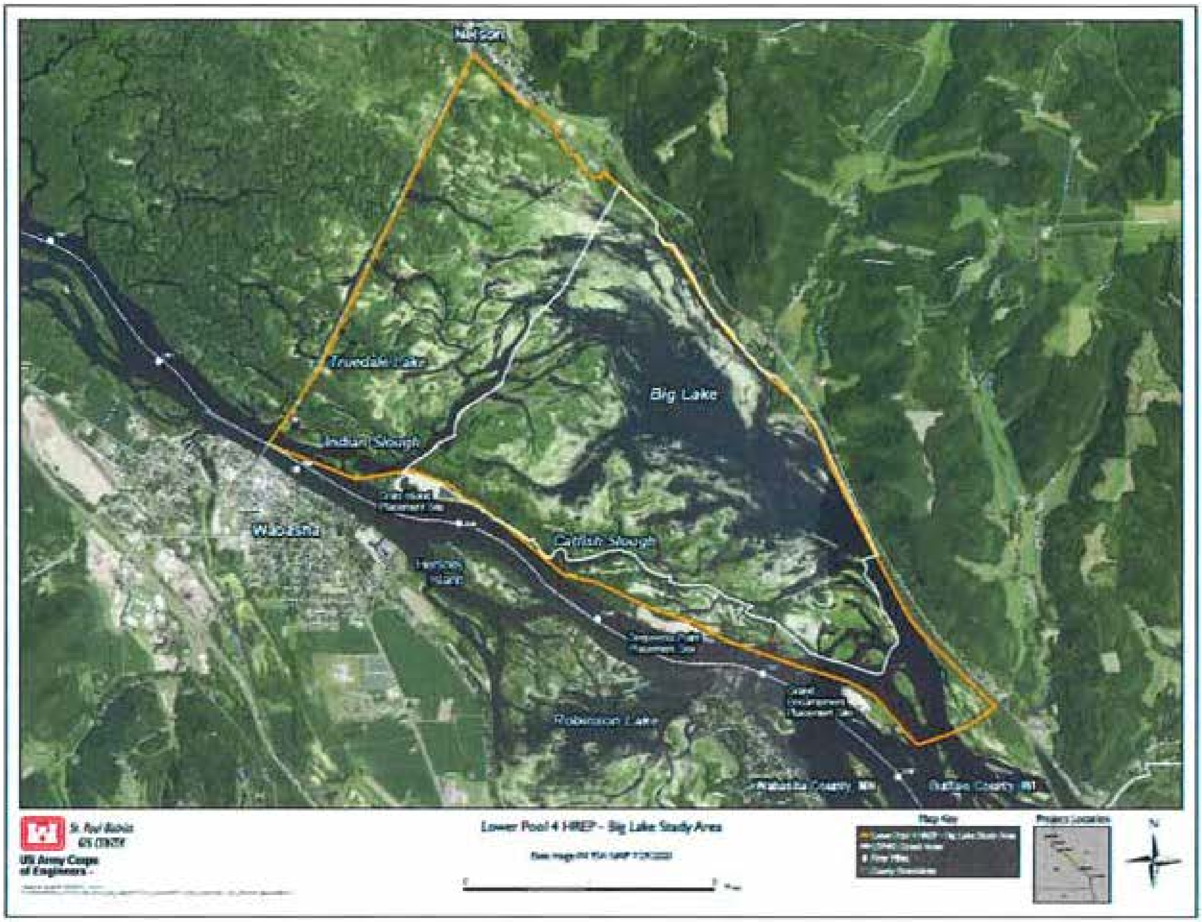

Figure 1 Lower Pool 4 Big Lake Study Area Inside Yellow Boundary

6.2 Site and Vicinity Description

The properties are currently uninhabited and primarily used for recreation and wildlife management. The area is bounded on the west by the Mississippi River, on the east by uplands, on the north by Highway 25.

In 1924 the properties were established as a National Wildlife Refuge. The Wabasha-Nelson Bridge was opened in 1931. Historical topographic maps from 1950 show the subject properties as back water channels, wetlands, and riparian forests, similar to present day. A vast majority of the property lies within the 100 year FEMA Federal Flood Zone and are comprised of or bounded by National Wetlands.

The closest communities to the project area are Nelson, Wisconsin and Wabasha, Minnesota, which have a population of 322 and 2,567 residents, respectively, according to the 2020 Census.

6.3 Current use of the Property

The subject properties are currently owned by the U.S. Fish and Wildlife. The properties are part of a corridor along the Mississippi River comprised of wildlife habitat and recreation. Refuge management of the Big Lake Project area includes canoe trails, boat landings, and the Big Lake No Entry Sanctuary with closures based on waterfowl hunting seasons.

6.4 Adjoining Property Information

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

Direction from Site	Use	Comments
North	Wetland/ River	Hwy 25
South	Wetland/ River	
West	River	Mississippi River Navigation Channel
East	Upland	Railroad, HWY 35, Residential, Deer Creek

6.5 *Federal Government Refuge Management Provided Information*

The USACE conducted an electronic interview with Mary Stefanski, District 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 findings from the interview.

6.6 *Local Government Provided Information*

The Wabasha Fire Department was contacted regarding responses with in and adjacent to the subject area.

There were no records of reposes in and adjacent to the study area.

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 Area 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	0	None
Federal NPL Sites	N	0	None
Federal CERCLIS Sites	N	0	None
Federal CERCLIS NFRAP Sites	N	0	None
RCRA CORRACTS Sites	N	0	None
RCRA TSD Facilities	N	0	None
RCRA SQG	N	0	None
RCRA LQG	N	0	None
Federal ERNS Sites	N	0	None
SPILLS Reports	N	0	None
State HW Sites	N	0	None
State CERCLIS Sites	N	0	None
Landfill/SW Disposal Sites	N	0	None
LUST/LAST Sites	N	0	None
UST/AST Sites	N	0	None
State AIRS Sites	N	0	None

No known sites of environmental contamination were identified in the EDR search of Federal and State databases.

7.2 Physical Setting Sources

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

The EDR Well Report with GeoCheck revealed that no water supply or monitoring wells were identified on the subject properties. Groundwater flow direction was interpolated from the Generalized Water-Table Elevation Map of Buffalo County, Wisconsin by the Wisconsin Geological and Natural History Survey. The general localized groundwater flow gradient across the assessment areas is south, south-east.

The general topographical gradient is south and east. Based upon site setting and surrounding areas, possible contamination could be brought to the subject site, however based upon documentation, there are no likely sources of runoff or groundwater contaminant from outside the project area, that would impact project activities.

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: 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. 1932, 1950, and 1951 USGS 15 Minute Topographic quadrangles, 1974, 2013, 2016 and 2019 USGS 7.5 Minute Topographic quadrangles were obtained. The 1956 and 1965 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 entries 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: 1939, 1953, 1973, 1980, 1992, 2006, 2010, 2013 and 2017. 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 29 July 2022, and a second team site visit on May 25th 2023, by Ashley Woods, geologist with the U.S. Army Corps of Engineers, St. Paul District. The inspector was accompanied with PDT and Project Partners during the site reconnaissance, conducted during a site visit. Weather conditions at the time of the site reconnaissance were sunny, warm, (approximately 80^{0}F), and light winds. During the inspection thick vegetation and wilted grasses covered a vast majority of the inspection area land obscuring the ground surface. Photographs taken during the site reconnaissance can be found in Appendix G of this report.

8.2 General Site Setting

The subject properties are located in the floodplain of the Mississippi River, between river miles 760.2 to 756.6, on the eastern side of the river channel in backwaters. The land is primarily undeveloped riparian forest and wetlands. The soil consists of alluvial overbank sediments, backwater channel deposits, and shallow lacustrine to marsh deposits.

8.3 Site Visit Findings

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

8.3.1 Subject Property

- Typical site setting and vegetation (Figs. 1, 2, 3, and 4)
- Typical site setting of a slough (Fig. 5)
- Typical site setting of Big Lake with lotus vegetation (Fig. 6)

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 1527-21. This assessment revealed that there were no observed potential risks for contamination due to recognized environmental conditions on the subject property.

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.

Appendix F

Site Reconnaissance Photos

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Big Lake HREP
HTRW Site Visit Photos
Legend
Figure
Wabasha
Fig. 4
Fig. 6
Fig. 5
Wabasha
Fig. 3
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Figure 1: Typical Vegetation 1

Figure 2: Typical Vegetation 2

Figure 3: Typical Vegetation 3

Figure 4: Typical Vegetation 4

Figure 5: Slough

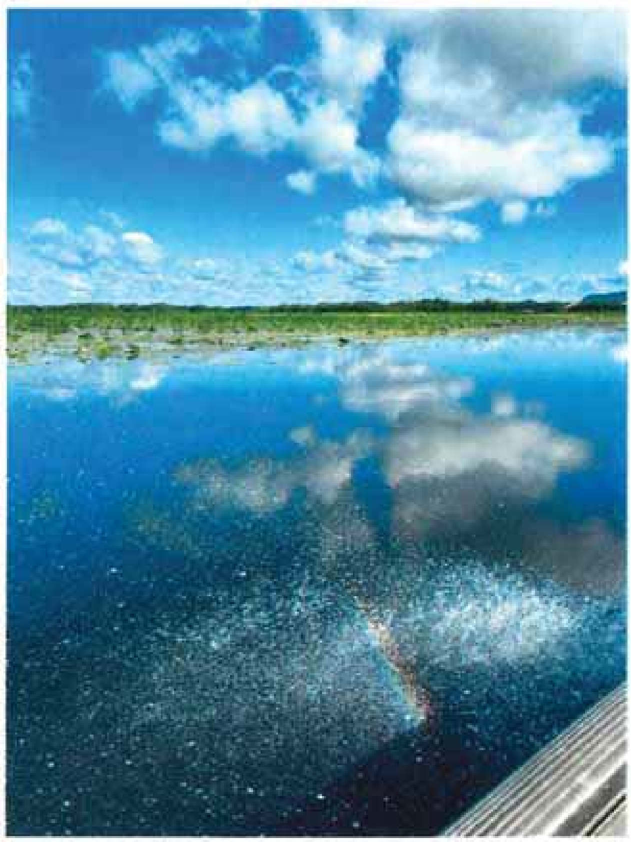

Figure 6: Big Lake Lotus

US Army Corps of Engineers ®
St. Paul District

Appendix E: Climate Change, Hydrology and Hydraulics

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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Appendix E: Climate Change, Hydrology and Hydraulics

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1 Introduction

Big Lake is a backwater lake on the Wisconsin side of Pool 4 of the Upper Mississippi River. It is located across from Wabasha, MN and 5 river miles (RM) below Lake Pepin in Lower Pool 4 between river mile (RM) 756.5 and 760 of the Mississippi River (Figure 1).

The construction of Lock and Dam 4 (L&D 4) in the mid-1930s and its operation to maintain a minimum pool elevation for navigation, submerged the floodplain throughout Pool 4, increasing the size of the lake, expanding secondary channels and deteriorating existing floodplain islands of the project area. The Chippewa River also enters the main channel 4 miles upstream of the project area. During below-bankfull flow conditions, Big Lake receives inflows from the Main Channel on the western side of the lake through Indian Slough and Catfish Slough. During above-bankfull conditions/small flood events the natural levee between Big Lake and the Main Channel are overtopped.

This report contains a number of analyses and design components that utilize elevation values and data. The project datum is North American Vertical Datum of 1988 (NAVD 88), so all elevations in this report (unless noted otherwise) will utilize that datum. The US Army Corps of Engineers (USACE) discharge and stage gages utilize the Mean Sea Level 1912 (MSL 12) datum. USGS gages typically utilize the National Geodetic Vertical Datum of 1929 (NGVD 29) datum. For reference, conversions from these datums to the project datum are provided below.

Project Datum NAVD 88 (feet) = MSL 12 (feet) - 0.44 feet
Project Datum NAVD 88 (feet) = NGVD 29 (feet) + 0.04 feet

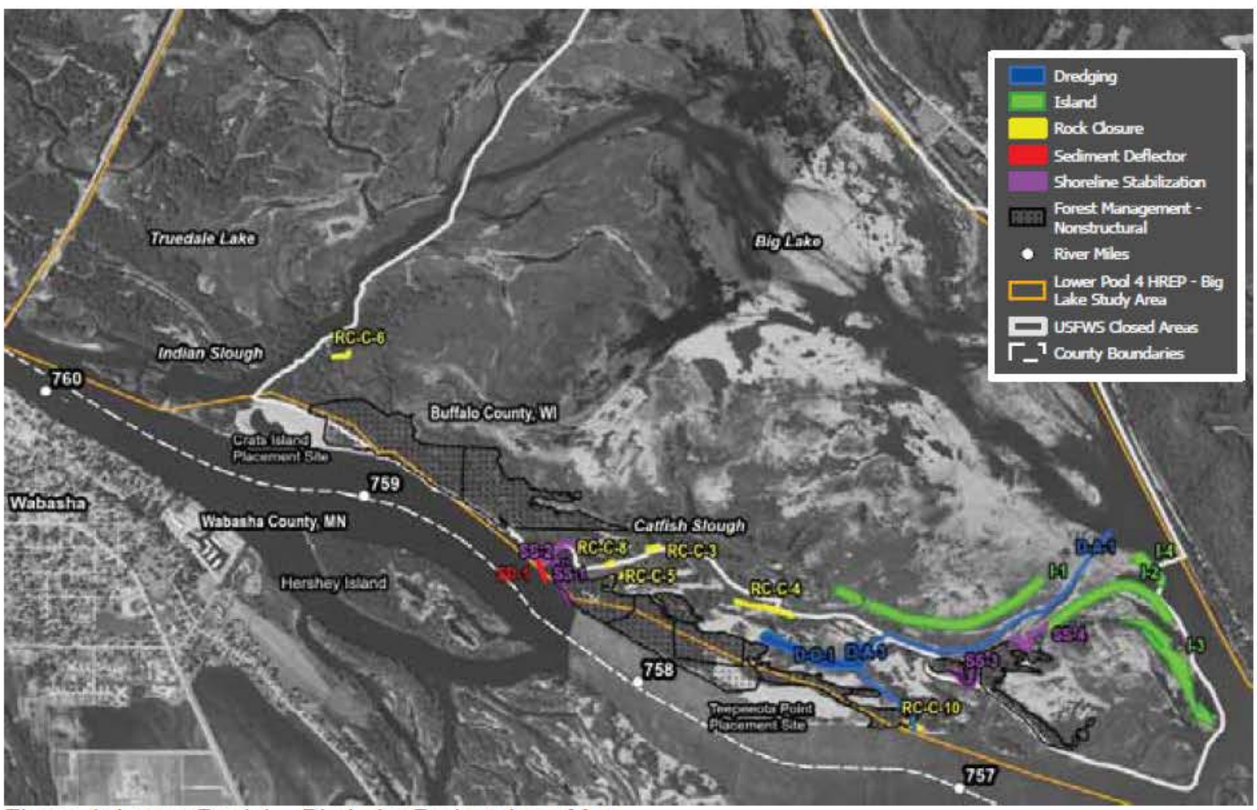

Figure 1: Lower Pool 4 – Big Lake Project Area Map

2 ECB 2018-14 Analysis of Potential Climate Change Vulnerabilities

This assessment is performed to highlight existing and future challenges facing the study area due to climate change and is conducted in accordance with United States Army Corps of Engineers' (USACE) Engineering Construction Bulletin (ECB) 2018-14, *Guidance For Incorporating Climate Change Impacts To Inland Hydrology In Civil Works Studies, Designs, and Projects*, revised 19 August 2022. In accordance with ECB 2018-14, this evaluation identifies potential climate change vulnerabilities for the Lower Pool 4 HREP which is being completed in three Feasibility Study phases (Big Lake, Robinson Lake and Tank Pond). The project area is located between Mississippi River miles 753 and 760 in the southernmost portion of Lock & Dam (L&D) 4's pool near Wabasha, MN. This assessment highlights existing and future climate change driven risks for the study area. Study background information can be found in the main report, and more general background information on climate change driven risk can be found in ECB 2018-14 (USACE, 2022).

2.1 Study Background

The proposed Lower Pool 4 HREP seeks to improve and create habitat by constructing island features, backwater channel closures, shoreline stabilization features and overwintering fish habitat as described in Section 7. Ecosystem restoration is the focus of this analysis because the proposed project seeks to improve and create habitat primarily through the reconstruction of islands and bank stabilization. Future climate conditions may impact the establishment and design of project features. As indicated by the U.S Geological Survey (USGS) in their 2022 report, *Ecological Status and Trends of the Upper Mississippi and Illinois Rivers* (Van Appledorn, 2022), hydrologic indicator variables most relevant to the ecological health of a watershed are defined as annual discharge (maximum, mean, and minimum), duration of high discharges (exceeding the 20% annual exceedance probability (AEP) discharge), and monthly mean discharge. Thus, to analyze the effects of climate change on ecosystem restoration features for this study, the annual average streamflow records are evaluated since they are representative of flows impacting project features throughout the year. This is a small-scale study and the No-Rise constraint described in 6.1 does not allow for a full suite of design options to combat future climate conditions, so analyzing a seasonality timeframe or other variables would not provide any additional insight into this project.

2.2 Literature Review

The *Fourth National Climate Assessment* (NCA4) and the USACE *Civil Works Technical Report CWTS-2015-13,* as well as state and watershed specific resources published by the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) (NCEI, 2020), the U.S. Geological Survey (USGS), and the Minnesota Department of Natural Resources (MN DNR) are the basis for this literature review. The focus of these references is on summarizing trends in historic, observed temperature, precipitation, and streamflow records, as well providing an indication of future, climate-changed hydrology based on the outputs from Global Climate Models (GCMs). For this assessment, background on observed and projected temperature and precipitation is provided as context for the impact that they have on observed and projected streamflow.

The NCA4 considers climate change research at both a national and regional scale (USGCRP, 2018). *Civil Works Technical Report CWTS-2015-13* was published as part of a series of regional summary reports covering peer-reviewed climate literature. The 2015 USACE Technical Reports cover 2-digit, United States Geological Survey (USGS), hydrologic unit code

(HUC) watersheds in the United States (U.S). The Lower Pool 4 HREP is located in 2-digit HUC 07, the Upper Mississippi Region (USACE, 2015) and in the NCA4 Midwest climate region. In many areas, temperature, precipitation, and streamflow have been measured since the late 1800s and provide insight into how the hydrology in the study area has changed over the past century. GCMs are used in combination with different representative concentration pathways (RCPs) reflecting projected radiative forcings up to year 2100 to model future climate. Radiative forcings encompass the change in net radiative flux due to external drivers of climate change, such as, for example changes in carbon dioxide or land use/land cover. Projected temperature and precipitation results can be transformed to regional and local scales (a process called downscaling) for use as inputs in precipitation-runoff models (Graham, Phil, & Bengt, 2007). Uncertainty is inherent to projections of temperature and precipitation due to the GCMs, RCPs, downscaling methods, and many assumptions needed to create projections (USGCRP, 2017). When applied, precipitation-runoff models introduce an additional layer of uncertainty. However, these methods represent the best available science to predict future hydrologic variables (e.g. precipitation, temperature, streamflow). Many researchers use multiple GCMs and RCPs in their studies to understand how various model assumptions impact results (Glecker, Taylor, & Doutriax, 2008).

Temperature. Based on observed temperature records, the annual, average air temperature between 1986 and 2016 for the Midwest has increased by 1.26°F from the 1901-1960 annual average temperature (USGCRP, 2017). Increasing temperatures can accelerate snowmelt and lengthen the frost-free season (Carelton & Hsiang, 2019); (Liu, Goodrick, & Stantfurf, 2013); (Woodward, Perkins, & Brown, 2010). Many studies indicate a change in the seasonality in the region, marked by increasing winter temperatures and early spring melt (Schwartz, Ault, & Betancourt, 2013); (Wang, et al., 2009); (Wolter, et al., 2015); (Westby, Lee, & Black, 2013). GCM based, projections of temperature for the Midwest show a statistically significant increase in both annual, average temperature and the number of extreme heat days over the next century (Vavrus & Behnke, 2014).

In Minnesota, observed temperatures have risen more than 2.5°F since the beginning of the 20th century (Runkle, E., Frankson, Easterling, & Champion, 2022). Since 1970, winter temperatures have warmed 15 times faster than summer temperatures, and nighttime temperatures have warmed 55% faster than daytime temperatures. The frequencies of -35°F readings in northern Minnesota and -25°F readings in the south have fallen by up to 90% (Minnesota DNR, 2022). Although climate conditions vary from year to year, in Minnesota observed increases in temperature are projected to continue throughout the 21st century. Regardless of emission scenario applied, annual average temperatures are projected to exceed historic record levels in Minnesota by the end of the 21st century (Runkle, E., Frankson, Easterling, & Champion, 2022).

Precipitation. Average, annual precipitation in the Midwest has increased by 5% to 15% from the first half of the last century (1901–1960) as compared to present day (1986–2015). The amount of rain falling in extreme rain events (1% AEP storm events), has increased by 42% from 1958 to 2016 (USGCRP, 2018). According to the NCA4, GCM based projections indicate that winter and spring precipitation in the Midwest could increase by up to 30% by the end of the century. Precipitation increases of 10-15% are projected in winter and spring for 2-digit HUC 07 from 2070–2099 relative to 1986–2015. However, in the summer and fall, projected precipitation amounts are not expected to change significantly. A northward shift in the rain–snow transition zone in the central and eastern United States is projected by end of the 21st century causing large areas that are currently snow dominated in the cold season to be rainfall dominated (USGCRP, 2017); (Ning & Bradley, 2015).

According to the MN DNR, on average, Minnesota has become 3.4 inches wetter between 1895 and 2020 (Minnesota DNR, 2022). Since 1895, the wettest five-year period is 2015-2020 (Runkle, E., Frankson, Easterling, & Champion, 2022). Not only is Minnesota receiving more precipitation, but high intensity, 1-inch and 3-inch rains, have become more common. The volume of the heaviest annual rainfall has increased (Minnesota DNR, 2022); (Runkle, E., Frankson, Easterling, & Champion, 2022). Average annual precipitation is generally expected to increase in Wisconsin, Minnesota, and the Midwest (GLISA, 2019); (Johnson, Butcher, Parker, & Weaver, 2012); (Notaro, et al., 2011); (Pryor, et al., 2014); (USGCRP, 2017); (Vavrus & Behnke, 2014).

Streamflow. Observed streamflow trends are strongly influenced by precipitation, temperature, and other factors such as land use and land cover in a region, groundwater dynamics, drainage patterns, channel geomorphology, and regulation. In the Upper Mississippi Region (2-digit HUC 07), multiple studies have identified increasing trends in the observed, annual, average streamflow (Novotny & Stefan, 2007); (Mauget, 2004); (Small, Islam, & Vogel, 2006) and in the observed, annual, mean/median baseflow (Juckem, Randall, Anderson, & Robertson, 2008); (Xu, Scanlon, Schilling, & Sun, 2013). Seasonally, studies have reported increasing annual, minimum, 7-day, low flows in the fall (Small, Islam, & Vogel, 2006) and annual, average, 7-day, low flows in the fall and winter (Novotny & Stefan, 2007). Some studies have found that annual peaks are increasing in the spring and summer (Novotny & Stefan, 2007).

The 2020, USACE *Mississippi River Geomorphology and Potamology* (MRG&P) *Study* also indicates that annual water yield, annual maximum daily water yield, and annual maximum 7-day water yield are increasing throughout the Upper Mississippi River Basin (USACE, 2020). Water yield represents discharge per unit of watershed area. For the 2020 USGS study, water yield was normalized by total annual precipitation to differentiate between the influence of altered precipitation versus other drivers of change in hydrologic response. Evaluations of precipitation-normalized water yield indicate that changes to water management and land use/cover in the Upper Mississippi River Basin are exacerbating increases in water yield (Simon, Artita, Simon, Darby, & Leyland, 2020). There is little to no consensus in the literature regarding changes in projected streamflow in the Upper Mississippi Region.

Ecosystem Health. Based on a 2022 report generated by the USGS (Van Appledorn, 2022), the following variables are critical to ecosystem health and have changed over time: annual discharge (maximum, mean, and minimum), duration of high discharges (exceeding the 20% AEP discharge), and monthly mean discharge. Results from the 2022 USGS report indicate that mean and minimum annual discharges are increasing at the USGS gages at Winona, Minnesota (05378500) and Keokuk, Iowa (05474500). The duration of high discharges has also increased from 1940 to 2019 for all gages analyzed. Significant increases in annual maximum discharges were detected for the Keokuk, Iowa (05474500) and Valley City, Illinois (05586100) USGS gages. Based on an analysis of monthly, mean discharges, large increases in May mean discharges were identified for all three Mississippi River gages analyzed. There is some evidence that the maximum in monthly, mean discharge for a given year has shifted from occurring in April to either May or June. These increases in discharge may be due to the increases in observed annual precipitation throughout the Upper Mississippi River basin.

Water quality analysis presented in the 2022 USGS report indicates that total suspended sediment (TSS) concentrations associated with mean discharges have decreased long-term in many reaches and tributaries of the Upper Mississippi River. The most significant changes have been observed in L&D pools 4 and 8. Phosphorus loads in all the L&D pools analyzed (pools 4, 8, 13, and 26) on the Upper Mississippi River have also decreased long-term. Although there are no long-term, significant trends in dissolved oxygen (DO) for the portions of the Upper Mississippi River assessed, low DO in backwater areas has been observed more frequently in the summer than in winter. Overall improvements in Mississippi River water quality are likely due to improved agricultural/land use practices throughout the Upper Mississippi River basin.

The concentration of submerged aquatic vegetation (SAV) is considered the primary indicator of aquatic vegetative health in the Upper Mississippi River. High prevalence of SAV (generally >50-percent) indicates quality habitat for waterfowl. Aquatic vegetation analysis identified trends in SAV in L&D pools 4, 8, and 13. The prevalence of SAV in L&D pools 4 and 8 increased by 30% from 2002 to 2010. Since 2010, SAV concentrations at these two locations have plateaued. The prevalence of SAV in L&D 13 ‘s pool increased from 1998 to 2008. Since 2009, SAV concentrations have been decreasing in L&D 13’s pool. Additionally, since 2000, increases in aquatic plant species diversity have been observed in L&D pools 4 and 8. In the L&D 8 and 13’s pools, a positive trend in emergent vegetation has been recorded. Emergent vegetation provides habitat for aquatic species. No trends in aquatic vegetation were found within the lower portion of the Upper Mississippi River (L&D Pool 26). The overall improvements in SAV prevalence and diversity may be due to the cumulative impacts of HREPs and other restoration efforts along the Upper Mississippi River.

Summary. Within the literature reviewed, there is evidence that temperature, precipitation, and streamflow have increased over the observed period of record within the Upper Mississippi Watershed. Trends in water quality within the Upper Mississippi Watershed indicate decreases in total phosphorus and total suspended solids. Aquatic vegetation analysis indicates increases in SAV in L&D pools 4, 8, and 13 in early 2000s through 2010. SAV concentrations have plateaued through 2019. Projections of future climate show strong consensus on increases in future temperature, and moderate consensus on increases in future precipitation. There is little to no consensus related to trends in future streamflow. Figure 2 from the 2015 USACE *Civil Works Technical Report CWTS-2015-13* provides a visual summary of the trends in observed and projected hydrometeorological variables for 2-digit HUC 07, the Upper Mississippi Region.

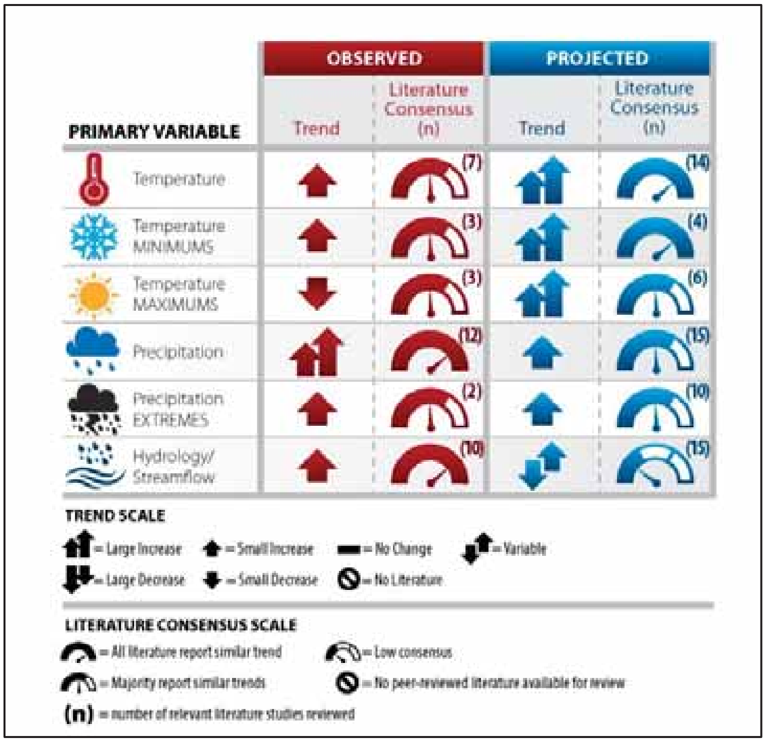

Figure 2: Summary matrix of UMR (HUC 07) observed and projected climate trends (USACE, 2015)

2.3 Nonstationarity Detection and Trend Analysis

The assumption that hydrologic timeseries are stationary (their statistical characteristics are unchanging) in time underlies many traditional hydrologic analyses. Statistical tests can be used to test this assumption using the techniques outlined in USACE Engineering Technical Letter (ETL) 1100-2-3, *Guidance for Detection of Nonstationarities* (USACE, 2017). The USACE Time Series Toolbox (TST) tool (Olson, et al., 2022) is a web-based tool that performs the statistical tests described in the guidance. Average annual streamflow is analyzed for the Lower Pool 4 HREP because project features are vulnerable to damage from flows during the first few years of establishing habitat. Average annual streamflow is most representative of flows features experience throughout the year (Van Appledorn, 2022). In the long-term, project feature elevations need to be designed so that they can withstand future conditions. More frequent overtopping of project features can have adverse effects on overwintering habitat and floodplain forests.

Observed average annual discharge for L&D 4 is calculated in HEC-DSSVue v3.0 (HEC, 2017) from the mean daily flow values computed by USACE from observed mean daily stage measurements. Because the streamflow record analyzed has been generated based on a flow-stage rating curve, the quality of the data was verified using observed USGS streamflow records recorded at locations upstream and downstream of L&D 4. If unverified, changes in the flow-stage rating curve applied can introduce a source of nonstationarity and/or uncertainty into the streamflow record. This should be taken into consideration when interpreting the results of trend and nonstationarity analyses. Based on this evaluation, no discrepancies were found in the L&D 4 streamflow record.

The USACE L&D 4 gage captures 57,100 square miles of drainage area and is influenced by regulation from the L&Ds on the Mississippi River. The L&Ds were constructed and placed into operation in 1937. The L&D 4 Water Control Manual (USACE, 2004) states that the general objective of the L&Ds is to maintain the authorized nine-foot navigation channel upstream of L&D 4. The L&Ds maintain the minimum storage of water required for navigation at all times and any additional water volume is outflowed. Consequently, operation of the L&Ds does not have a significant impact on annual average streamflow. The TST tool is applied to detect nonstationarities and trends for the period of record from 1960 to 2020.

As shown in Figure 3, the average flow record observed at L&D 4 does not have strong evidence of a nonstationarity. A strong nonstationarity is one that demonstrates a degree of consensus, robustness and a significant increase or decrease in the sample mean and/or variance.

Linear and monotonic trends are evaluated using the t-test, Mann-Kendall and Spearman Rank Order tests. The significance of trends is evaluated using a 0.05 level of significance threshold (p-value<0.05 is considered statistically significant). Trend analysis indicates a statistically significant, positive trend for the 1960-2020 period of record by the t-Test (p-value= 0.006), Mann-Kendall test (p-value=0.016), and Spearman Rank-Order (p-value=0.015) test, see trendline in Figure 4. Because there is not strong evidence of nonstationarity in the flow record, a subset of the record was not analyzed for monotonic trends.

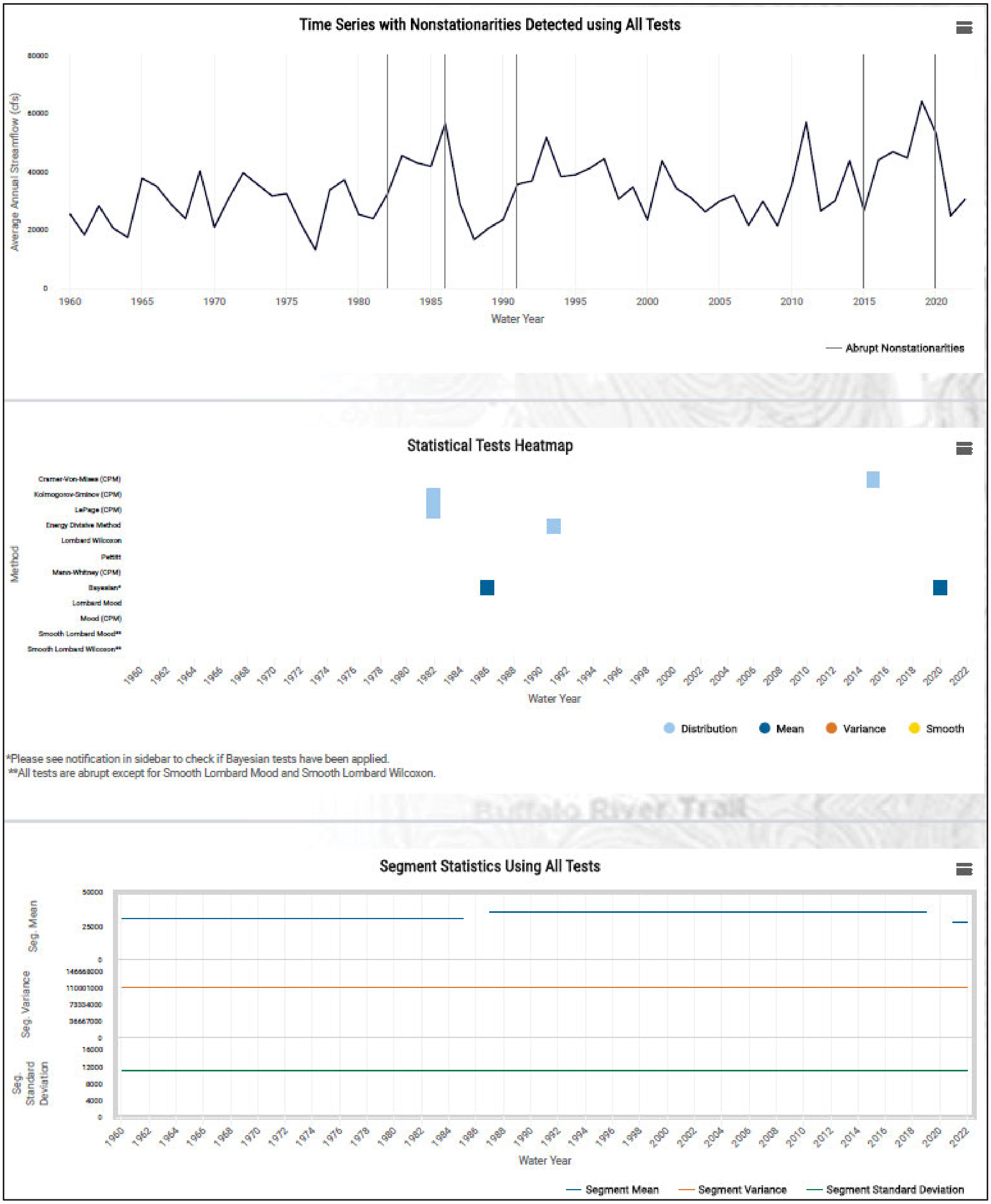

Figure 3: Time Series Toolbox Output for Annual Average Streamflow for L&D 4.

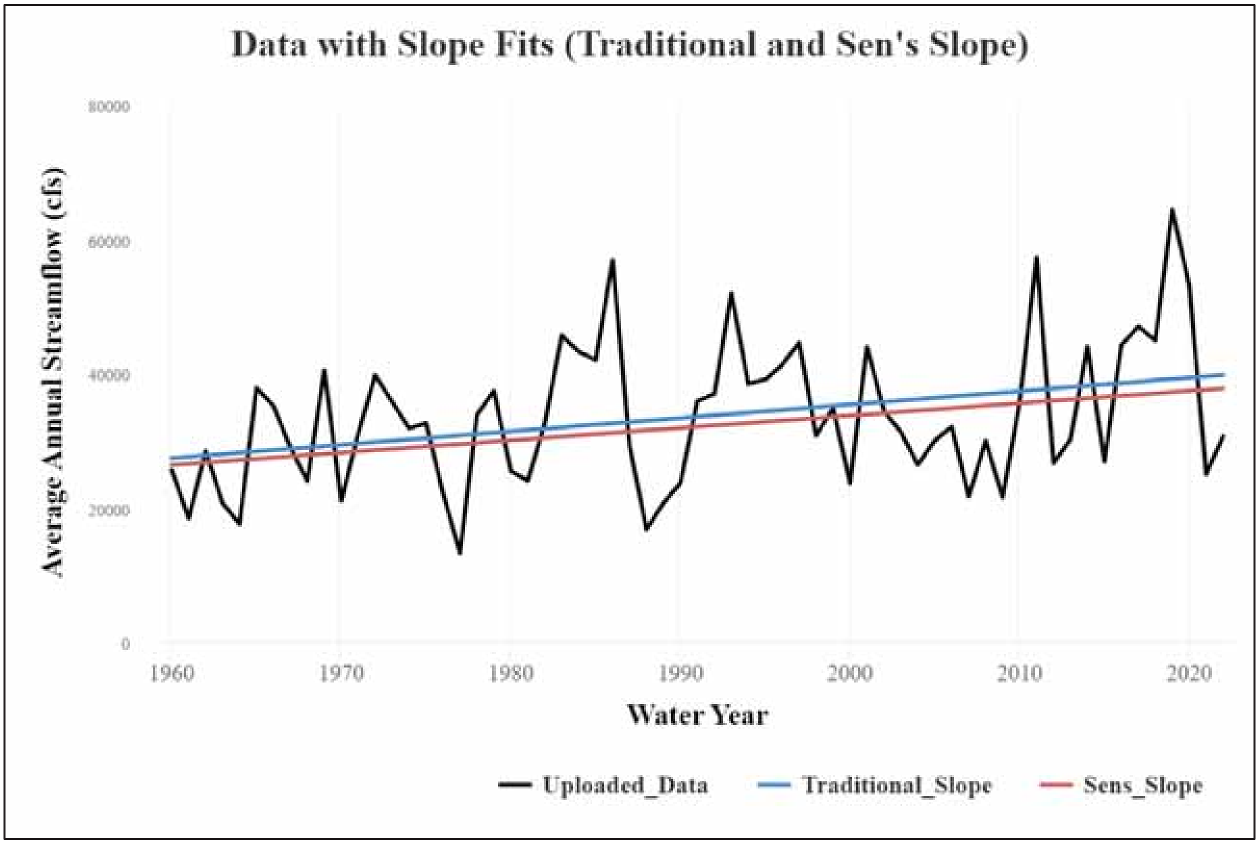

Figure 4: Trend Analysis for Average Annual Streamflow for L&D 4.

2.4 Climate Hydrology Assessment Tool (CHAT)

The USACE Climate Hydrology Assessment Tool (CHAT) (Patel, et al., 2022) displays various simulated, historic and future, climate-changed streamflow, temperature, and precipitation outputs derived from 32 GCMs. The CHAT uses Coupled Model Intercomparison Project Phase 5 (CMIP5) GCM meteorological data outputs that have been statistically downscaled using the Localized Constructed Analogs (LOCA) method. GCMs rely on scenarios representing different pathways to a given atmospheric concentration of greenhouse gas emissions (GHG) referred to as representative concentration pathways (RCPs). RCPs describe the change in radiative forcing at the end of this century, as compared with pre-industrial conditions. Projected hydroclimate data in the CHAT for 2006 to 2099 are produced using two future scenarios: RCP 4.5 (where greenhouse gas emissions stabilize by the end of the century) and RCP 8.5 (where greenhouse gas emissions continue to increase throughout the century). Simulated output representing the historic period of 1951 to 2005 is generated using a reconstitution of historic GHG emissions.

To analyze runoff, LOCA-downscaled GCM outputs are used to force an unregulated, Variable Infiltration Capacity (VIC) hydrologic model. Areal runoff from VIC is then routed through a stream network using MizuRoute. Outputs represent the daily in-channel, routed streamflow for each stream segment – valid at the stream segment endpoint. Since the runoff is routed, the streamflow value associated with each stream segment is a representation of the cumulative flow, including all upstream runoff, as well as the local runoff contributions to that specific segment. Within the CHAT, streamflow output can be selected by stream segment and precipitation/temperature output can be selected for a given 8-digit HUC watershed.

The Lower Pool 4 HREP is in 4-digit HUC 0704 (Upper Mississippi Black-Root). The 8-digit HUC of interest specific to the study area is the Buffalo Whitewater watershed (HUC07040003). Figure 5 below shows the 4-digit HUC 0704 (Upper Mississippi Black-Root) and corresponding 8-digit HUC watersheds including the 8-digit HUC of interest specific to the study area is the Buffalo Whitewater watershed (HUC07040003).

Figure 5: HUC 0704 (Upper Mississippi Black-Root) and corresponding 8-digit HUC specific to the study area, Buffalo Whitewater watershed (HUC07040003)

Mississippi River stream segment 07000146 as well as Buffalo River stream segment 07000145 transects the Lower Pool 4 HREP (Figure 6 - highlighted in yellow). Figure 7, Figure 8, and Figure 9 show the range of the modeled, annual-mean streamflow and annual-maximum temperature output presented for the historic period (1951-2005) and the future period (2006-2099) for stream segments 07000146 and 07000145. The annual-mean streamflow is analyzed for this assessment to investigate if and how potential, future streamflow conditions will change. Maximum-annual temperature is analyzed for this assessment as a proxy for water temperature. Warmer water holds less dissolved oxygen (DO) which affects the survival of aquatic life (USGS, 2018). The range of data is indicative of the uncertainty associated with projected, climate-changed streamflow and temperature.

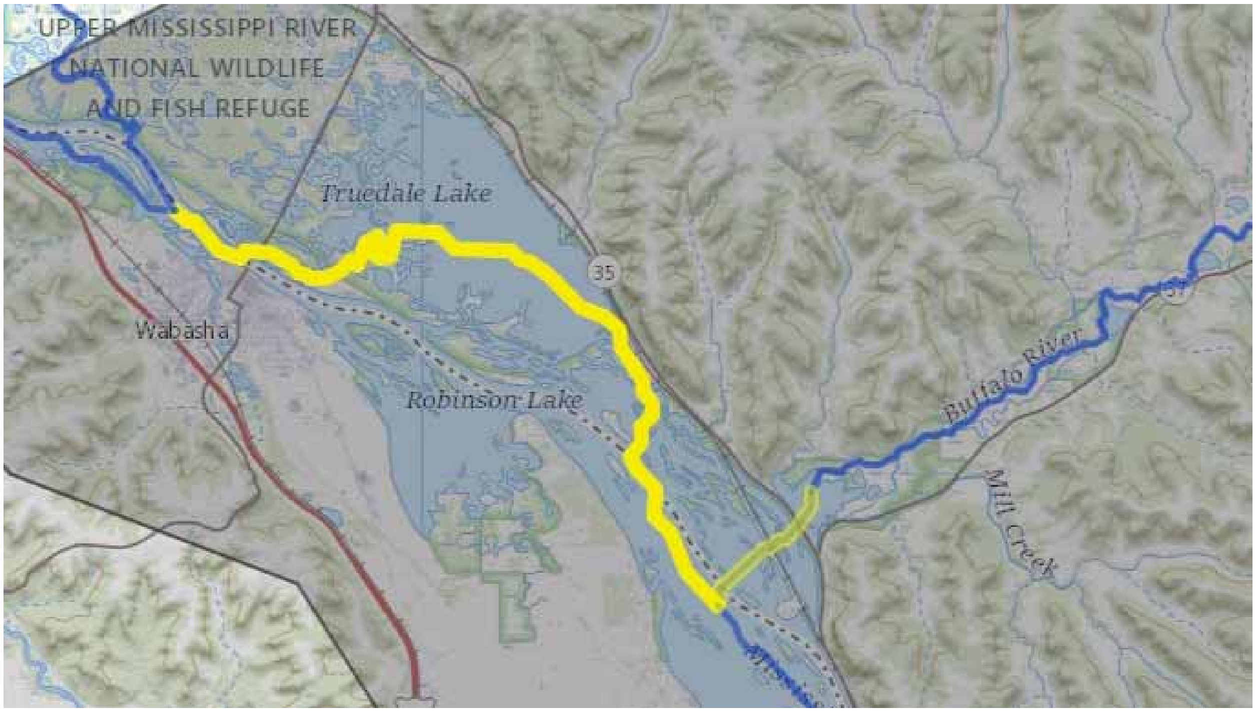

Figure 6: Mississippi River Stream Segment 07000146 and Buffalo River Stream Segment 07000145 (highlighted in yellow)

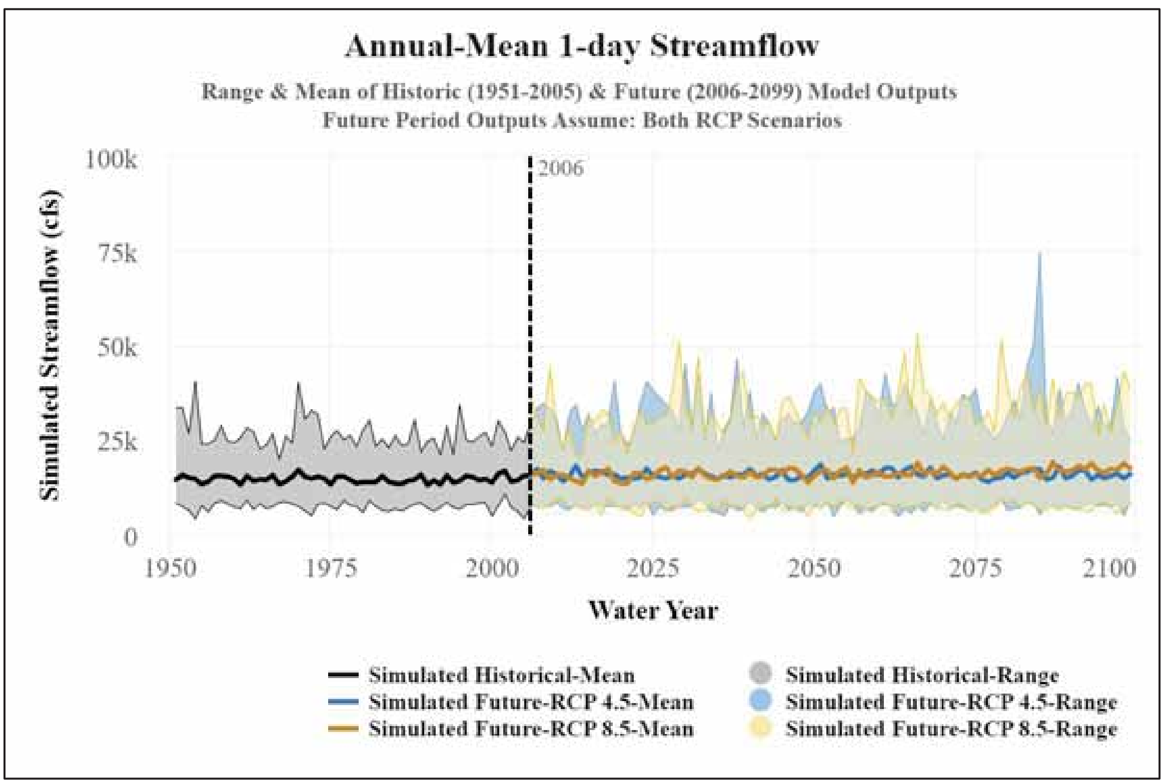

Figure 7: Range of Annual-Mean Streamflow Model Output for the Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000146 (Mississippi River)

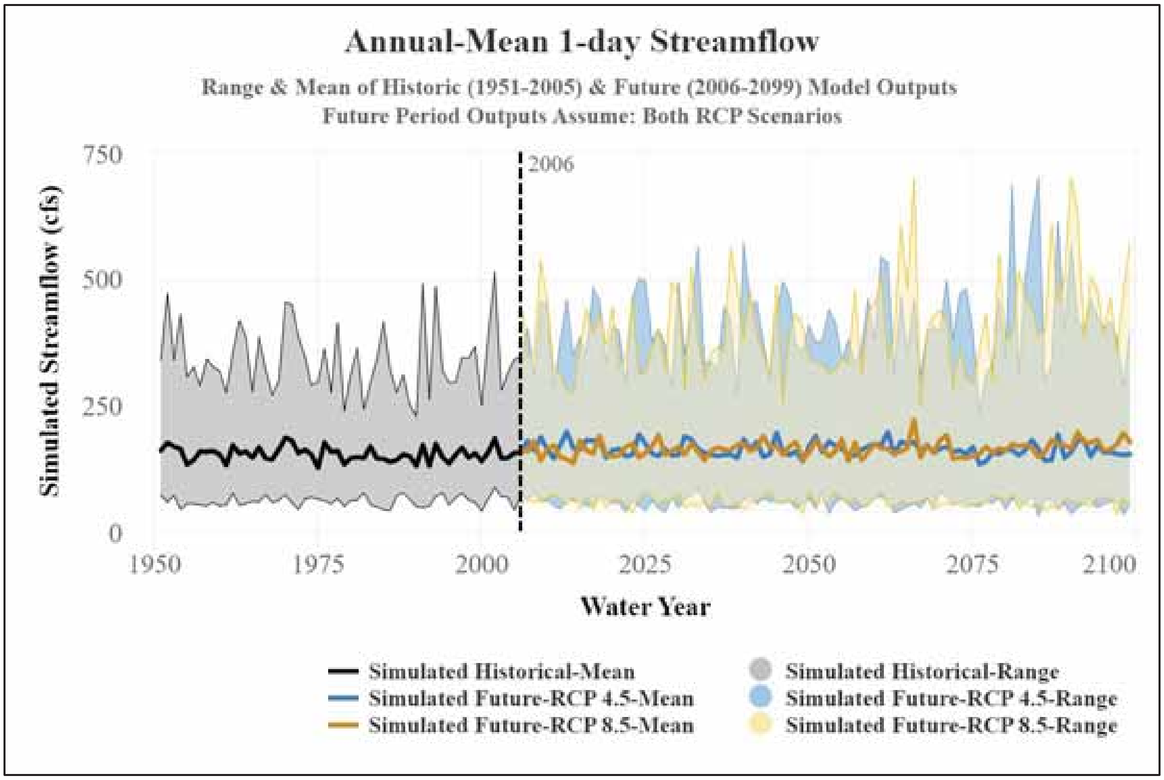

Figure 8: Range of Annual-Mean Streamflow Model Output for the Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000145 (Buffalo River)

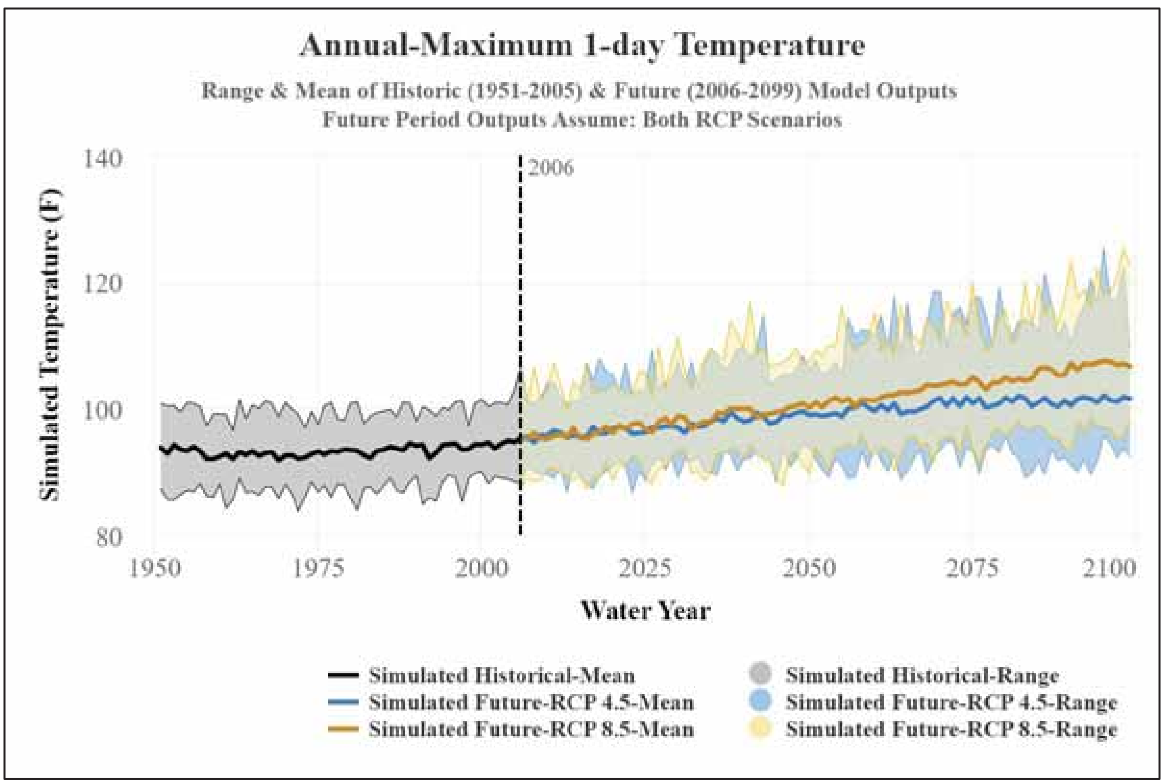

Figure 9: Range of Annual Maximum Temperature Model Output for the Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000146 and 07000145

For the Buffalo Whitewater watershed (HUC07040003) trends are evaluated using the t-Test, Mann-Kendall and Spearman Rank-Order tests. All three statistical tests are applied using a 0.05 level of significance (p-values<0.05 are considered statistically significant). As displayed in Figure 10 and Figure 11, the directionality and magnitude of change in statistically significant trends in annual-mean streamflow are evaluated using the slope of the fitted linear regression relationship. The results of the three statistical tests and the slopes associated with identified, statistically significant trends are presented in Table 1 and Table 2. The mean of the 32 projections of simulated, annual-mean streamflow for the future period (2006-2099) shows a statistically significant, positive trend for the Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000146 and 07000145 when RCP 8.5 is assumed. The trendline has a slope of 20 cfs and 0.13 cfs a year, respectively. This equates to a 998 cfs and 7.4 cfs change in the average of the 32 projections of annual- mean streamflow over a 50-year period, respectively.

When the CHAT is used to evaluate the change in Epoch-Mean of simulated annual-mean streamflow for Stream Segment 07000146 it is found that the median change from the base Epoch (1976-2005) to the mid-century epoch (2035-2064) is 6.6% when RCP 8.5 is assumed. By the end-century epoch (2070-2099) the change relative to the base period is 13.7% when RCP 8.5 is assumed. There is no statistically significant trend in simulated, historic flows (1951-2005) or annual-mean streamflow for the future period (2006-2099) when RCP 4.5 is assumed.

When the CHAT is used to evaluate the change in Epoch-Mean of simulated annual-mean streamflow for Stream Segment 07000145 it is found that the median change from the base Epoch (1976-2005) to the mid-century epoch (2035-2064) is 8.2% when RCP 8.5 is assumed. By the end-century epoch (2070-2099) the change relative to the base period is 7.2% when RCP 8.5 is assumed. There is no statistically significant trend in simulated, historic flows (1951-2005) or annual-mean streamflow for the future period (2006-2099) when RCP 4.5 is assumed.

Table 1: Trend Analysis of Average Model Output: Annual – Mean Streamflow Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000146 (Mississippi River)

<table>
<tr><th rowspan="3">Trend Analysis</th><th rowspan="2">Historic (1951-2005)</th><th colspan="2">Future (2006-2099)</th><th colspan="3" rowspan="2">Historic (1951-2005)</th><th colspan="6">Future (2006-2099)</th></tr>
<tr><th>RCP 4.5</th><th>RCP 8.5</th><th colspan="3">RCP 4.5</th><th colspan="3">RCP 8.5</th></tr>
<tr><th colspan="3">p-values</th><th>Statistically Significant? (<0.05)</th><th>Slope (cfs/year)</th><th>Direction</th><th>Statistically Significant? (<0.05)</th><th>Slope (cfs/year)</th><th>Direction</th><th>Statistically Significant? (<0.05)</th><th>Slope (cfs/year)</th><th>Direction</th></tr>
<tr><td>t-Test</td><td>0.856</td><td>0.898</td><td>8.38E-6</td><td>No</td><td colspan="2" rowspan="3">Not applicable (no trend)</td><td>No</td><td colspan="2" rowspan="3">Not applicable (no trend)</td><td>Yes</td><td rowspan="3">19.96</td><td rowspan="3">↑</td></tr>
<tr><td>Mann-Kendall</td><td>0.717</td><td>0.819</td><td>3.86E-5</td><td>No</td><td>No</td><td>Yes</td></tr>
<tr><td>Spearman Rank Order</td><td>0.681</td><td>0.865</td><td>3.53E-5</td><td>No</td><td>No</td><td>Yes</td></tr>
</table>

Table 2: Trend Analysis of Average Model Output: Annual – Mean Streamflow Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000145 (Buffalo River)

<table>
<tr><th rowspan="3">Trend Analysis</th><th rowspan="2">Historic (1951-2005)</th><th colspan="2">Future (2006-2099)</th><th colspan="3" rowspan="2">Historic (1951-2005)</th><th colspan="6">Future (2006-2099)</th></tr>
<tr><th>RCP 4.5</th><th>RCP 8.5</th><th colspan="3">RCP 4.5</th><th colspan="3">RCP 8.5</th></tr>
<tr><th colspan="3">p-values</th><th>Statistically Significant? (<0.05)</th><th>Slope (cfs/year)</th><th>Direction</th><th>Statistically Significant? (<0.05)</th><th>Slope (cfs/year)</th><th>Direction</th><th>Statistically Significant? (<0.05)</th><th>Slope (cfs/year)</th><th>Direction</th></tr>
<tr><td>t-Test</td><td>0.25</td><td>0.101</td><td>0.0218</td><td>No</td><td colspan="2" rowspan="3">Not applicable (no trend)</td><td>No</td><td colspan="2" rowspan="3">Not applicable (no trend)</td><td>Yes</td><td rowspan="3">0.128</td><td rowspan="3">↑</td></tr>
<tr><td>Mann-Kendall</td><td>0.139</td><td>0.164</td><td>0.0161</td><td>No</td><td>No</td><td>Yes</td></tr>
<tr><td>Spearman Rank Order</td><td>0.147</td><td>0.162</td><td>0.0207</td><td>No</td><td>No</td><td>Yes</td></tr>
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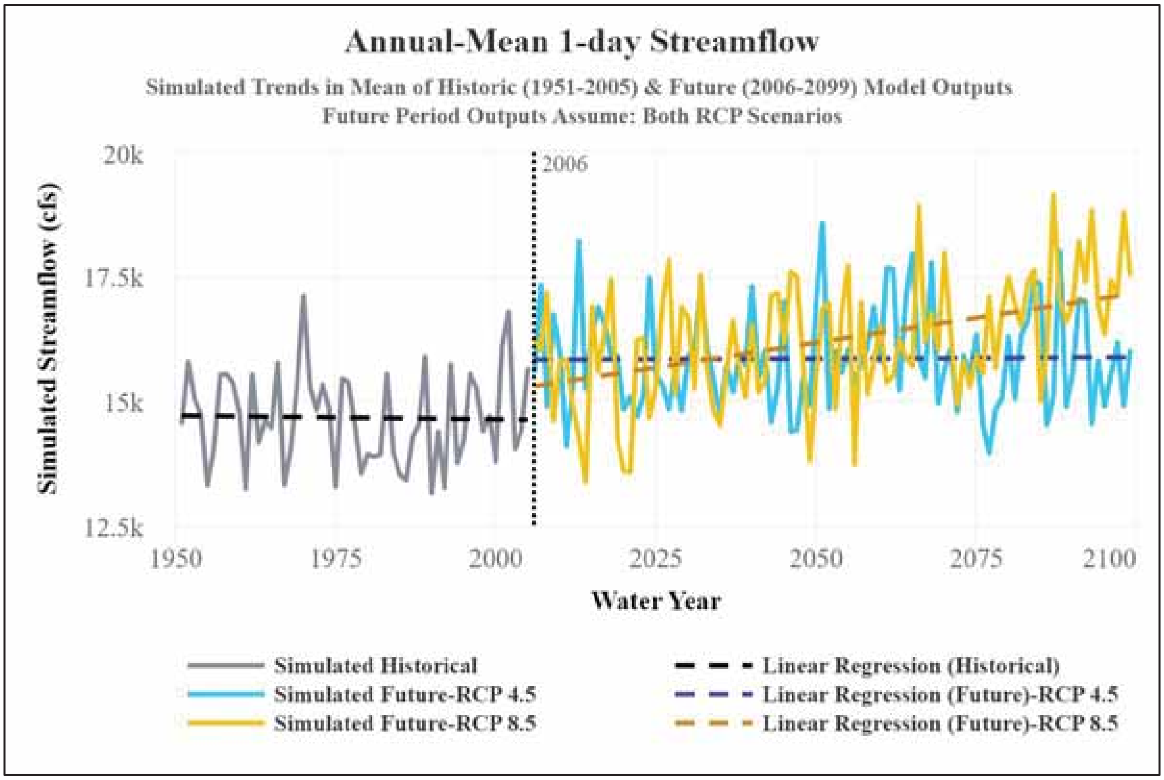


Figure 10: Trend Analysis of Average Model Output: Annual-Mean Monthly Streamflow Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000146 (Mississippi River)

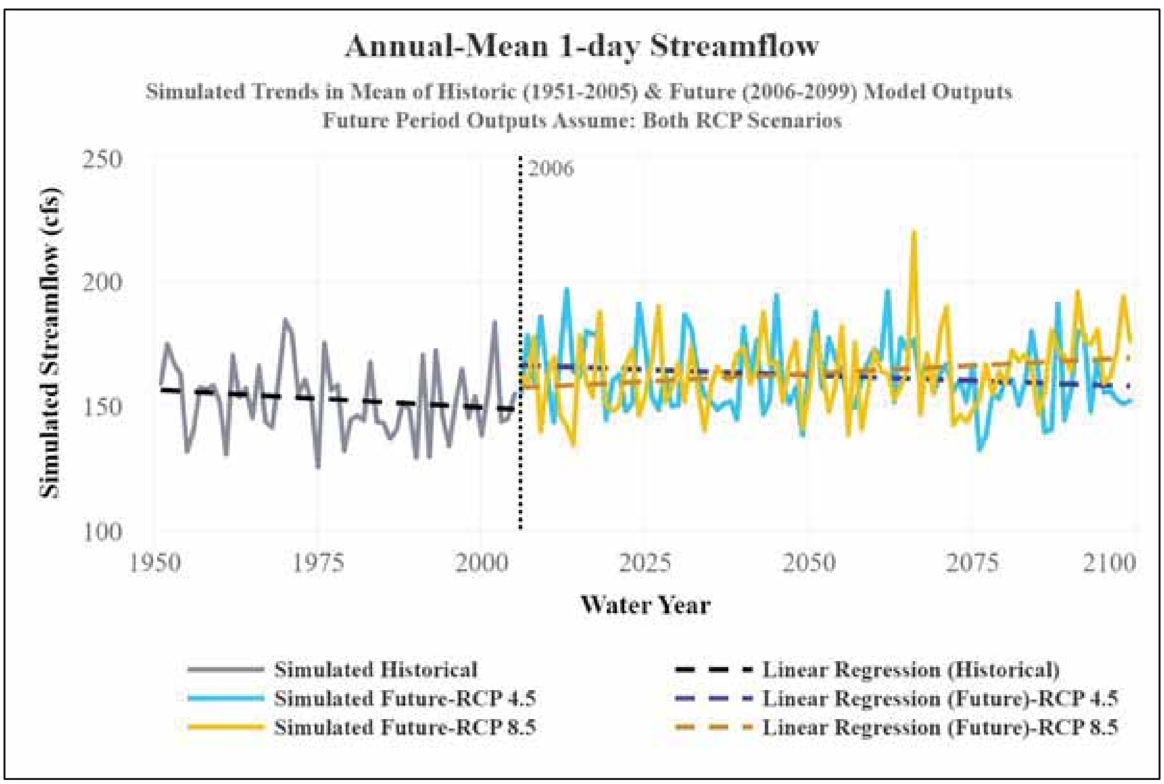


Figure 11: Trend Analysis of Average Model Output: Annual-Mean Monthly Streamflow Buffalo Whitewater watershed (HUC07040003) Stream Segment: 07000145 (Buffalo River)

For the mean of the 32 projections (per RCP) of annual-maximum temperatures, the results of the three statistical tests and the slopes associated with statistically significant trends are presented in Table 3 and Figure 12. The mean of the simulated annual-maximum temperature projections (future period: 2006-2099) shows a statistically significant, positive trend for the Buffalo Whitewater watershed under both the moderate (RCP 4.5) and higher (RCP 8.5) emission scenarios. Both outputs project a significant magnitude of change in temperature over the next fifty years. The CHAT computes a trendline slope of 0.07 °F per year for the lower emission scenario, which would be a 3.6 °F increase in maximum temperature over a 50-year period. The CHAT computes a trendline slope of 0.14 °F per year for the RCP 8.5 emission scenario, which would be a 6.4 °F increase in maximum temperature over a 50-year period. There is also a statistically significant increasing trend in simulated, historic temperatures between 1951 and 2005 (slope of 0.03 °F per year). When the CHAT is used to evaluate the change in Epoch-Mean of simulated annual-maximum temperature it is found that the median change from the base Epoch (1950-2005) to the mid-century epoch (2035-2064) is 4.9 °F for RCP 4.5 and 6.6 °F for RCP 8.5. By the end-century epoch (2070-2099) the change relative to the base period is 5.8 °F for RCP 4.5 and 11.4 °F for RCP 8.5.

Table 3: Trend Analysis of Average Model Output: Annual Maximum Temperature for Buffalo Whitewater watershed (HUC07040003)

Trend Analysis	Historic (1951-2005)	Future (2006-2099)		Historic (1951-2005)			Future (2006-2099)					
		RCP 4.5	RCP 8.5				RCP 4.5			RCP 8.5		
	p-values			Statistically Significant? (<0.05)	Slope (°F/year)	Direction	Statistically Significant? (<0.05)	Slope (°F/year)	Direction	Statistically Significant? (<0.05)	Slope (°F/year)	Direction
t-Test	$1.5x10^{-5}$	$2.2x10^{-16}$	$2.2x10^{-16}$	Yes	0.03	↑	Yes	0.07	↑	Yes	0.14	↑
Mann-Kendall	$8.6x10^{-6}$	$2.2x10^{-16}$	$2.2x10^{-16}$	Yes			Yes			Yes		
Spearman Rank Order	$1.2x10^{-5}$	$2.2x10^{-16}$	$2.2x10^{-16}$	Yes			Yes			Yes		

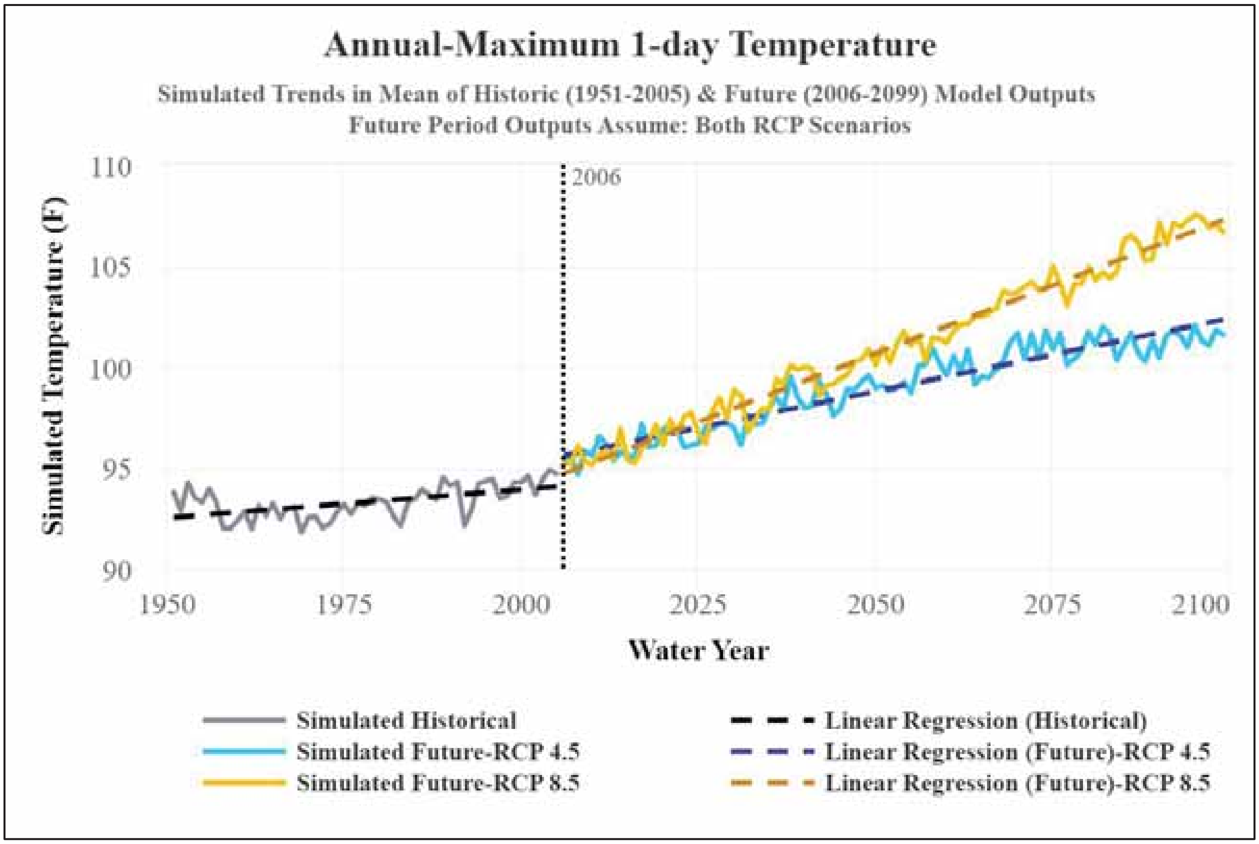


Figure 12: Historic and Projected trends in historic and projected mean annual maximum temperatures for the Buffalo Whitewater watershed (HUC07040003)

The CHAT provides streamflow and temperature outputs analyzed comparatively by describing simulated changes in monthly streamflow and temperature between different epochs (time periods). Monthly streamflow and temperature output is analyzed by determining the mean of the monthly value for the variable of interest for each GCM for three epochs: 1950-2005 (baseline), 2035-2064 (mid-century), and 2075-2099 (end of century). The difference between GCM/Month/Epoch means are determined for both the baseline vs. mid-century and baseline vs. end of century epochs and results are presented as boxplots. These boxplots provide insight into both the range of results and the seasonality of changes in streamflow and temperature overtime.

For stream segments 07000146 and 07000145 in the Buffalo Whitewater watershed (HUC07040003), changes in epoch-mean of simulated monthly mean streamflow are presented in Figure 13 and Figure 14. For the stream segment of the Mississippi River analyzed, it appears that for both the mid-century and end-century epochs December through April mean flows are increasing with those flows derived using RCP 8.5 than those derived by assuming RCP 4.5. Greater increases are observed during December through April for the end of the century epoch. Conversely, August flows appear to be decreasing regardless of what RCP is assumed for both epochs and RCPs analyzed. Increasing mean flows has the potential to adversely impact floodplain forest by extending the duration and extent of floodplain inundation during the growing season in the study area.

For the Buffalo Whitewater watershed (HUC07040003), changes in epoch-mean of simulated monthly maximum temperature are presented in Figure 15. For the Buffalo Whitewater watershed, simulated maximum temperatures for both the mid-century epoch (2035-2064) and the end-century epoch (2070-2099) are increasing relative to historic temperature simulations (1950-2005) for all months and both RCPs. For the mid-century comparisons, 4.5° F increases or greater in temperature are projected under RCP 8.5 for all months but April. Larger changes in temperature are projected by the end of century. As compared to the temperature changes projected by mid-century, for the 2070-2099 epoch, there are larger differences in results where RCP 8.5 was assumed versus RCP 4.5. When RCP 8.5 is assumed, over 10° F of warming is projected in February and June through October. All RCP 8.5 comparisons (using 2035-2064 and 2070-2099 epochs) show between 4 and 13° F of warming. All RCP 4.5 comparisons (using 2035-2064 and 2070-2099 epochs) show between 3 and 7° F of warming. Increases in maximum air temperature, particularly in the summer (June-August), are likely to increase water surface temperatures. This has the potential to adversely impact water quality by decreasing DO in backwater areas within the study area.

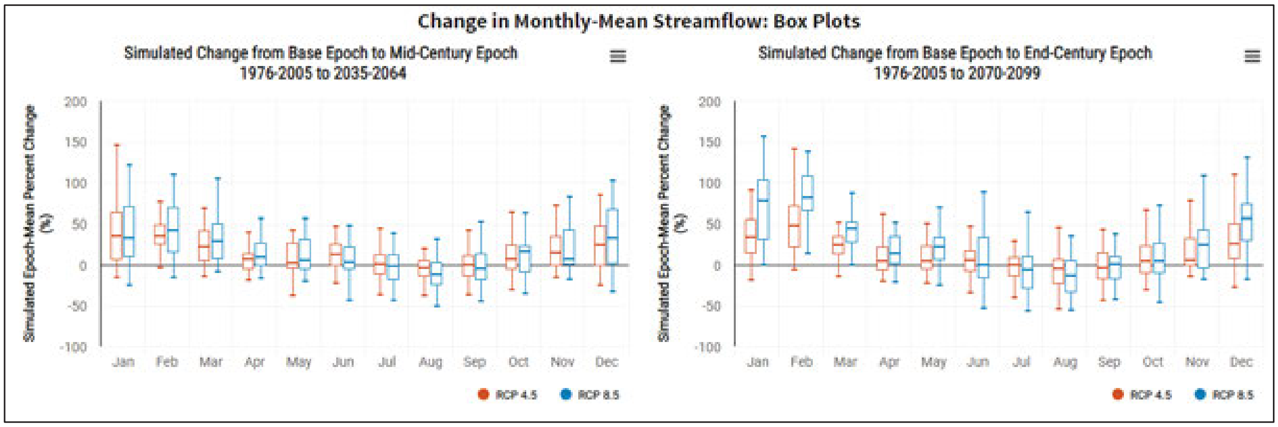


Figure 13: Change in Epoch-Mean of Simulated Monthly Mean Streamflow - HUC 07040003 - Buffalo Whitewater - Stream segment ID: 07000146 (Mississippi River)

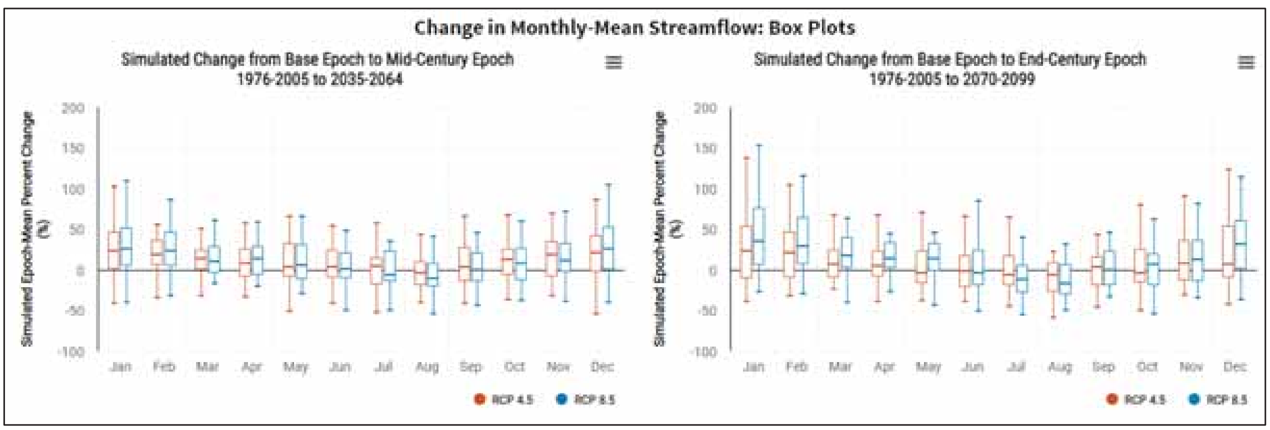


Figure 14: Change in Epoch-Mean of Simulated Monthly Mean Streamflow - HUC 07040003 - Buffalo Whitewater - Stream segment ID: 07000145 (Buffalo River)

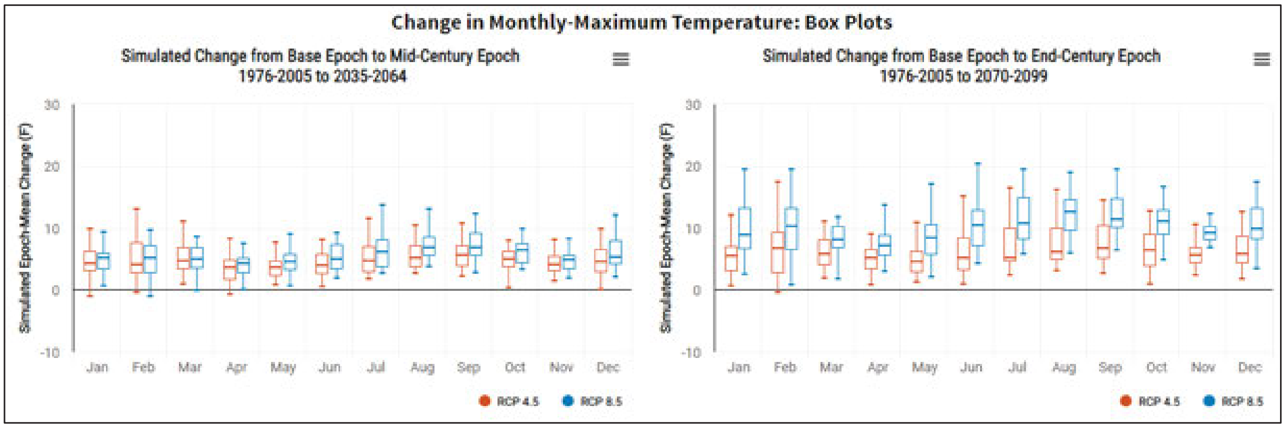


Figure 15: Change in Epoch-Mean of Simulated Monthly Maximum Temperature- HUC 07040003 - Buffalo Whitewater

2.5 Vulnerability Assessment

The USACE Climate Change Vulnerability Assessment (VA) Tool (USACE, 2016) facilitates a screening level, comparative evaluation of climate change exposure to projects for a selected USACE business line in a given 4-digit HUC watershed relative to the other 4-digit HUC watersheds within the continental United States (CONUS). A series of indicator variables are computed and aggregated into a vulnerability score using the weighted-order, weighted-average (WOWA) approach. The tool uses the CMIP5 GCM based Bias Corrected, Spatially Disaggregated (BCSD) VIC dataset (2014) to define projected, hydrologic, and meteorologic inputs to the tool's WOWA scores.

The WOWA scores and indicator variable values are available for two subsets of simulations (wet- top 50% by cumulative runoff projections and dry- bottom 50% by cumulative runoff projections). Data are available for three epochs. The epochs include a historic period (Base epoch) and two 30-year, future epochs (centered on 2050 and 2085). The Base epoch is not based on projections and so it is not split into a wet and dry subset. Watersheds with WOWA scores specific to a given business line, that fall within the top 20% of WOWA scores for watersheds in the CONUS are identified as being vulnerable to climate change impacts. The projected datasets incorporated into VA scores contain considerable uncertainty. Some of this uncertainty is reflected by the differences in results for each of the subset-epoch combinations.

The tool is applied using the default, National Standards Settings and for the ecosystem restoration business line. Indicators used to compute the Ecosystem Restoration WOWA score include: change in sediment load due to change in future precipitation, cumulative monthly runoff variation relative to mean annual runoff, runoff elasticity (ratio of streamflow runoff change to precipitation change), macroinvertebrate index of biotic condition, local mean annual runoff, low flow reduction, percent of freshwater plant communities at risk, and two indicators of flood magnification (indicator of how much high flows are projected to change over time).

As shown in Figure 16, compared to the other 4-digit HUC watersheds in the CONUS, the Upper Mississippi-Black-Root (HUC 0704) watershed does not have a climate change vulnerability score in the top 20% for the ecosystem restoration business line. This is a comparative evaluation and thus does not imply that the watershed is not vulnerable to future, climate change impacts. Results indicate that for the select metrics incorporated into the tool, this watershed may be less exposed to potential climate change impacts relative to other watersheds in the CONUS. This is true for both the wet and dry subsets and both the 2050 and 2085 epochs.

As can be seen in Figure 16 and Table 4, the dominant indicator variable contributing to the Ecosystem Restoration business line VA score for the Upper Mississippi- Black-Root (HUC 0704) watershed is (8) At Risk Freshwater Plants for all epoch and subset combinations. The WOWA score changes by less than 1% between the 2050 and 2085 epochs for both the wet and dry subsets. The percentage by which the indicator variable contributes to the VA score does not significantly change overtime. Because this indicator variable is not dependent on computed, GCM based changes in future hydrology (temperature, precipitation, streamflow) this indicator variable value is constant overtime.

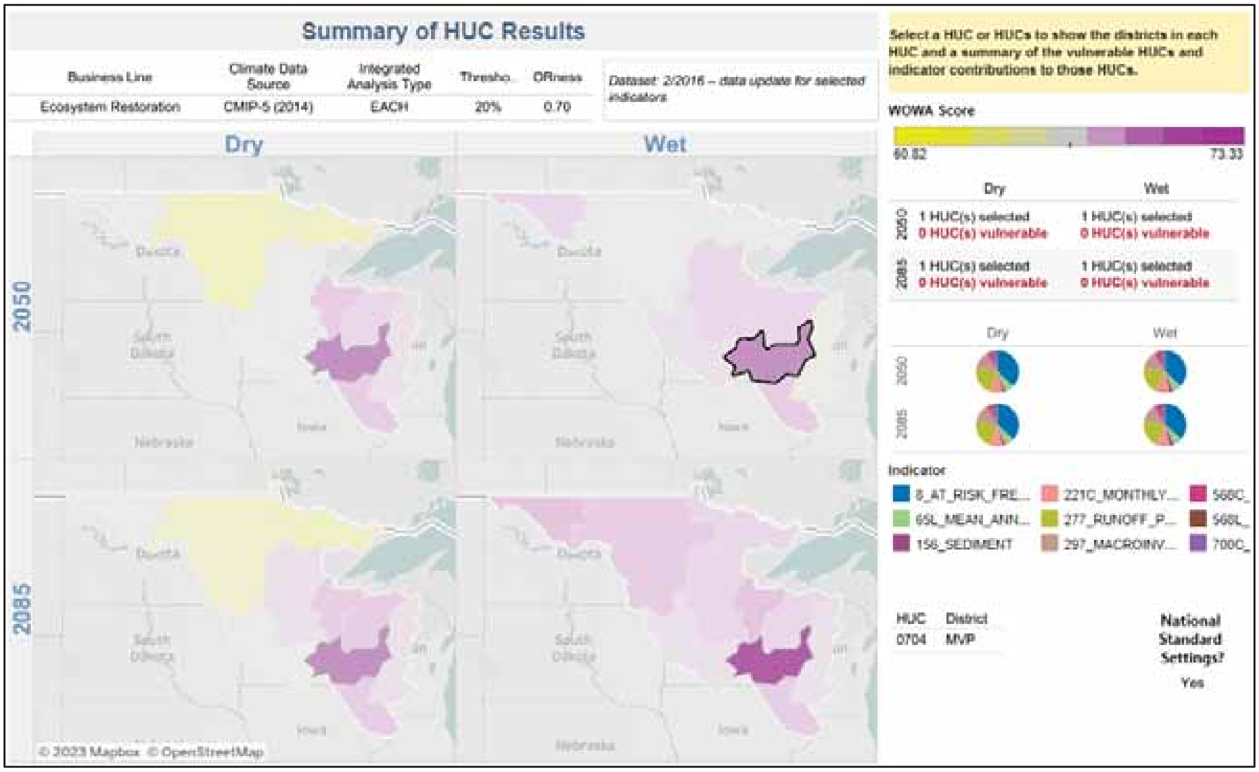


Figure 16: Output of the Vulnerability Assessment tool - Upper Mississippi-Black-Root watershed

Table 4: VA Tool Output- HUC 0706 Upper Mississippi-Maquoketa-Plum Watershed- Ecosystem Restoration

Subset	Epoch	VA Score	% Change in VA Score (2050 to 2085)	Dominant Indicator	Dominant Indicator % Change (2050 to 2085)	
					Contribution to Overall WOWA Score	Indicator Value
WET	2050	68.28	+0.91%	8- At Risk Freshwater Plants	0%	Constant Overtime
	2085	69.19		8- At Risk Freshwater Plants		
DRY	2050	68.60	+0.16%	8- At Risk Freshwater Plants	0%	Constant Overtime
	2085	68.76		8- At Risk Freshwater Plants		

2.6 Conclusion

The purpose of the Lower Pool 4 HREP is to restore, protect, and create terrestrial and aquatic habitat. The selected plan encompasses wetland, floodplain forest, shoreline, floodplain terrestrial vegetation and fish habitat. The project includes island creation and forest management as well as constructed rock closures, shoreline stabilization features, a sediment deflector, and overwintering dredging. Output based on both historic observed hydrometeorological data and projected climate-changed hydrometeorological data is reviewed to support qualitative statements about how to incorporate resilience to climate change impacts over the Lower Pool 4 HREPs lifecycle.

Based on the weight of evidence presented in this assessment, climate change impacts are anticipated to affect the study area's hydrology over the project's 50-year life cycle. Available climate change literature suggests a warmer and wetter climate in the future. There are statistically significant increasing trends in projected flow data analyzed specific to this study area. As flow increases, floodplain forest habitat may be inundated more often. There is also evidence that temperatures are increasing in the study area which may negatively affect water quality and aquatic habitat. Table 5 indicates potential residual risks for this project due to climate change, along with a qualitative rating of how likely those residual risks are to materialize and undermine project features resulting in harm to the study area.

Within the Upper Mississippi River Region climate change poses a potential risk to ecosystems due to the likelihood of the region experiencing shifts in the flow regime and increases in temperature in the future. Projects, like the Lower Pool 4 HREP will serve to offset some of this risk by improving water quality and diversifying habitat. The standard practices used to design and construct USACE, ecosystem restoration projects include a degree of resilience because features are typically designed to accommodate a wide range of flow conditions. Thus, it is unlikely that climate change induced increases in flow will undermine project features. It is likely that increasing temperatures will place added stress on the ecosystem in the future. Ecosystem restoration standard design practices have been generated based on lessons learned from successful projects constructed between 1981 and 2023. The majority of these standards are listed in the 2012 *Upper Mississippi River Restoration (UMRR) Design Handbook* (USACE, 2012).

Even though USACE ecosystem restoration projects can already be considered inherently resilient, it would be worthwhile to consult with experts in floodplain habitat creation and maintenance to see if there are any additional opportunities to incorporate additional innovative, resilient features into the final design during PED without incurring a significant change in cost. Added resilience should be targeted at ensuring project features can withstand higher flows (and higher water surface elevations) and greater periods of inundation. The project design is significantly constrained by the No-Rise certification requirement, so project features are not able to be increased in elevation or feature footprint to withstand higher flows (and higher water surface elevations) and greater periods of inundation. Currently the project is incorporating the climate assessment results by increasing the riprap gradation so that it can withstand higher velocities and larger wave heights (i.e., increased flows and water surface elevations). The riprap design is described in Section 7.1.3. The project is also incorporating shoreline stabilization features to protect existing and proposed land features against these increasing trends. Additionally, the overwintering dredge project feature and rock closures may help to reduce potential future, climate change driven water quality impacts from rising water temperatures. More information on the project feature design as it relates to the climate change risks are included in Table 5 below.

Table 5: Residual Risk Due to Climate Change

Project Feature	Trigger	Hazard	Harm	Qualitative Likelihood	Justification of Likelihood Rating
Island Creation	Increased discharge and water surface elevation (WSE)	Future flood volumes may be greater than at present.	This will extend the duration and extent of island inundation resulting in habitat degradation and erosion.	Unlikely	The island top elevation is designed at or above an elevation to establish and maintain floodplain plant communities. This top elevation is heavily constrained by the No-Rise.
Floodplain Habitat-vegetation	Increased discharge and WSE	Future flood volumes may be greater than at present.	This may extend the duration and extent of floodplain inundation during the growing season. This can be detrimental to the establishment of vegetative features.	Unlikely	Seedlings will be planted at an optimal elevation. Vegetation is likely to be well-established before any changes due to climate change occur.
Submergent and Emergent Vegetation	Increased discharge and WSE	Future flood volumes may be greater than at present.	Increased sedimentation reduces the depth diversity present in the study area	Unlikely	Emergent wetlands and overwintering habitat will be designed with topographic diversity using construction methods and/or dredge cut benches and gradual slopes.
Overwintering Habitat	Increased discharge and WSE	Future flood volumes may be greater than at present.	Increased sedimentation reduces the amount of available backwater habitat	Unlikely	Proposed design will ensure necessary depth for overwintering habitat. Additionally, overwintering habitat are designed with appropriate depths and inflows to reduce the possibility of anoxic conditions.
	Increased air temperature	Water surface temperatures may be greater than at present.	Warmer water temperatures will degrade water quality (e.g., decreased DO) degrading backwater habitat.	Likely	There is strong evidence in the literature and observed and projected data that temperatures will increase. Habitat dredging in backwater areas are designed offset ambient temperature increases.
Shoreline Protection-Rip Rap	Increased discharge and WSE	Future flood velocities and elevations may be higher.	Increased discharge and velocity will increase the shear stress on shoreline projection features and may overtop protected features.	Unlikely	Riprap is sized and graded to ensure a robust design and reduce project feature damage. Where appropriate, habitat friendly solutions are included that allow for habitat access (i.e., vanes/groins).
Rock Sills & Mounds	Increased discharge and WSE	Higher WSE, flow peaks & average flows may increase, and flooding may occur more frequently	Flow may overtop rock sills/mounds more frequently causing erosion of the backwater channels.	Unlikely	Orientation of rock sills and mounds are designed to withstand high flows to minimize wave impacts. Features also include riprap to protect from shoreline erosion.

3 Hydrology

The project area is located just downstream of the Wabasha, MN gage which only records water surface elevation (WSE) data (USACE, 2023). The WSE/stage analyses will adopt this gage for the project area WSEs with the use of a conversion table. The discharge analyses will adopt the discharges at the L&D 4 gage as there are no significant inflows between the project area and the L&D 4 gage (USACE, 2023). Figure 17 below shows the project area in relation to these two gages.

The following sections utilize these two gages for duration and frequency analyses to inform the project design.

Figure 17: Gage Locations Relative to the Project Area

3.1 WSE Conversions

The majority of the project features are located approximately three river miles downstream of the Wabasha, MN gage. Table 6 below provides approximate conversion values to correlate the WSE at Wabasha to the project area. These conversions use a combination of the 1D/2D model results and the 2004 Flow Frequency Study (USACE, 2004) to calculate the conversion. The 1D/2D model is described in detail in Section 6.2. The 2004 FFS does not cover events smaller than the 50% AEP event (i.e., 670.4 feet at the Wabasha Gage).

Table 6: Wabasha, MN gage WSEs to Project Area WSEs (NAVD 88)

Wabasha Gage to Project Area Conversions (NAVD88)				
Source	Approx. Annual Days of Inundation	Wabasha Gage WSE - ft	Project Area WSE - ft	Conversion (ft)
		XS 760.5	XS 757.3	
1D/2D Project Model	342	666.6	666.3	-0.3
	198	667.0	666.5	-0.5
	138	667.5	666.7	-0.8
	107	668.0	666.9	-1.2
	85	668.5	667.1	-1.4
	66	669.0	667.4	-1.6
	48	669.5	667.7	-1.8
	35	670.0	668.1	-1.9
2004 FFS	26	670.4	668.6	-1.9
	25	670.5	668.6	-1.9
	16	671.0	669.2	-1.8
	11	671.5	669.7	-1.8
	8	672.0	670.3	-1.7
	5	672.5	670.8	-1.7
	4	673.0	671.3	-1.7
	3	673.5	671.9	-1.6
	2	674.0	672.4	-1.6
	1	674.5	673.0	-1.5
	1	675.0	673.5	-1.5

3.2 Stage – Discharge

According to the L&D 4 Water Control Manual (WCM) (USACE, 2004), the dam has 6 roller gates and 22 tainter gates which are adjusted to maintain pool elevations at either the Wabasha, MN (RM 760.5) control point (primary control) or the dam (secondary control) for discharges less than 89,000 cfs based on the operating plan. The original operating plan (established in 1937) allowed a drawdown of 4 feet at the dam. It was soon learned however that this drawdown impacted navigation and it was reduced to 2.5 feet in 1943. Then, in 1960 it was further reduced to 1.5 feet to maintain a more stable pool elevation. Finally, this was modified further in 1971 to allow only a 0.5-foot drawdown. The minimum pool elevations or low control pool (LCP) elevations for the existing operating plan are 666.1 (NAVD 88) at the lock, and 666.6 (NAVD 88) at the Wabasha control point. The pool is in secondary control when discharges are between 27,000 and 89,000 cfs. When river discharges decline to 27,000 cfs, regulation of the pool shifts to primary control. For discharges exceeding 89,000 cfs, the gates at the lock are raised above the water surface and open river conditions are in effect (i.e., the dam is considered out of control). The WSE at points upstream of the dam rises and falls with river discharge and the range of fluctuation is greater the father upstream from the dam one progresses. Since the project area is in the lower pool and near a control point, the WSE do not fluctuate significantly as compared to other locations in this pool.

The WCM operating curves (USACE, 2004) for the Wabasha and L&D 4 Pool gages are shown in Figure 18 below.

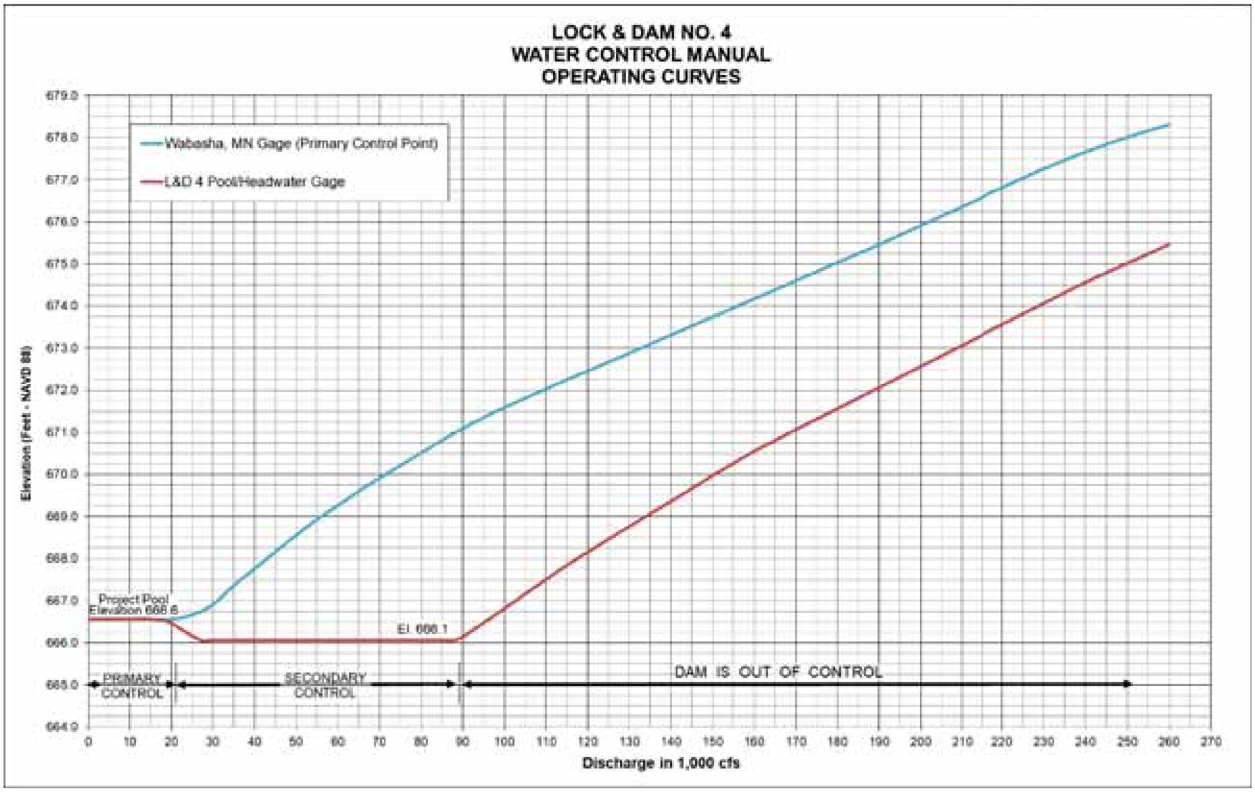


Figure 18: L&D 4 WCM Operating Curves for Wabasha and L&D 4 Pool

3.3 Discharge – Duration

Discharge frequency data was obtained when possible from the most recent frequency study, 2004 FFS (USACE, 2004). Discharges for the 50%, 20% and 1% Annual Exceedance Probability (AEP) events are shown in Table 7 below. Although this information is 18 years old, the exact frequency corresponding to various river discharges isn't critical to project design because FEMA no-rise criteria was the controlling criteria in terms of project feature elevations. What is important is the range of discharges that affect ecological conditions and subsequently project design. This information mainly serves to establish a general representation of different flow conditions in the project area. The "Description of Flow Condition" column items are described in Section 4.1.

Table 7 also includes calculated discharge percent of time exceeded events. These were calculated using HEC-SSP (HEC, 2019) using the entire discharge period of record from the L&D 4 gage. The L&D 4 Pool and Wabasha WSEs in the table were extracted from the L&D 4 WCM operating curves shown in Figure 18 above. The Project Area WSEs were calculated using the conversion table (Table 6) above.

Table 7: Discharge Events and Corresponding WSEs

Discharge – L&D 4 (cfs)	Percent of Time Exceeded[1]	Annual Exceedance Probability Event[2]	Description of Flow Condition	Water Surface Elevation (ft - NAVD 88)		
				L&D 4 Pool, RM 753.0 [3]	Wabasha, RM 760.5 [3]	Project Area, RM 757.3 [4]
15,000	75	-	Low Flow	666.6	666.6	666.3
24,700	50	-		666.2	666.7	666.4
43,100	25	-	Moderate Flow	666.1	668.0	666.9
67,300	10	-	Bankfull Event	666.1	669.7	667.9
82,000	-	50		666.1	670.6	668.8
83,200	5	-		666.1	670.7	668.8
106,000	2	-	Small Flood	667.2	671.9	670.1
120,000	-	20		668.2	672.5	670.7
230,000	-	1	Large Flood	674.1	677.3	675.8

[1] *Corresponding Discharges calculated using HEC-SSP* (HEC, 2019) *for the entire period of record discharge data at L&D 4*

[2] *Corresponding Discharges taken from the 2004 FFS* (USACE, 2004)

[3] *WSE values extracted from the L&D 4 WCM Operating Curves* (USACE, 2004)

[4] *WSE values calculated using Table 6 above*

3.4 Stage - Duration

It is important to understand and analyze the number of times the natural levees are overtopped. Overtopping of the natural levees can affect any downstream existing or proposed overwintering fish habitat. In summary, if overtopping occurs in the late fall or winter months, overwintering fish habitat can be lost as cold water enters warm water zones and cools the water temperature below what fish can safely tolerate. A single overtopping event during these months can have irreversible impacts on overwintering habitat for the remainder of the winter.

It is also important to analyze the number of times the proposed project features in the project area are overtopped. Overtopping of the proposed project features can also affect the overwintering fish habitat depending on the feature location. In addition to overwintering effects, the number of times the proposed project features are overtopped influences the tree and plant species that can be planted on that feature. Because of this, proposed rock closures along Catfish Slough are included to reduce the winter inputs into the proposed overwintering dredge area. Section 7 includes discussion on the proposed rock closures as well as overwintering dredging.

Table 8 and Table 9 below show the percent of time and number of days a specific elevation is equaled or exceeded using the updated period of record of 1981 to 2021 for the Wabasha, MN gage. These tables include data for each month as well as the annual value. These tables were referenced while completing design iterations for the proposed top of island elevation. These tables (Table 8 and Table 9) in conjunction with the conversion table (Table 6) above can be used to understand the percent of time exceeded for the project area WSEs.

Other HREPs have adopted the 1981 – present timeframe for analysis as it has been found to be more representative of the current hydrologic regime which is preferable for the design of floodplain forest features.

Table 8: Stage – Duration (Percent) at the Wabasha, MN Gage

Percent of Time Water Surface Elevations are At or Above the Indicated Elevation at Wabasha [1981-Present]													
Elevation (ft-NAVD88)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Year
675.0	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%
674.5	0%	0%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
674.0	0%	0%	0%	5%	0%	1%	0%	0%	0%	0%	0%	0%	1%
673.5	0%	0%	0%	7%	1%	1%	0%	0%	0%	0%	0%	0%	1%
673.0	0%	0%	0%	8%	1%	1%	1%	0%	0%	0%	0%	0%	1%
672.5	0%	0%	1%	10%	3%	2%	2%	0%	0%	0%	0%	0%	2%
672.0	0%	0%	2%	12%	6%	2%	2%	0%	1%	1%	0%	0%	2%
671.5	0%	0%	2%	16%	10%	4%	2%	0%	1%	2%	0%	0%	3%
671.0	0%	0%	3%	22%	15%	6%	3%	0%	1%	3%	0%	0%	5%
670.5	0%	0%	5%	30%	23%	11%	6%	0%	1%	6%	0%	0%	7%
670.0	0%	0%	9%	38%	31%	15%	10%	0%	2%	8%	1%	0%	10%
669.5	1%	0%	11%	49%	42%	23%	14%	3%	3%	11%	2%	0%	13%
669.0	1%	1%	16%	58%	51%	31%	22%	6%	6%	17%	5%	2%	18%
668.5	2%	1%	20%	66%	58%	44%	31%	9%	11%	21%	9%	5%	23%
668.0	4%	1%	27%	76%	67%	55%	39%	14%	16%	25%	17%	10%	29%
667.5	9%	3%	35%	83%	77%	69%	52%	24%	23%	32%	26%	20%	38%
667.0	25%	15%	53%	91%	90%	82%	73%	40%	38%	44%	53%	44%	54%
666.5	92%	91%	96%	100%	100%	98%	99%	98%	98%	99%	99%	96%	97%
666.0	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 9: Stage – Duration (Days) at the Wabasha, MN Gage

Number of Days Water Surface Elevations are At or Above the Indicated Elevation at Wabasha [1981-Present]													
Elevation (ft-NAVD88)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Year
675.0			0	1	0	0	0			0			1
674.5			0	1	0	0	0			0			1
674.0			0	2	0	0	0			0			2
673.5			0	2	0	0	0			0			3
673.0			0	2	0	0	0			0			4
672.5			0	3	1	1	0			0			5
672.0			0	4	2	1	1		0	0			8
671.5			1	5	3	1	1	0	0	1	0		11
671.0			1	7	5	2	1	0	0	1	0		16
670.5			2	9	7	3	2	0	0	2	0	0	25
670.0			3	11	10	5	3	0	1	3	0	0	35
669.5			4	15	13	7	4	1	1	3	1	0	48
669.0	0	0	5	17	16	9	7	2	2	5	1	1	66
668.5	1	0	6	20	18	13	10	3	3	7	3	2	85
668.0	1	0	8	23	21	17	12	4	5	8	5	3	107
667.5	3	1	11	25	24	21	16	7	7	10	8	6	138
667.0	8	4	16	27	28	24	23	13	11	14	16	14	198
666.5	29	26	30	30	31	30	31	30	29	31	30	30	355
666.0	31	28	31	30	31	30	31	31	30	31	30	31	365

3.5 AEP Discharges and WSEs

The Annual Exceedance Probability (AEP) WSEs were adopted from the FFS (USACE, 2004) for the Wabasha, MN gage (RM 760.4) and the project area (RM 757.38). The AEP WSE values are reported in the NGVD 1929 datum within the FFS and then converted to the project datum of NAVD 1988. The datum conversion equation is listed in Section 1 above.

Note, the Wabasha WSE elevation values for the corresponding AEP events do not exactly match the AEP events values in Table 7 above. This is because Table 7 above utilized the WCM operating curve to extrapolate the WSE values whereas the WSEs in Table 10 below are directly from the 2004 FFS report.

Table 10: AEP Events at Wabasha, MN according to the Upper Mississippi River FFS (USACE, 2004)

Annual Exceedance Probability	Discharge at Wabasha, MN from FFS 2004 (cubic feet per second)	WSE at Wabasha, MN (RM 760.5) from FFS 2004 (feet - NAVD 88)	WSE at Project Area (RM 757.38) from FFS 2004 (feet - NAVD 88)
50.0%	82,000	670.4	668.4
20.0%	120,000	672.6	670.8
10.0%	146,000	674.0	672.3
4.0%	179,000	675.6	674.1
2.0%	204,000	676.7	675.3
1.0%	230,000	677.8	676.4
0.5%	255,000	678.9	677.5
0.2%	290,000	680.3	678.9

4 Hydraulics

The hydraulic stressors affecting the project area include high and increasing hydraulic connectivity (i.e., the amount of water conveyed) between the Main Channel and Big Lake, an altered water level hydrograph, and wind-driven wave action within Big Lake.

A rock liner was constructed across Catfish Slough as part of the Indian Slough HREP (USACE, 1990). Based on the 1990-92 and 1994-97 data, there was an increase in water exchange rate even with the rock liner. The 2023 data indicates that Catfish Slough has continued to expand, which matches observed erosion within Catfish Slough. For the total river discharge of 50,000 cfs, the flow in Catfish Slough has nearly doubled from 1,000 cfs to 1,850 cfs (Figure 19).

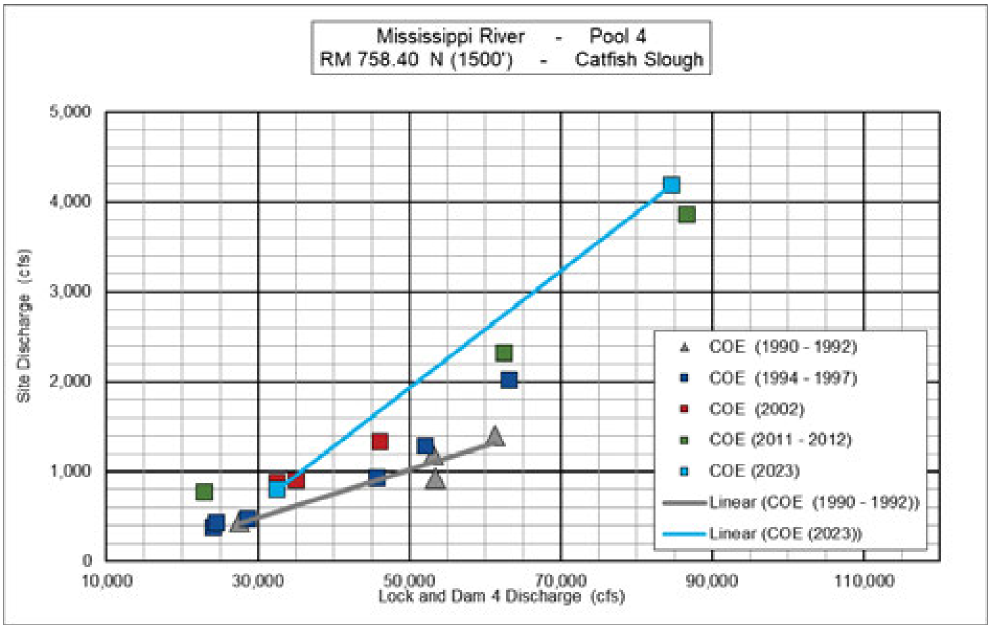


Figure 19: Catfish Slough Discharge Transect Plot

4.1 Flow Conditions

4.1.1 Low and Moderate Flow Conditions

The defined exceedance events for low flow conditions are 75% and 50%. The defined exceedance event percentage for moderate flow is the 25% exceedance. These exceedance event percentages are commonly used within the HREP program and were calculated using the entire period of record at L&D 4 (Table 7). The corresponding WSE values at the Wabasha, MN gage were determined using the WCM operating curve for Wabasha, MN in Figure 18. Table 7 includes a column for the approximate WSE at the project area which was developed using the conversion table in Table 6.

4.1.2 Bankfull Conditions

Based on recorded data, it can be assumed that bankfull events begin at a discharge of 67,000 cfs which correlates to an approximate exceedance event of 10%. This exceedance event was calculated using the entire period of record at L&D 4 (Table 7). The corresponding WSE values at the Wabasha, MN gage were determined using the WCM operating curve for Wabasha, MN in Figure 18. Table 7 includes a column for the approximate WSE at the project area which was developed using the conversion table in Table 6.

Typically, the discharges adopted to represent the upper limit of bankfull conditions correspond to discharges at the 50% AEP event (approximately 82,000 cfs and 83,000 cfs at the project area and at L&D 4, respectively). Using the WCM operating curve in Figure 18 for the Wabasha, MN gage, this is estimated to correspond to a WSE of approximately 670.6 feet and approximately 668.8 feet at the project area. Alternatively, using the data from the 2004 FFS (USACE, 2004), this discharge corresponds to a WSE of 670.4 feet at Wabasha, MN and approximately 668.4 feet at the project area.

4.1.3 Overtopping/Flood Conditions

Based on a LiDAR analysis, it was determined that major overtopping of the natural levees surrounding Big Lake begins at an elevation of approximately 672 feet at the Wabasha, MN gage which corresponds to between a 20% and 50% AEP event. By interpolating the 2004 FFS WSEs, the 672-foot overtopping elevation at Wabasha, MN is approximately the 27.5% AEP event. This is also the approximate elevation of the 2% exceedance event calculated using the entire period of record at L&D 4 (Table 7) and the WCM operating curve for Wabasha, MN (Figure 18). At the project area, the Wabasha, MN gage elevation of 672.0 feet is approximately 670.2 feet.

4.2 Ground Water

Groundwater can influence habitat at small spatial scales (e.g., springs and seeps), however its influence on habitat in the overall project area is extremely small compared to surface water discharge. In 2017, the Wisconsin Geological and Natural History Survey completed an inventory of springs in Wisconsin (Wisconsin Geological and Natural History Survey, 2017). The spring inventory shows no springs affecting the project area. Figure 20 below shows the spring inventory dataset near the project area (spring data point shown in blue). There are likely 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, but is not expected to affect the performance of the project features.

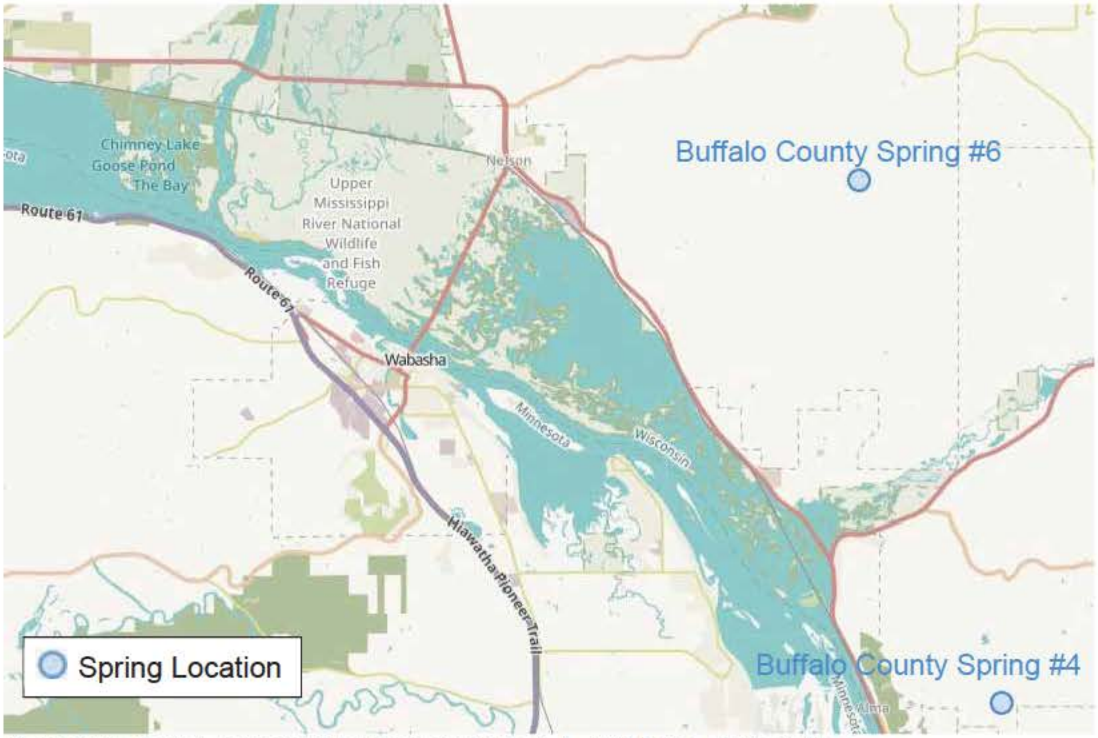


Figure 20: Spring Inventory for the Lower Pool 4 - Big Lake Project Area

5 Sediment Transport and Geomorphology

Sedimentation in the Upper Mississippi River has been a major concern throughout the implementation of HREPs. Land use changes have contributed to high sediment delivery to tributaries and the channelization of some tributaries have also increased the rate that the tributaries deliver the sediment to the Upper Mississippi River. In off-channel backwaters common in Pool 4, accumulation of sediment may result in loss of depth and encroachment of terrestrial vegetation into formerly aquatic areas.

Sediment transport in the project area is affected by upstream sediment loads and local hydraulic conditions. Variation in upstream sediment loads occur due to seasonal patterns of river discharge and sediment mobilization. The hydraulic characteristics of the project area can best be described as a connected system with flow entering the project area through openings in the upstream Highway 25 bridge as well as side channels called Indian and Catfish Slough. Wind driven wave action is a significant factor that can remobilize sediment in backwater areas.

To better understand sediment transport and geomorphology in the project area, both fine material and coarse material sediment deposition rates were analyzed.

5.1 Fine Sediment Rates – Pool 4

A study was completed as part of the Upper Mississippi River Restoration Program's Long Term Resource Monitoring that estimated sedimentation rates at a number of transects in Pools 4 and 8 (Rogala, Kalas, & Burdis, 2020). This study is titled *Rates and Patterns of Net Sedimentation from 1997-2017 in Backwaters of Pools 4 and 8 of the Upper Mississippi River*. The first study completed as part of this effort was completed in 1997-2002 (Rogala, Boma, & Gray, 2003). Sedimentation rates were estimated through this effort on a short-term scale (5 years).

Approximately 20 years later (1997-2017) the transects were re-analyzed which provides recent sedimentation rates that would be less influenced by short-term variability.

Historically, there have been a number of other sedimentation rate studies completed along the Upper Mississippi River. There are several shortcomings regarding these past studies which are listed below (Rogala, Kalas, & Burdis, 2020).

1. Many of the studies were completed immediately upstream of the dams only.
2. Most of the studies sampled in areas of known sedimentation, so rates were likely overestimated.
3. Most of the studies are outdated and do not provide recent estimates (>25 years old).
4. Past studies provide little information on spatial variability.

For the reasons listed above, the Lower Pool 4 sedimentation rate estimates will utilize this most recent report.

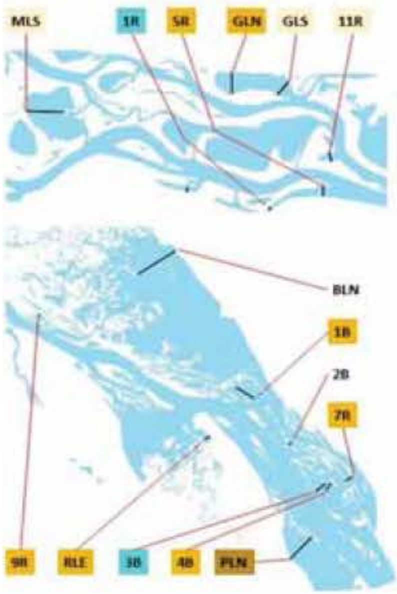
According to the report, pool-wide mean rates of backwater sedimentation in aquatic portions of the sampling transects during this 20-year period were 0.27 cm/yr (0.106 in/yr) in Pool 4. When considering portions of transects defined by bed elevation, rates were lowest in nearshore terrestrial areas with mean rates of -0.09 cm/yr (-0.035 in/yr) in Pool 4. Highest rates (0.34 cm/yr or 0.134 in/yr) were found in areas deeper than 0.5 meters (1.64 feet) in Pool 4.

Mean sedimentation for this study were generally lower than rates observed in previous studies for the Upper Mississippi River. Table 11 below shows the previous study rates.

Table 11: Sedimentation Rates from Previous Studies on the Upper Mississippi River (Rogala, Kalas, & Burdis, 2020)

Study	Location	Method / Period	Rates (cm yr^{-1})
McHenry et al. (1984)	Impounded areas in Pools 4-10	Cesium-137 dating / 1954-1975	1 - 4
Korschgen et al. (1987)	Large lake in Pool 7	Bathymetric maps / 50 years since impoundment	0.2
Eckblad et al. (1977)	Large lake in Pool 9	Cesium-137 dating / 1964 - 1974	1.69
Rogala et al. (1997)	Lakes of Pool 8	Coring to parent material / 58 years since impoundment	0 - 1.5
Rogala and Boma (1996)	Lakes in Pools 4, 8, and 13	Repeated surveys / 1990-1996	0.29, 0.12, 0.80

All Pool 4 transects, and mean sedimentation rates (cm/yr) are shown in Figure 21 below. Using all of the lower pool 4 transects (bottom visual in the figure), the average sedimentation rate is approximately 0.41 cm/yr (0.162 in/yr). There were three transects analyzed within lower pool 4 that are in the vicinity of the project area (9R, BLN and 1B transects).



pool	transect	mean	std	pool	transect	mean	std
4	PLN	1.23	0.55	4	BLN	0.04	0.31
4	7R	0.66	0.76	4	1R	-0.23	0.17
4	4B	0.65	0.86	4	3B	-1.37	3.45
4	5R	0.58	0.42	8	SMS	1.34	1.55
4	1B	0.57	0.34	8	3B	1.30	0.66
4	GLN	0.54	0.22	8	SMN	1.12	0.47
4	RLE	0.50	0.32	8	2R	1.01	0.14
4	9R	0.50	0.26	8	2B	0.93	0.33
4	GLS	0.38	0.22	8	BYS	0.92	0.40
4	11R	0.24	0.10	8	4R	0.76	0.18
4	MLS	0.20	0.18	8	BYN	0.71	0.18
4	2B	0.14	0.74	8	FLS	0.64	0.11

Figure 21: Pool 4 Sedimentation Rate Transects

The results tied to the three transects of interest (9R, BLN and 1B transects) are shown in Table 12 below. Using an average of these transects results in an average sedimentation rate near the project area of 0.146 in/yr. Over the 50-year project life, this average equates to approximately 7.3 inches of sediment accumulation. Using the maximum value of these three transects (0.224 in/yr) results in approximately 11.2 inches of sediment accumulation in 50 years.

Table 12: Project Area Sedimentation Rate Transects

Transect	Average (cm/yr)	Average (in/yr)
9R	0.5	0.197
BLN	0.04	0.016
1B	0.57	0.224

5.2 Coarse Sediment Rates – Catfish Slough

The USFWS has reported coarse sediment deposition in Catfish Slough that is very dynamic and oftentimes coarse depositional areas change throughout the year. The aerial imagery in Figure 22 below shows evidence of the coarse sediment deposition.

Figure 22: Aerial Imagery Sediment Deposition within Catfish Slough

The final sediment analysis completed as part of this project utilized the 1D/2D HEC-RAS Project Design Model described in Section 6.2 below. From this model, discharges were extracted for the 50% AEP event for the Main Channel and Catfish Slough. Historically, discharge measurements have been collected along the Main Channel and backwater channels (including Catfish Slough) near the project area using an Acoustic Doppler Current Profiler (ADCP). Measurements were collected in 1990-1992, 1994-1997, 2002, 2011-2012 and 2023. These measurements are compiled into an observed discharge rating curve relating the L&D 4 discharge to the discharge measurement site. The locations of these measurements are shown in Figure 23 below. The discharge location names are listed below.

- Main Channel – RM 759.00
- Indian Slough – RM 759.70 N (1200')
- Hershey Island – RM 759.10 S (1200')
- Catfish Slough – RM 758.40 N (1500')
- Main Channel – RM 757.30

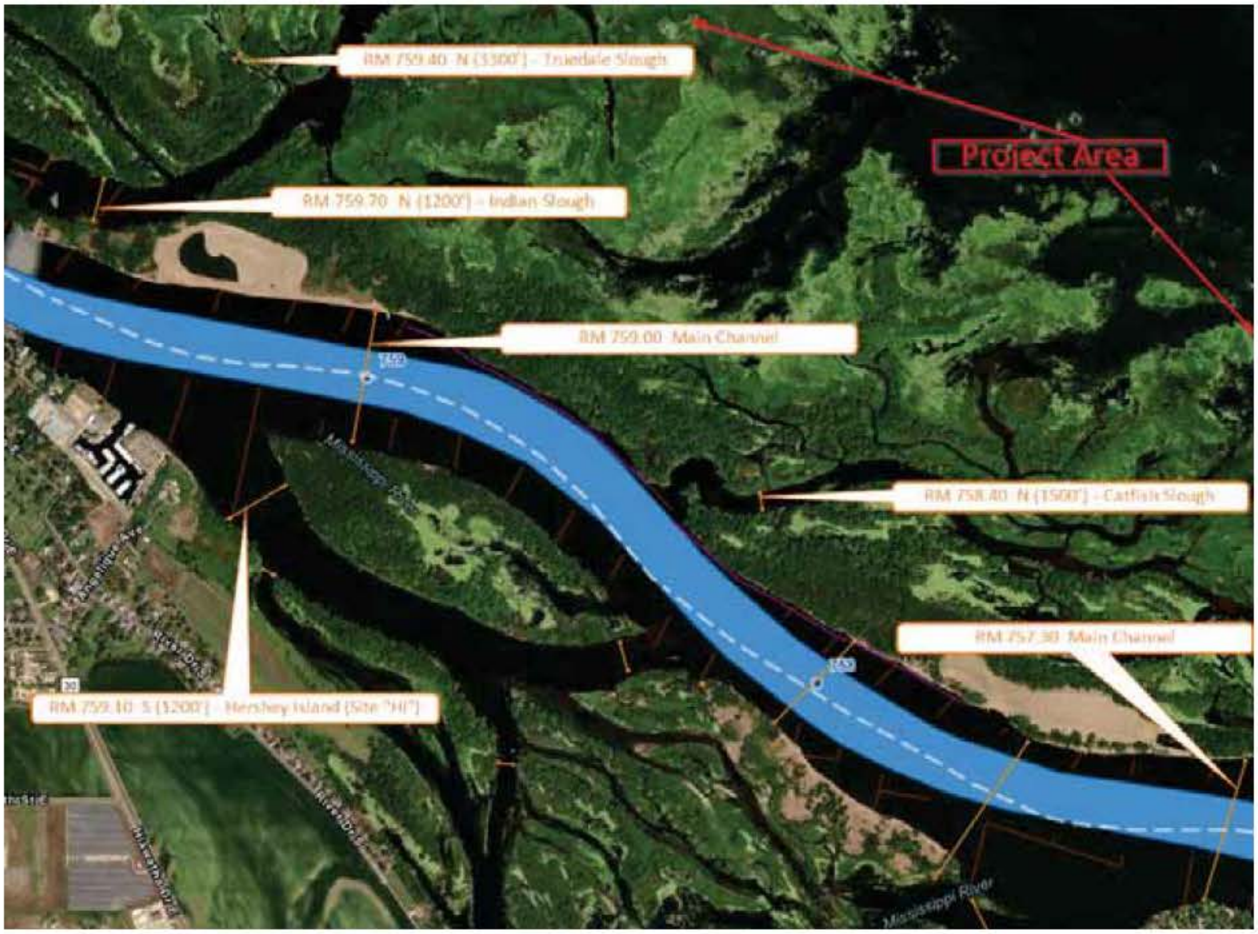


Figure 23: Lower Pool 4 ADCP Discharge Measurement Locations near Project Area

The comparison for the discharges at six of the discharge measurement locations are shown in Table 13 below. The measurement location of interest is the Catfish Slough transect. This discharge transect measurement location will be used to calculate the water exchange ratio (WER) between the Main Channel and Catfish Slough.

Table 13: Comparison of Modeled vs. Observed Discharges for the 50% AEP Event

Comparison of Modeled vs. Observed Discharges - 50% AEP (Model: 81,200 cfs)			
Location	**Project Design Model**	**2023 Observed Data**	**% Difference**
L&D 4	81,200	83,000*	2.2%
Main Channel – RM 759.00	49,800	51,000	2.4%
Indian Slough – RM 759.70 N (1200')	5,100	4,700	-8.5%
Hershey Island – RM 759.10 S (1200')	17,000	17,800	4.5%
Catfish Slough – RM 758.40 N (1500')	4,300	4,000	-7.5%
Main Channel – RM 757.30	62,100	65,000	4.5%

**Taken from the 2004 FFS*

The modeled data matches relatively well for both the main channel discharge transect locations and the side channel discharge transect locations. Because of this, the modeled outputs will be used for the following calculations.

The Catfish Slough 50% AEP event discharge was extracted from the observed rating curve and estimated to be approximately 4,300 cfs. Using this value and the value in the above table for the total river discharge (L&D 4: 81,200 cfs), the WER ratio for the observed rating curve was 0.053.

To estimate sediment loads for the analysis, the St. Paul District Bed Material Sediment Budget was utilized (Hendrickson, 2003). This district-wide bed material sediment budget was created in 2003 to estimate the effects of navigation channel dredging, off-channel sediment deposition, and tributary sediment loads on sediment transport on the UMR. Bed material refers to sand-size sediment that can be found on the bed of the main channel but can be transported as bed load or suspended load. This bed material budget was based on interpretation of available sediment transport information at U.S. Geological Survey (USGS) gaging stations, long-term channel dredging data, studies of sediment transport and deposition, and measured hydraulic characteristics on the UMR.

A side channel sediment load equation for the 50% AEP event was developed and is used in the St. Paul District Bed Material Sediment Budget (Hendrickson, 2003). This equation uses a channel's WER and the sediment load in the main channel to estimate the sediment load in the side channel of interest. According to the St. Paul District Bed Material Budget, the main channel sediment load is approximately 485,000 tons/year. The WER for this equation is the ratio of the side channel discharge versus the total river discharge for the 50% AEP event and was calculated to be 0.053 as stated above.

Note, the Chippewa River sediment load greatly effects the assumption of the main channel sediment load value. A report titled "The use of continuous sediment-transport measurements to improve sand-load estimates in a large sand-bedded river: The lower Chippewa River, Wisconsin" (Dean, et al., 2022) indicates that recent measurements of bed material load by the USGS indicate that the amount of sand coming out of the Chippewa River has decreased significantly compared to the 1992 report titled "Sediment Transport, Particle Sizes, And Loads In Lower Reaches Of The Chippewa, Black, And Wisconsin Rivers In Western Wisconsin" (Rose, 1992). The more conservative sediment load value for the main channel is used for this analysis.

$$Q_{Sediment-Side} = WER^{1.4} * Q_{Sediment-Main}$$

Using the calculated sediment load, the amount of coarse sediment deposition within the project area can be estimated. Assuming a specific weight of inflowing bed material sediment to be 98 pounds per cubic foot, the calculated sediment load can be used to estimate the amount of coarse sediment deposition in the project's 50-year life.

The coarse sediment depositional footprint was estimated for this effort. It is typically assumed that the coarse sediment transport is prevalent for the 50% AEP event. The 50% AEP event in the project area is approximately elevation 669 feet. The footprint in Figure 24 below shows the locations where the existing topography is above that 50% AEP event elevation. The footprint also utilized the planform change polygons in red from the LTRM report titled "Recent Planform Changes in the Upper Mississippi River" (Rogala, Fitzpatrick, & Hendrickson, 2020). These planform change polygons indicate areas of land expansion occurring due to sediment deposition (i.e., deltas). As seen in this figure, the coarse sediment depositional footprint aimed to follow the 50% AEP event elevation contour while also encompassing the planform polygons and referencing the aerial imagery where coarse sediment transport is visible.

The calculations resulted in the footprint in Figure 24 experiencing approximately 0.5 feet of sediment deposition in the 50-year project life. Please note that this value is uniformly applied throughout the coarse sediment depositional footprint shown and does not account for spatial variability. There is uncertainty in the bed load and equations used to determine the bed load because of lack of observed data in the system. A sensitivity analysis increasing and decreasing the main channel sediment load by 50% resulted in 0.8 and 0.3 feet of sediment deposition in the 50-year project life.

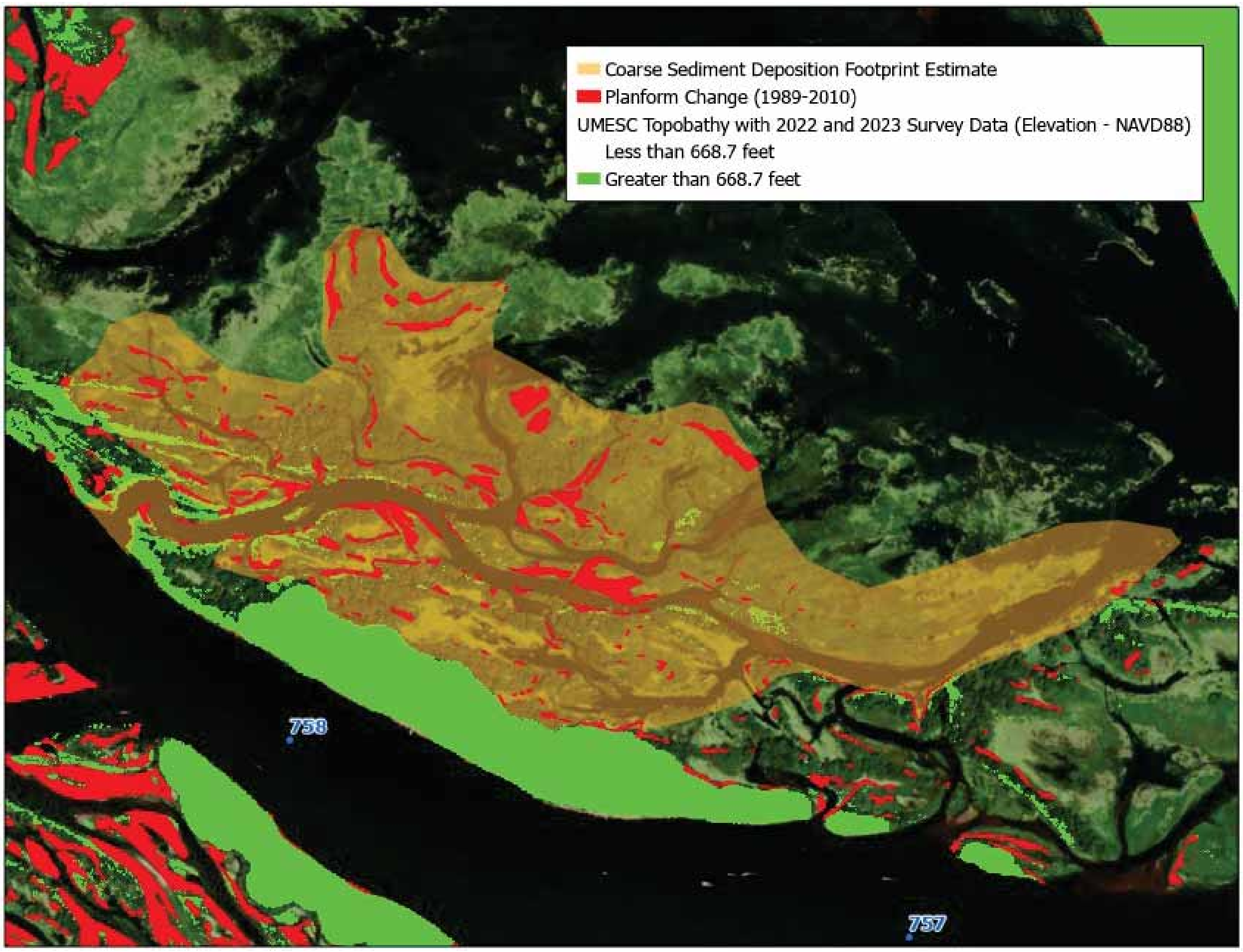


Figure 24: Coarse Sediment Deposition Estimated Footprint

5.3 Sedimentation Conclusion

While there is uncertainty in the bed material loads and deposition rates in the project area, the results from the analyses discussed above show that both fine and coarse sedimentation rates and sediment loads specifically in Big Lake will affect the project area in the future. Reducing sediment loads through Catfish Slough could be beneficial to reduce the dynamic sediment deposition seen within the slough as well as increase the longevity of the overwintering dredging site.

In past projects, partial rock closures have been utilized to reduce sediment through a side channel. Due to the analysis results, a sediment deflector structure at Catfish Slough has been added to the project alternatives to reduce the sediment load entering Catfish Slough.

6 Hydraulic Modeling

Two models were utilized during the study. The first model is the one-dimensional steady state FEMA Effective model used for the flood stage impacts analysis to obtain the No-Rise Certification. The second model is a one- and two-dimensional unsteady state model derived from the USACE Corps Water Management System (CWMS) model, which was used to inform the team's project design elements like general feature alignments and the necessary erosion protection methods. These two models are described in the sections below.

6.1 Flood Stage Impacts Model

One-dimensional modeling was completed using HEC-RAS (Hydrologic Engineering Center – River Analysis System) Version 5.0.7 (HEC, 2019). The HEC-RAS model was used to simulate the effects of the project on the one percent AEP event. The flow for the one percent AEP event at the project area is approximately 230,000 cfs. The model includes the features shown in Figure 25.

The floodplain forest features are modeled to have a top elevation of either 668.5 feet or 669.5 feet (NAVD88). The final project map is included in Figure 1. None of the dredging features are included in the model which makes the model more conservative. This decision is based on lessons learned on past projects. Since anything included in the model must be constructed in order to comply with the no-rise requirement, and the precise sizes of dredge cuts are uncertain until construction, from the risk perspective, it is more conservative to leave dredge cuts out of the hydraulic model to reduce the risk of the project not meeting the no-rise requirement.

Additionally, the model does not include the project rock features. This is because the rock features are minimal in design thickness (2–6-foot width). Another reason for not modeling the rock features is that the Manning's n value in the vicinity of these rock features is 0.05-0.10. If this feature were to be added to the model, the Manning's n value that would be assigned would be approximately 0.04. In most locations, the existing Manning's n value is a more conservative modeling approach.

Overall, the modeled project features meet FEMA's no rise constraint. This constraint is based on the Wisconsin DNR's definition of zero, which is a rise of less than 0.01 feet. More information on the Wisconsin DNR's no-rise guidelines is included in Section 6.1.2.

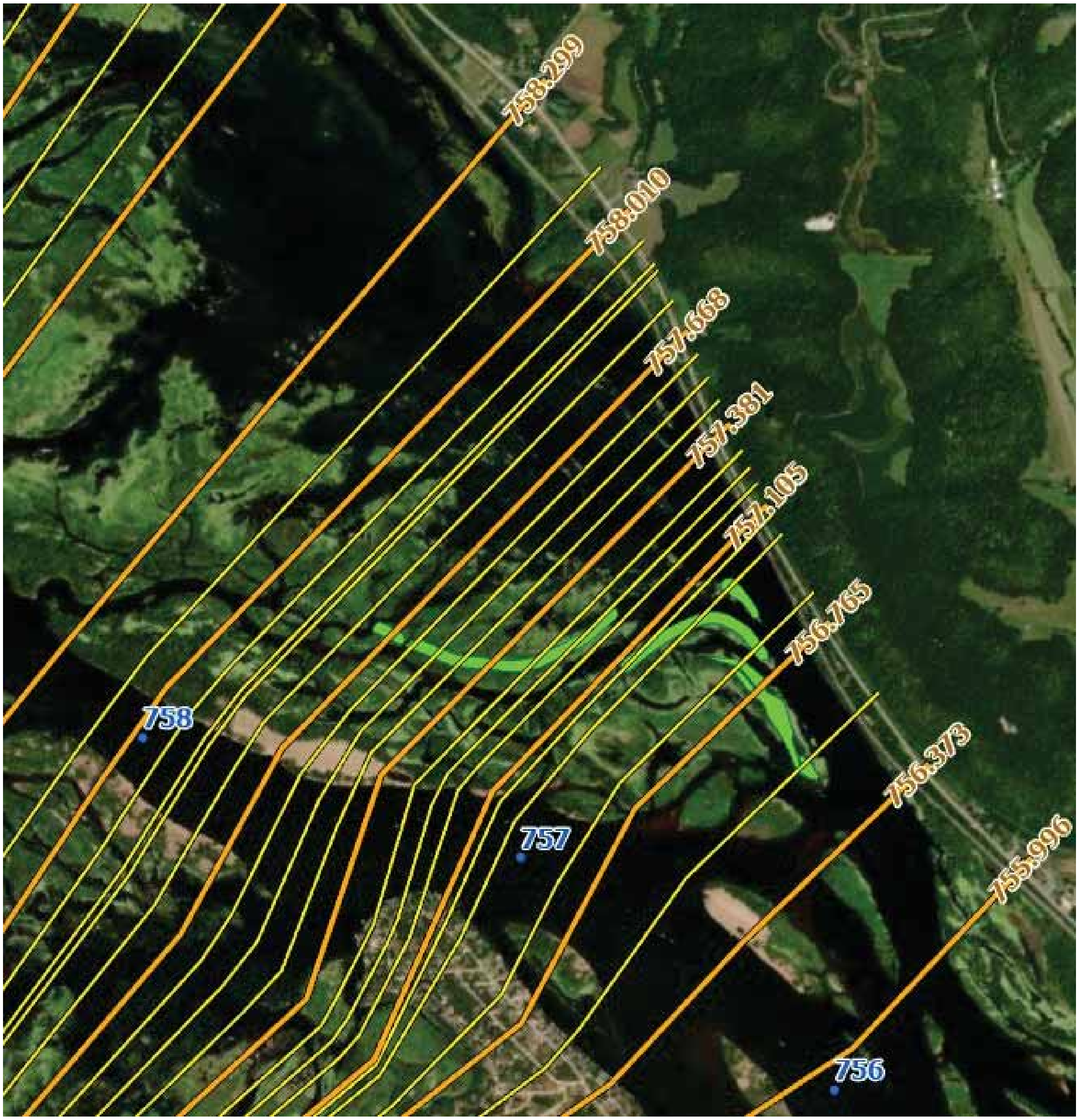


Figure 25: Modeled Features and Cross Sections (FEMA Effective Cross Sections in Orange – Interpolated Cross Sections in Yellow)

6.1.1 Model Development

A one-dimensional steady flow hydraulic model was modified to analyze flood stage impacts of proposed project features. The existing HEC-RAS model that was modified was the Upper Mississippi River Floodway Computation developed by USACE for FEMA (USACE, 2004). The model extends from Lock and Dam 2 to Lock and Dam 10. The model projection is North American Datum of 1983. Since the original model used NGVD 29, all elevations related to the project area were converted to NGVD 29 from NAVD 88. This conversion is available below.

NAVD 1929 (feet) = NGVD 1988 (feet) – 0.04 feet

Existing cross sections were used along with new ones that were added to better capture the impact of the proposed project features. Figure 25 above shows the FEMA effective model and project specific added cross sections. The FEMA Effective cross sections are denoted in orange while the interpolated, project specific cross sections are denoted in yellow. The new cross sections were created using the cross-section interpolation tool in the "Geometry" window. These cross sections were then recut using the most recent bathymetry and LiDAR.

The Manning's n values were then adjusted based on 2020 imagery and the most recent bathymetry and LiDAR. The Manning's n values for the project area were defined as the following:

- Main Channel: 0.03
- Heavily Forested Land: 0.10
- Backwater Open Water/Side Channels: 0.05

This model is considered the updated base model which is used as the existing conditions model. The proposed project land features were then modeled as obstructions at their design elevations and the dredging features were manually cut into the cross sections. This model is used as the proposed conditions model.

6.1.2 Model Results

Per Wisconsin guidelines – NR 116.07(4)(f) (Wisconsin State, 2019), "The regional flood profile and changes to that profile caused by development in the floodplain, as determined by the hydraulic model, shall be calculated to the nearest 0.01 foot" – the resulting WSEs must be exported from the model by rounding to the nearest hundredth of a foot.

Completing the modeling process and following these guidelines resulted in the flood stage impacts shown in Table 14 below. In this table, the FEMA effective cross sections are highlighted in orange. The second column provides the existing conditions model WSE results (titled Updated Base Model also called the Corrected Effective Model) and the third column provides the proposed conditions model WSE results (titled Updated Base Model + Project Features WSE). The cross-section extent in the table below begins just upstream of the project area and extends to the cross section just downstream of the project area. However, there are no impacts shown in the model results (including through the upstream extent of the model).

Table 14: Flood Stage Impacts

River Station	Updated Lower Pool 4 Big Lake Base Model WSE (ft)	Updated Lower Pool 4 Big Lake Base Model + All Features WSE (ft)	Flood Stage Impact (ft)
759.458	677.35	677.35	0.00
759.290	677.30	677.30	0.00
759.170	677.24	677.24	0.00
759.050	677.20	677.20	0.00
758.930	677.15	677.15	0.00
758.833	677.12	677.12	0.00

River Station	Updated Lower Pool 4 Big Lake Base Model WSE (ft)	Updated Lower Pool 4 Big Lake Base Model + All Features WSE (ft)	Flood Stage Impact (ft)
758.299	676.94	676.94	0.00
758.110	676.84	676.84	0.00
758.010	676.80	676.80	0.00
757.920	676.75	676.75	0.00
757.860	676.77	676.77	0.00
757.840	676.70	676.70	0.00
757.750	676.65	676.65	0.00
757.668	676.62	676.62	0.00
757.600	676.59	676.59	0.00
757.520	676.55	676.55	0.00
757.450	676.51	676.51	0.00
757.381	676.47	676.47	0.00
757.290	676.41	676.41	0.00
757.230	676.45	676.45	0.00
757.180	676.44	676.44	0.00
757.105	676.28	676.28	0.00
757.080	676.35	676.35	0.00
757.020	676.25	676.25	0.00
756.850	676.17	676.17	0.00
756.765	676.13	676.13	0.00
756.570	676.03	676.03	0.00
756.373	675.88	675.88	0.00

6.2 Project Design Model

This model was developed to compare the with and without project flow conditions and velocities for design purposes. The with-project conditions model was used to design project land features and the erosion protection elements needed for the land features. The model will provide water surface elevations, depths, and velocities for a range of flow conditions helpful for the project design.

6.2.1 Model Development

6.2.1.1 Base Model

The project model used the Upper Mississippi River Phase IV Flood Risk Management Existing Conditions Hydraulic Model as a base (UMR FRM hydraulic model) (USACE, 2020). This model was developed by the Corps to provide a better understanding of how floodwaters are carried by the system in its current/existing condition. This new existing-conditions model is a tool that can lead to better and more consistent characterization of flood risk. The hydraulic model will improve flood preparation and response, real time river forecasting and real time inundation mapping.

This model was developed using USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) software (5.0.7) (HEC, 2019). This model covers 251 river miles of the UMR mainstem from the Coon Rapids Dam tailwater in Coon Rapids, Minnesota (RM 866.29) to the middle of Pool 11, downstream of Guttenberg, Iowa (RM 615).

The UMR FRM hydraulic model leveraged the ongoing Corps Water Management System (CWMS) water control focused modeling effort by using the CWMS model as a base model. The UMR FRM hydraulic model differs from the CWMS model by having more detailed features, additional cross sections, and bluff to bluff coverage of the entire floodplain.

FEMA acknowledges that the UMR FRM hydraulic model cannot be used to produce an update or replacement of the 2004 FFS (USACE, 2004) and FEMA's regulatory products in its current state.

The model geometry was developed using a digital terrain layer comprised of the best available LiDAR (Light Detection and Ranging) terrain data and bathymetry data. The USGS Upper Midwest Environmental Sciences Center (UMESC) topobathy (topography + bathymetry) dataset for the UMR provided much of the necessary terrain and bathymetry data. The topobathy dataset is a combination of USACE-collected LiDAR and bathymetry data, supplemented with other surveyed bathymetry datasets. For the UMR modeling the topobathy datasets were supplemented with state LiDAR data for tributary reaches and more recent USACE collected bathymetry, where available. The calibrated existing conditions model uses one set of parameters that produce reasonable results for three flood events (2001, 2014, and 2019). The existing levee elevations represent the sum of all activities (flood fighting, repairs, dredge material placement, approved and unapproved alterations) that have occurred over time. The goal of this model is to provide a common tool using the best available data and software that can reasonably recreate a range of events that have occurred or may occur in the future to assess system performance and flood risk management strategies.

6.2.1.2 Truncated and Adjusted Model

The UMR FRM hydraulic model described in the section above was utilized for the Lower Pool 4 Big Lake project design model. The model adjustments were made in HEC-RAS version 6.3 (HEC, 2022). The UMR FRM hydraulic model was truncated upstream and downstream of the project area to decrease model run times. The upstream portion of the model was truncated to a cross section at RM 795.37 just upstream of the USGS Red Wing, MN gage (05355250) (USGS, 2023) because it was the easiest location to break the model and did not require a geometry change in that area. The downstream potion of the model was truncated to a cross section at RM 732.98 just downstream of Lock and Dam 5. This was the first location downstream of the project area that provided an easy break location and did not require a geometry change. This location is also an entire pool downstream of the project area which ensures the downstream boundary condition does not affect the project area of interest.

The UMR FRM hydraulic model did not include a 2D flow area at the project area which is desired for the project design model to adequately look at flow paths and velocities. The following adjustments were made to the geometry to convert the project area to 2D.

- The Chippewa River 2D flow area was extended to the left bank of the back channel and includes the project area downstream of Highway 25.

- The cross sections in the vicinity of the extended 2D flow area were truncated and recut from the terrain.
- Highway 25 was included in the 2D flow area as a 2D area connection. The geometry of the Highway 25 connection copied the bridge data from the UMR FRM hydraulic model.
- A breakline was included in the 2D flow area where the original Chippewa 2D flow area ended. This breakline represents Highway 35.
- A breakline was included in the 2D flow area where the railroad connects to Highway 25.
- Lateral structures were added to connect the extended 2D flow area to the adjacent cross sections.
- The new lateral structures and the original UMR FRM hydraulic model structure opposite the project area on the right descending bank utilize the 2D equations for the weir computations rather than the weir equation utilized in other lateral structures in the original UMR FRM hydraulic model. A sensitivity analysis was completed, and it was determined that the 2D equations resulted in a smaller head differential between the main channel and backwater channels which is more realistic and necessary for the project area modeling.
- Cells within the 2D area near the project area were refined to follow side channels and high ground.

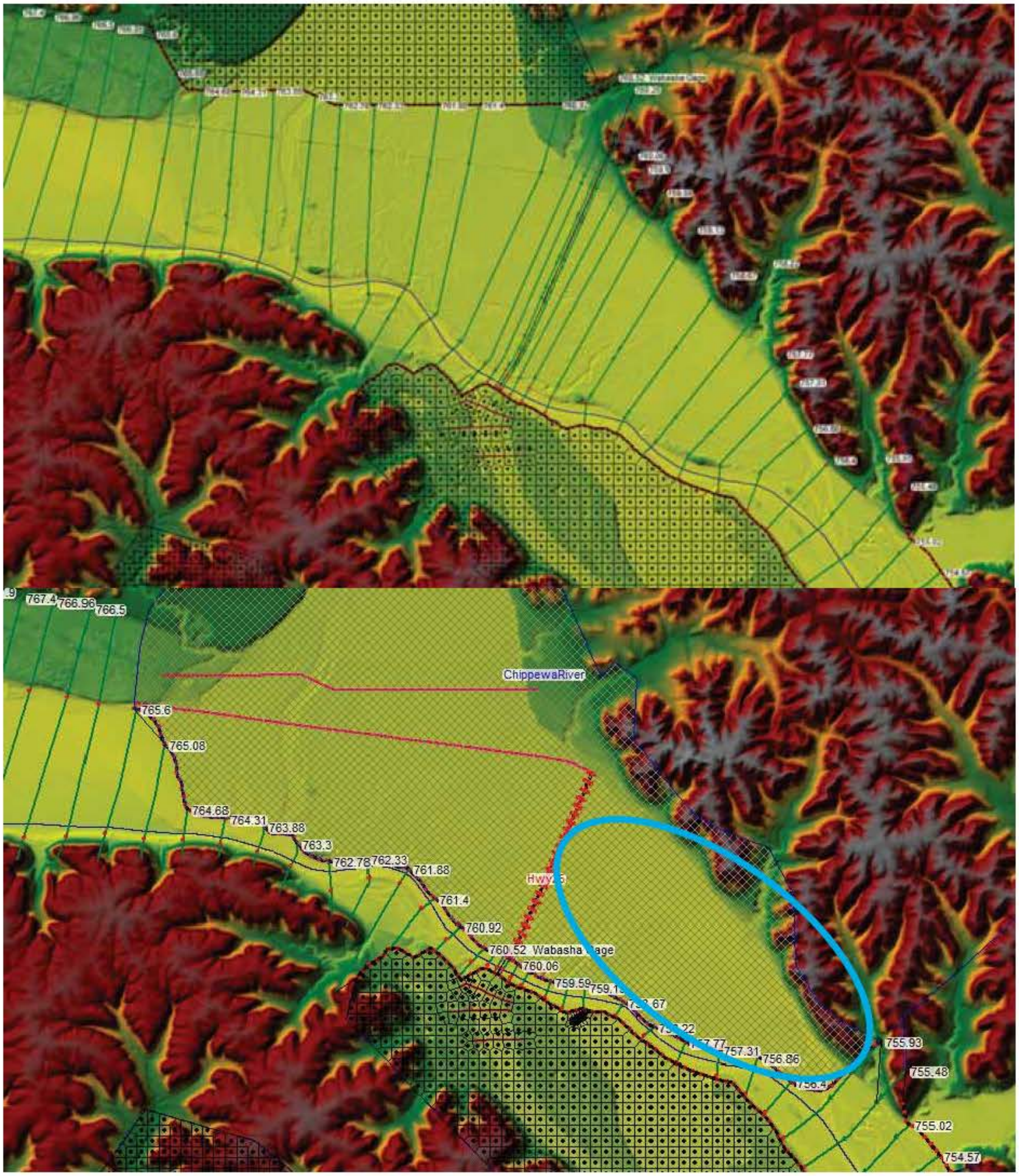


Figure 26: UMR FRM hydraulic model - Original Geometry (Top) vs. Adjusted Geometry (Bottom). Project area highlighted with blue ellipse.

6.2.1.3 Boundary Conditions

The upstream boundary condition used for the project design model is a flow hydrograph at the most upstream cross section which is the approximate location of the USGS Red Wing, MN gage (05355250). Navigation dam rules were added for L&D 4 and 5, and the downstream boundary condition utilized normal depth (0.00001 ft/ft). The downstream boundary condition matches the original UMR FRM hydraulic model. A sensitivity analysis of this parameter did not yield differences in the results. There are also inflow hydrographs included from the UMR FRM hydraulic model at the Chippewa River and Zumbro River. The Zumbro River hydrograph was not adjusted for the project design model runs because it's located downstream of L&D 4 which hydraulically separates the Zumbro River from the project area.

In total, there were seven events modeled which include five events based on a percentage of time exceeded or annual exceedance probability (AEP) and two calibration events (observed data). The purpose of each model run is described in Table 15 and Table 16 below. The five percent time exceeded/AEP event discharges and corresponding WSEs are listed in Table 17 below.

The five events based on a percentage of time exceeded or annual exceedance probability (AEP) utilized a typical shape and duration event taken from the period of record at Red Wing, MN and then scaled to each of the five hypothetical events. The Chippewa River also used this typical shape and duration event since the Chippewa River discharges are much less than the Mississippi and have minimal effect on the results (especially after calibration).

The Red Wing gage data (USGS, 2023) was analyzed to find a typical summer event hydrograph that could be scaled to the events in Table 15 below. The flow boundary conditions for both the Mississippi River at Red Wing (USGS, 2023) and the Chippewa River at Durand, WI (USGS, 2023) that were used for these events are shown in Figure 27 and Figure 28.

The two calibration specific events shown in Table 16 are described further below.

Table 15: Modeled Percent Time Exceeded and AEP Events Descriptions

Modeled Percent Time Exceeded and AEP Events					
Discharge – L&D 4 (cfs)	**Percent of Time Exceeded[1]**	**Annual Exceedance Probability Event[2]**	**Description of Flow Condition**	**Purpose of modeled event**	**Geometry Condition(s)**
24,700	50	-	Low Flow	Verify model accuracy for observed data discharge transects.	Existing
				Check proposed condition flow paths and velocities for overwintering design.	Proposed
43,100	25	-	Moderate Flow	Verify model accuracy for observed data discharge transects.	Existing
				Check proposed condition flow paths and velocities for design of project features .	Proposed
83,000	-	50	Bankfull Event	Verify model accuracy for observed data discharge transects	Existing
				Check proposed condition flow paths and velocities for design of project features for a typical spring event.	Proposed
121,500	-	20	Small Flood	Verify model accuracy for observed data discharge transects.	Existing

Modeled Percent Time Exceeded and AEP Events					
Discharge – L&D 4 (cfs)	Percent of Time Exceeded[1]	Annual Exceedance Probability Event[2]	Description of Flow Condition	Purpose of modeled event	Geometry Condition(s)
				Check proposed condition flow paths and velocities for design of project features.	Proposed
231,000	-	1	Large Flood	Verify model accuracy for large event on WCM Operating Curve.	Existing
				Check proposed condition flow paths and velocities for design for a large flood event and worst-case scenario. This event used a constant flow hydrograph (described in Section 6.2.2.2).	Proposed

Table 16: Modeled Calibration/Validation Events Descriptions

Modeled Calibration/Validation Events					
Year	Approx. Percent of Time Exceeded	Discharge – L&D 4 (cfs)	Description of Flow Condition	Purpose of modeled event	Geometry Condition(s)
2019	Just under 2% Exceedance Value	104,400	Small Flood	Verify model accuracy for large event on WCM Operating Curve Verify model accuracy for gage data hydrograph at Wabasha	Existing
2020	Just under 10% Exceedance Value	62,000	Bankfull Event	Verify model accuracy for large event on WCM Operating Curve Verify model accuracy for gage data hydrograph at Wabasha	Existing

[1]*Corresponding Discharges calculated using HEC-SSP for the entire period of record discharge data at L&D 4*

[2]*Corresponding Discharges taken from the 2004 FFS*

Percent Time Exceeded Events

The USGS 05355250 Mississippi River at Red Wing, MN gage is missing data between 1999 and 2014 while the L&D 4 gage includes discharge data from 1935-present. The time exceeded values from the L&D 4 gage was used to capture the longest period of record for the analysis (USACE, 2023). The USGS 05369500 Chippewa River at Durand, WI gage was also analyzed for each time exceeded value and has a period of record from July 1928 to present (USGS, 2023). The Red Wing, MN discharge was calculated by subtracting the discharge for the Chippewa River from the discharge for L&D 4. There are no other substantial inputs between L&D 4 and the Red Wing gage, so the difference between these discharges can be adopted for the Chippewa River discharge.

AEP Events

The AEP event discharges were taken from the 2004 FFS (USACE, 2004). The Chippewa River discharge for these events were calculated by subtracting the discharge in the cross sections encompassing the project area by the Red Wing gage discharge in the FFS. There are no other substantial inputs between the project area and the Red Wing gage, so the difference between these discharges can be adopted for the Chippewa River discharge.

Table 17: HEC-RAS Discharge Events and Corresponding WSEs

Discharge (cfs)			Percent of Time Exceeded[1]	Annual Exceedance Probability Event[2]	Description of Flow Condition	Water Surface Elevation (ft - NAVD 88)[3]	
L&D 4	USGS 05369500 Chippewa River at Durand, WI	USGS 05355250 Mississippi River at Red Wing, MN				L&D 4 Pool, RM 753	Wabasha, RM 760.45
24,700	5,700	19,000	50	-	Low Flow	666.2	666.7
43,100	8,780	34,320	25	-	Moderate Flow	666.1	668.0
83,000	21,500	61,500	-	50	Bankfull Event	666.1	670.7
121,500	26,000	95,500	-	20	Small Flood	668.2	672.5
231,000	33,000	198,000	-	1	Large Flood	674.1	677.3

[1]*Corresponding Discharges calculated using HEC-SSP for the entire period of record discharge data at L&D 4*

[2]*Corresponding Discharges taken from the 2004 FFS*

[3]*WSE values extracted from the L&D 4 WCM Operating Curves*

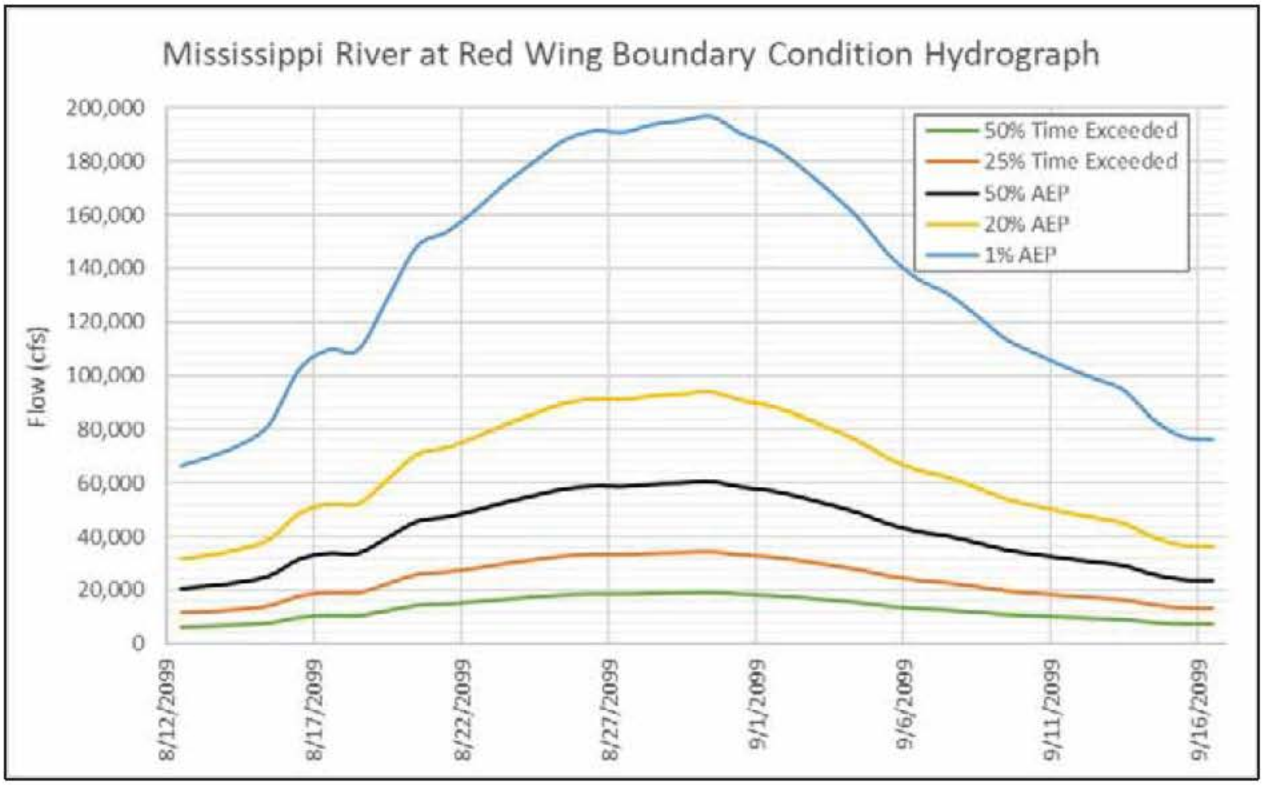


Figure 27: HEC-RAS Boundary Condition Hydrographs for the Mississippi River at Red Wing

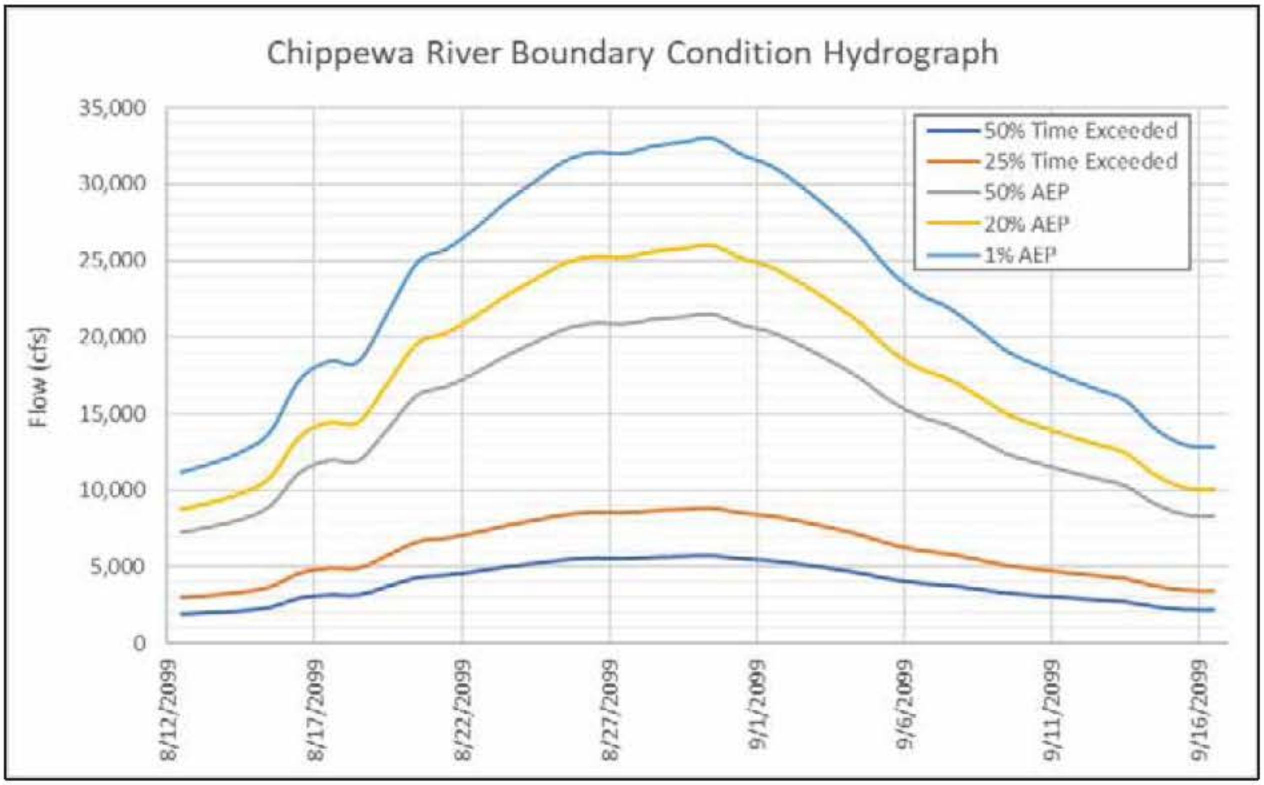


Figure 28: HEC-RAS Boundary Condition Hydrographs for the Chippewa River

6.2.2 Model Calibration/Verification

6.2.2.1 Mainstem Calibration

The UMR FRM hydraulic model was used as the basis of the project design model. That model was calibrated to the three events listed in Table 18 below. The UMR FRM hydraulic model was not calibrated to a flow associated with a specific return interval (e.g., 1% AEP event). A comparison of this model with the 2004 FFS was outside the scope of this model.

Table 18: UMR FRM Hydraulic Model Calibration Events

Calibration Events	Lock and Dam No. 2		Lock and Dam No. 10	
	Peak Flow (cfs) (approx. AEP)	Date	Peak Flow (cfs) (approx. AEP)	Date
2001	141,000 (~0.01)	28APR01	271,000 (~0.01)	21APR01
2014	101,000 (~0.04)	27JUN14	190,000 (~0.1)	04JUL14
2019	105,000 (~0.04)	01APR19	240,000 (~0.03)	27APR19

Because there were changes to the project area geometry, the project design model (existing conditions) was briefly calibrated/verified for this effort using an observed event in 2020, an observed event in 2019 and the one percent AEP event to capture the large-scale flooding event. Observed discharge at the Red Wing, MN USGS gage was used as the upstream boundary condition for the 2020 and 2019 events (USGS, 2023). The L&D 4 peak flow values from the observed calibration events are listed in Table 19 below.

Table 19: Project Design Hydraulic Model Observed Calibration Events

Calibration Event	L&D 4 Peak Flow (cfs)	Date
2019	104,400	9-Oct-19
2020	62,000	2-Jul-20

The initial calibration model runs showed WSE values at the Wabasha, MN gage higher than the observed data. The main channel Manning's n values from the most upstream cross section to L&D 4 were adjusted to increase the WSE around the project area. The UMR FRM hydraulic model Manning's n values in this reach were 0.024. The project design model Manning's n values in this reach were adjusted to 0.019 to better match the observed WSE data. The 2020 and 2019 events are plotted with the observed data in Figure 29 and Figure 30 below, respectively. As seen in these plots, the modeled results from HEC-RAS are still slightly higher than the observed data in some portions of the hydrographs, but overall, the hydrographs are similar. This was deemed sufficient for the model calibration around the project area.

The three existing conditions calibration events (2020, 2019 and 1% AEP) were also plotted against the USACE WCM operating Curves (USACE, 2004). The results of this portion of the calibration effort are shown in Figure 31 and Figure 32 below.

The Wabasha, MN gage plot shows an overall good calibration and is slightly conservative for L&D 4 discharges of greater than 125,000 cfs. The L&D 4 pool gage plot shows a good calibration for events less than a L&D 4 discharge of 90,000 cfs. Above this discharge, the recorded data and the WCM operating curve differ. The "Rules" at the L&D 4 operating curve location in the model makes it such that adjusting Manning's n values or other parameters has minimal effect at this location. Because it is more important to the project to match at Wabasha, no other attempt was made to match the pool gage curve in Figure 32 below.

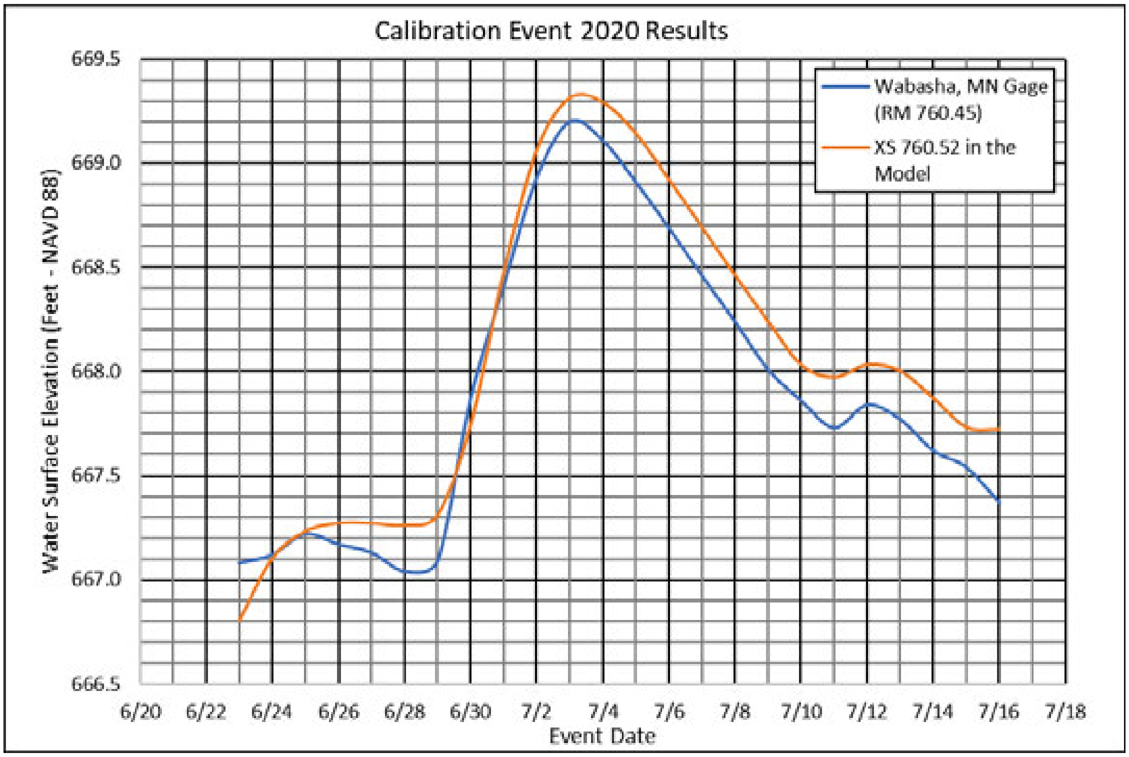


Figure 29: Calibration Event 2020 Results - Wabasha, MN

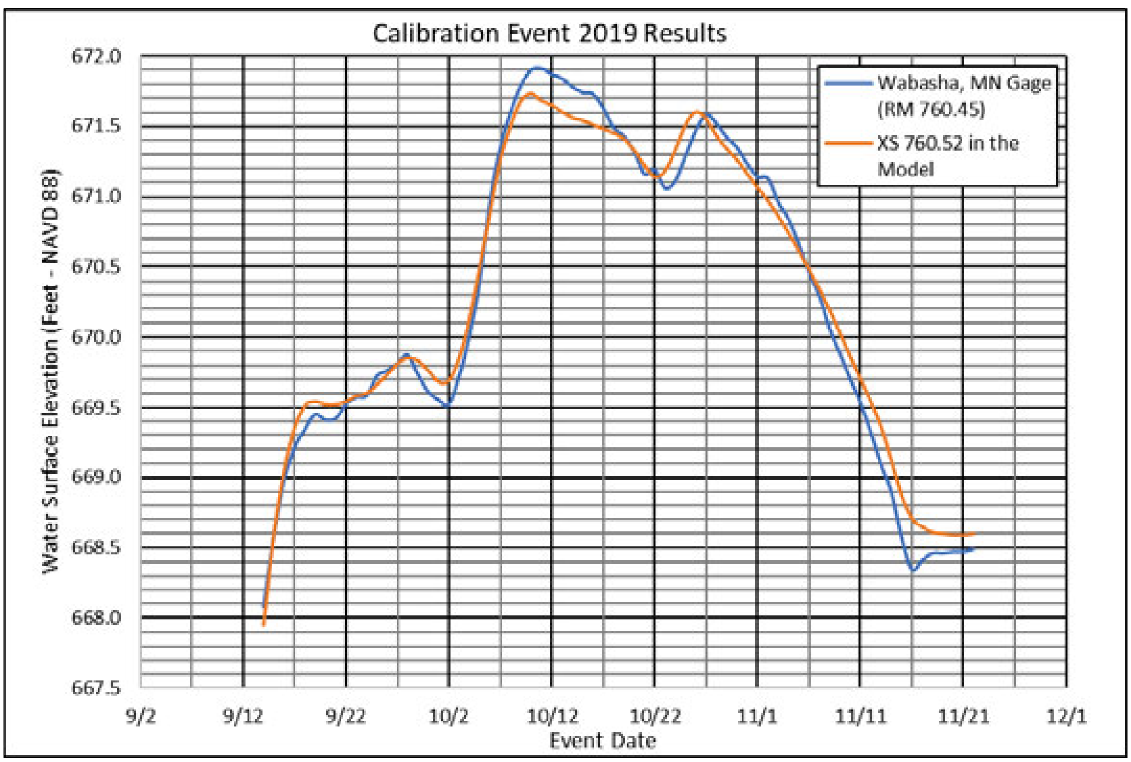


Figure 30: Calibration Event 2019 Results - Wabasha, MN

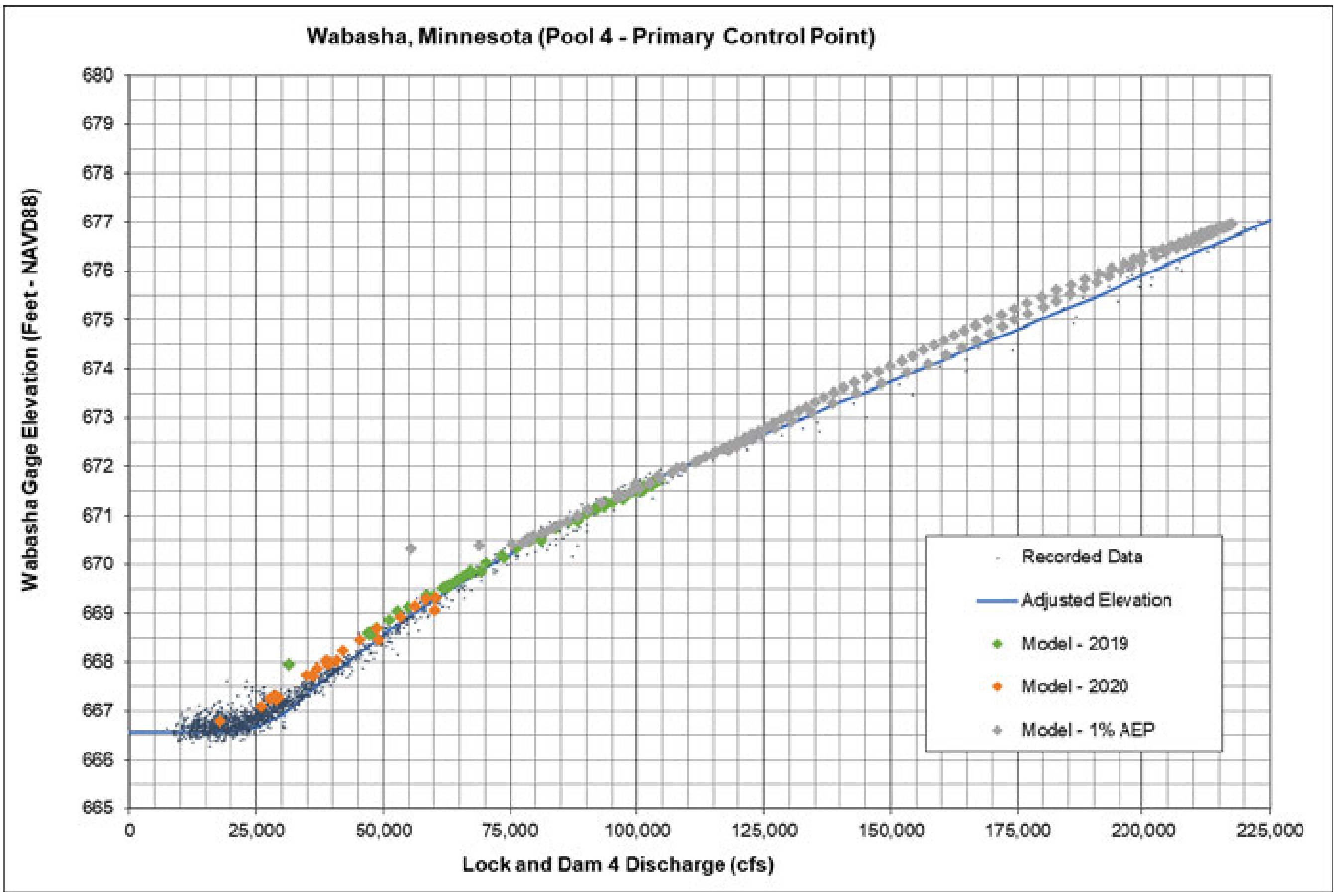


Figure 31: Wabasha, MN Gage WCM Operating Curve with Hydraulic Model Results

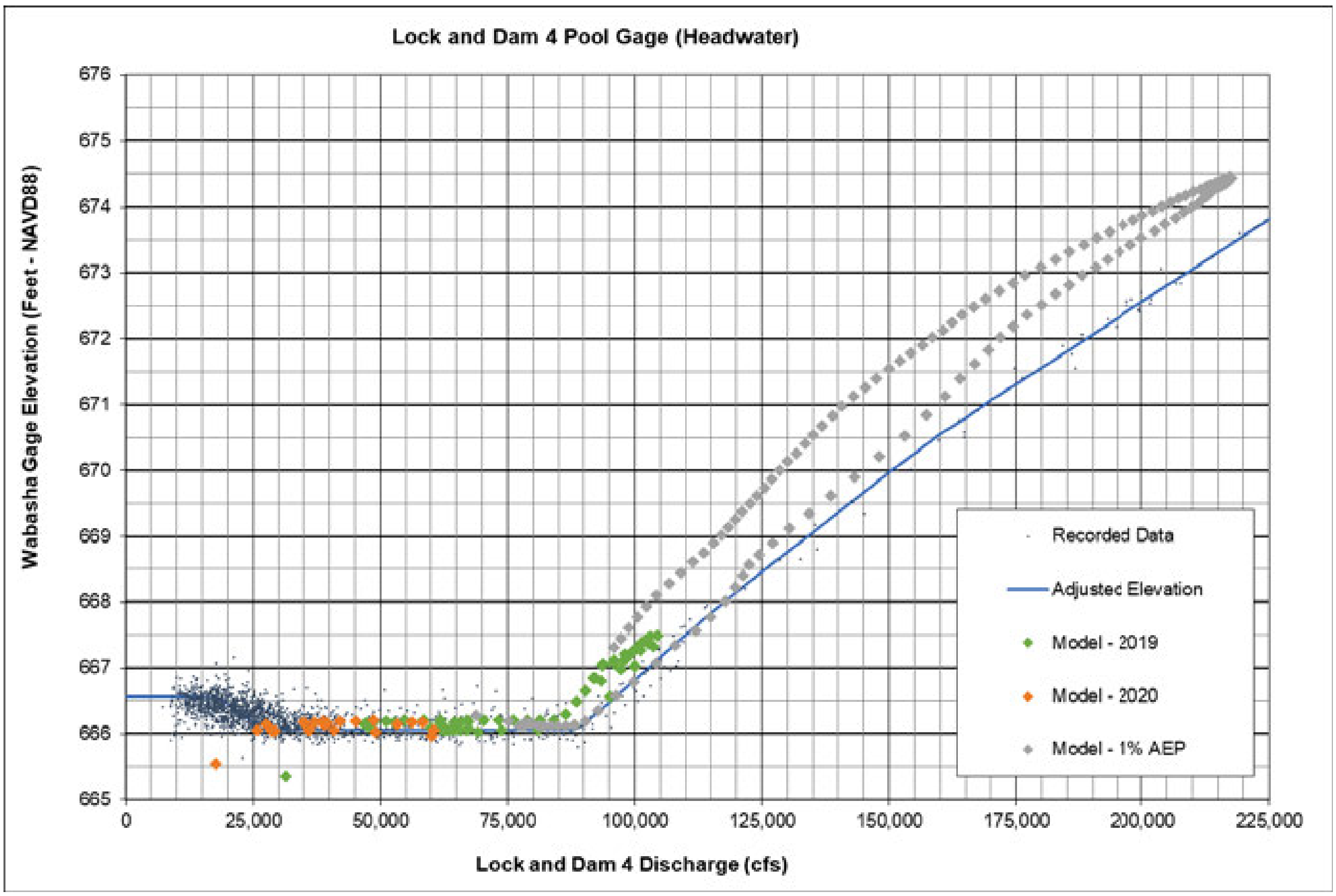


Figure 32: L&D 4 Pool (Headwater) Gage WCM Operating Curve with Hydraulic Model Results

6.2.2.2 Alternative 1% AEP Event Constant Hydrograph – Proposed Conditions

The 1% AEP event resulted in very long run times, errors and warnings in the model results window and unexpected high velocities in secondary channels due to the transition from a 1D geometry in the main channel to 2D geometry. Although the existing conditions plot looks sufficient for the WCM operating curves shown in Figure 31 and Figure 32, an alternative 1% AEP event was run for proposed conditions that used constant discharge boundary conditions for the Mississippi River and Chippewa Rivers from the 2004 FFS. The discharge boundary conditions are 198,000 cfs and 33,000 cfs for the Mississippi River and Chippewa River, respectively. This model run has a reasonable run time, realistic velocities, and very minimal warnings in the model results window. The maximum velocities from this run as well as the proposed conditions 20% AEP event are used for the project design velocity analysis discussed in Section 7.1.3.2.

6.2.2.3 Side Channel Calibration

Discharge measurements have been taken at a number of transects near the project area. Figure 33 shows the major transect locations near the project area. This figure can be referenced to identify the discharge measurement transects whose rating curves are given in subsequent figures. In general, the measurement site names are based on river mile, along with a distance and direction from the navigation channel centerline.

Figure 33: Discharge Transects Near the Project Area

Rating curves at all the major transect locations in this reach of the Mississippi River are included in Figure 34 through Figure 39 below. These figures include modeled and observed datasets. The observed datasets are listed as COE (USACE) or Hydroscience which indicates the source of the observed data. The model datasets indicate the project design hydraulic model's existing conditions discharges. In general, the observed data and the modeled results match well. The Truedale Slough Transect in Figure 35 shows flow reversing for L&D 4 discharges greater than 95,000 cfs which is not shown in the observed data. However, this transect is not crucial for the project feature design described in Section 7 below.

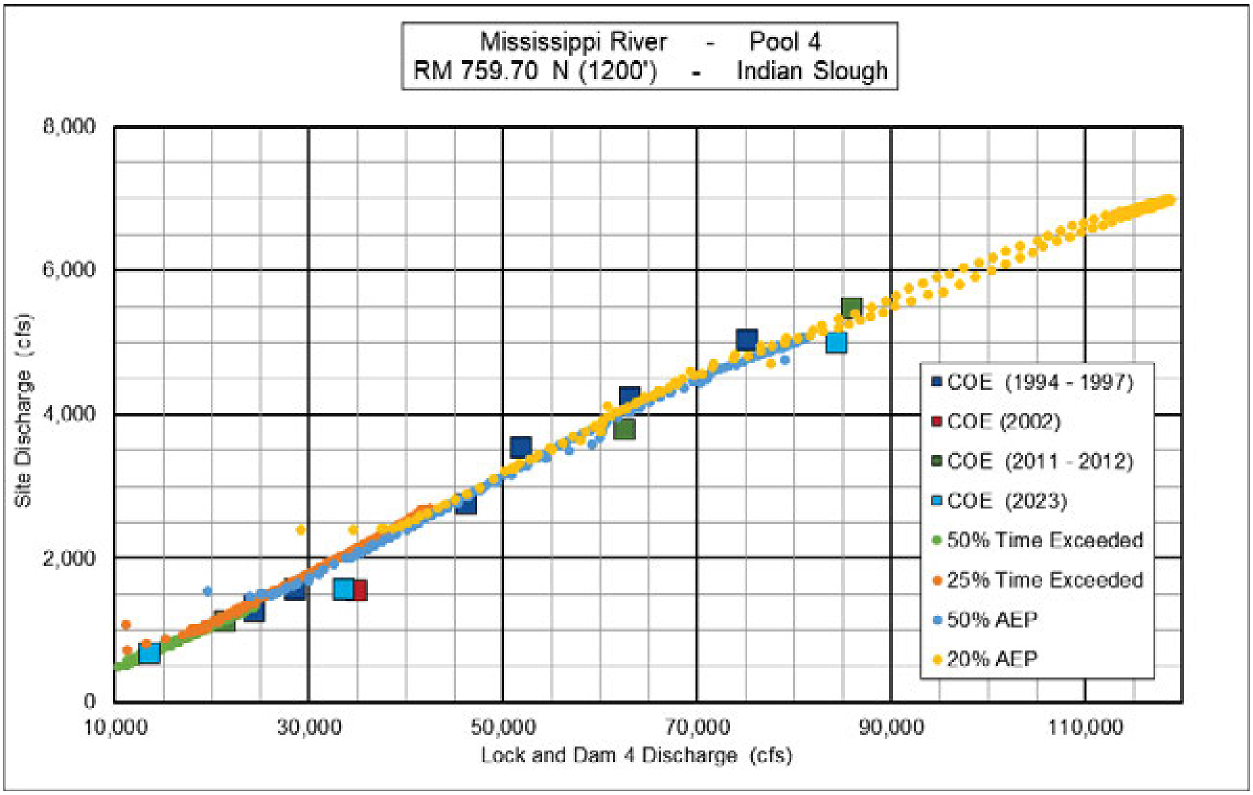


Figure 34: Rating Curve RM 759.70 N (1200') – Indian Slough

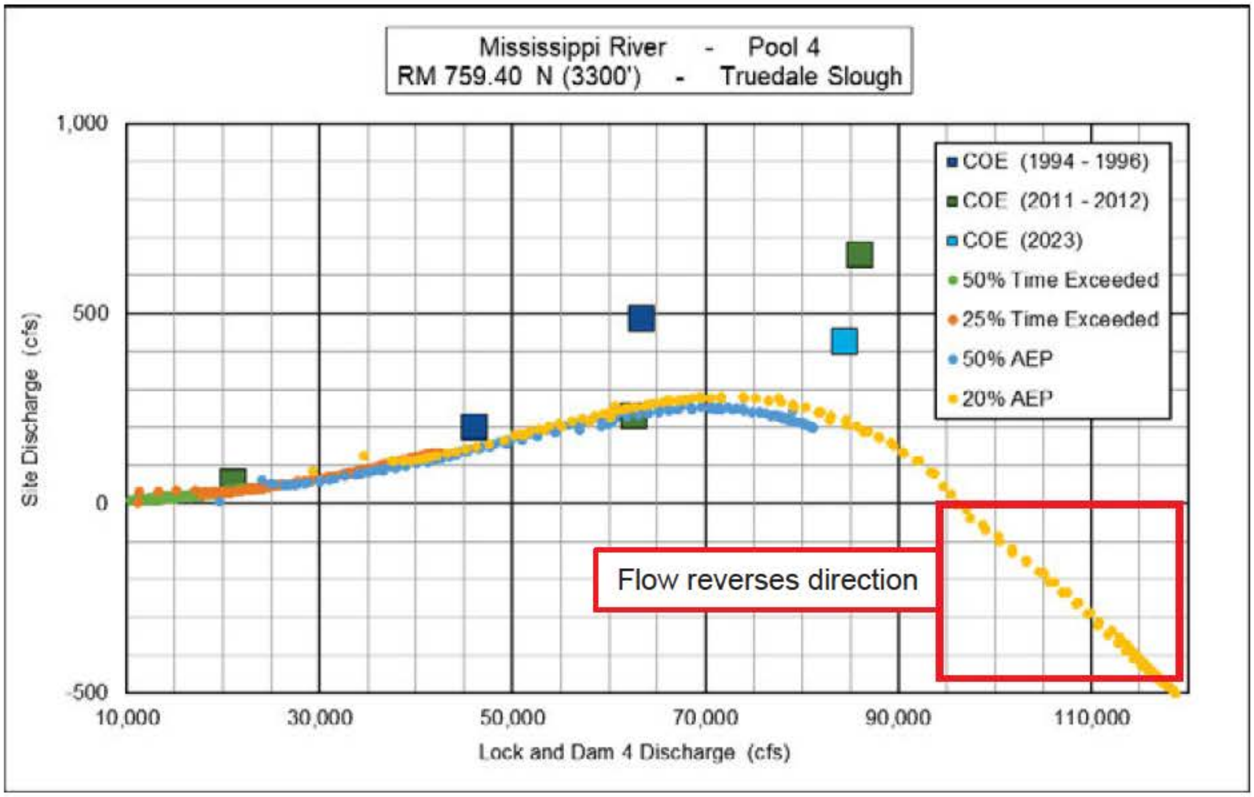


Figure 35: Rating Curve RM 759.40 N (3300') – Truedale Slough

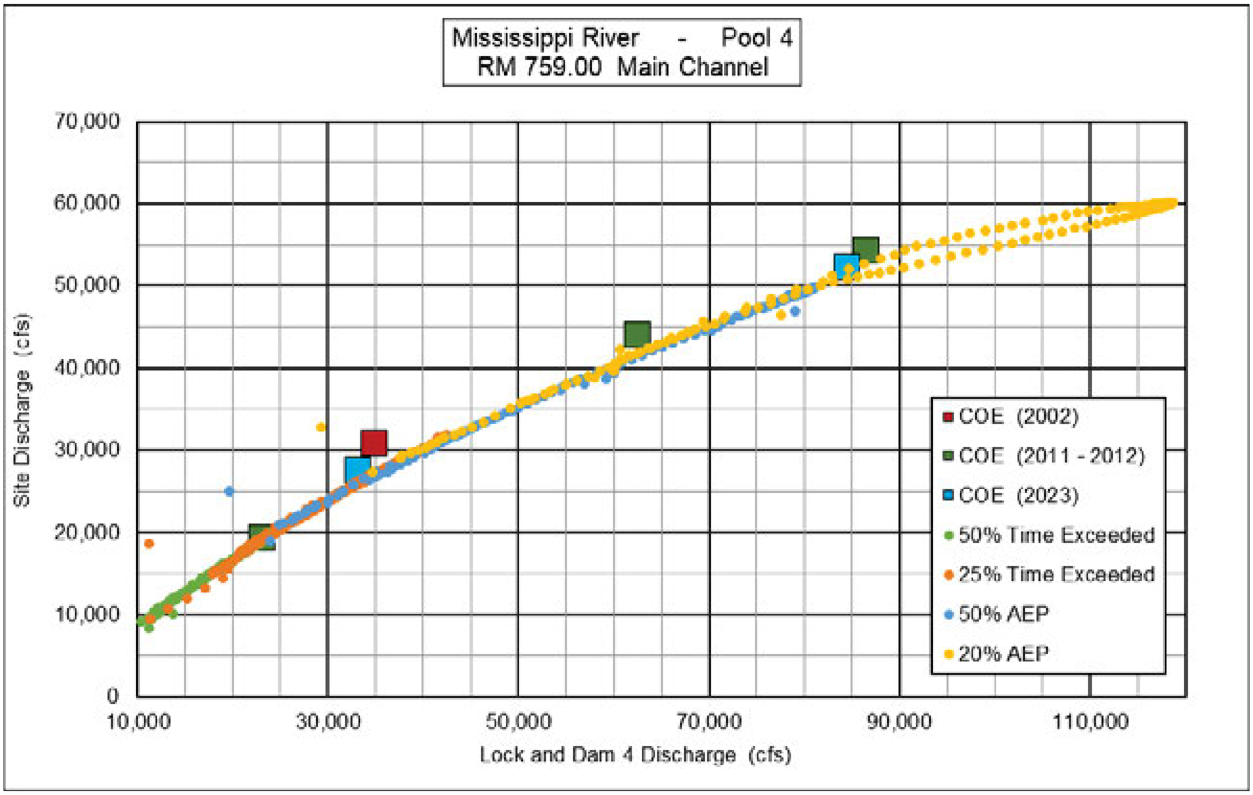


Figure 36: Rating Curve RM 759.00 N Main Channel

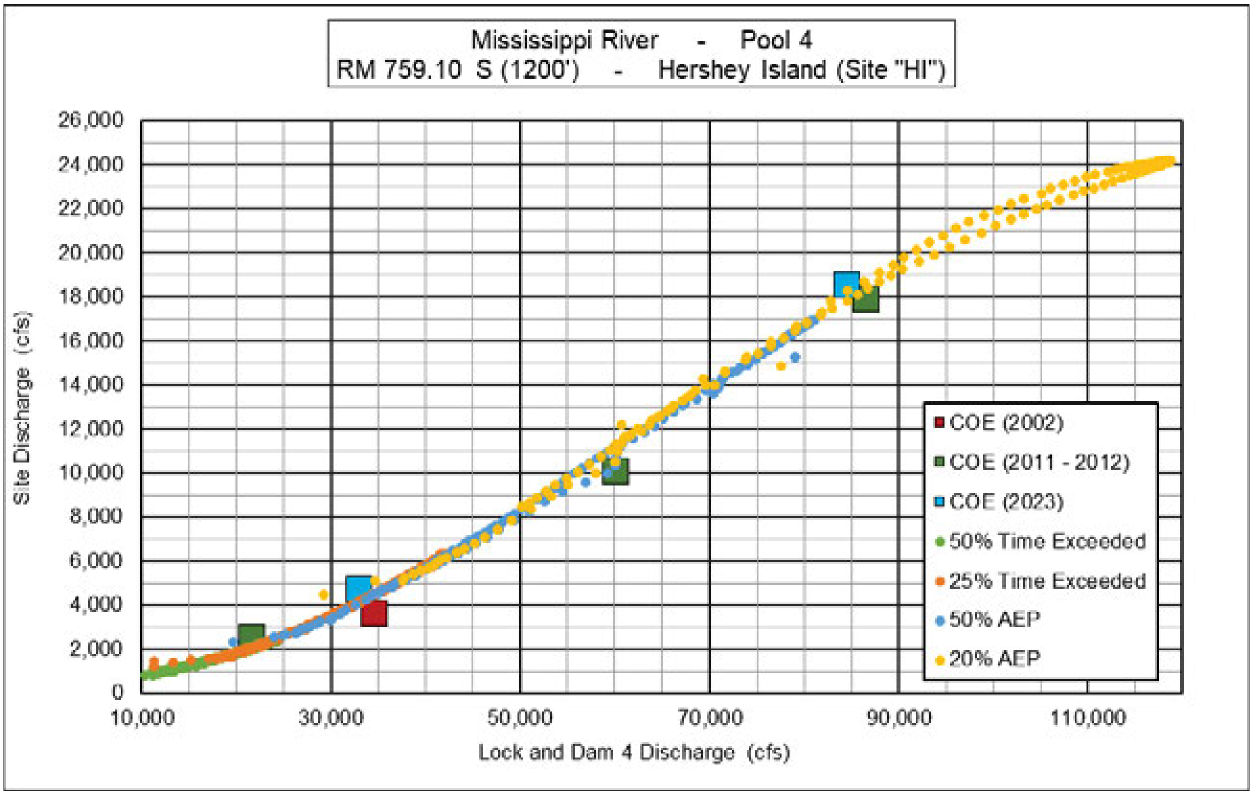


Figure 37: Rating Curve RM 759.10 S (1200') – Hershey Island

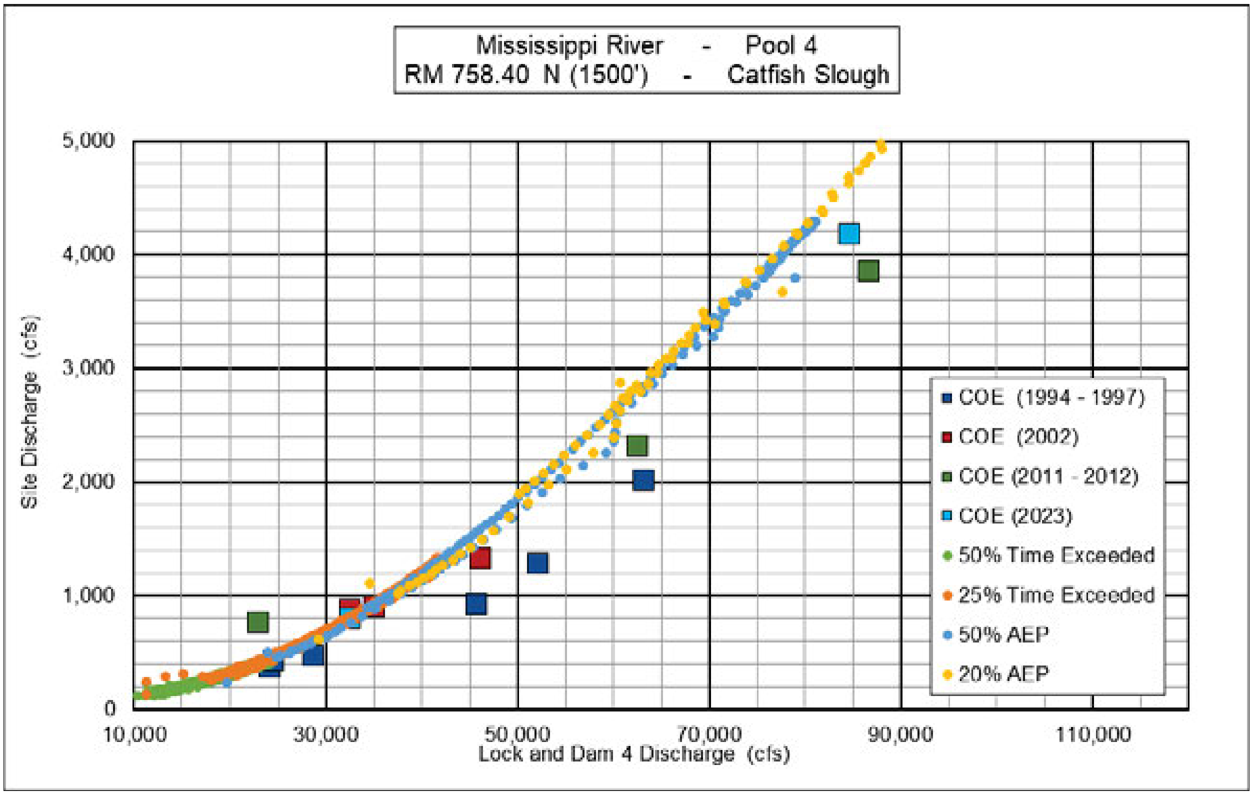


Figure 38: Rating Curve RM 758.40 N (1500') – Catfish Slough

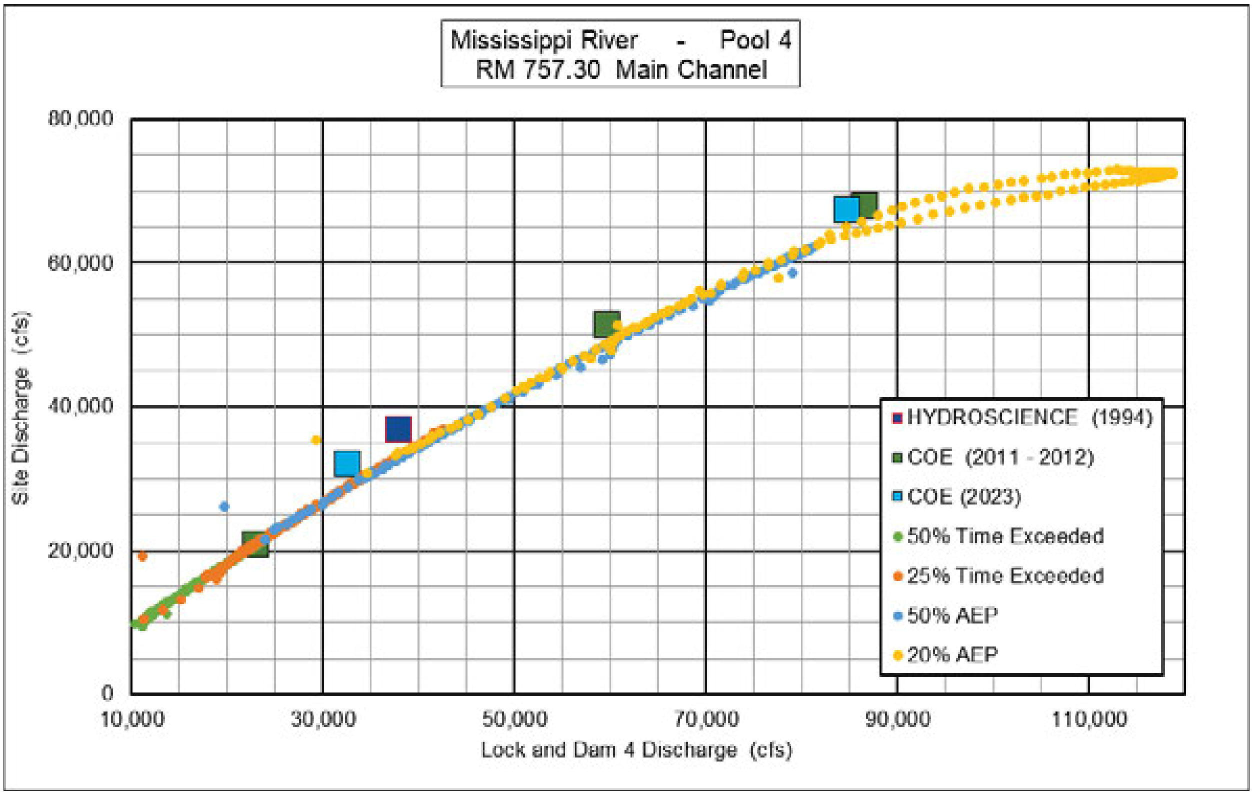


Figure 39: Rating Curve RM 757.30 N Main Channel

6.2.3 Model Results

The velocity results are included below (Figure 40, Figure 41, Figure 42) for both existing and proposed conditions. The velocity results for the 1% AEP event are included in Figure 43. This figure shows the proposed conditions results for the constant hydrograph model run described in Section 6.2.2.2. These result plots are showing maximum values from the simulation and are used for the design of the Recommended Plan in Section 7 below. The translucent polygons within the Proposed Conditions figures outline the Recommended Plan features.

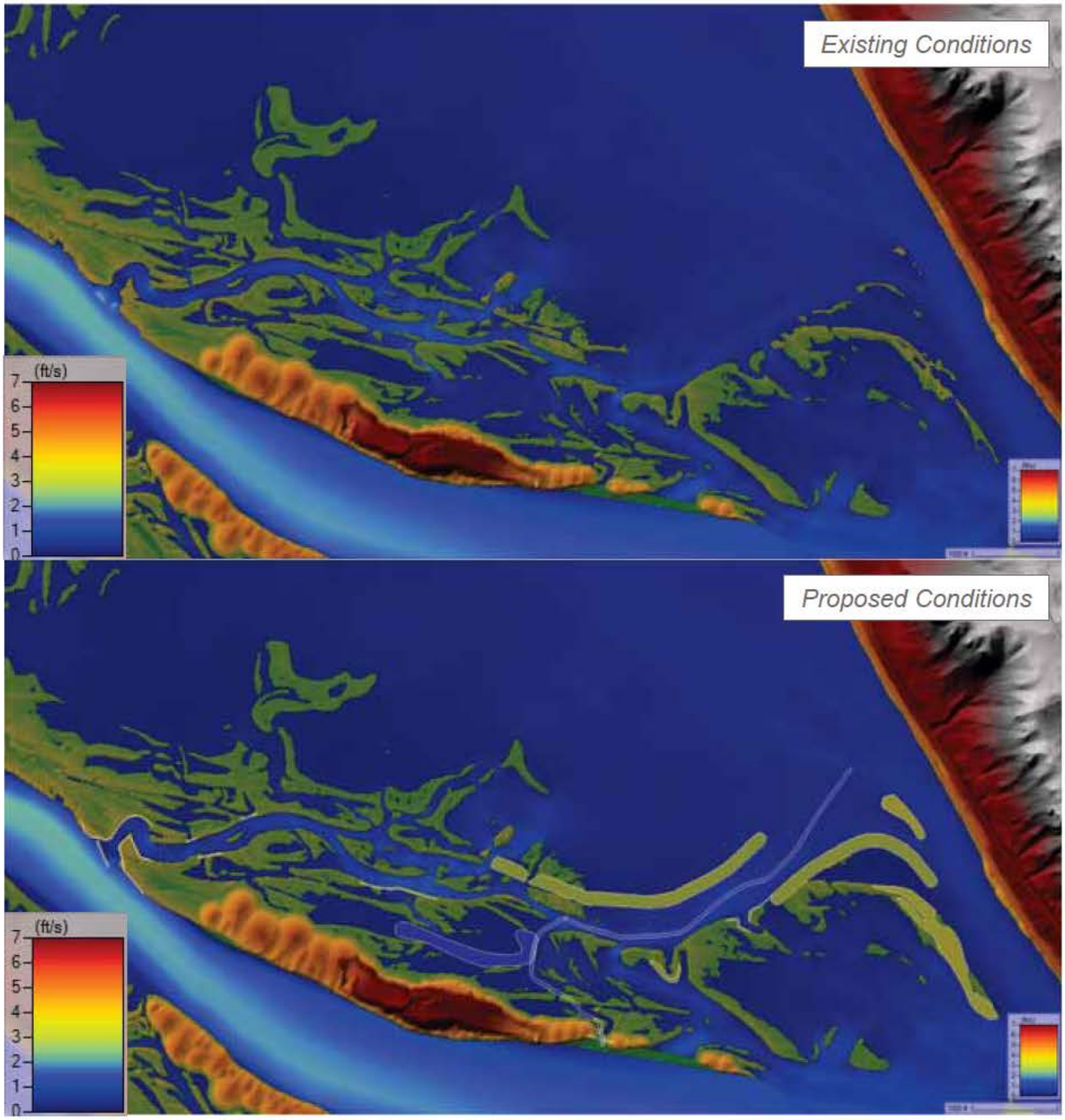


Figure 40: Velocity Results: 50% Time Exceeded Event

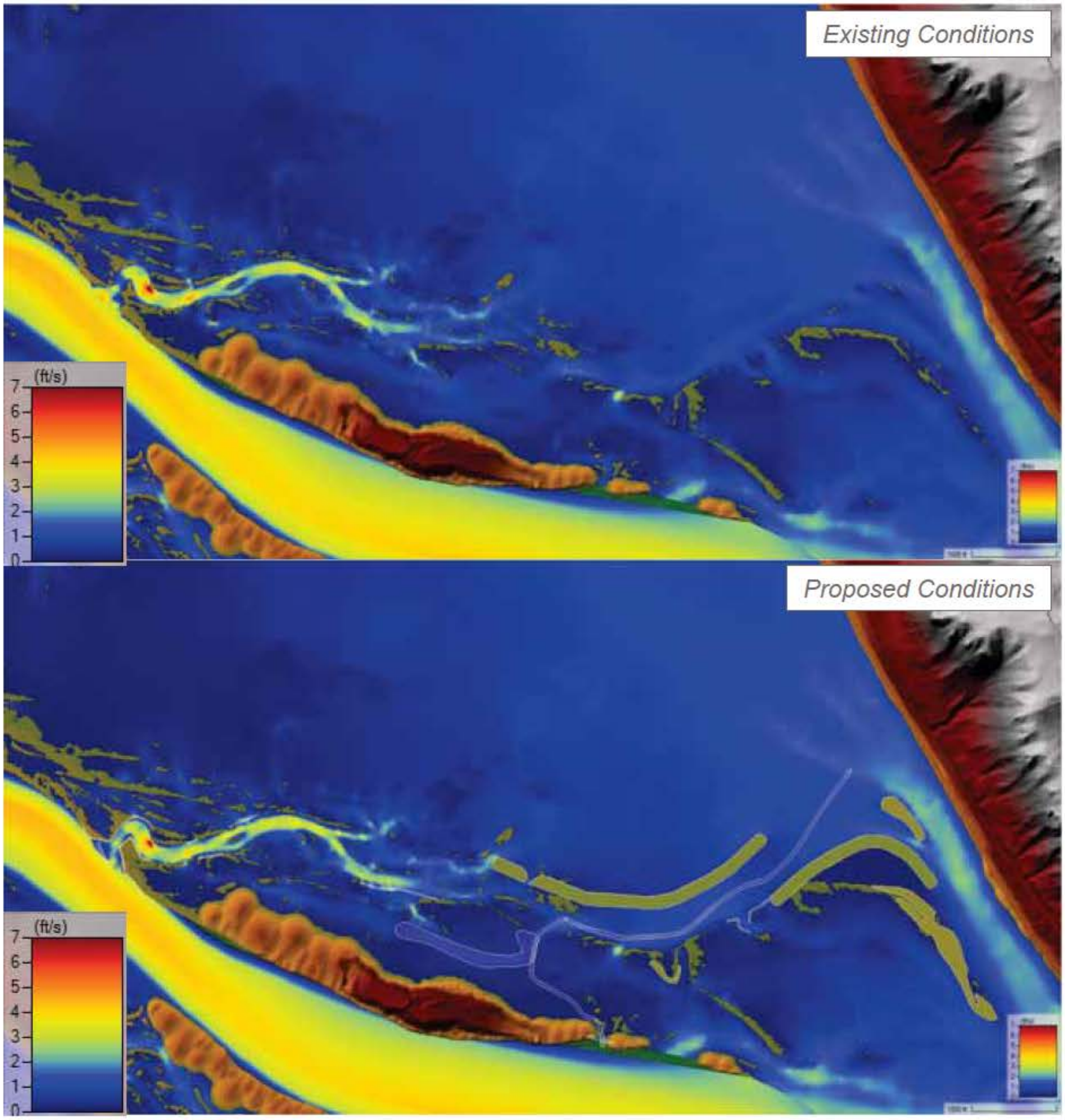


Figure 41: Velocity Results: 50% AEP Event

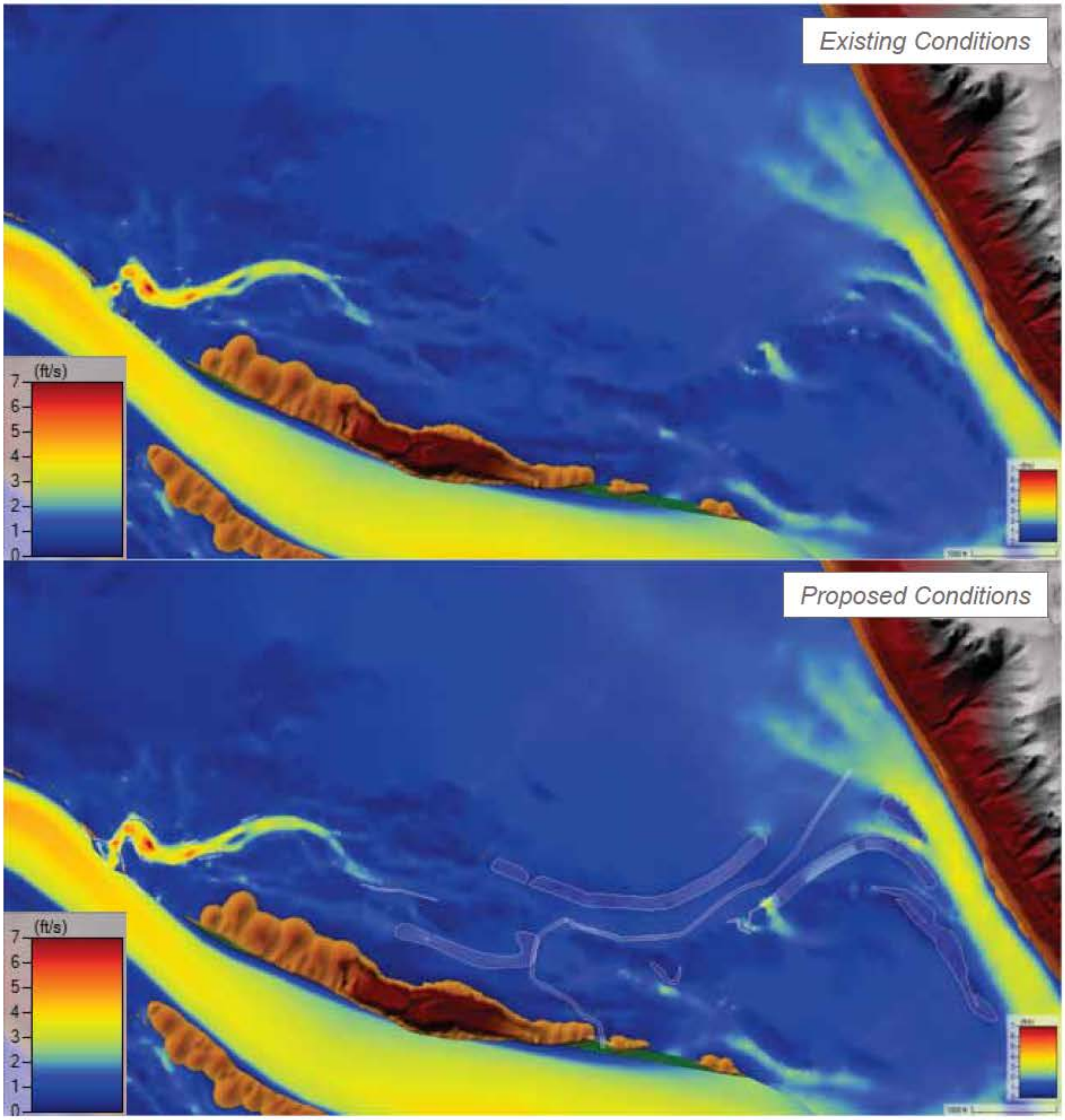


Figure 42: Velocity Results: 20% AEP Event

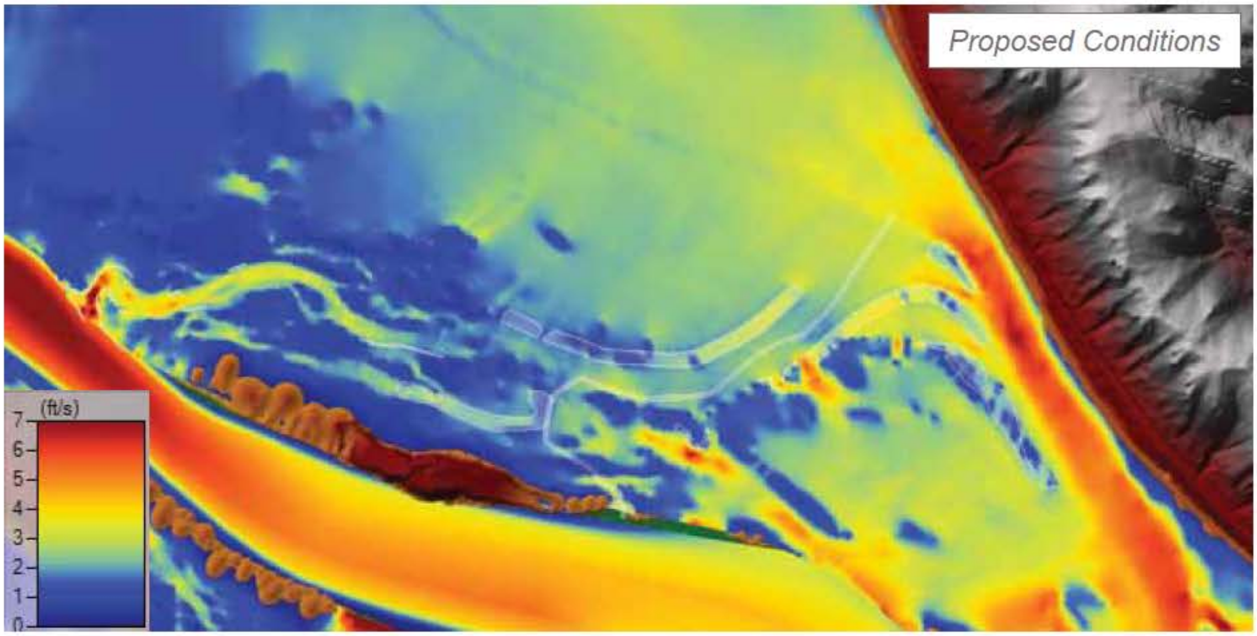


Figure 43: Velocity Results: 1% AEP Event (Constant Hydrograph)

7 Hydraulic Design of the Recommended Plan

The Recommended Plan was identified as the most efficient way to address the main study area problems in Big Lake. These problems are listed below.

- Loss of island and floodplain forest habitat due to erosional forces (e.g., wind, wave, ice, river current).
- Expansion of invasive species.
- Declining single age floodplain forest that is unable to naturally regenerate due to invasive herbaceous cover and inundation frequency and duration.
- Degradation and changes to flow and depth diversity throughout the study area used by native fish and mussels, due to island loss and sediment deposition.

The Recommended Plan enhances the Big Lake area through the construction of earthen islands, rock closures, shoreline stabilization features, a sediment deflector, overwintering dredging and access dredging. Figure 1 shows the Recommended Plan feature layout. Also, for reference, a table summarizing the design assumptions (i.e., invert elevations, top elevations, etc.) can be observed below in Table 20. Many of the features and recommendations have been denoted in the Upper Mississippi River Restoration Program - Environmental Design Handbook (USACE, 2012). This document was used to ensure structure dimensions and design criteria were in general agreement with currently accepted design characteristics.

Table 20: Design Assumptions

Feature	Feature Type	Design Assumptions
D-A	Access Dredging	Slide Slope: 1V:4H Bottom Elevation: 660.5 feet Channel Bottom Width: 40 feet
D-O-1	Overwintering Dredging	Slide Slope: 1V:4H Bottom Elevation: 658.5 feet
I-1	Island	Top Elevation: 668.5 feet Fine Thickness: 6 inches Top Width: 150 Feet Side Slope: 1V:3H
I-2	Island	Top Elevation: 668.5 feet Fine Thickness: 6 inches Top Width: 150 Feet Side Slope: 1V:3H
I-3	Island	Top Elevation: 669.5 feet Fine Thickness: 18 inches Top Width: Varies Side Slope: 1V:3H
I-4	Island	Top Elevation: 669.5 feet Fine Thickness: 18 inches Top Width: Varies Side Slope: 1V:3H
RC-C-3	Complete Rock Closure	Top Elevation: 668.0 feet Top Width: 6 feet Side Slope: 1V:2.5H
RC-C-4	Complete Rock Closure	Top Elevation: 667.5 feet Top Width: 6 feet Side Slope: 1V:2.5H
RC-C-5	Complete Rock Closure	Top Elevation: 669 feet Top Width: 6 feet Side Slope: 1V:2.5H
RC-C-6	Complete Rock Closure	Top Elevation: 669 feet Top Width: 6 feet Side Slope: 1V:2.5H
RC-C-8	Complete Rock Closure	Top Elevation: 669 feet Top Width: 6 feet Side Slope: 1V:2.5H
RC-C-10	Complete Rock Closure	Top Elevation: 667 feet Top Width: 6 feet Side Slope: 1V:2.5H
SD-1	Sediment Deflector	Top Elevation: 668.7 feet (50% AEP event at this approx. RM) Side Slope: 1V:2.5H Top Width: 6 Feet
SS-1	Shoreline Stabilization	Top Elevation: Match existing adjacent land Side Slope: Match existing bank Thickness: 24 inches Granular/fine material fill with riprap thickness layer.
SS-2	Shoreline Stabilization	Top Elevation: Match existing adjacent land Side Slope: Match existing bank

Feature	Feature Type	Design Assumptions
		Thickness: 24 inches Granular/fine material fill with riprap thickness layer.
SS-3	Shoreline Stabilization	Top Elevation: Match existing adjacent land Side Slope: Match existing bank Thickness: 24 inches Granular/fine material fill with riprap thickness layer.
SS-4	Shoreline Stabilization	Top Elevation: Match existing adjacent land Side Slope: Match existing bank Thickness: 24 inches

Note: RC-C features' top elevations are designed based on existing adjacent land (targeting 0.5-1 feet lower than existing land)

7.1 Islands

Islands improve habitat conditions by reducing wind and waves, protecting backwater habitat from higher velocities, and providing addition floodplain forest habitat. Four islands will be built with a granular material base and topped with 6 and 18 inches of fines to an island top elevation of 668.5 and 669.5 feet, respectively. The island orientation and size were chosen based on 1949 imagery that was collected at approximately today's LCP elevation. Using historic island footprints ensures the islands have a firmer base and restores the area to a condition closer to historic existing conditions. The islands are designed with an average top width of 150 feet. The islands will include rock erosion protection techniques like a rock end protection section, rock vanes and rock groins as well as vegetation erosion protection methods.

7.1.1 Top Elevation Determination

An overtopping analysis was conducted to understand the overtopping frequency these islands will experience. The overtopping analysis used stage data from the Wabasha, MN gage at approximately RM 660.52. The gage is located three miles upstream of the project area and this reach experiences a relatively significant change in WSE from the gage to the project area. Using the 2D model discussed in Section 6.2 as well as the 2004 FFS, a conversion table was developed for a range of WSE values at the gage which is shown in Table 21. The values in blue utilized the 2004 FFS while the values in white utilized the 2D project model. The 2004 FFS does not cover events smaller than the 50% AEP event (i.e., 670.4 feet at the Wabasha Gage).

Table 21. Wabasha Gage to Project Area Conversions with Approximate Days of Inundation Values

Wabasha Gage to Project Area Conversions (NAVD88)				
Source	Approx. Annual Days of Inundation	Wabasha Gage WSE - ft XS 760.5	Project Area WSE - ft XS 757.3	Conversion (ft)
1D/2D Project Model	342	666.6	666.3	-0.3
	198	667.0	666.5	-0.5
	138	667.5	666.7	-0.8
	107	668.0	666.9	-1.2
	85	668.5	667.1	-1.4
	66	669.0	667.4	-1.6
	48	669.5	667.7	-1.8
	35	670.0	668.1	-1.9
2004 FFS	26	670.4	668.6	-1.9
	25	670.5	668.6	-1.9
	16	671.0	669.2	-1.8
	11	671.5	669.7	-1.8
	8	672.0	670.3	-1.7
	5	672.5	670.8	-1.7
	4	673.0	671.3	-1.7
	3	673.5	671.9	-1.6
	2	674.0	672.4	-1.6
	1	674.5	673.0	-1.5
	1	675.0	673.5	-1.5

The team's forester suggested targeting a maximum of 25 days of inundation elevation during the growing season (April 1st - September 30th). The annual 25 days of inundation elevation corresponds to 670.5 and 668.6 feet at Wabasha and the project area, respectively. Referencing Table 9, this corresponds to 21 days of inundation during the growing season. Using the annual inundation duration is generally more conservative and can be considered more resilient than using the growing season inundation duration. The team chose to use a top elevation of 668.5 and 669.5 feet for the island elevations which corresponds to approximately 25 and 11 days of inundation annually (21 and 10 days of inundation during the growing season) to provide diversity of floodplain forest and areas that have additional resiliency.

It is worth noting that natural forest areas at these elevations in the project area have existing natural forest regeneration that survived summer flooding in 2016-2019. The years 2016-2019 are in the top eight highest average annual discharge values for L&D 4 with 2019 being the highest average annual discharge on record. Table 8 provides the percent of time water surface elevations are at or above the indicated elevation at Wabasha. The conversion table above can be used to adjust these elevations to the approximate project area elevation. As seen in Table 8, the proposed island top elevations would have been overtopped 7% and 3% of the time in the years 1981-2022. The Lower Pool 4 Big Lake HREP is similar in design concept to recent past HREPs like Harpers Slough and Capoli Slough. These two HREPs are located in Pool 9 of the Upper Mississippi River. The islands constructed as part of Harpers Slough HREP (USACE, 2014) and Capoli Slough HREP (USACE, 2011) would have been overtopped approximately 4% and 8% of the time in the years 1981-2019, respectively. The floodplain forests in these projects have been successful with this inundation frequency and it is expected that the Big Lake forests will be similarly successful.

7.1.2 Fine Material Thickness

The fine material thickness must be sufficient in thickness for proposed planting while also balancing constructability considerations. The proposed top elevations of 668.5 and 669.5 feet are only 2.2 and 3.2 feet above LCP (666.3 feet at the project area). The average construction season (April 15th – October 15th) WSE at the project area is approximately 667.2 feet. The fine material layer must be able to dry out to grade the island, so the fine material layer must begin above the average construction season WSE. The fine material layer thicknesses to be implemented are listed below.

- Island Top Elevation 669.5 feet – Fine Material Thickness 18 inches
- Island Top Elevation 669.0 feet – Fine Material Thickness 12 inches (top elevation not used)
- Island Top Elevation 668.5 feet – Fine Material Thickness 6 inches

These fine material thicknesses ensure the fine material layer begins at elevation 668.0 feet which is above the average construction season WSE. This elevation also ensures the plantings are closer to the water table. Note, while not currently included as a top elevation value of any proposed islands, if the team considers using a top elevation of 669.0 feet in plans and specifications to include additional diversity and resiliency, a fine material layer of 12 inches can be used.

7.1.3 Erosion Protection Design

The erosion protection design required two analyses be completed: Velocity Analysis and Wind Wave Analysis. The two analyses will result in a suggested rock gradation size for the erosion protection measures. The erosion protection measures that will be used for the islands are rock end protection, rock groins and rock vanes. The rock groins protect the island from erosion forces due to wind-wave action whereas the rock vanes protect the island from erosion forces due to velocity forces. The locations where these erosion protection measures will be implemented are shown in Figure 44.

The following sections describe the Velocity Analysis and Wind Wave Analysis used to choose a riprap gradation.

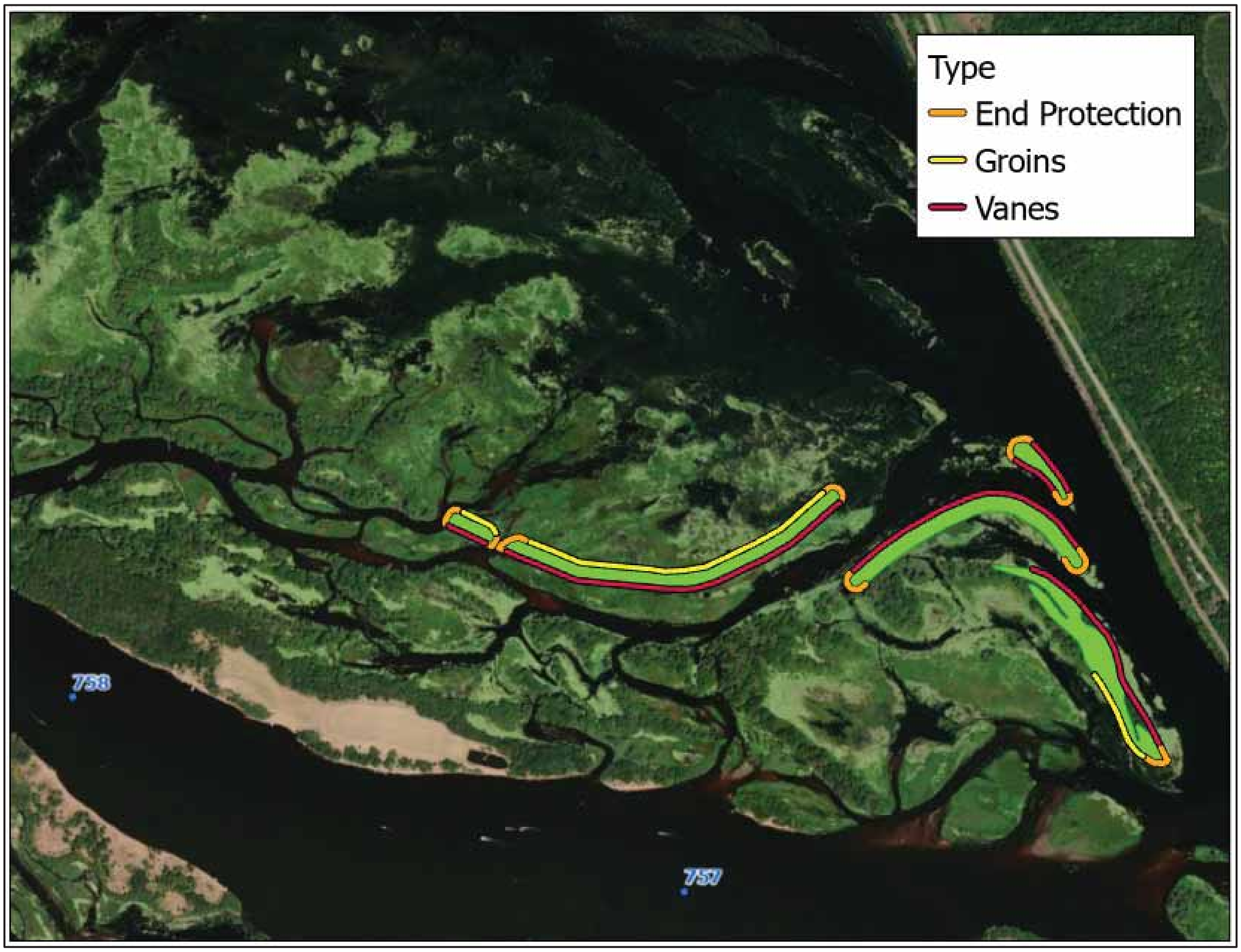


Figure 44: Island Erosion Protection (top of proposed islands shown in green)

7.1.3.1 Wind Wave Action

The rock tip/berm and rock groins were designed based on the effects of wind wave action. This methodology is based on the *RMC Wind Speed and Setup Toolbox* which utilizes the Coastal Engineering Manual (EM 1110-2-1100) (USACE, 2008).

The effective fetch was determined based on the longest reasonable distance the wind would have to blow without obstruction. The estimated fetch is about 3 miles (Figure 45 below).

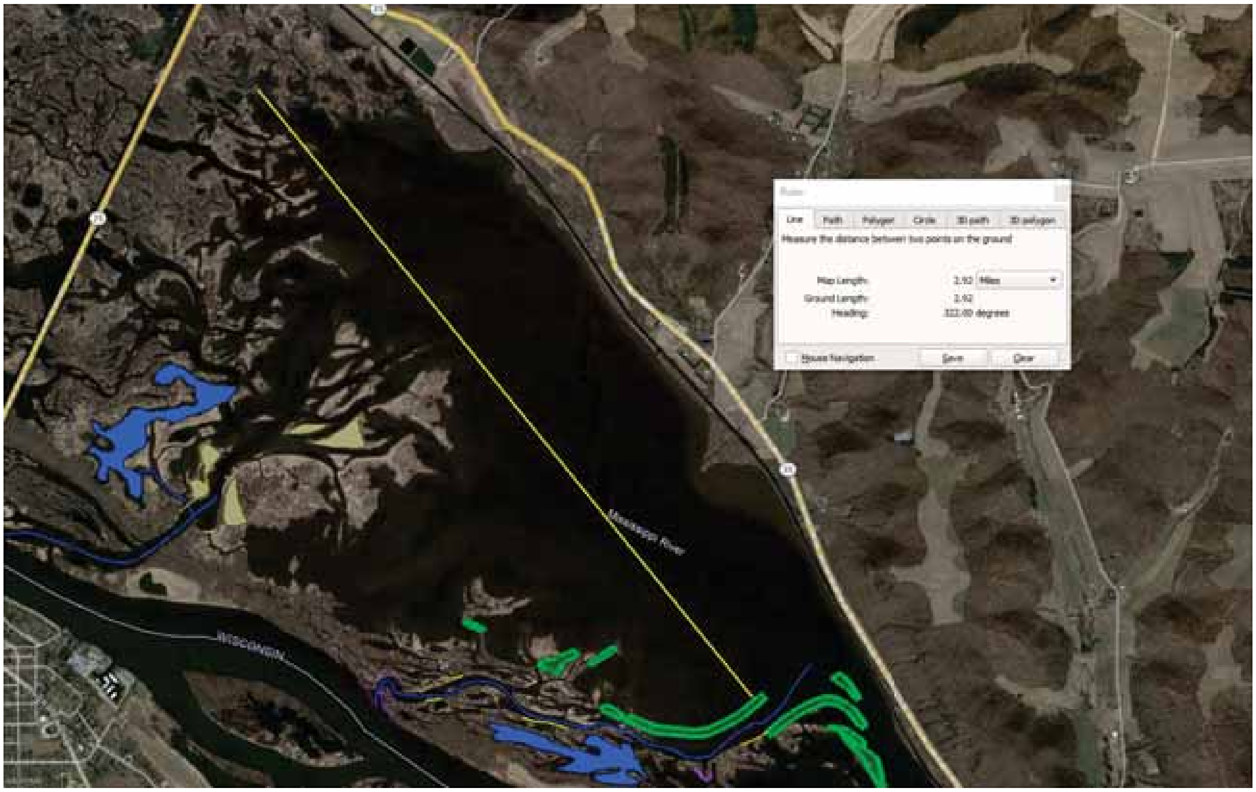


Figure 45: Wind Fetch Estimate

Wind data was obtained from the Winona station, which is located downstream of the project area, but is the closest available data location (Figure 46). This station provided the fastest daily 2-minute wind data for all directions from 2013-2022. During that time over 3,000 values were obtained. This data was then assessed in HEC-SSP (HEC, 2019) to determine the exceedance intervals, which can be seen in Table 22. With this data, it was determined that the 0.1 percent time exceedance wind speed (31 mph) would be used to determine the 10-minute mile (U_{10}), which would ultimately be used as the design wind speed. It should be noted that typically for wave action riprap design, the 10-percent exceedance wind speeds are used design. The 10-minute mile will provide a more robust and conservative riprap design.

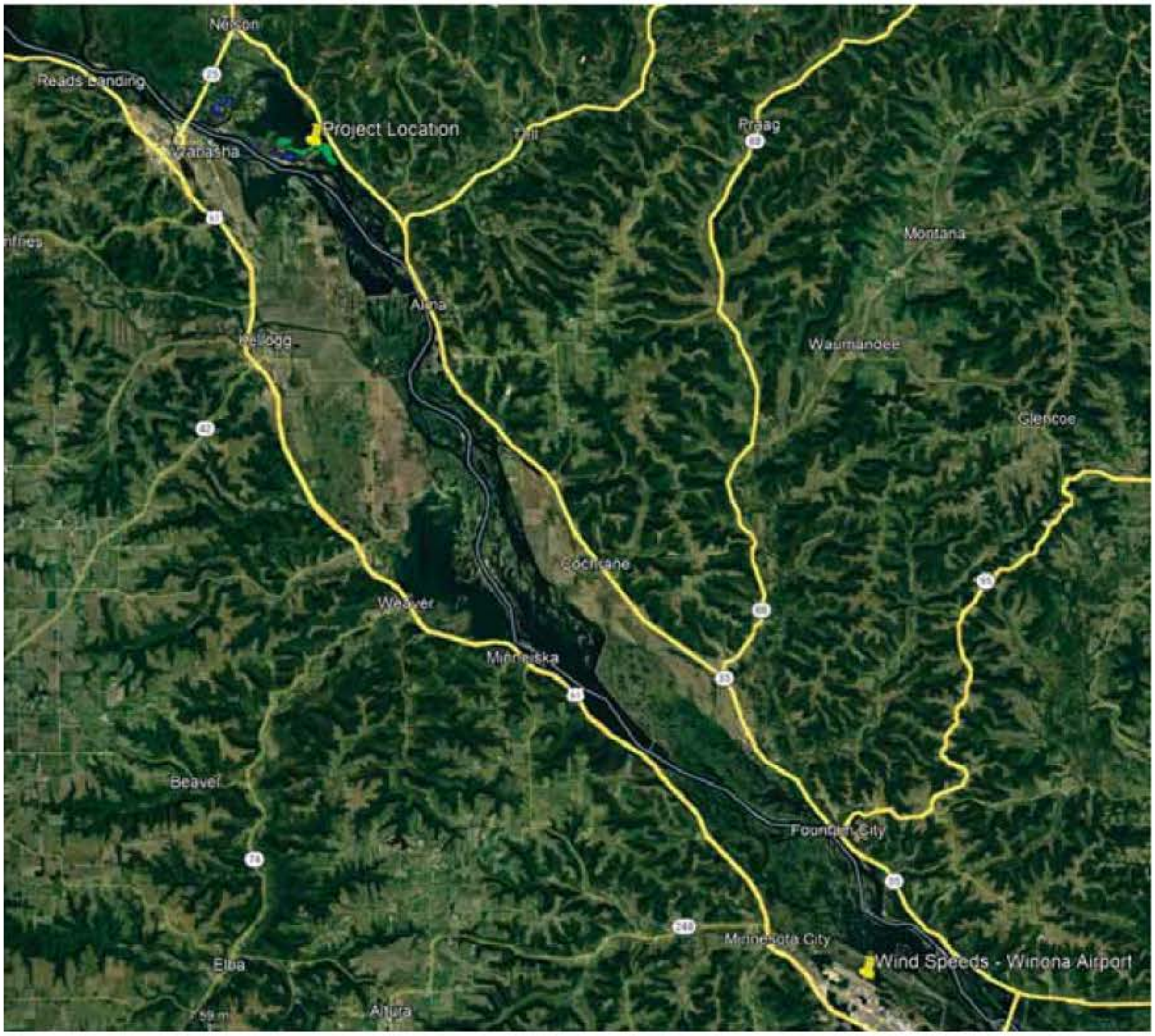


Figure 46: Wind Station Location

Table 22: Wind Speed Percent Time Exceedance

Percent Time Exceeded	Wind Speed (mph)
99	0.0
95	4.9
90	6.0
80	8.1
50	10.1
25	14.1
15	16.1
10	17.0
5	19.9
2	23.0
1	23.9
0.1	31.0

The first step in acquiring the design U_{10} is to convert the 0.1 exceedance wind speed to a 1-hour average wind speed (U_{3600}). This was accomplished with the use of an equation in EM 1110-2-1100, Coastal Engineering Manual (CEM), Figure II-2-1 (Figure 47). This resulted in a U_{3600} of 26.5 mph.

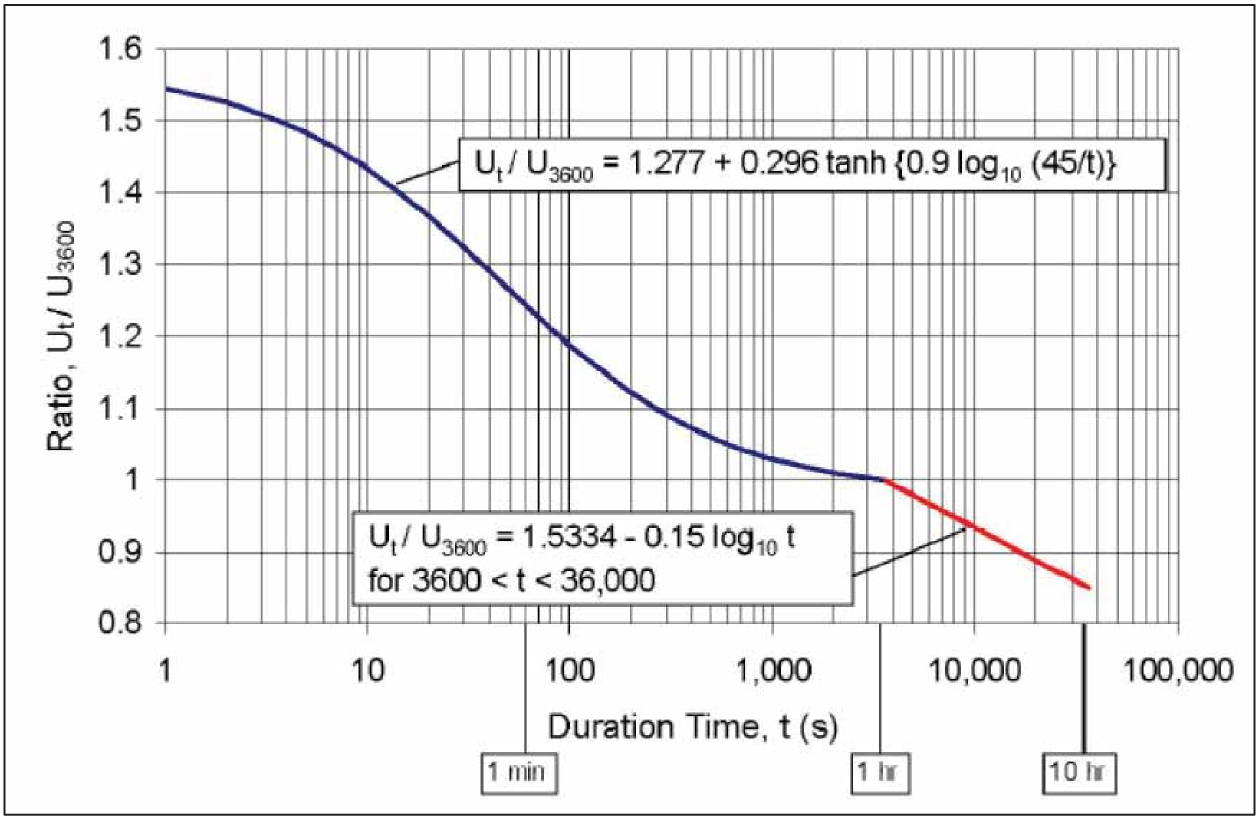


Figure 47: Ratio of wind speed of any duration Ut to 1-hour wind speed (U_{3600}) (USACE, 2008)

Once the U_{3600} was obtained the U_{10} was determined also with the use of Figure II-2-1 (Figure 19). Utilizing 600 seconds (10min = 600 seconds), and the t<3600 curve, the resulting ratio for conversion is about 1.1. Multiplying the U_{3600} and 1.1 resulted in a U_{10} of 29.2 mph.

During design many wind speed adjustments were considered, and are thoroughly explained in the CEM, starting on pg. II-2-37. Below are the adjustments considered:

- Level: The first possible adjustment is based on the location of the wind gage at the La Crosse airport. It is assumed to be at the standard 10-m height; therefore, no adjustment is needed.
- Overland or overwater: There is consideration on the location of the gage, on land versus over water. Due to the airport being directly adjacent to both the Mississippi River and Black River, it was determined an adjustment was not needed for this.
- Stability: For fetches longer than 16km, and adjustment for stability of the boundary layer may be needed. Due to the limited fetch, this adjustment was also not needed.

With all wind speed adjustments reviewed, the resulting design U_{10} was determined to be 29.2 mph.

The next step on the process is to calculate the design wave height, H_{m0}. This process is captured in the CEM on pg II-2-47. The governing wave growth with fetch are:

Drag coefficient (C_D): 0.0016

$$C_D = 0.001(1.1 + 0.035 * U_{10})$$

Friction velocity (u*): 0.51 m/s

$$u^* = U_{10}\sqrt{C_D}$$

Design wave height (H_{m0}): 0.47 m = 1.53 feet

$$H_{m0} = 4.13x10^{-2} * \left(\frac{gX}{u^*}\right)^{0.5} * \frac{u^{*2}}{g}$$

The last step in determining the riprap median stone mass (M_{50}) was to use the Hudson equation, which is pg VI-5-93 of the CEM. It should be noted that this equation utilizes a 10% exceedance wave height ($H_{10\%}$) to determine riprap sizing, but a more conservative 10-minute mile wave height (H_{10}) was used instead. Recall the U_{10} wind speed is 29.2 mph, where the $U_{10\%}$ speed is 17 mph. The Hudson equation consists of:

$$W_{50} = \frac{\rho_r {H_{10\%}}^3}{K_{rr}\ (\rho_r/\rho_w - 1)^3\ cot\alpha}$$

The equation requires metric units. The design wave height as stated in the previous equation is about 0.47 meters (1.53 feet). The minimum slope that would be utilized in the project is 1V:1.5H. A steeper slope results in a larger riprap design and is more conservative. The K_{rr} value used was 2.2, which is determined based on riprap shape (angular), and we are assuming breaking waves in the project area coming off of Big Lake proper. Assuming the riprap used has a specific gravity of 2.65, the resulting W_{50} is about 39 lbs. As a reminder, this W_{50} is utilizing the more conservative $H_{0.1\%}$, rather than the $H_{10\%}$ that the equation calls for. This W_{50} corresponds to MVP riprap gradation R30.

7.1.3.2 Maximum Velocity

The project design model discussed in Section 6.2 was used to analyze velocities for the 20% AEP event as well as the 1% AEP event (constant hydrograph). As discussed in Section 6.2.2, the alternative 1% AEP event model run utilized constant discharge boundary conditions for the Mississippi River and Chippewa Rivers from the 2004 FFS. The maximum velocity results are shown in Figure 48 and Figure 49 for the 20% AEP event and 1% AEP event, respectively.

The 20% and 1% AEP events in the project design model shows most project features experiencing velocities at 5 fps or less and is expected to be low turbulent flow. These velocities correspond to a St. Paul gradation of R20. At Catfish Slough specifically, velocities tend to be higher than other locations in the project area. For the 20% AEP event, velocities reach their maximum at 8.5 fps and are again assumed to be low turbulent flow. This velocity still falls under the MVP R20 gradation for low turbulent flow. For the 1% AEP event, velocities reach their maximum at 10.1 fps and are again assumed to be low turbulent flow. This velocity falls under the MVP R30 gradation for low turbulent flow.

St. Paul gradations and associated velocity thresholds are shown in Table 23 below.

Table 23: St. Paul District Gradations - D50 and Velocity Thresholds

Parameter	R20	R30	R45	R80	R140
D50min (feet)	0.61	0.70	0.80	0.97	1.17
Velocity threshold based on D50min (ft/s) for high turbulence flow	6.9	7.4	7.9	8.7	9.6
Velocity threshold based on D50min (ft/s) for low turbulence flow	9.7	10.4	11.1	12.2	13.4

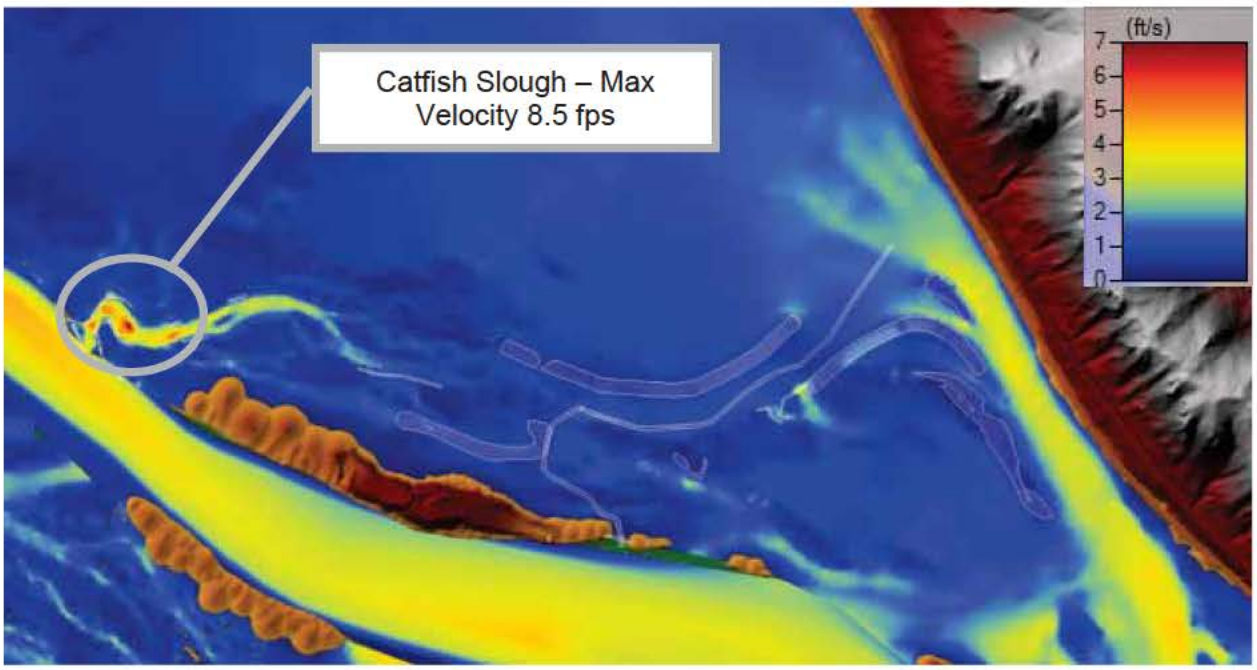


Figure 48: Maximum velocity results for the 20% AEP event - Proposed Conditions

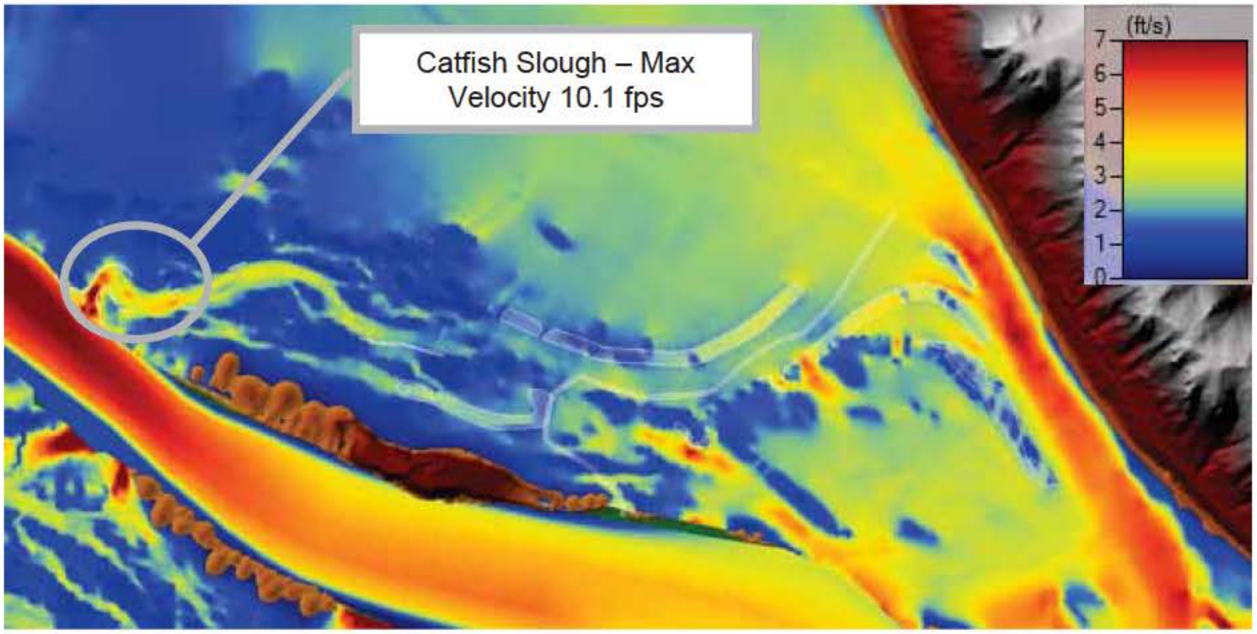


Figure 49: Maximum velocity results for the 1% AEP event - Proposed Conditions

7.1.3.3 Recommended Riprap Gradation and Thickness

The wind wave and velocity analyses described above result in a gradation of R30 and R20, respectively. The team has decided to use a larger MVP riprap gradation of R45 in the design. The gradation specifications for R45 are shown in Table 24 below. Reasons for sizing up the riprap are listed below. The rock gradation should be verified for each feature during PED after topographic surveys and/or updated LiDAR is collected.

- Through past project site observations, R20 and R30 have not held up as well over time.
- The public has a tougher time mobilizing the larger gradation (recreational vandalism).
- Sizing up the riprap adds resiliency to account for future climate conditions.
- The larger gradation performs better if ice action is a concern.

Table 24: Riprap Gradation using St. Paul District Guidance

St. Paul District Riprap Gradation			
ID	D100 max (in)	D50 max (in)	W50min (lb)
R45	16	12	45

To simplify construction methods, bedding material is not included in the riprap sections. Ecosystem projects are typically lower risk and allow for more risk to be associated with project features, so not incorporating a bedding layer is acceptable. However, to increase the performance of the riprap, the thickness of the riprap layer should be conservative.

According to Hydraulic Design Criteria 712-1 (HDC-712-1), the thickness of the riprap protection should be D50 x 2 or D100 x 1.5, whichever results in the greater thickness (USACE, 1970). Using the D50 and D100 values in Table 24, the thickness of the riprap will be 24 inches.

Guidance for riprap design in EM 1110-2-1601 (3-2 Riprap Characteristics Page 3-4 Section 1e) recommends the following (USACE, 1994):

- The thickness should be equal to D50 x 1.5 and D100 x 1.0.
- It should not be less than 12 inches for practical placement. The thickness determined by either method above should be increased by 50 percent when the riprap is placed underwater to provide for uncertainties associated with this type of placement.
- An increase in thickness of 6 to 12 inches, accompanied by appropriate increase in stone size, should be provided where riprap revetment will be subject to attack by large floating debris or by waves from boat wakes, wind, and bed ripples or dunes.

There is further thickness guidance in EM 1110-2-1601 (PDF page 175 – F-18) that suggests riprap thicknesses for the gradations for low and high turbulent flow conditions (USACE, 1994). These correlate to either D100 x 1.0 and D100 x 1.5 for low and high turbulent flow conditions, respectively.

The HDC-712-1 guidance is the most conservative riprap thickness guidance widely used by USACE (USACE, 1970). Using HDC 712-1 and the D50 and D100 values in Table 24, the thickness of the riprap will be 24 inches. For underwater placement, the thickness should be increased to 36 inches.

7.1.3.4 Groins

The rock groin design will utilize a typical design from the Upper Mississippi River Restoration Program - Environmental Design Handbook (USACE, 2012). The rock groin locations will be based on the Upper Mississippi River Restoration Program - Environmental Design Handbook guidance which states that rock structures must be constructed to reduce wave action from wind fetches greater than 1 mile. The island faces that will include groins are shown in Figure 44. The groin design parameters and concept figures are included in Table 25 and Figure 50 below.

Table 25: Groin Design Parameters

Design Element	Note/Justification
Top Elevation: 668.5 feet	UMRR Handbook states 1.5-2 ft above the average WSE. The average WSEL at the project area is approximately 666.9' (1981-present). The project area is downstream of the pool control point, so the islands can be constructed with a much lower top elevation (668.5 ft minimum). Thus, the groins will tie-in 1.5 ft above average rather than 2 feet.
Bottom Elevation: 667.0 feet	1.5 feet less than the top elevation which is typical from other projects.
Side Slope: 1V:1.5H	UMRR Handbook states 1V:1.5-2H value.
Top Width: 4 feet	UMRR Handbook states 2-5 feet. The standard groin concept is being used for areas where wind fetch is much less, so a 4-foot width will be used.

Design Element	Note/Justification
Length: 30 feet	UMRR Handbook states 30-40 ft. Harpers Slough HREP used 30 feet.
Key-in: 10 feet	UMRR Handbook states 5-10 feet for key length. Due to "lessons learned" from previously constructed groins that have detached, a longer key length of 10' is recommended.
Angle (q): 90°	Groins are always designed perpendicular to the island.
Spacing: 180 feet	UMRR Handbook states the spacing ratio (length to spacing) should be between 1:4-6. The area the standard groins will be placed are not exposed to a large wind fetch, so a less frequent groin spacing of 1:6 will be used.
Thickness: 2 feet	Typically, the thickness is 2 feet (minimum).
Gradation: R45	The wind fetch and wind data for the Winona Airport yield a gradation of R30 – However, the design will utilize a more robust gradation of R45.

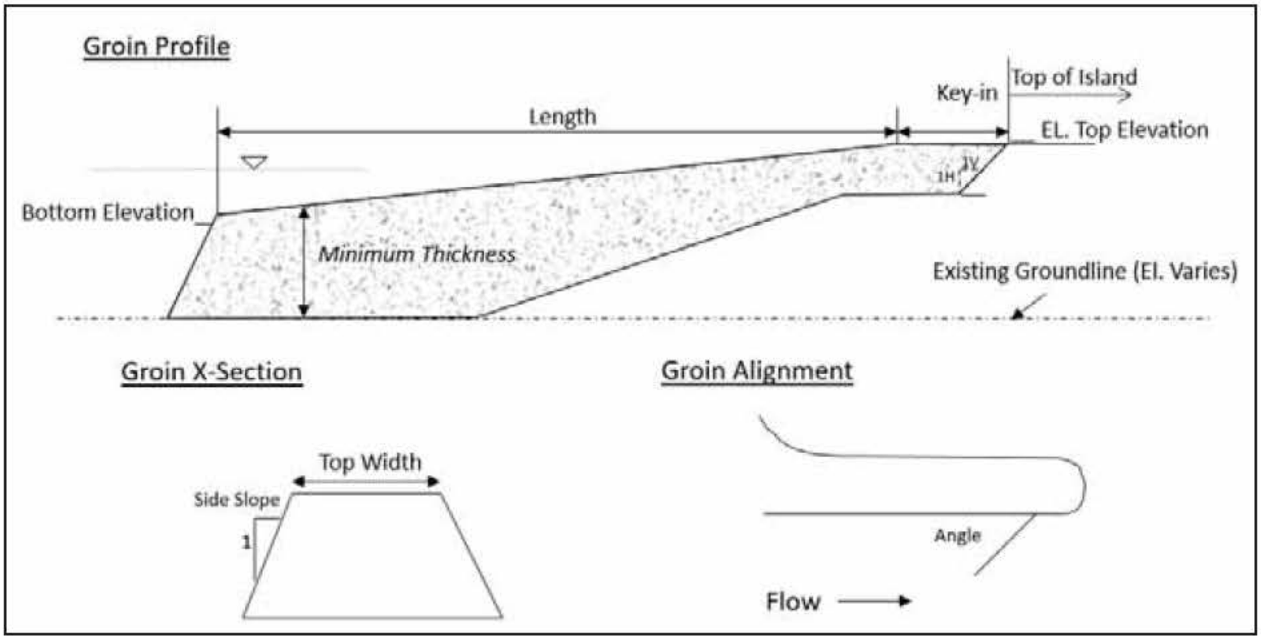


Figure 50: Groin Design Concept

7.1.3.5 Vanes

The rock vane design will utilize a typical design from the Upper Mississippi River Restoration Program - Environmental Design Handbook. The rock vane locations will be based on the Upper Mississippi River Restoration Program - Environmental Design Handbook guidance which states that vanes are effective on shoreline adjacent to moving current (USACE, 2012). Additionally, in many situations, vanes also function as groins by reducing littoral drift due to wind-driven wave action. To achieve this dual function, the angle of the vane with the upstream shoreline should be fairly large (45 to 60 degrees). The island faces that will include vanes are shown in Figure 44. The groin design parameters and concept figures are included in Table 26 and Figure 51 below.

Table 26: Vane Design Parameters

Design Element	Note/Justification
Top Elevation: 668.5 feet	UMRR Handbook states 1.5-2 feet above the average WSE. The average WSEL at the project area is approximately 666.9 feet (1981-present). The project area is downstream of the pool control point, so the islands can be constructed with a much lower top elevation (668.5 feet minimum). Thus, the top elevation of this feature will tie-in 1.5 feet above average rather than 2 feet. Harpers designed the vanes 2 feet above LCP → LCP here is about 666.3 feet which means these vanes are also approx. 2 feet above LCP.
Bottom Elevation: 664.5 feet	Fountain City 1 Shoreline Stabilization used 1V:10H slope. Harpers were steeper with a 3-foot difference between the top elevation and bottom elevation
Side Slope: 1V:1.5H	UMRR Handbook states this value.
Top Width: 3 feet	UMRR Handbook states 2-5 feet. Recent past projects including Fountain City 1 Shoreline Stabilization used 3 feet.
Length: 40 feet	UMRR Handbook states 30-45 feet. Recent past projects including Fountain City 1 Shoreline Stabilization used 40 feet.
Key-in: 10 feet	UMRR Handbook states 6.5 feet for key length. Due to "lessons learned" from previously constructed vanes that have detached, a longer key length of 10' is recommended. The key should extend 1/3 to 1/4 of the vane length into the shoreline to protect the structure from flanking or disconnection from the shoreline (NRCS, 2007).
Angle (q): 45°	UMRR Handbook states 40-55°. Some recent past projects have utilized a 30 degree angle. This area is susceptible to both river currents and wind driven wave action. Using an angle of 45 degrees should provide more protection to wind driven wave action than a 30 degree angle. Flanking of the vanes (disconnection from the shoreline) can occur if angle of the vanes are too large, so 45 degrees was determined to be a middle-ground for these considerations (NRCS, 2007).
Spacing: 90 feet	UMRR Handbook states the spacing ratio (length to spacing) should be between 1:3-4. Flanking of the vanes or disconnection from the shoreline can occur if the spacing between vanes is too large, angle of the vanes are too large, or the key-in length is too small (NRCS, 2007). Many recent past projects have used a spacing ratio between 1:2.25-4. A spacing of 90' results in a spacing ratio of 2.25 which falls within recent project designs and helps reduce the risk of flanking.

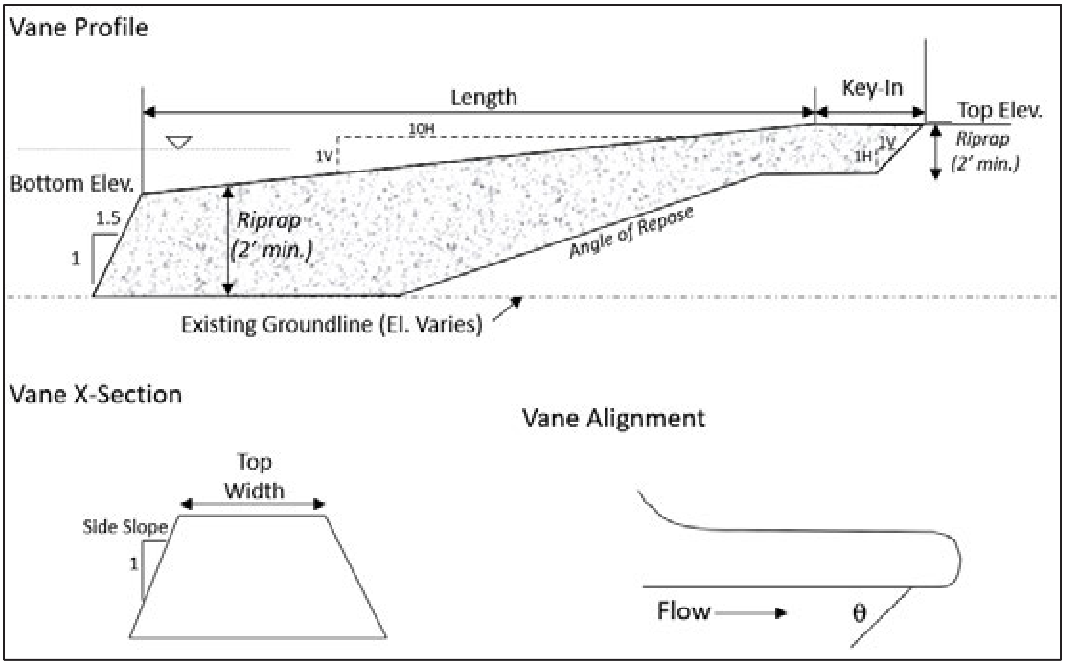


Figure 51: Vane Design Concept

7.1.3.6 Rock End Protection

The islands will include a rock end protection/tip to protect the tip of each island from erosion. Past projects have shown that the island tips are not satisfactorily protected with groins or vanes alone due to the curve of the island end, so a continuous armor of rock is included to provide adequate protection. The rock end protection schematic is similar to the rock toe protection guidelines outlined in EM 1110-2-1601 Method C (USACE, 1994). Method C is shown in Figure 52. For the rock end protection, the following parameters are used.

- T: 24 inches
- C: 10 feet
- A: 36 inches

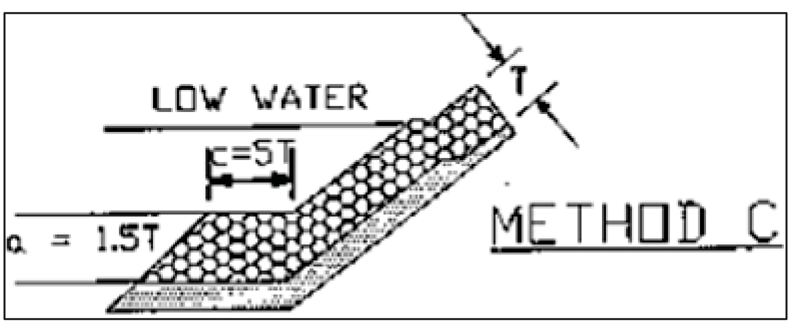


Figure 52: Toe Protection EM 1110-2-1601 Method C

The constant thickness of the rock end protection has worked well on past projects. The locations of these are shown in Figure 44. The rock tips are designed similarly to the Harpers Slough HREP Tapered End Protection features which have held up well since construction was completed in 2017 (USACE, 2023). The side slope of this feature is 1V:3H which should be sufficient to account for ice action which is expected to be relatively minimal based on discussions with the public and agency partners. These features are designed using R45 riprap and a thickness of 24 inches which is consistent with other rock features in the project area.

7.1.3.7 Seeding/Planting

The islands are to include temporary seeding between construction seasons and permanent seeding and willow planting following final grading of the features during construction. The islands will include two rows of willows on either side of each feature. The willows are to be installed at an elevation of 668.5 feet following final grading. According to the UMRR Environmental Design Handbook, willows should be installed 2 feet above the average WSE (approx. 666.9 feet in the project area). The island heights are 668.5 and 669.5 feet. Willows are installed on the top of the 668.5 feet elevation islands and on the slope at 668.5 feet for the 669.5 feet elevation islands.

There will be post-construction, comprehensive planting and seeding completed by USACE foresters following construction via a separate contract. These plantings on the islands include a mix of native herbaceous vegetation and tree plantings. The team's forester suggested that both natural and artificial regeneration will be used to establish forest trees on the islands. Natural regeneration will capitalize on seeding of light seeded species from adjacent trees, primarily cottonwood, willow and silver maple. Artificial regeneration will consist of planting a mix of tree seedlings form a wider range of native tree species than are currently present in the project area. Willow cuttings will also be planted at the lowest elevations.

7.2 Shoreline Stabilization

Shoreline stabilization is included to protect the existing natural berms and shoreline in the project area. A LiDAR analysis and multiple site visits were conducted to determine the needed location and extents of shoreline stabilization. The shoreline stabilization locations are shown in Figure 53 and described in the following sections. Toe protection of these features was designed using EM 1110-2-1601 Method C shown in Figure 52 above (USACE, 1994). The parameters used for this section are listed below.

- T= 24 inches
- c= 10 feet
- a= 36 inches

Figure 53. Shoreline Stabilization and Sediment Deflector Feature Locations

7.2.1 SS-1 and SS-2

SS-1 and SS-2 provide shoreline stabilization at the head of Catfish Slough. As discussed in Section 4, a rock liner was constructed at this location in the mid-1990's as part of the Indian Slough HREP. Erosion can be observed on both the upstream and downstream sides of the rock liner. Additionally, a significant scour hole has formed on the downstream side of the rock liner. This erosion is evident in both the bathymetry discharge data as well. Figure 19 demonstrates the increase in channel capacity of Catfish Slough.

The shoreline stabilization at this location is designed to restore the shoreline and flow capacity of Catfish Slough pre-rock liner to both reduce flow and sediment through Catfish Slough. The upstream and downstream extents were chosen based on field observations of erosion.

Preliminary results in the project design model are showing a relatively high velocity pocket downstream of the SS-1 extent for most modeled events. Figure 54 below shows velocity and velocity vectors for the 20% AEP event. The higher velocities in this area could be due to an abrupt transition in the topobathy dataset. Topographic surveys were not collected during the feasibility study, so the topobathymetric dataset is using 2023 bathymetry and 2009 LiDAR. Topographic surveys will be collected during PED which will be incorporated into the project design model discussed in Section 6.2 and used to inform the refinements of the design and extent of the feature. This risk and uncertainty is reflected in the Cost and Schedule Risk Analysis completed by the team.

The design of these two shoreline stabilization features includes granular fill topped with fine material and a riprap layer.

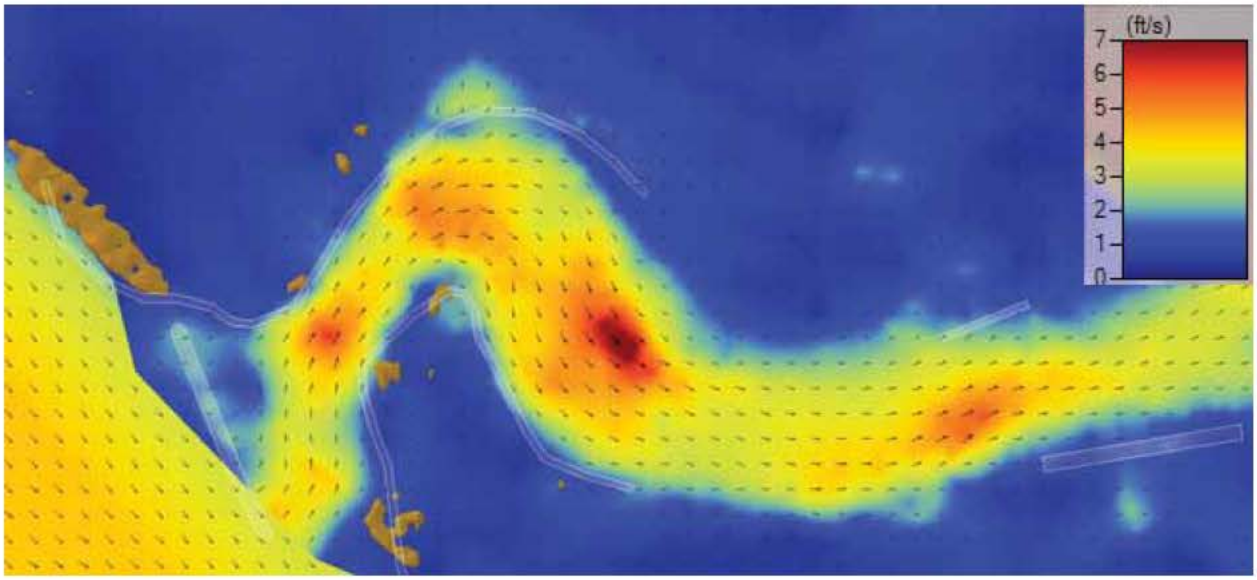


Figure 54: Maximum velocity results for the 20% AEP event with SS-1 and SS-2 features included as translucent polygons - Proposed Conditions

7.2.2 SS-3

SS-3 provides shoreline stabilization to a remnant natural berm. The natural berm has narrowed since 1949 according to historic imagery. The design of this shoreline stabilization feature includes granular fill topped with fine material and a riprap layer.

7.2.3 SS-4

SS-4 provides shoreline stabilization at an inlet of the Thatchers backwater area. Evidence of erosion was observed at this inlet. According to the project model discussed in Section 6.2 above, this inlet appears to be a pressure point in the system. To ensure this channel does not become larger in capacity, SS-4 is included in the project design. The design of this shoreline stabilization feature does not include granular fill topped with fine material and only includes a riprap layer placed on the existing shoreline.

Because Thatchers is within the USFWS closed area, this channel that SS-4 is protecting was not closed off as to not enhance this area as an overwintering area and attractive nuisance during the closed season.

7.3 Sediment Deflector

Based on the sediment analysis in Section 5.2, a rock sediment deflector was recommended and added to the project design. The sediment deflector will reduce the sediment load entering the project area which will help to stabilize Catfish Slough for the project life. The location of the sediment deflector is shown in Figure 53 above. The combined functions of the sediment deflector (SD-1) and shoreline stabilization features (SS-1 and SS-2) result in a partial closure schematic similar to the Long Lake HREP (USACE, 1991) partial closure located in Pool 7 shown in Figure 55 below.

The sediment deflector is constructed completely of rock and is designed with a top elevation of 668.7 feet, top width of 6 feet and 2.5H:1V side slopes. This feature will deflect sediment downstream of Catfish Slough. This top elevation of this feature is consistent with the adjacent natural berm minimum elevation and equates to approximately the 50% AEP event elevation at this location. The rock sediment deflector will tie into the rock shoreline stabilization feature on the left descending bank (SS-1). The rock used for the sediment deflector will utilize a R45 gradation to ensure the project gradation is consistent throughout the rock features.

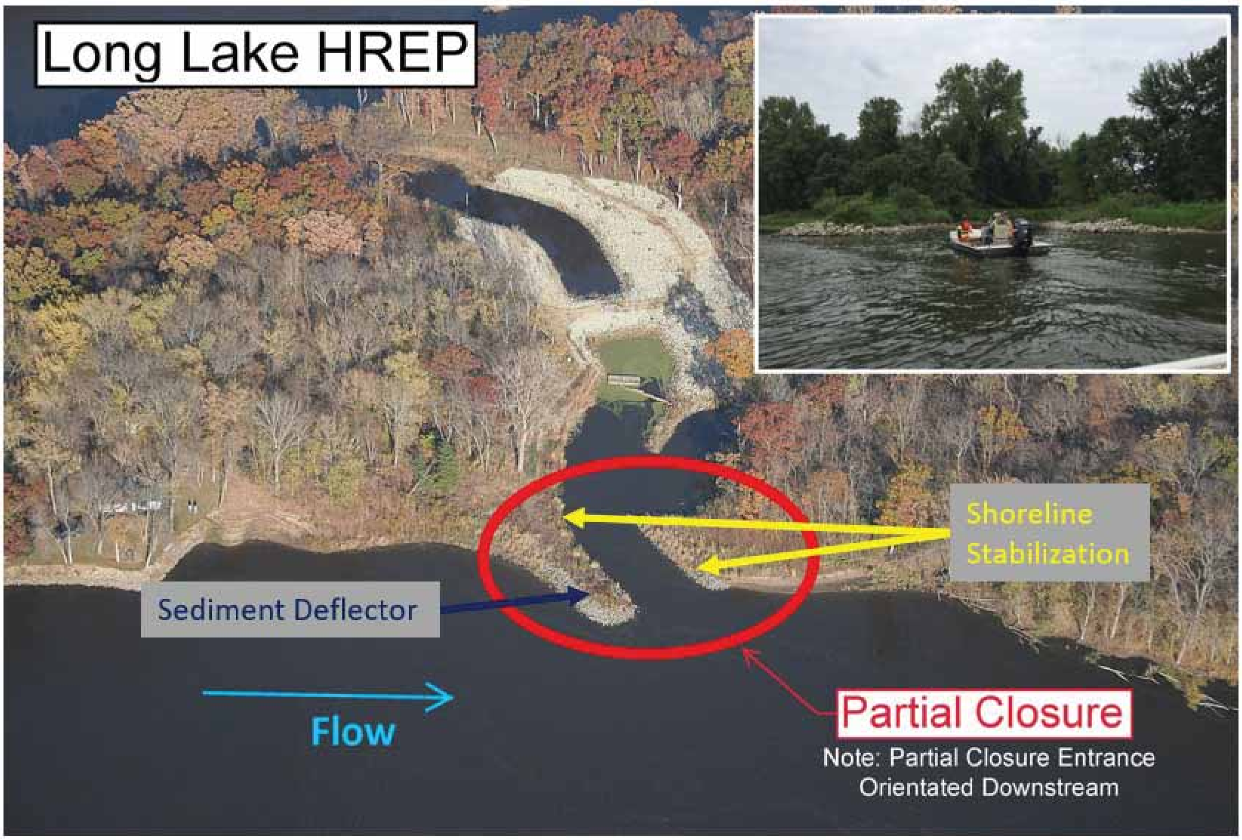


Figure 55: Partial Closure Design Example – Long Lake HREP

7.4 Rock Closures

Rock closures will be constructed to protect existing and proposed overwintering sites in the project area. Figure 56 shows the rock closures and the respective protected overwintering locations. These structures are designed to be complete closures for the feasibility study. However, further analysis will be completed to determine if these should be lowered or notched to allow more flow into the overwintering areas (partial closure). For feasibility, these are designed approximately half a foot lower than adjacent existing land to ensure these locations are a controlled overtopping location in the event of overtopping. Per the UMRR Environmental Design Handbook, secondary channel closure elevations should be constructed to the bankfull elevation or less. This increases the amount of floodplain conveyance occurring during flood events thereby restoring a more natural flow and sediment transport. If a secondary channel closure elevation is higher than the adjacent land (island or floodplain) high water events would increase erosive forces on the adjacent lands (USACE, 2012).

These structures will be constructed of riprap using the sizing discussed in Section 7.1.3.3 above, a top width of 6 feet and side slopes of 1V:2.5H. Rock closures have utilized up to 1V:1.5H side slopes, so these structures can be refined during plans and specifications if the team chooses.

Figure 56: Overwintering Sites and Rock Closures

7.5 Overwintering Dredging

Overwintering dredging will be constructed to provide overwintering fish habitat behind the Teepeota Point dredge placement site (D-O-1). This site was chosen for an overwintering feature as it is outside of the USFWS closed area and can achieve optimal flow inputs and residence times through construction of rock closures at the side channels on the surrounding natural berms.

According to a report from the Wisconsin DNR (Giblin, 2019): *Water clarity and aquatic plant abundance are among the major factors driving fish community characteristics across the Upper Mississippi River. Widespread landscape disturbance, resulting in increased sediment loading, has been identified as driving declines in aquatic plant abundance.*

This study recommends overwintering dredge depth based on the UMR pool to target the depth of one percent of surface light which is generally viewed as the delineation between the photic and euphotic zones. For lower Pool 4, the recommended depth is 7.4 feet.

According to the fine sediment analysis completed in Section 5.1, over the 50-year project life, the average sediment accumulation is approximately 7.3 inches.

The WIDNR depth recommendation plus the fine sediment accumulation estimate results in an overwintering dredge depth of 8 feet. Taking this depth from the LCP elevation at the project area results in a habitat dredge invert elevation of 658.3 feet. Dredged fines would be used as island topsoil. Note, the feasibility level civil design utilized 658.5 feet. This invert will be refined in future phases of design.

7.6 Access Dredging

Access dredge cuts would have a width of 40 feet and would provide both access to construct features in the study area. Access dredge cuts would be dredged to provide a depth of 6 feet to account for barge draft. Taking this depth from the LCP elevation at the project area results in an access dredge invert elevation of 660.3 feet. Dredged material would be used as island base (granular material) or island topsoil (fine material) depending on the dredged material type and its suitability for the island layer. Note, the feasibility level civil design utilized 660.5 feet. This invert will be refined in future phases of design.

7.7 Design Considerations

Design considerations for PED are listed in the Main Report Section 5.3. It is important to note, that any changes to feature footprints and elevations will have to be further considered for the No-Rise certification. If features are moved, increased in size, or increased in elevation, further No-Rise modeling will need to be completed.

8 References

Carelton, T. A., & Hsiang, S. M. (2019). Social and Economic Impacts of Climate. *Science 353: 6304*.

Dean, D., Topping, D., Buscombe, D. D., Groten, J. T., Ziegeweid, J. R., Fitzpatrick, F. A., . . . Coenen, E. N. (2022). The use of continuous sediment-transport measurements to improve sand-load estimates in a large sand-bedded river: The lower Chippewa River, Wisconsin. *47*(8).

Giblin, S. (2019). *Let There Be Light: Making the Case for Improved Water Quality and Targeted Restoration.* Wisconsin DNR.

Glecker, P., Taylor, K., & Doutriax, C. (2008). Performance metrics for climate models. *Journal of Geophysical Research 113*.

GLISA. (2019). *Historical Climatology: Minneapolis-Saint Paul, Minnesota.* Great Lakes Integrated Sciences and Assessments Program (GLISA).

Graham, L., Phil, J., & Bengt, C. (2007). Assessing Climate Change Impacts on Hydrology from an Ensemble of Regional Climate Models, Model Scales and Linking Methods – a Case Study on the Lule River Basin. *Climatic Change 81: 293–307*.

HEC. (2017). *HEC-DSSVue Version 3.0.* Davis, CA: Hydrologic Engineering Center (HEC).

HEC. (2019). *HEC-RAS (Version 5.0.7) [Computer software].* Davis, CA: Hydrologic Engineering Center (HEC).

HEC. (2019). *HEC-SSP: Statistical Software Package (Version 2.2) [Computer software].* Davis, CA: Hydrologic Engineering Center (HEC).

HEC. (2022). *HEC-RAS (Version 6.3) [Computer software].* Davis, CA: Hydrologic Engineering Center (HEC).

Hendrickson, J. S. (2003). *Bed Material Budget for the St. Paul District Reach of the Upper Mississippi River, Anoka, Minnesota to Guttenburg, Iowa.* St. Paul: USACE.

Johnson, T. E., Butcher, J. B., Parker, A., & Weaver, C. P. (2012). Investigating the Sensitivity of U.S. Streamflow and Water Quality to Climate Change: U.S. EPA Global Change Research Program's 20 Watersheds Project. *Journal of Water Resources Planning and Management, 138*(5).

Juckem, P. F., Randall, J. H., Anderson, M. P., & Robertson, D. M. (2008). ffects of Climate and Land Management Change on Streamflow in the Driftless Area of Wisconsin. *Journal of Hydrology 355 (1–4): 20.*

Liu, Y., Goodrick, S., & Stantfurf, J. (2013). Future U.S. Wildfire Potential Trends Projected Using a Dynamically Downscaled Climate Change Scenario. *Forest Ecology and Management 294 (15): 120-35*.

Mauget, S. A. (2004). Low Frequency Streamflow Regimes over the Central United States: 1939–1998. *Climatic Change 63: 121–44*.

Minnesota DNR. (2022). *Climate Trends*. Retrieved from https://www.dnr.state.mn.us/climate/climate_change_info/climate-trends.html

NCEI. (2020). *Land-Based Datasets and Products*. Retrieved from https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets

Ning, L., & Bradley, R. S. (2015). Snow Occurrence Changes over the Central and Eastern United States under Future Warming Scenarios. *Scientific Reports 5: 17073*.

Notaro, M., Lorenz, D. J., Vimot, D., Vavrus, S., Kucharik, C., & Franz, K. (2011). 21st century Wisconsin snow projections based on an operational snow model driven by statistically downscaled climate data. *International Journal of Climatology, 31*(11).

Novotny, E. V., & Stefan, H. G. (2007). Stream Flow in Minnesota: Indicator of Climate Change. *Journal of Hydrology 334 (3–4): 319–33*.

NRCS. (2007). Technical Supplement 14H - Flow Changing Techniques. In NRCS, *National Engineering Handbook.* USDA - NRCS.

Olson, S., Nguyen, M., Sant-Miller, A. M., Mueller, C., Veatch, W. C., & White, K. D. (2022). *U.S. Army Corps of Engineers Time Series Toolbox User Guide.* Washington DC: USACE.

Patel, H. H., M., R. A., C., N. M., K., H., G., K., S., O., . . . White, K. D. (2022). *Climate Hydrology Assessment Toolbox User Guide.* Washington DC: USACE.

Pryor, S. C., Scavia, D., Downer, M. G., Iverson, L., Nordstrom, R., Patz, J., . . . Yohe, G. W. (2014). Ch. 18: Midwest. Climate Change Impacts in the United States. In *The Third National Climate Assessment* (pp. 418-440). U.S. Global Change Research Program.

Rogala, J. T., Fitzpatrick, F. A., & Hendrickson, J. S. (2020). *Recent Planform Changes in the Upper Mississippi River (LTRM-2019GC8).* U.S. Geological Survey, Upper Midwest Environmental Sciences Center.

Rogala, J. T., Kalas, J., & Burdis, R. M. (2020). *Rates and Patterns of Net Sedimentation From 1997-2017 in Backwaters of Pool 4 and 8 of the Upper Mississippi River.* U.S. Geological Survey, Upper Midwest Environmental Sciences Center.

Rogala, J., Boma, P. J., & Gray, B. R. (2003). *Rates and patterns of net sedimentation in backwaters of Pools 4, 8 and 13 of the Upper Mississippi River.* La Crosse, WI: U.S. Geological Survey, Upper Midwest Environmental Sciences Center.

Rose, W. J. (1992). Sediment Transport, Particle Sizes, And Loads In Lower Reaches Of The Chippewa, Black, And Wisconsin Rivers In Western Wisconsin. *Water-Resources Investigations, 90*(4142).

Runkle, J., E., K. K., Frankson, R., Easterling, D. R., & Champion, S. M. (2022). Minnesota State Climate Summary 2022. *NOAA Technical Report NESDIS 150-MN*.

Schwartz, M. D., Ault, T. R., & Betancourt, J. L. (2013). Spring Onset Variations and Trends in the Continental United States: Past and Regional Assessment Using Temperature-Based Indices. *International Journal of Climatology 33: 2917–22*.

Simon, A., Artita, K., Simon, G., Darby, S. E., & Leyland, J. (2020). *Changes in hydrology and suspended-sediment transport in the Mississippi River Basin over the past century.* MRG&P Report No. 34, United States Army Corps of Engineers Lower Mississippi Valley Division.

Small, D., Islam, S., & Vogel, R. M. (2006). Trends in Precipitation and Streamflow in the Eastern U.S.: Paradox or Perception? *Geophysical Research Letters 33*.

USACE. (1970). *Hydraulic Design Criteria Sheet 712-1 (HDC 712-1) - Stone Stability.* Washington DC: USACE.

USACE. (1990). *Indian Slough Habitat Rehabilitation and Enhancement Project - Definite Project Report/Environmental Assessment (SP-8).* Washington, DC: USACE.

USACE. (1991). *Long Lake Habitat Rehabilitation and Enhancement Project - Definite Project Report/Environmental Assessment (SP-13).* Washington, DC: USACE.

USACE. (1994). *Engineer Manual EM 1110-2-1601 Hydraulic Design of Flood Control Channels.* Washington DC: USACE.

USACE. (2004). *Upper Mississippi River System Flow Frequency Study.* Washington DC: USACE.

USACE. (2004). *Water Control Manual: Mississippi River Nine-Foot Channel Navigation Project - Lock and Dam No. 4 Guttenberg, Iowa - Master Water Control Manual.* St. Paul: USACE.

USACE. (2008). *Coastal Engineering Manual (EM-1110-2-1100).* Washington DC: USACE.

USACE. (2011). *Capoli Slough Habitat Rehabilitation and Enhancement Project - Definite Project Report with Integrated Environmental Assessment Project #114832.* Washington DC: USACE.

USACE. (2012). *Upper Mississippi River Restoration Environmental Management Program Environmental Design Handbook.* USACE.

USACE. (2014). *Harpers Slough Habitat Rehabilitation and Enhancement Project - Definite Project Report with Integrated Environmental Assessment Project #114844.* Washington, DC: USACE.

USACE. (2015). Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Water Resources Region 07, Upper Mississippi. *USACE Institute for Water Resources Civil Works Technical Report CWTS-2015-13*.

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

USACE. (2017). *Engineering Technical Letter (ETL) 1100-2-3 - Guidance for Detection of Nonstationarities in Annual Maximum Discharges.*

USACE. (2020). Changes in Hydrology and Suspended-Sediment Transport in the Mississippi River Basin over the Past Century. *MRG&P Report No. 34*.

USACE. (2020). *Upper Mississippi River Phase IV Flood Risk Management Existing Conditions Hydraulic Model Documentation Report.* USACE.

USACE. (2022). *Engineering Construction Bulletin (ECB) 2018-14. Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects.* USACE.

USACE. (2023). *Harpers Slough HREP Operation and Maintenance Manual.* Washington, DC: USACE.

USACE. (2023). *Mississippi R at Wabasha*. Retrieved from US Army Corps of Engineers - Water Management: https://www.mvp-wc.usace.army.mil/data/Wabasha.Data.shtml

USACE. (2023). *Mississippi R Lock and Dam 04*. Retrieved from US Army Corps of Engineers - Water Management: https://www.mvp-wc.usace.army.mil/data/LockDam_04.Data.shtml

USGCRP. (2017). Climate Science Special Report: Fourth National Climate Assessment. (D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, & T. K. Maycock, Eds.) *1 & 2*. Retrieved from https://science2017.globalchange.gov/

USGCRP. (2018). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment. (D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. Lewis, & B. C. Stewart, Eds.) *2*. Retrieved from https://science2017.globalchange.gov/

USGS. (2018). *Temperature and Water*. Retrieved from Water Science School: https://www.usgs.gov/special-topics/water-science-school/science/temperature-and-water#:~:text=Warm%20stream%20water%20is%20can,aquatic%20life%20at%20higher%20temperatures

USGS. (2023). *USGS 05355250 Mississippi River at Red Wing, MN*. Retrieved from USGS Water Data: https://waterdata.usgs.gov/nwis/inventory/?site_no=05355250

USGS. (2023). *USGS 05369500 Chippewa River at Durand, WI*. Retrieved from USGS Water Data: https://waterdata.usgs.gov/nwis/inventory/?site_no=05369500

Van Appledorn, M. (2022). *Chapter B: Hydrologic indicators of Ecological status and trends of the Upper Mississippi and Illinois Rivers.* USGS. doi:https://doi.org/10.3133/ofr20221039

Vavrus, S. J., & Behnke, R. J. (2014). A Comparison of Projected Future Precipitation in Wisconsin Using Global and Downscaled Climate Model Simulations: Implications for Public Health. *nternational Journal of Climatology 34 (10): 3106–24*.

Wang, H., Schubert, S., Suarez, S., Chen, J., Hoerling, M., Kumar, A., & Pegion, P. (2009). Attribution of the Seasonality and Regionality in Climate Trends over the United States during 1950-2000. *Journal of Climate 22: 2571–90*.

Westby, R. M., Lee, Y. Y., & Black, R. X. (2013). Anomalous Temperature Regimes during the Cool Season: Long-Term Trends, Low-Frequency Mode Modulation, and Representation in CMIP5 Simulations. *Journal of Climate 26 (22): 9061–76*.

Wisconsin Geological and Natural History Survey. (2017). *An inventory of springs in Wisconsin*. Retrieved from https://wgnhs.wisc.edu/water-environment/springs/

Wisconsin State. (2019). *Chapter NR 116 Wisconsin's Floodplain Management Program*. Retrieved from https://docs.legis.wisconsin.gov/code/admin_code/nr/100/116/07/4

Wolter, K., Eischeid, J. K., Quan, X. W., Chase, N., Hoerling, M., Dole, R. M., . . . Walsh, J. E. (2015). How Unusual Was the Cold Winter of 2013/14 in the Upper Midwest? In Explaining Extreme Events of 2014 from a Climate Perspective. *Bulletin of the American Meteorological Society 96 (12): S10–14*.

Woodward, G., Perkins, D. M., & Brown, L. E. (2010). Climate change and freshwater ecosystems: Impacts across multiple levels of organization. *Philosophical Transactions of the Royal Society Biological Sciences 365 (1549): 2093-2106*.

Xu, X., Scanlon, B. R., Schilling, K., & Sun, A. (2013). Relative Importance of Climate and Land Surface Changes on Hydrologic Changes in the US Midwest since the 1930s: Implications for Biofuel Production. *Journal of Hydrology 497 (8): 110–20*.

US Army Corps of Engineers®
St. Paul District

Appendix G: Real Estate Plan

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

April 2024

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Appendix G: Real Estate Plan

TABLE OF CONTENTS

FIGURES

TABLE

EXHIBIT

1 PURPOSE AND GENERAL PROJECT INFORMATION

1.1 Purpose

The information presented in this Real Estate Plan (REP) is based on preliminary data tentative in nature. The final property acquisition information and real estate cost estimates are subject to changes. No prior REP has been submitted for the Project.

This REP supports the Feasibility Report and its efforts to address concerns and opportunities correlating to the Project. The Feasibility Report will also target, investigate, and recommend a Plan for the identified problems. The selected Recommended Plan will focus on the Project objectives to protect, enhance, restore, or create naturally regenerating, resilient, habitats for diverse bottomland forests, flowing channels, and backwaters. Maintaining a balanced coverage and relative abundance of native emergent, rooted floating, and submersed aquatic vegetation communities are also included as Project objectives.

The Lower Pool 4 Big Lake is a Habitat Rehabilitation and Enhancement Project (Project), and Pool 4 is under the Upper Mississippi River Restoration (UMRR) Program and features are located within the Upper Mississippi River National Wildlife and Fish Refuge (Refuge) boundary and on lands owned in fee title by the United States of America and managed by the United States Fish and Wildlife Service (USFWS). Section 906 (e) of WRDA 1986 states the first cost funding for enhancement measures will be 100% Federal cost because the Project lands are located in a national wildlife refuge.

The Wisconsin Department of Natural Resources (WIDNR) and the Minnesota Department of Natural Resources (MNDNR) serve as Project Partners. Although the State of Minnesota is a Partner for the Project, no work is proposed within the State boundary. The USFWS is the Project Sponsor. Operation and maintenance (O&M) are the responsibility of the Sponsor in accordance with 33 U.S.C. § 652(e)(7)(A).

The Federal government owns all the land within the study area. All lands within the study area will be managed as part of the Refuge.

1.2 Project Location

The Big Lake study area is located on the Wisconsin side of Pool 4 in the Upper Mississippi River and is located across from Wabasha, Minnesota, from river mile (RM) 759.5 to 756.6. Big Lake is a backwater lake situated below Lake Pepin. The study includes Indian Slough which connects to Big Lake and is managed by U.S. Fish and Wildlife Service.

The entire Lower Pool 4 study area encompasses approximately 8,276 acres of open backwater, meandered side-channel, main channel border, and island formations from Highway 25 (Nelson Dike) at Wabasha, Minnesota to Lock and Dam No. 4 (L/D 4) near Alma, Wisconsin. See Figure 1. Big Lake Project Location.

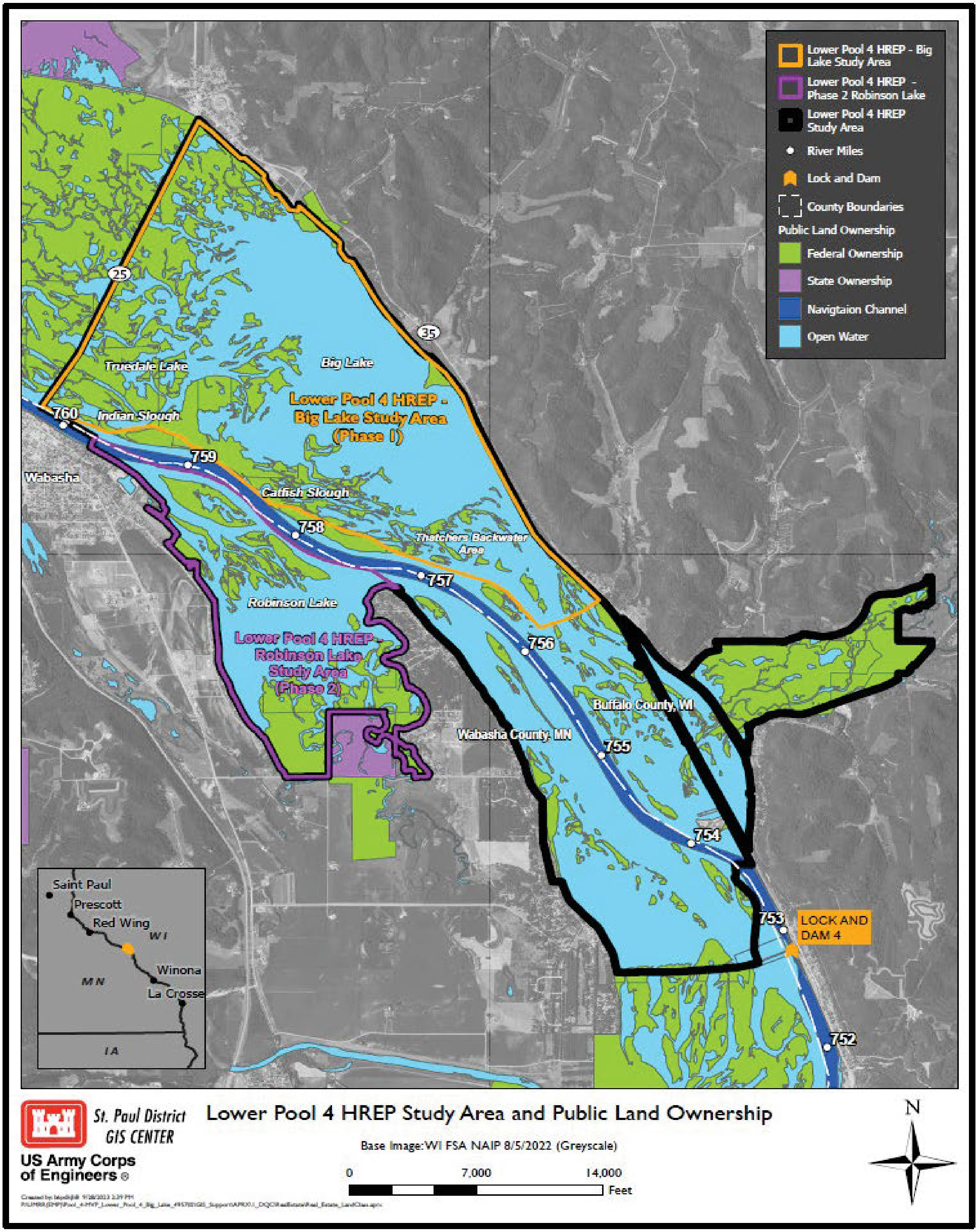

Figure 1: Big Lake Project Location

1.3 Project Authority

The UMRR program was authorized by Section 1103 of the Water Resources Development Act (WRDA) of 1986 (P.L. 99-662), as amended, codified at 33 U.S.C. 652(e). The UMRR program is composed of two elements: (1) plan, construct, and evaluate measures for fish and wildlife habitat improvement through Habitat Rehabilitation and Enhancement Projects (HREPs), and (2) monitor the natural resources of the river system through the long-term resource monitoring element. It is a regional program that includes USACE St. Paul, Rock Island, and St. Louis Districts. Additional information on the program authority can be found in the Main Report, Section 1 (1.1), Authority and Project Selection.

1.4 Future without Project

Refer to Section 3 of the Main Report for a detailed description of the future without the Project.

1.5 The Recommend Plan

Alternative 6 was selected as the Recommended Plan for the Project. The Recommended Plan addresses all Project objectives and would be 100% federally funded. It includes access and overwintering dredging, four island features, four shoreline stabilization features, and six rock closures. The Recommended Plan also includes a sediment deflector and forest management. No staging on land outside of the Project area is expected and no disposal sites are expected to be needed. Crats Island, Teepeeota Point, and Grand Encampment are island transfer sites that are being identified as placement sites for the project. These sites are Federally owned, USACE manages Crats Island and the USFWS manages Teepeeota Point and Grand Encampment.

For Project Access to the water, the contractors may use the various public boat ramps throughout the Project vicinity. It is undetermined which boat ramps the contractors will decide to use at this time. The Contractor will need to abide by local boat ramp usage regulations.
See below Figure 2. for the Recommended Plan.

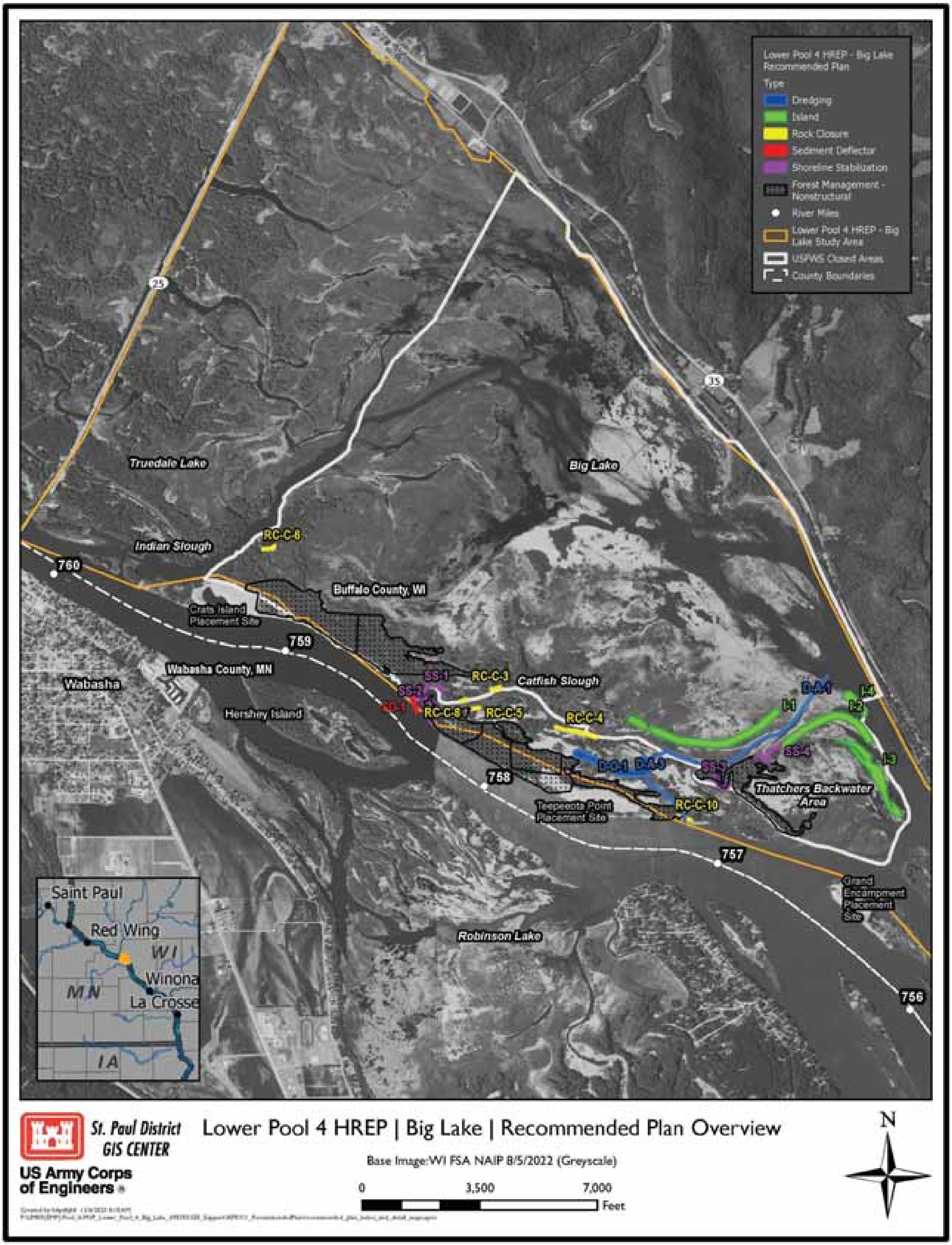

Figure 2: Recommended Plan

Project features will be constructed on a total of 48.15 acres, excluding forest management. Forest Management will include an additional 159 acres. For a complete assessment and comparison of each of the alternatives, please see the Main Report. See Table 1. below.

Feature ID	Cut Volume Granular CY	Cut Volume Fines CY	Fill Volume Granular CY	Fill Volume Fines Cu Yards With Shrinkage	Fines Thickness	Underwater Placement Rock Volume CY	Surface Area Acres
Forest Management							159
D-A-1	14,908	6,810					5.4
D-A-3	10,063	0					2.9
D-O-1		49,506					6.9
I-1			104,942	11,163	6"	12,627	11.67
I-2			68,095	7,568	6"	14,188	7.95
I-3			105,677	27,261	18"	1,866	7.7
I-4			36,595	106,399	18"	7,139	2.1
RC-C-3						866	0.12
RC-C-4						2,201	0.55
RC-C-5						480	0.17
RC-C-6						629	0.17
RC-C-8						528	0.17
RC-C-10						1,674	0.23
SD-1						11,877	0.6
SS-1			2,114	870		8,430	0.25
SS-2			2,114	1,178		19,674	0.28
SS-3			854	1,877		1,227	0.64
SS-4			0	0		3,468	0.35
Totals	24,971	56,316	320,391	56,316		86,871	48.15

Table 1. Summary of Quantities for the Recommended Plan Measures

2 PROJECT LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATION, AND DISPOSAL/BORROW AREAS (LERRD)

2.1 Project LERRD

All lands needed for the construction of the Project are currently owned by the United States of America. As stated in the main report, "The federal government acquired land for construction of the lock and dams and to accommodate the flooding that would occur due to damming; lands were also acquired for the Refuge. The transfer of land from private individuals to federal ownership led to the re-establishment of forest and other habitats on lands that had been grazed and cropped." USACE will obtain a Special Use Permit from the Refuge Manager prior to the commencement of work under the construction contract. No additional lands will be acquired for the Project.

The worksites will be accessed through the water and will require approximately 1.3 miles of dredge cut to reach several of the construction locations. The nearest small craft launch is 2.4 miles upriver at Izaak Walton Park. Larger crafts can be accommodated at marinas located in Lake City (MN), Pepin (WI), or directly across the main channel from the Project site in Wabasha (MN). Access dredging would be needed to reach Catfish Slough from the main channel of the river. Dredging would also occur in the southern portion of Catfish Slough towards the Wisconsin shoreline to access areas needed for island building. Dredging to a depth of six feet from the Low Control Pool (LCP) and 40-foot width would be done for the construction access areas throughout the Project area. All granular and fine placement material will be excavated from within the Project area as part of the construction of other Project features except that borrow (granular material) is also anticipated to come from temporary dredge material placement sites controlled by the Corps (e.g., Teepeeota Point). There is no other dredge material being considered for the borrow. As stated above, all material dredged from within the study area will be used for the construction of the island features captured in Table 1. above.

There is a portion of the Forest Management Non-Structural area depicted in Figure 3 that appears to cross onto Teepeeota Point and the Crats Island Dredged Material Placement Sites. Specific Forest Management actions include timber improvement, removal of invasive woody vegetation and grass, planting and seeding, and planting hard mast trees, which would not occur on active dredge material placement sites such as Teepeeota Point and Crats Island. The Forest Management Area of the project will be refined during Pre-Construction Engineering and Design as necessary.

3 NON-FEDERAL SPONSORS LAND, EASEMENTS, RIGHTS-OF-WAY, RELOCATION, AND DISPOSAL AREAS (LERRD)

3.1 Required Lands

All lands needed for the construction of this Project are owned by the United States of America and managed by USACE and USFWS. The subject properties within the study area will be managed as part of Upper Mississippi River National Wildlife and Fish Refuge (Refuge). No additional lands will be acquired for the Project. A Special Use Permit is required for the Project area and will be obtained by the Refuge Manager. The Special Use Permit and timeline will be coordinated by the USACE Environmental team.

Water access will be available using public boat ramps in the Project vicinity (see Figure 4). The Contractor will need to abide by local boat ramp usage regulations.

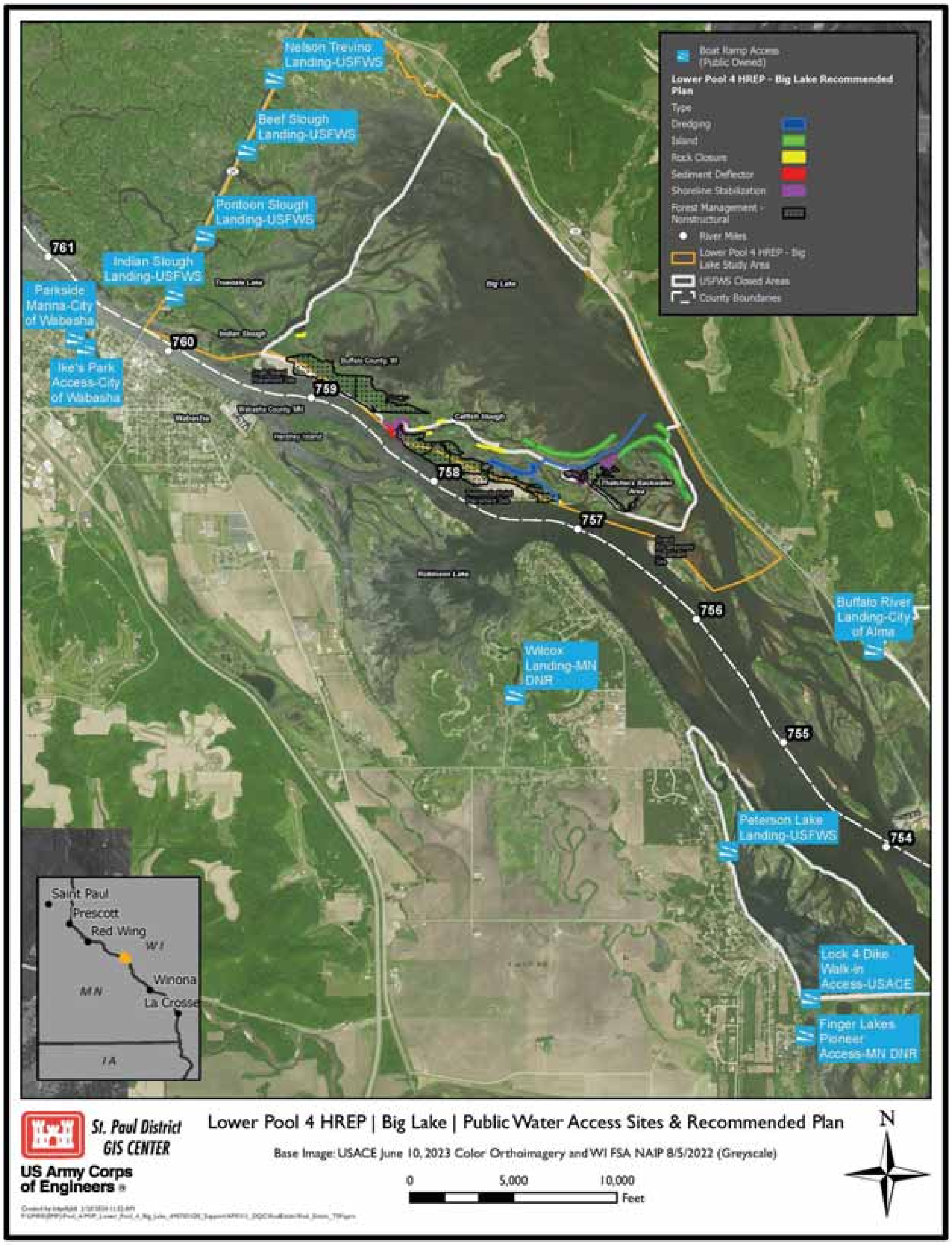

Figure 3. Possible Access Points from land and/or water near the project area

4 ESTATES TO BE ACQUIRED

4.1 Estates

All lands for the Project are federally owned, some of the land is managed by USFWS, and some land is managed by USACE. Additional Real Estate acquisition is not required for this Project. Minimum interests required for Project purposes are met.

Below are the standard estates for restoration and any temporary construction work area easements that would be necessary for the Project in the event additional lands are needed. There are no Non-Standard Estates being proposed for this project at this time.

FEE.

The fee simple title to (the and described in Schedule A) (Tracts Nos. __, __and__), Subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____,____and____), for a period not to exceed_______, beginning with the date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform and other work necessary and incident to the construction of the_______________ Project, together__________________________.

5 EXISTING FEDERAL OR OVERLAPPING PROJECTS

5.1 Overlapping Projects

The Indian Slough HREP Project overlaps in the study area. The subject properties within the study area will be managed as part of the Upper Mississippi River National Wildlife and Fish Refuge.

6 FEDERALLY OWNED LANDS OR OTHER INTEREST

6.1 Project Lands

The study area and Project features are located within lands owned by the United States of America and managed as part of the Upper Mississippi River National Wildlife Refuge (Refuge). All access to the Project will be by water.

Before any work is commenced under a construction contract, USACE will obtain a Special Use Permit from the Refuge Manager. This permit will be included in the technical specification package and be part of the contract documents.

7 NAVIGATION SERVITUDE

7.1 Navigation Servitude

Because the United States owns all necessary property interests for the land required for construction of the Project, the navigation servitude right within the river and any dredging operations will be conducted exercising that right.

8 PROJECT MAP

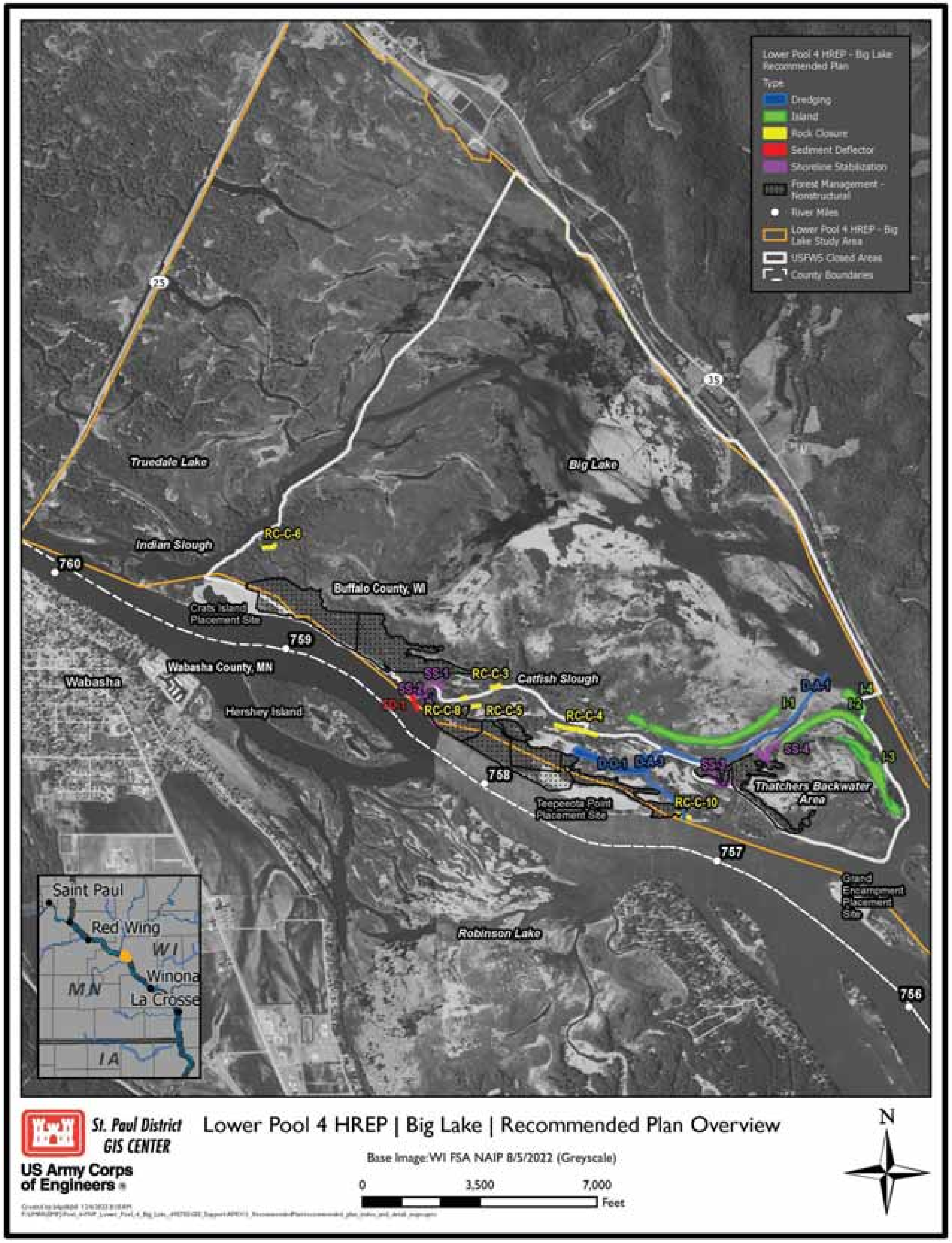

Figure 4. Project Map

9 INDUCED FLOODING

9.1 Flooding

The Project is not anticipated to induce any flooding. For additional information, refer to Appendix E: Hydraulics & Hydrology, and section 6 of the Main Report.

10 BASELINE COST ESTIMATES FOR REAL ESTATE (BCERE)

10.1 Costs

The lands required for the construction of the Project measures are on federal lands. There are no lands, damages or uniform relocation costs associated with the Project. The Special Use Permit will be coordinated by the USACE Environmental Team. The estimated Federal and Sponsor Administrative Expenses total $3,750.00.

11 RELOCATION ASSISTANCE BENEFITS, PUBLIC LAW 91-646

11.1 Relocation

Public Law 91-646 will not be implemented for this Project due to lands being owned by the United States of America and managed by Federal agencies. No land acquisition, damages, or uniform relocation is needed for the construction of the Project.

12 MINERAL ACTIVITY

12.1 Mineral

There are no known mineral recovery activities currently ongoing or anticipated, or oil/gas wells present on the Project LERRD or in the immediate vicinity that will impact the construction, operation, or maintenance of the Project. No acquisition of any mineral interest from surface owners or rights outstanding in third parties will be required.

13 NFS REAL ESTATE ACQUISITION CAPABILITIES ASSESSMENT

13.1 Capabilities

The land required for construction of the Project is Federally owned land.

14 ZONING ORDINANCE REQUIREMENTS

14.1 Zoning

No application or enactment of zoning ordinances is proposed for the Project at this time.

15 ACQUISITION SCHEDULE

15.1 Schedule

No acquisition is anticipated for this Project. The Special Use Permit and schedule will be coordinated by the USACE Environment Team. The Real Estate will be certified during the BCOES phase of the Project. The anticipated BCOES schedule is to be determined.

16 PUBLIC UTILITY OR FACILITY RELATIONS, ALTERATIONS, OR REPLACEMENT

16.1 Facility

No facility or utility relocations are necessary for this Project.

Any conclusion or categorization contained in this REP, or elsewhere in this report, that an item is a utility or facility relocation to be performed by the Sponsor as part of its LERRD responsibilities is preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation, or maintenance of the Project after further analysis and completion and approval of the final attorney's opinion of compensability for each of the impacted utilities and facilities.

17 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW)

17.1 HTRW

In 2023, a Phase I Hazardous, Toxic, and Radioactive Waste (HTRW) analysis was conducted in accordance with ER-1165-2-132, Water Resource Policies and Authorities HTRW Guidance for Civil Works Projects. The HTRW assessment revealed that there were no recognized environmental conditions; therefore, USACE does not recommend a Phase II assessment at this time.

The risk of contamination of river sediments in the Project area is low. Results of contaminant testing will be coordinated with natural resources partners to verify any concerns with contamination levels.

18 LANDOWNER OPPOSITION/PUBLIC CONCERNS

18.1 Concerns

A public scoping meeting was held on 29 August 2022 in Wabasha, MN. Approximately 50 individuals attended the meeting. USACE presented slides on the overall feasibility study, provided handouts, and received feedback from the public. In general, the public is interested in the study and potential work, as witnessed by the turnout at the public meeting.
The draft Feasibility Report and Integrated Environmental Assessment was released for a 30-day public review and comment period on 12 October 2023 and expired on 17 November 2023. A public meeting was held on 8 November 2023 in Wabasha, MN. USACE presented slides on the overall feasibility study, provided handouts, and answered questions from the public. No public comments were received on the draft report.

The U.S. Fish and Wildlife Service (USFWS) is the Project sponsor. A letter of support from the USFWS can be found in Appendix A, Correspondence and Coordination.

19 LERRD ACQUISITION PRIOR TO PROJECT PARTNERSHIP AGREEMENT (PPA) EXECUTION

19.1 Agreement

As stated throughout this report property rights and interests required for the construction of the Big Lake Project are federally owned land in fee title. Therefore, no notification of the risk for acquisition before an executed PPA will be needed. The USACE and USFWS will need to execute a Memorandum of Agreement before construction of the Project. The operations and maintenance responsibilities of the Sponsor will be addressed in the proposed draft Memorandum of Agreement (MOA). The MOA is provided as Appendix K.

20 OTHER RELEVANT REAL ESTATE ISSUES

20.1 Issues

No additional real estate issues have been raised at this time.

{SIGNATURE PAGE TO FOLLOW}

WESLEY.DENITA.FAE.1573700151 Digitally signed by WESLEY.DENITA.FAE.1573700151 Date: 2024.04.26 15:29:18 -05'00'

Denita F. Wesley, Real Estate Specialist (Preparer) — Date

DUPEY.STEPHANIE.T.1231209480 Digitally signed by DUPEY.STEPHANIE.T.1231209480 Date: 2024.04.26 14:45:10 -05'00'

Stephanie T. Dupey, Chief, Planning & Acquisition Branch (Reviewer) — Date

SOMMERLAND.KEVIN.J.1231189048 Digitally signed by SOMMERLAND.KEVIN.J.1231189048 Date: 2024.04.26 15:24:49 -05'00'

Kevin J. Sommerland, Chief of Real Estate, St. Paul District (Approver) — Date

Exhibit A

Quality Control Plan Checklist

Real Estate Plans

And other similar Feasibility-Level Real Estate Planning Documents

ER 405-1-12, Section 12-16, Real Estate Handbook, 1 May 1998

A Real Estate Plan (REP) is prepared in support of a decision document for full-Federal or cost shared specifically authorized or continuing authority projects. It identifies and describes lands, easements and rights-of-way (LER) required for the construction, operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of a proposed project including requirements for mitigation, relocations, borrow material, and dredged or excavated material disposal. It also identifies and describes facility/utility relocations, LER value, and the acquisition process. The REP does not just cover LER to be acquired by the non-Federal sponsor (NFS) or Government. The report covers all LER needed for the project, including LER already owned by the NFS, Federal Government, other public entities, or subject to the navigation servitude.

The REP must contain a detailed discussion of the following 20 topics, as set out in Section 12-16 of the ER, including sufficient description of the rationale supporting each conclusion presented. If a topic is not applicable to the project, this should be stated in the REP. The pages of a REP should be numbered.

PROJECT: <u>Lower Pool 4 Big Lake HREP</u>

REPORT TITLE: <u>Project Feasibility Report & Integrated Environmental Assessment</u>

Date of Report: April <u>2024</u> **Date of REP: April <u>2024</u>**

1. **Purpose of the REP**. _X____

a. Describe the purpose of the REP in relation to the project document that it supports.

b. Describe the project for the Real Estate reviewer.

c. Describe any previous REPs for the project.

2. **Describe LER**. _X_____

a. Account for all lands, easements, and rights-of-way underlying and required for the construction, OMRR&R of the project, including mitigation, relocations, borrow material and dredged or excavated material disposal, whether or not it will need to be acquired or will be credited to the NFS.

b. Provide description of total LER required for each project purpose and feature.

c. Include LER already owned by the Government, the NFS and within the navigation servitude.

d. Show acreage, estates, number of tracts and ownerships, and estimated value.

e. Break down total acreage into fee and the various types and durations of easements.

f. Break down acreage by Government, NFS, other public entity, and private ownership, and lands within the navigation servitude.

3. **NFS-Owned LER**._X_____

a. Describe NFS-owned acreage and interest and whether or not it is sufficient and available for project requirements.

b. Discuss any crediting issues and describe NFS views on such issues.

4. Include any proposed **Non-Standard Estates**. _N/A____

a. Use Standard Estates where possible.

b. Non-standard estates must be approved by HQ to assure they meet DOJ standards for use in condemnations.

c. Provide justification for use of the proposed non-standard estates.

d. Request approval of the non-standard estates as part of document approval.

e. If the document is to be approved at MSC level, the District must seek approval of the non-standard estate by separate request to HQ. This should be stated in the REP.

f. Exception to HQ approval is District Chiefs of RE approval of non-standard estate if it serves intended project purposed, substantially conforms with and does not materially deviate from the standard estates found in the RE Handbook, and does not increase cost or potential liability to the Government. A copy of this approval should be included in the REP. (See Section 12-10c. of RE 405-1-12)

g. Although estates are discussed generally in topic 2, it is a good idea to also state in this section which standard estates are to be acquired and attach a copy as an appendix. The duration of any temporary estates should be stated.

5. **Existing Federal Projects**. _X____

a. Discuss whether there is any existing Federal project that lies fully of partially within LER required for the project.

b. Describe the existing project, all previously-provided interests that are to be included in the current project, and identify the sponsor.

c. Interest in land provided as an item of local cooperation for a previous Federal project is not eligible for credit.

d. Additional interest in the same land is eligible for credit.

6. **Federally-Owned Lands** __X___

a. Discuss whether there is any Federally owned land included within the LER required for the project.

b. Describe the acreage and interest owned by the Government.

c. Provide description of the views of the local agency representatives toward use of the land for the project and issues raised by the requirement for this land.

7. **Navigation Servitude**. _X____

a. Identify LER required for the project that lies below the Ordinary High Water Mark, or Mean High Water Mark, as the case may be, of a navigable watercourse.

b. Discuss whether navigation servitude is available

c. Will it be exercised for project purposes? Discuss why or why not.

d. Lands over which the navigation servitude is exercised are not to be acquired nor eligible for credit for a Federal navigation or flood control project or other project to which a navigation nexus can be shown.

e. See paragraph 12-7 of ER 405-1-12.

8. **Map** _X____

a. An aid to understanding

b. Clearly depicting project area and tracts required, including existing LER, LER to be acquired, and lands within the navigation servitude.

c. Depicts significant utilities and facilities to be relocated, any known or potential HTRW lands.

9. **Induced Flooding** can create a requirement for real estate acquisition. __X_____

a. Discuss whether there will be flooding induced by the construction and OMRR&R of the project.

b. If reasonably anticipated, describe nature, extent and whether additional acquisition of LER must or should occur.

c. Physical Takings Analysis (separate from the REP) must be done if significant induced flooding anticipated considering depth, frequency, duration, and extent of induced flooding.

. d. Summarize findings of Takings Analysis in REP. Does it rise to the level of a taking for which just compensation is owed?

10. **Baseline Cost Estimate** as described in paragraph 12-18. _X_____

a. Provides information for the project cost estimates.

b. Gross Appraisal includes the fair market value of all lands required for project construction and OMRR&R.

c. PL 91-646 costs

d. Incidental acquisition costs

e. Incremental real estate costs discussed/supported.

f. Is Gross Appraisal current? Does Gross Appraisal need to be updated due to changes in project LER requirements or time since report was prepared?

11. **Relocation Assistance Benefits** Anticipated. _N/A_____

a. Number of persons, farms, and businesses to be displaced and estimated cost of moving and reestablishment.

b. Availability of replacement housing for owners/tenants

c. Need for Last Resort Housing benefits

d. Real Estate closing costs

e. See current 49 CFR Part 24

12. **Mineral Activity**. __N/A___

a. Description of present or anticipated mineral activity in vicinity that may affect construction, OMRR&R of project.

b. Recommendation, including rationale, regarding acquisition of mineral rights or interest, including oil or gas.

c. Discuss other surface or subsurface interests/timber harvesting activity

d. Discuss effect of outstanding 3rd party mineral interests.

e. Does estate properly address mineral rights in relation to the project?

13. **NFS Assessment** _X____

a. Assessment of legal and professional capability and experience to acquire and provide LER for construction, OMRR&R of the Project.

b. Condemnation authority

c. Quick-take capability

d. NFS advised of URA requirements

e. NFS advised of requirements for documenting expenses for credit.

f. If proposed that Government will acquire project LER on behalf of NFS, fully explain the reasons for the Government performing work.

g. A copy of the signed and dated Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability (Appendix 12-E) is attached to the REP.

14. **Zoning** in Lieu of Acquisition _N/A_____

a. Discuss type and intended purpose

b. Determine whether the proposed zoning proposal would amount to a taking for which compensation will be due.

15. **Schedule** __X___

a. Reasonable and detailed Schedule of land acquisition milestones, including LER certification.

b. Dates mutually agreed upon by Real Estate, PM, and NFS. _X_____

16. **Facility or Utility Relocations** _N/A_____

a. Describe the relocations, identity of owners, purpose of facilities/utilities, whether owners have compensable real property interest.

b. A synopsis of the findings of the Preliminary Attorney's Investigation and Report of Compensable Interest is included in the REP as well as statements required by Sections 12-17c.(5) and (6).

c. Erroneous determinations can affect the accuracy of the project cost estimate and can confuse Congressional authorization.

d. Eligibility for substitute facility

1. Project impact

2. Compensable interest

3. Public utility or facility

4. Duty to replace

5. Fair market value too difficult to determine or its application would result in an injustice to the landowner or the public.

e. See Sections 12-8, 12-17, and 12-22 of ER 405-1-12.

17. **HTRW** and Other Environmental Considerations ___X___

a. Discussion the impacts on the Real Estate acquisition process and LER value estimate due to known or suspected presence of contaminants.

b. Status of District's investigation of contaminants.

c. Are contaminants regulated under CERCLA, other statues, or State law?

d. Is clean-up or other response required of non-CERCLA regulated material?

e. If cost share, who is responsible for performing and paying cost of work?

f. Status of NEPA and NHPA compliances

g. See ER 1165-2-132, Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects.

18. **Landowner Attitude**. __X___

a. Is there support, apathy, or opposition toward the project?

b. Discuss any landowner concerns on issues such as condemnation, willing seller provisions, estates, acreages, etc.?

19. A statement that the **NFS has been notified in writing about the risks of acquiring LER before the execution of the PPA**. If not applicable, so state. __X___

20. **Other Relevant Real Estate Issues**. Anything material to the understanding of the RE aspects of the project. **NONE**

A copy of the completed Checklist is attached to the REP. __X___

(Draft REPs must contain a draft checklist and draft Technical Review Guide)

I have prepared and thoroughly reviewed the REP and all information, as required by Section 12-16 of ER 405-1-12, is contained in the Plan.

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Date: 2024.04.26 15:32:32 -05'00'

Denita F. Wesley
Preparer/ Realty Specialist

Date

A copy of the Real Estate Internal Technical Review Guide for Civil Works Decision

Documents is attached and signed by me as the Reviewer

Justine Hunt
Real Estate Internal Technical Reviewer

Date

REAL ESTATE INTERNAL TECHNICAL REVIEW GUIDE
FOR CIVIL WORKS DECISION DOCUMENTS

Real Estate Guide for Review of Civil Works Decision Documents

1. Initially, read the entire Real Estate Plan (REP). After reading the REP:

   a. Do you have a good idea of the scope of the project?

   b. Did you note any omissions?

   c. What questions do you have regarding the project?

   d. Were all the elements of an REP as listed in Chapter 12 covered?

   e. Do you have a completed Quality Control Plan for the REP?

2. Next, read the main body of the decision document (including the chapter on the recommended plan), paying particular attention to the overall scope of the project, proposed facility relocations, environmental investigations, mitigation requirements, navigational servitude, and possibility of induced flooding.

3. Then, read the REP again, noting any discrepancies between the REP and the main report. Pay particular attention not only to what the report says, but also to what the report does not say. Many review comments are due to items being omitted or not discussed in enough detail in the REP.

4. Finally, ask yourself specific questions about the project such as the following. You should be able to answer them by reading the REP.

a. What is the project's purpose and have there been prior real estate planning documents for this project?

b. Is the purpose of the report to gain Congressional authorization (e.g., a Feasibility Report)? If not, what is the real estate acquisition authority for the project and is the proper authority cited in the report?

c. Who is the sponsor that will execute the PPA? Has an assessment of the sponsor's capability been completed and included in the report? Does the sponsor have eminent domain and quick take authority? If not, does the report address how acquisition will be accomplished if condemnation is required? Does the sponsor currently own any lands required for the project? If so, were any of these lands obtained as part of another Federal project or funded with Federal funds in whole or in part?

d. Are there any lands currently owned by the Federal government involved in this project? If so, has it been coordinated with the

e. Does the project involve a navigable waterway and could the navigational servitude be utilized for purposes of the project? If the project is not a navigation project and asserting navigational servitude is proposed, does the report state the legal basis for asserting navigational servitude?

f. Is there a possibility of induced flooding, and has a taking analysis been completed? What was the outcome of that analysis? Are flowage easements required because the anticipated flooding will rise to the level of a taking?

g. Are the interests and estates sufficient to provide for construction, operation, maintenance, repair, replacement and rehabilitation (OMRR&R) of the project? Do the estates not only grant the interest needed for construction and maintenance, but do they prohibit practices that might interfere with the project in the future? Is the term for any temporary easements defined and are they for an appropriate duration?

h. How do we physically access the project site? Is an additional real estate interest required for construction access and/or OMRR&R access?

i. Is there a need to dispose of borrow material? If so, are these areas included in the report as LERRD items or, if proven cost efficient, contractor provided items? Are the environmental issues associated with borrow/disposal effectively addressed?

j. Will a contractor's staging area be required?

k. Are any persons being displaced from their homes as a result of the project? If so, how many? Is replacement housing available? Will standard PL 91-646 benefits be provided? Will any businesses require relocation assistance? Has a replacement housing survey been accomplished?

l. Are there any public facilities to be altered or relocated? Do the below relocations meet all of the following five tests?

(1) The project design requires the facility to be moved in whole or in part (temporarily or permanently), or the project will negatively impact the ongoing function or operation of the facility.

(2) The owner of the facility has a compensable real property interest in the land on which the impacted portion of the facility is located.

(3) The facility serves a public purpose.

(4) The owner of the facility has a duty to replace the facility as a result of legal or factual necessity (continuing need).

(5) The fair market value of the interest that must be acquired due to project impact is too difficult to ascertain, or payment of fair market value instead of providing a substitute facility would result in manifest injustice to the owner or the public. Have preliminary opinions of compensability be completed for each facility? If the REP is part of a decision document that will serve as the basis for Congressional authorization, does it contain the disclaimer language required by ER 405-1-12, para. 12-17c(6)?

m. Are any cemeteries in the project area? If so, how will they be impacted? If they are allowed to remain in place, how will permanent access be provided? If they are to be relocated, the report should address the preparation of a cemetery relocation plan.

n. Does the report address the types of ownership, number of tracts and acres, and estates to be acquired? Does the report address mineral activity and whether the minerals will be acquired, subordinated, or left outstanding?

o. Does the report state if any nonstandard interest or estate will be utilized? If so, is a copy of the estate in the report?

p. Do the acres, values, and estates contained in the baseline cost estimate agree with those contained in an approved gross appraisal for the project? If not, any discrepancy should be discussed with the Appraisal Branch and reconciled. Does the acreage and cost presented in the REP agree with real estate acreage and costs shown elsewhere in the main report or MCACES estimate? Does the cost estimate show the estimated cost by estate, contingency, administrative cost, and relocation assistance? The cost should be shown for both Federal and non-Federal, where appropriate.

q. Does the report address the status of all environmental considerations and approvals, HTRW assessments, NEPA compliance, and NHPA compliance? If any land required for the project is contaminated, is it CERCLA or non-CERCLA regulated material?

r. Does the report contain a reasonable schedule for acquisition, and has the schedule been coordinated with the sponsor? Is the project to be accomplished in more than one phase?

s. Does the report contain a map depicting all of the tracts and estates to be acquired? Does it show any known or potential HTRW lands?

t. Obviously, all of the above items will not apply to every project; however, if the REP fails to address an item, the reviewer does not know if it is considered. If the individual preparing the document is aware that an item is not applicable, but fails to include that information in the REP, the report should contain a statement that this item is not applicable.

u. The Reviewer should verify that the real estate requirements shown in the REP are in consort with the latest design drawings.

v. The Reviewer should consult with the other team members and Real Estate employees, as necessary, to resolve questions or misunderstandings prior to preparing comments to the Report Preparer.

I have reviewed the Lower Pool 4 Big Lake HREP Real Estate Plan and have considered all of the above.

____ ________________

Justine C. Hunt Date
Real Estate Internal Technical Reviewer

US Army Corps of Engineers®
St. Paul District

Appendix H: Civil

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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Appendix H: Civil

TABLE OF CONTENTS

LIST OF FIGURES

No table of figures entries found.

LIST OF TABLES

1 General Project Information

DATUM INFORMATION		
Horizontal:	NAD83	Minnesota State Plane, South Zone, U.S. Survey Feet
Vertical:	NAVD 88	North American Vertical Datum of 1988 (GEOID 18), Feet
Notes:	Survey collected 2011 with additional bathymetry collected May 2023.	

Design considerations for PED are listed in the Main Report Section 5.3.

2 Project Access

The work sites will be accessed through the water and will require approximately 1.3 miles of dredge cut to reach several of the construction locations. The nearest small craft launch is 2.4 miles upriver at Izaak Walton Park. Larger crafts can be accommodated at marinas located in Lake City (MN), Pepin (WI) or directly across the main channel from the project site in Wabasha (MN).

3 Project Features

3.1 Access Dredging (D-A-1 & D-A-3)

Access dredge cuts have a bottom width of 40 feet and a bottom elevation of 660.5 feet to allow for approximately 6 feet of depth at low control pool (LCP). Side slope are to be maintained at 1:4. More information on side slopes can be found in Appendix D.

3.2 Overwintering Dredging (D-O-1)

Overwintering dredge cuts have a bottom elevation of 658.5 feet to allow for approximately 8 feet of depth at LCP and side slopes at 1:4. Side slope are to be maintained at 1:4. More information on side slopes can be found in Appendix D. The area of this feature is to be defined by the need of fine material required for the fine material (topsoil) cap on the island features.

3.3 Islands (I-1, I-2, I-3, & I-4)

3.3.1 Granular Material Base

Granular base will be placed at each island site. Additional material required to offset settlement and lateral displacement will be accounted for in this layer. The top elevation of the granular base is determined by the final island elevation, thickness of fines and total overbuild. The granular base material will be generated from the access dredging within Catfish Slough and the remaining material will be taken from Teepeeota Point dredged material placement site.

3.3.2 Fine Materials

Fine material cap will be placed over the granular base layer to a specified thickness as found in the cross sections. This material will be generated from the overwintering dredge feature.

Additional details on design assumptions of the island features, including specifics for the rock groins and vanes, can be found in Appendix E.

3.4 Rock Closures

Rock closures to be constructed of R45 riprap and placed directly on the existing grade. All rock closures have a minimum top width of 6 feet with 1:2.5 side slopes. On both ends of the feature shoreline stabilization features will be placed to protect the existing bank directly adjacent to the closure. These will have a thickness of 24 inches to protect the rock closure feature.

3.5 Shoreline Stabilization

Shoreline stabilization to be constructed with R45 riprap and placed directly on the existing grade. On features SS-1,SS-2, and SS-3 some locations require fill (granular with 6 inches of fine as cap) in order repair excessive erosion. Stone above water to be placed at 24 inches thick, the stone on the bottom is 36 inches thick and the apron at the bottom is a minimum of 10 feet wide (EM 1110-2-1601, launch rock method C).

3.6 Sediment Deflector

Sediment deflector to be constructed with R45 riprap and placed directly on the existing grade. A top width of minimum 6 feet and minimum 1:2.5 side slopes shall be maintained.

4 Civil Design Assumptions

4.1 Overbuild

All island features are modeled with an additional 3 feet of granular fill to account for consolidation settlement (up to 2 feet)and lateral displacement (1 foot). This is a conservative value and will need to be refined through further data collection in PED.

All fines material volumes account for an additional 20 percent overbuild.

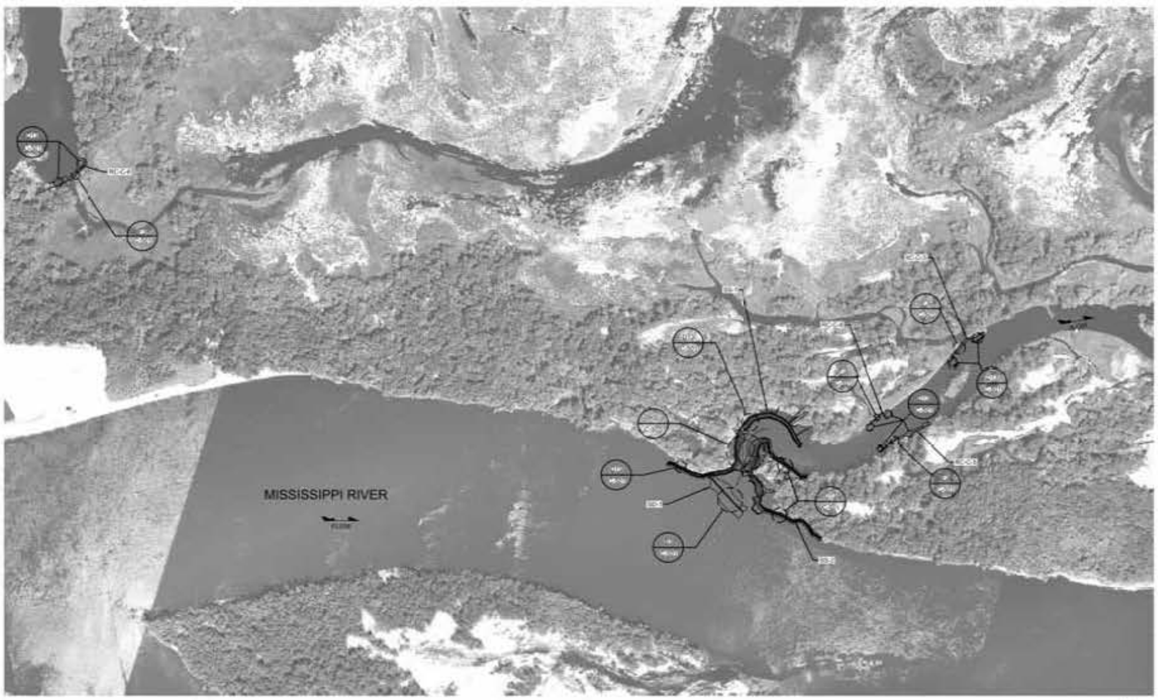
4.2 Overwintering Dredging

Site D-O-1 was assumed to provide sufficient fine material to balance the required materials for the island fine material/topsoil cap.

5 Quantity Report

Table 1: Calculated Quantities from OpenRoads Models

Feature ID	Cut Volume Granular Cu Yards	Cut Volume Fines Cu Yards	Fill Volume Granular Cu Yards	Fill Volume Fines Cu Yards With Shrinkage	Fines Thickness	Underwater Placement Rock Volume Cu Yards	Surface Area Acres
D-A-1	14,908	6,810					5.4
D-A-3	10,063	0					1.4
D-O-1		49,506					6.9
I-1			104,942	11,163	6"	12,627	15.9
I-2			68095	7568	6"	14,188	9.6
I-3			105677	27261	18"	1,866	11.2
I-4			36595	6399	18"	7,139	4.0
RC-C-3						866	0.35
RC-C-4						2,201	0.68
RC-C-5						480	0.19
RC-C-6						629	0.27
RC-C-10						1,674	0.46
SD-1						11,877	0.65
SS-1			2,114	870		8,430	3.1
SS-2			2,114	1,178		19,674	2.7
SS-3			854	1,877		1,227	2.3
SS-4			0	0		3,465	1.7
Totals	24,971	56,316	320,391	56,316		86,343	66.8



B1 SITE PLAN
UPSTREAM PROJECT AREA

US Army Corps of Engineers

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

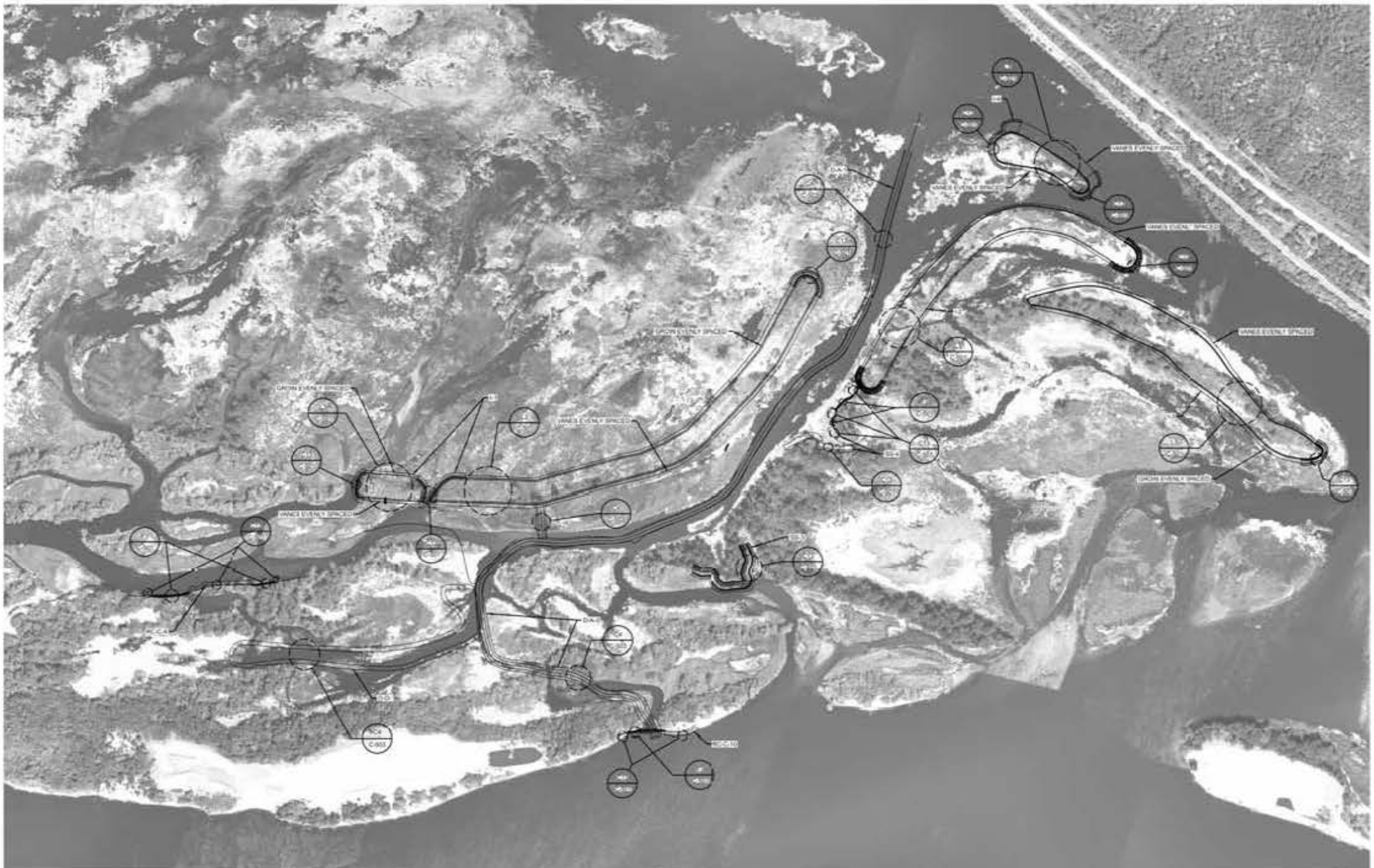
DESIGNED BY: JDC
DRAWN BY: JDC
CHECKED BY:
SUBMITTED BY:
SIZE: ANSI D
FILE NAME:
ISSUE DATE:
SOLICITATION NO.:
CONTRACT NO.:
AS BUILT NO.:

LOWER POOL 4 BIG LAKE HREP
MISSISSIPPI RIVER
LOWER POOL 4
ALMA, WI

UPSTEAM SITE PLAN

SHEET ID
C-101

CONCEPT DESIGN



A1 SITE PLAN

DOWNSTREAM PROJECT AREA

US Army Corps of Engineers

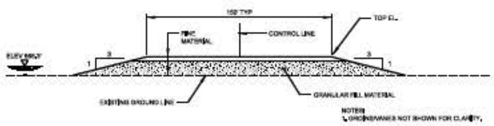
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

DOWNSTEAM SITE PLAN

SHEET ID

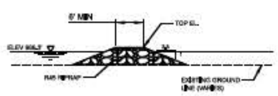
C-102

CONCEPT DESIGN

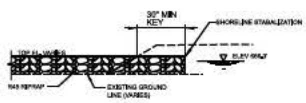


FEATURE	FINAL TOP EL.	FINES THICKNESS
I-1	668.5ft	6in
I-2	668.5ft	6in
I-3	669.5ft	18in
I-4	669.5ft	18in

L3 **Detail**
ISLAND SECTION TYPICAL



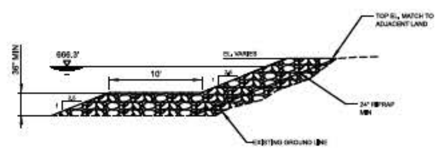
SECTION
ROCK CLOSURE



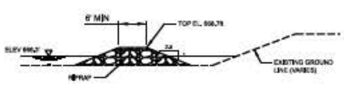
PROFILE VIEW
ROCK CLOSURE AT END (TYP)

FEATURE	FINAL TOP EL.
RC-C-3	668.0ft
RC-C-4	667.5ft
RC-C-5	668.0ft
RC-C-6	669.0ft
RC-C-8	668.0ft
RC-C-10	667.0ft

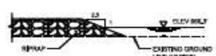
F3 **Detail**
RIPRAP ROCK CLOSURE



D13 **Detail**
RIPRAP FOR SLOPE STABILIZATION



SEDIMENT DEFLECTOR TYPICAL SECTION



SEDIMENT DEFLECTOR END PROFILE

B3 **Detail**
RIPRAP SILT DEFLECTOR

US Army Corps of Engineers

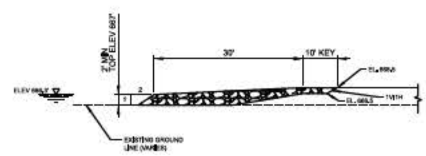
U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

LOWER POOL 4 BIG LAKE HREP
MISSISSIPPI RIVER
LOWER POOL 4
ALMA, WI

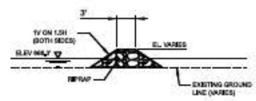
DETAILS (1 OF 3)

SHEET ID
C-501

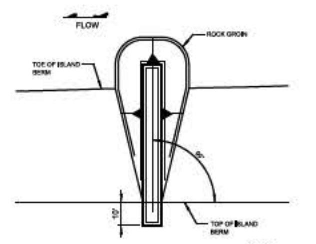
CONCEPT DESIGN



TYPICAL ROCK GROIN



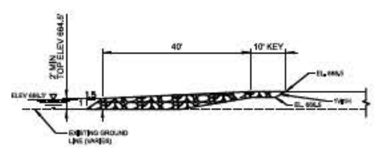
TYPICAL ROCK GROIN



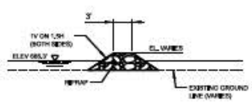
NOTES:
1. 150' SPACING TYP.

TYPICAL ROCK GROIN PLAN

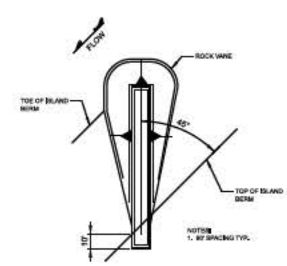
J3 DETAIL
RIPRAP GROIN DETAIL



TYPICAL ROCK VANE PROFILE



TYPICAL ROCK VANE SECTION



NOTES:
1. 80' SPACING TYP.

TYPICAL ROCK VANE PLAN

B3 DETAIL
RIPRAP VANE DETAIL

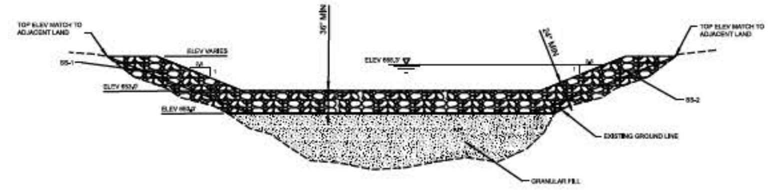
US Army Corps
of Engineers

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

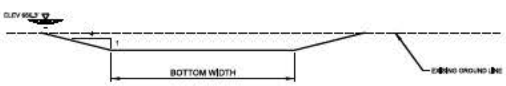
DETAIL (502)

SHEET ID
C-502

CONCEPT DESIGN



K6 DETAIL
SS-1 & SS-2 OVERLAP IN CATFISH SLOUGH



FEATURE	BOTTOM WIDTH	BOTTOM EL.
D-C-1	40ft	660.5ft
D-C-3	40ft	660.5ft
D-O-3	DEFINED BY FINES REQ	658.5ft

C4 DETAIL
DREDGE CUT

US Army Corps of Engineers

U.S. ARMY CORPS OF ENGINEERS
ST. PAUL DISTRICT
ST. PAUL, MINNESOTA

DESIGNED BY: JDC | DRAWN BY: JDC | CHECKED BY: NM | SUBMITTED BY: | SIZE: ANSI D | FILE NAME: LP4BLH_C-503.dgn
ISSUE DATE: | SOLICITATION NO.: | CONTRACT NO.: | AS-BUILT NO.:

LOWER POOL 4 BIG LAKE HREP
MISSISSIPPI RIVER
LOWER POOL 4
ALMA, WI

DETAILS (3 OF 3)

SHEET ID
C-503

CONCEPT DESIGN

US Army Corps of Engineers ®
St. Paul District

Appendix I: RECONS

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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Appendix I

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LIST OF TABLES

1 General

The U.S. Army Corps of Engineers (USACE) Institute for Water Resources, Louis Berger, and Michigan State University have developed a regional economic impact modeling tool, RECONS (Regional ECONomic System), that provides estimates of jobs and other economic measures such as labor income, value added, and sales that are supported by USACE programs, projects, and activities. This modeling tool automates calculations and generates estimates of jobs, labor income, value added, and sales through the use of IMPLAN®'s multipliers and ratios, customized impact areas for USACE project locations, and customized spending profiles for USACE projects, business lines, and work activities. RECONS allows the USACE to evaluate the regional economic impact and contribution associated with USACE expenditures, activities, and infrastructure.

2 Description of Metrics

"Output" is the sum total of transactions that take place as a result of the construction project, including both value added and intermediate goods purchased in the economy. "Labor Income" includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. "Value Added" or "Gross Regional Product" represents the value-added output of the study regions. This metric captures all final goods and services produced in the study areas because of the existence of the project. It is different from output in the sense that one dollar of a final good or service may have multiple transactions associated with it. "Jobs" is the estimated worker-years of labor required to build the project. The secondary impacts are a summary of the multiplier effects, which include both indirect and induced effects. Indirect impacts include industries that support the direct and indirect industries spend their salaries in the impact area, creating jobs, income, and value added. The jobs and output at each level (Local, State, US) are inclusive. For example, the state job impact value contains the local job impact value within it.

3 Assumptions

Input-output analysis rests on the following assumptions. The production functions of industries have constant returns to scale, so if output is to increase, inputs will increase in the same proportion. Industries face no supply constraints; they have access to all the materials they can use. Industries have a fixed commodity input structure; they will not substitute any commodities or services used in the production of output in response to price changes. Industries produce their commodities in fixed proportions, so an industry will not increase production of a commodity without increasing production in every other commodity it produces. Furthermore, it is assumed that industries use the same technology to produce all their commodities. The costs were calculated using FY 2023 price levels. The RECONS

4 Results

4.1 Alternative 2 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $22,786,000. Of this total expenditure, $15,229,694 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $22,786,000 support a total of 193.8 full-time equivalent jobs, $9,023,641 in labor income, $12,041,669 in the gross regional product, and $20,760,221 in economic output in the local impact area. More broadly, these expenditures support 446.3 full-time equivalent jobs, $25,956,352 in labor income, $36,047,680 in the gross regional product, and $59,535,583 in economic output in the nation. Table 1 summarizes these results.

Table 1: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 2

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$15,229,694	160.2	$7,465,404	$9,101,752
Secondary Impact	$5,530,528	33.6	$1,558,237	$2,939,916
Total Impact	$20,760,221	193.8	$9,023,641	$12,041,669
State				
Direct Impact	$19,392,741	198.4	$11,028,423	$13,478,680
Secondary Impact	$18,050,129	94.4	$6,288,929	$10,202,422
Total Impact	$37,442,870	292.9	$17,317,352	$23,681,102
US				
Direct Impact	$22,627,353	277.5	$14,266,972	$15,894,276
Secondary Impact	$36,908,230	168.8	$11,689,380	$20,153,404
Total Impact	$59,535,583	446.3	$25,956,352	$36,047,680
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.2 Alternative 3 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $31,135,000. Of this total expenditure, $20,809,993 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $31,135,000 support a total of 264.8 full-time equivalent jobs, $12,329,986 in labor income, $16,453,847 in the gross regional product, and $28,366,958 in economic output in the local impact area. More broadly, these expenditures support 609.8 full-time equivalent jobs, $35,466,999 in labor income, $49,255,882 in the gross regional product, and $81,349,969 in economic output in the nation. Table 2 summarizes these results.

Table 2: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 3

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$20,809,993	218.9	$10,200,797	$12,436,718
Secondary Impact	$7,556,964	45.9	$2,129,189	$4,017,128
Total Impact	$28,366,958	264.8	$12,329,986	$16,453,847
State				
Direct Impact	$26,498,420	271.2	$15,069,338	$18,417,393
Secondary Impact	$24,663,862	129.0	$8,593,251	$13,940,683
Total Impact	$51,162,282	400.2	$23,662,589	$32,358,076
US				
Direct Impact	$30,918,223	379.2	$19,494,522	$21,718,085
Secondary Impact	$50,431,745	230.6	$15,972,477	$27,537,797
Total Impact	$81,349,969	609.8	$35,466,999	$49,255,882
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.3 Alternative 4 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $33,974,000. Of this total expenditure, $22,707,523 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $33,974,000 support a total of 288.9 full-time equivalent jobs, $13,454,278 in labor income, $17,954,167 in the gross regional product, and $30,953,558 in economic output in the local impact area. More broadly, these expenditures support 665.4 full-time equivalent jobs, $38,701,006 in labor income, $53,747,208 in the gross regional product, and $88,767,748 in economic output in the nation. Table 3 summarizes these results.

Table 3: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 4

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$22,707,523	238.8	$11,130,941	$13,570,742
Secondary Impact	$8,246,035	50.1	$2,323,336	$4,383,424
Total Impact	$30,953,558	288.9	$13,454,278	$17,954,167
State				
Direct Impact	$28,914,640	295.9	$16,443,414	$20,096,756
Secondary Impact	$26,912,801	140.8	$9,376,814	$15,211,844
Total Impact	$55,827,441	436.6	$25,820,229	$35,308,600

US				
Direct Impact	$33,737,457	413.7	$21,272,102	$23,698,417
Secondary Impact	$55,030,291	251.7	$17,428,904	$30,048,791
Total Impact	$88,767,748	665.4	$38,701,006	$53,747,208
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.4 Alternative 5 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $35,865,000. Of this total expenditure, $23,971,428 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $35,865,000 support a total of 305.0 full-time equivalent jobs, $14,203,145 in labor income, $18,953,500 in the gross regional product, and $32,676,439 in economic output in the local impact area. More broadly, these expenditures support 702.4 full-time equivalent jobs, $40,855,112 in labor income, $56,738,789 in the gross regional product, and $93,708,580 in economic output in the nation. Table 4 summarizes these results.

Table 4: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 5

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$23,971,428	252.1	$11,750,492	$14,326,093
Secondary Impact	$8,705,011	52.9	$2,452,653	$4,627,407
Total Impact	$32,676,439	305.0	$14,203,145	$18,953,500
State				
Direct Impact	$30,524,035	312.4	$17,358,658	$21,215,346
Secondary Impact	$28,410,773	148.6	$9,898,730	$16,058,538
Total Impact	$58,934,808	460.9	$27,257,388	$37,273,884
US				
Direct Impact	$35,615,291	436.8	$22,456,111	$25,017,476
Secondary Impact	$58,093,289	265.7	$18,399,000	$31,721,313
Total Impact	$93,708,580	702.4	$40,855,112	$56,738,789
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.5 Alternative 6 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $34,175,000. Of this total expenditure, $22,841,867 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $34,175,000 support a total of 290.6 full-time equivalent jobs, $13,533,877 in labor income, $18,060,389 in the gross regional product, and $31,136,688 in economic output in the local impact area. More broadly, these expenditures support 669.3 full-time equivalent jobs, $38,929,972 in labor income, $54,065,192 in the gross regional product, and $89,292,924 in economic output in the nation. Table 5 summarizes these results.

Table 5: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 6

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$22,841,867	240.2	$11,196,795	$13,651,031
Secondary Impact	$8,294,821	50.4	$2,337,082	$4,409,358
Total Impact	$31,136,688	290.6	$13,533,877	$18,060,389
State				
Direct Impact	$29,085,707	297.6	$16,540,698	$20,215,655
Secondary Impact	$27,072,025	141.6	$9,432,290	$15,301,841
Total Impact	$56,157,732	439.2	$25,972,988	$35,517,496
US				
Direct Impact	$33,937,058	416.2	$21,397,954	$23,838,624
Secondary Impact	$55,355,866	253.2	$17,532,018	$30,226,568
Total Impact	$89,292,924	669.3	$38,929,972	$54,065,192
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.6 Alternative 7 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $34,176,000. Of this total expenditure, $22,842,535 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $34,176,000 support a total of 290.6 full-time equivalent jobs, $13,534,273 in labor income, $18,060,917 in the gross regional product, and $31,137,599 in economic output in the local impact area. More broadly, these expenditures support 669.4 full-time equivalent jobs, $38,931,111 in labor income, $54,066,774 in the gross regional product, and $89,295,537 in economic output in the nation. Table 6 summarizes these results.

Table 6: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 7

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$22,842,535	240.2	$11,197,123	$13,651,430
Secondary Impact	$8,295,064	50.4	$2,337,150	$4,409,487
Total Impact	$31,137,599	290.6	$13,534,273	$18,060,917
State				
Direct Impact	$29,086,558	297.6	$16,541,182	$20,216,246
Secondary Impact	$27,072,817	141.6	$9,432,566	$15,302,289
Total Impact	$56,159,375	439.2	$25,973,748	$35,518,535
US				
Direct Impact	$33,938,051	416.2	$21,398,580	$23,839,321
Secondary Impact	$55,357,486	253.2	$17,532,531	$30,227,453
Total Impact	$89,295,537	669.4	$38,931,111	$54,066,774
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.7 Alternative 8 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $43,806,000. Of this total expenditure, $29,279,029 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $43,806,000 support a total of 372.5 full-time equivalent jobs, $17,347,916 in labor income, $23,150,063 in the gross regional product, and $39,911,448 in economic output in the local impact area. More broadly, these expenditures support 858.0 full-time equivalent jobs, $49,900,990 in labor income, $69,301,530 in the gross regional product, and $114,456,937 in economic output in the nation. Table 7 summarizes these results.

Table 7: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 8

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$29,279,029	307.9	$14,352,211	$17,498,085
Secondary Impact	$10,632,419	64.6	$2,995,704	$5,651,978
Total Impact	$39,911,448	372.5	$17,347,916	$23,150,063
State				
Direct Impact	$37,282,472	381.5	$21,202,102	$25,912,713
Secondary Impact	$34,701,305	181.5	$12,090,443	$19,614,118
Total Impact	$71,983,778	563.0	$33,292,545	$45,526,830

US				
Direct Impact	$43,501,002	533.5	$27,428,201	$30,556,686
Secondary Impact	$70,955,935	324.5	$22,472,790	$38,744,844
Total Impact	$114,456,937	858.0	$49,900,990	$69,301,530
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.8 Alternative 9 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $38,657,000. Of this total expenditure, $25,837,543 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $38,657,000 support a total of 328.7 full-time equivalent jobs, $15,308,825 in labor income, $20,428,982 in the gross regional product, and $35,220,218 in economic output in the local impact area. More broadly, these expenditures support 757.1 full-time equivalent jobs, $44,035,579 in labor income, $61,155,761 in the gross regional product, and $101,003,557 in economic output in the nation. Table 8 summarizes these results.

Table 8: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 9

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$25,837,543	271.7	$12,665,238	$15,441,343
Secondary Impact	$9,382,674	57.0	$2,643,586	$4,987,639
Total Impact	$35,220,218	328.7	$15,308,825	$20,428,982
State				
Direct Impact	$32,900,254	336.7	$18,709,986	$22,866,907
Secondary Impact	$30,622,480	160.2	$10,669,321	$17,308,655
Total Impact	$63,522,734	496.8	$29,379,307	$40,175,562
US				
Direct Impact	$38,387,852	470.8	$24,204,263	$26,965,024
Secondary Impact	$62,615,705	286.4	$19,831,316	$34,190,737
Total Impact	$101,003,557	757.1	$44,035,579	$61,155,761
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

4.9 Alternative 10 RECONS Results

The expenditures associated with All Work Activities, with Ability to Customize Impact Area and Work Activity at Wabasha (MN) are estimated to be $48,849,000. Of this total expenditure, $32,649,666 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the expenditures $48,849,000 support a total of 415.4 full-time equivalent jobs, $19,345,029 in labor income, $25,815,126 in the gross regional product, and $44,506,103 in economic output in the local impact area. More broadly, these expenditures support 956.7 full-time equivalent jobs, $55,645,653 in labor income, $77,279,607 in the gross regional product, and $127,633,359 in economic output in the nation. Table 9 summarizes these results.

Table 9: Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Regional Economic Development (RED) Summary for Alternative 10

Area	Output	Jobs*	Labor Income	Value Added
Local				
Direct Impact	$32,649,666	343.4	$16,004,455	$19,512,486
Secondary Impact	$11,856,436	72.1	$3,340,574	$6,302,640
Total Impact	$44,506,103	415.4	$19,345,029	$25,815,126
State				
Direct Impact	$41,574,476	425.4	$23,642,913	$28,895,816
Secondary Impact	$38,696,162	202.4	$13,482,310	$21,872,119
Total Impact	$80,270,638	627.8	$37,125,223	$50,767,935
US				
Direct Impact	$48,508,890	594.9	$30,585,768	$34,074,409
Secondary Impact	$79,124,468	361.9	$25,059,885	$43,205,198
Total Impact	$127,633,359	956.7	$55,645,653	$77,279,607
* Jobs are presented in full-time equivalence (FTE). FY 2023 Price levels.				

US Army Corps
of Engineers ®
St. Paul District

Appendix J: Monitoring and Adaptive Management

Lower Pool 4 Big Lake
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Upper Mississippi River Restoration
Program

May 2024

Appendix J

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1 Introduction

The 1985 Supplemental Appropriations Act (Public Law 99-88) and Section 1103 of the Water Resources Development Act (WRDA) of 1986 (Public Law 99-662) authorized implementation of ecosystem restoration projects to ensure the coordinated development and enhancement of the Upper Mississippi River System (UMRS). Section 2039 of WRDA 2007, as amended, directs the Secretary of the Army directs the Secretary to ensure that, when conducting a feasibility study for a project (or component of a project) for ecosystem restoration, the recommended project includes a plan for monitoring the success of the ecosystem restoration. The monitoring plan shall include a description of: a. Types and number of restoration activities to be carried out; b. Physical actions to be undertaken to achieve project objectives; c. Functions and values that will result from the restoration plan; d. Monitoring activities to be carried out; e. Criteria for ecosystem restoration success; f. Estimated cost and duration of the monitoring; and g. A contingency plan for taking corrective actions in cases in which the monitoring demonstrates that restoration measures are not achieving ecological success in accordance with criteria described in the monitoring plan.. Applicable implementation guidance for Section 2039 is provided in CECW-P Memorandum, Subject: Implementation Guidance for Section 1161 of the Water Resources Development Act of 2016 (WRDA 2016), Completion of Ecosystem Restoration Projects, dated October 19, 2017

At the programmatic level, knowledge gained from monitoring one project can be applied to other projects. Opportunities for this type of adaptive management are common within the Upper Mississippi River Restoration (UMRR) Program. Using an adaptive management approach during project planning enabled better selection of appropriate design and operating scenarios to meet project objectives. Lessons learned in designing, constructing, and operating similar restoration projects within the UMRS have been incorporated into the planning and design of this HREP to ensure that the proposed plan represents the most effective design and operation to achieve the project goal and objectives.

This appendix outlines how the results of the project specific monitoring plan would be used to adaptively manage the project, including monitoring targets which demonstrate project success in meeting objectives. The intent of the project delivery team (PDT) was to develop monitoring and adaptive management actions appropriate for the project's goal and objectives.

Adaptive management provides a process for making decisions in the face of uncertainty. The primary incentive for implementing an adaptive management plan is to increase the likelihood of achieving desired project outcomes given the identified uncertainties, which can include incomplete description and understanding of relevant ecosystem structure and function; imprecise relationships among project actions and corresponding outcomes; engineering challenges in implementing project alternatives; and ambiguous management and decision-making processes. Additional uncertainties (i.e., scientific and technological) relating to the proposed project that were identified by the PDT included:

- Use of backwater habitat by broader range of species
- Inflow rates past closing structures and resulting water quality
- Sedimentation rates
- Presence and introduction of invasive species
- Future climate change (e.g., flood events, growing season lengths, ice cover, migration patterns, vegetation range shifts)
- Success of forest establishment
    - Resulting soil makeup on islands

- o Site specific inundation
- o Impacts of competing vegetation
- o Impacts of animal and insect herbivory

Adaptive management in the Big Lake HREP would involve iterative management decisions influenced by the results observed through monitoring. Actions of active adaptive management for the project may include the physical modification of project features and documentation of the changing conditions.

Specific tasks identified within this plan are either labeled "Monitoring" or "Adaptive Management." Monitoring activities assumes that specific tasks will be monitored to collect data and information but won't necessarily require further action. Adaptive management assumes that if an identified task is not meeting its desired performance criteria, as indicated through monitoring, that a follow up action may be implemented to improve the performance of a designed construction feature.

This Appendix is anticipated to be further revised for the Final Report. The monitoring plan is under review and discussion with natural resource agency partners.

2 Project Objectives

The Big Lake HREP has three primary objectives that project features are addressing. None of the objectives are directly in competition with each other within this project. These priorities include:

- Protect, enhance, restore, or create naturally regenerating, resilient, and diverse bottomland forest habitats.
- Maintain a balance of coverage and relative abundance of native emergent, rooted floating leaved, and submergent aquatic vegetation communities.
- Protect, enhance, restore, or create flowing channel habitats.
- Protect, enhance, restore, or create backwater habitats.

3 Performance Indicators

3.1 Floodplain Forest

Protect, enhance, restore, or create naturally regenerating, resilient, and diverse bottomland forest habitat.

Habitat Target A: Optimize habitat conditions conducive to healthy floodplain forest habitat. Increase tree species diversity, ensure regeneration in aging forest stands, improve forest structure, and increase forest coverage. Increase coverage of lowland hardwood forest, characterized by (but not limited to) oak species, hackberry, and possibly hickory. The discussion below focuses on shorter-term project success that will lead to the longer-term objective that extends over 50 years.

Within the Big Lake HREP there are six areas involving floodplain forest management. They are constructed features (island creation); F-Inv-2, major woody invasive control; F-Inv-1, minor woody invasive control; F-TSI-3, timber stand improvement and major woody invasive control; F-TSI-2, timber stand improvement and minor woody invasive control; F-Und-5, underplanting in greater than 50% closed canopy; F-Und-4, underplanting and minor woody invasive control in less than 50% closed canopy. Table J.1 provides a layout of what treatments will be performed in each area of interest and Figure J.1 provides a map of forest features within the project area. Each treatment performed has associated performance benchmarks described in Table J.2. In areas where multiple treatments are being performed benchmarks from both treatments must be met.

Forest management performance criteria will consist of key benchmarks related to the different treatments that are performed in each area delineated in the project plans. Some areas will have multiple treatments conducted within them leading to different performance criteria than a zone with only a singular treatment. Treatments include, underplanting seedlings to establish advanced regeneration under varying light conditions, invasive species controls, timber stand improvement (TSI) activities to promote less common species, competing vegetation reduction treatments to improve seedling success and traditional tree planting activities on newly constructed features for forest initiation. Each treatment will have different criteria of success (Table J.2) which when combined with other treatment success criteria will determine the effectiveness of habitat enhancement within a particular area. If benchmarks are not met adaptive management will be performed at the project partners and managers discretion. All criteria will be calculated as averages across the original treatment area, unless adaptive management occurs outside of the original treatment area, in which case the adaptive management areas would be included within the treatment area for evaluation.

Table J.1. Project areas and treatments being conducted in them

Project Area	**Acreage**	**Treatments**
F-Inv-2	39.4	Invasive Control
F-Inv-1	13.3	Invasive Control
F-TSI-3	12.4	TSI
F-TSI-2	35.2	TSI + Invasive Control
F-Und-5	18.7	Underplanting >50% canopy closure
F-Und-4	30.9	Underplanting <50% canopy closure + Invasive Control
Constructed Features	34.8	Forest Initiation

Figure J.1. Treatment area map, note areas including invasive species removal in their treatments have a crosshatching symbology.

Table J.2. Treatment Performance Benchmarks through time

Year following initial treatments	Forest Initiation	TSI	Invasive Control	Underplanting	
				>50% canopy closure	<50% canopy closure
1	• <10% cover of competing vegetation within a 2 foot radius of planted trees* • >1,200 stems per acre of natural and planted tree seedlings >6 inches tall • >100 stems per acre of natural and planted shrubs >6 inches tall • >600 stems per acre of planted trees >12 inches tall, condition code 1-5, FTG+ • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each	• Maintain at least 40 trees per acre of desirable masting species (hard and soft mast) to be free of overhead competition to increase their likelihood of becoming a dominant tree in the canopy	• 0% cover of invasive species	• <20% cover of competing vegetation within a 2 foot radius of planted trees* • >100 stems per acre of natural and planted seedlings >6 inches tall • >20 stems per acre of natural and planted shrubs >6 inches tall • >100 stems per acre of planted trees >12 inches tall, condition code 1-5, FTG+ • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each	• <20% cover of competing vegetation within a 2 foot radius of planted trees* • >400 stems per acre of natural and planted seedlings >6 inches tall • >100 stems per acre of natural and planted shrubs >6 inches tall • >300 stems per acre of planted trees >12 inches tall, condition code 1-5, FTG+ • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each
3	• <10% cover of competing vegetation within a 2 foot radius of planted trees* • >900 stems per acre of natural and planted tree seedlings >12 inches tall • >75 stems per acre of natural and planted shrubs >12 inches tall • >600 stems per acre of planted trees >36 inches tall, condition code 1-2, FTG+ • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each	• Maintain at least 40 trees per acre of desirable masting species (hard and soft mast) to be free of overhead competition to increase their likelihood of becoming a dominant tree in the canopy	• 0% cover of invasive species	• <30% cover of competing vegetation within a 2 foot radius of planted trees* • >80 stems per acre of natural and planted seedlings >12 inches tall • >20 stems per acre of natural and planted shrubs >12 inches tall • >80 stems per acre of planted trees >36 inches tall, condition code 1-2, FTG+ • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each	• <30% cover of competing vegetation within a 2 foot radius of planted trees* • >300 stems per acre of natural and planted seedlings >12 inches tall • >70 stems per acre of natural and planted shrubs >12 inches tall • >200 stems per acre of planted trees >36 inches tall, condition code 1-2, FTG+ • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each
6	• <30% cover of competing vegetation within a 2 foot radius of planted trees* • >500 stems per acre of natural and planted tree seedlings >54 inches tall	• Maintain at least 40 trees per acre of desirable masting species (hard and soft mast)	• 0% cover of invasive species	• <40% cover of competing vegetation within a 2 foot radius of planted trees* • >60 stems per acre of natural and planted	• <40% cover of competing vegetation within a 2 foot radius of planted trees* • >200 stems per acre of natural and planted seedlings >54 inches tall

	• >50 stems per acre of natural and planted shrubs >36 inches tall • >300 stems per acre of planted trees >60 inches tall, condition code 1-2, FTG[+] • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each	to be free of overhead competition to increase their likelihood of becoming a dominant tree in the canopy		seedlings >54 inches tall • >10 stems per acre of natural and planted shrubs >36 inches tall • >60 stems per acre of planted trees >60 inches tall, condition code 1-2, FTG[+] • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each	• >40 stems per acre of natural and planted shrubs >36 inches tall • >100 stems per acre of planted trees >60 inches tall, condition code 1-2, FTG[+] • 4 or more planted species capable of tolerating <20 days of inundation making up more than 10% of total stems each • 2 or more planted species capable of tolerating >20 days of inundation making up more than 10% of total stems each

**Competing vegetation is any vegetation that is shading or competing for growing space with a planted seedling. Competing vegetation can be native or non-native and is site dependent.*
[+]FTG=Free to grow; a seedling or small tree free from direct competition of other trees, shrubs, grasses and herbaceous plants

Performance Criteria A:

First growing season following final regeneration or invasive control treatment:
For invasive species control, the first growing season following the final treatment would be the growing season after the entire set of invasive control treatments have been completed. For example, common buckthorn control routinely requires an initial treatment with a follow-up treatment 2 growing seasons after the initial treatment and a second follow-up treatment 3 growing seasons after the initial treatment. Performance criteria in this case would only be assessed in the fourth growing season following the initial treatment.

For tree planting and competing vegetation control, assessments are made in the growing season immediately following planting, seeding or natural regeneration treatments, and/or vegetation control treatments.

For timber stand improvement treatments performance criteria will begin following release and establishment of the desired number of trees per acre.

Three years following final regeneration or invasive control treatment
By the third year following final treatments, the focus shifts to persistent control of invasives and the establishment and growth of regenerated seedlings. Some level of mortality is expected between the first growing season and year three, but remaining trees should be growing vigorously. Trees released during timber stand improvement activities should be starting to move towards the upper level of the canopy and expanding into the space provided them from release treatments.

Sixth year following final regeneration or invasive control treatment
In the sixth year following final treatments, criteria are focused on the permanence of initial measures. Targeted invasive species should be absent from the site, and regenerated trees and shrubs should be large enough and well enough established to thrive without further

management. Released trees should be in a position to become a co-dominant tree in the canopy. Sites that meet performance criteria at year six would be considered to be in a condition that requires no further management within the scope of the initial project.

Ninth year following final regeneration or invasive control treatment

If less than 75% of treatment areas do not meet target criteria in year six, an additional monitoring cycle will occur in year nine in those areas that did not meet year six targets. Year nine conditions will be assessed based on the year six targets. Sites that did not meet performance criteria at year six but do meet those criteria at year nine would be considered to be in a condition that requires no further management within the scope of the initial project. Sites that do not meet the criteria in year six or nine may be treated with additional measures if the team determines it is likely to be successful.

Task A1 – First Growing Season Regeneration Establishment and Growth and Invasive Species Control Status (Adaptive Management)

Regeneration surveys monitoring seedling survival and growth are standard in most large-scale tree planting programs, both within the Corps and in many public and private organizations throughout the country. Results from survival and establishment surveys will allow for modifications in planting plans to account for agents responsible for low seedling survival and growth as well as for mitigation measures to account for these stressors. They will also be used to determine areas where unfavorable weather conditions may have led to low restoration success. The results will also be used to inform any efforts required for replanting or repeating initial management actions.

For this project, regeneration surveys will be paired with invasive species control surveys as well as timber stand improvement stand walkthroughs and will occur in the first growing season following the final regeneration or invasive species control treatment (Task A1), as well as the third and sixth growing seasons following the final regeneration or invasive species control treatment (Task A2), or in the ninth growing season for sites that did not meet criteria in the sixth growing season.

Rationale: The first growing season following planting is a critical period to determine whether tree seedlings will become established. Low seedling survival may indicate deficiencies in planting procedures or seedling stock, the presence of significant site related stressors, or seedling-site incompatibility. Low seedling survival may also be a result of unfavorable weather conditions in the year of planting: hot, dry summers are very challenging for trees on newly built islands, while cool, wet summers are very challenging for trees on low elevation existing forest sites. Many events influencing seedling establishment and survival are hard to predict, so first growing season assessments are critical to allow for an immediate assessment of early establishment. For natural regeneration treatments in particular, seed production and site conditions can be variable from year to year and multiple treatment years may be necessary to capture conditions favorable to natural regeneration.

Methodology: All regeneration assessments will be made initially by observational walkthroughs. If initial walkthroughs indicate that treatments have not been successful, the formal regeneration survey methodology used by the MVP Environmental Stewardship Section Foresters and will involve high, medium and low intensity surveys as well as tally and stocking plots as defined in that protocol, depending on site objectives. The current protocol is attached to this appendix. The routes of the walkthroughs will be recorded with GPS and shapefiles will be created so that these routes can be shared with partners.

Due to the large potential acreage to be surveyed in a given year, stocking plots will be the primary plot type used with a small subset of survey plots (about 10%) implemented using higher intensity measurements. This protocol may be updated prior to assessments occurring, and the most current protocol will be used for surveys. Invasive species surveys will be conducted either by assessing average percent cover of invasive species in regeneration survey plots, by establishment of plots within the treatment area to specifically quantify percent cover of invasives, or via visual observation of percent cover of invasive species across the treatment area. Timber stand improvement stand walkthroughs will assess the number of released trees, and whether further release is warranted or if new trees need to be selected due to mortality.

When plot sampling is determined to be necessary, plots will be assigned by treatment area. In all treatment areas, between 0.5% and 1% of the total treatment area would ideally be sampled (see Table 1.3 in the attached regeneration survey protocol for the number of plots based on percent of area sampled). In treatment areas of less than 10 acres, no fewer than 10 plots and no more than 50 plots should be sampled, regardless of plot size. In treatment areas between 10 and 50 acres, no fewer than 25 plots and no more than 250 plots should be sampled. In treatment areas greater than 50 acres, no fewer than 50 plots and no more than 500 plots should be sampled. Actual plot sizes will be determined based on the required regen assessment for the treatment area.

Plots may be 1/100th or 1/1000th ac fixed area plots, 1/100th or 1/1000th ac tally plots, or density-distance transect plots (trees per acre calculated based on the distance of a tree from a point on a transect). All surveys will be summarized as the average number of trees per acre across the treatment area, or average invasive species cover across the treatment area based on the species-specific criteria in the criteria table above. Maps and tables summarizing the results in each treatment area will be produced.

Plot number and size will be optimized to the fullest extent practical, within the budget available.

Adaptive Management: If the average number of surviving trees, the percent cover of invasive species or competing vegetation prescribed for control, or the species diversity at the end of the first growing season are below the threshold for that area shown for the first growing season after final treatment, supplemental treatments will be needed to meet those thresholds for the first growing season (Table J.2).

Task A2 – Long-term (Growing Season 2-10) Seedling Survival and Growth (Adaptive Management)

Rationale: Initial seedling survival is critical, but seedlings cannot be considered to be successfully established on a site generally until they reach 4.5 feet (54 inches) in height and are mostly free from competition for light. Long-term seedling survival and growth and effective control of competing vegetation and woody invasives will be critical for determining whether the habitat enhancment effort was successful or not in establishing self-sustaining levels of forest regeneration and forest cover.

Methodology: The methodology for 1-year seedling survival and growth described above will also be used to assess long-term seedling survival and growth, though the timing will differ. For long-term seedling survival and growth, three surveys will be implemented. Surveys will be conducted for the entire area 3 years, 6 years and 10 years following project completion, using the methodology in task A1.

Adaptive Management: If the average number of surviving trees, the percent cover of invasive species or competing vegetation prescribed for control, lack of released trees in a suitable position to become dominant or co-dominant in the canopy or the species diversity in the third, sixth, or ninth year after the final treatment are below the threshold for that area shown for the first growing season after final treatment, supplemental treatments may be needed to meet those thresholds.

If the desired results of Task A1 and A2 do not meet the performance criteria, the Corps and project sponsor will reevaluate the criteria to determine whether actual conditions are still acceptable and, if not, to determine the best ways to meet those criteria. See Section 7 (Contingency Planning and Project Modification) for more information on the formal process of handling adaptive management.

3.2 Aquatic vegetation

Maintain a balance of coverage and relative abundance of native emergent, rooted floating leaved, and submersed aquatic vegetation communities.

Performance Criteria B:
Maintain the relative aerial coverage of native emergent, rooted floating leaved, and submersed aquatic vegetation communities post-project, compared to pre-project. A pre-project survey will be performed to set baseline conditions prior to construction. The acreages of vegetation types will be quantified for the project area, as well as adjacent control sites. Post-project surveys will then be performed to verify changes to the floral community. Surveys will be performed in both test and control sites to verify whether changes may be due to the project, or broader environmental conditions.

If bathymetry surveys are performed, as outlined below, agency partners will assess the relative change and discuss whether adaptive management actions are necessary. Given the large variability in sedimentation rates, and limited knowledge of existing sedimentation rates, specific bathymetry criteria will not be established.

Task B1 – Vegetation Assessment
Rationale B1: This assessment will help determine vegetation changes in Big Lake over time, to include the conversion of submerged aquatic vegetation (e.g., wild celery) to emergent aquatic vegetation (e.g., wild rice).

Methodology: The specific methods will be refined during the design and construction phase. However, analysis of aquatic vegetation change over time will be done with aerial imagery analysis. This will likely be performed by the USGS Upper Mississippi Environmental Sciences Center (UMESC). They would follow methodology similar to that they have recently used for aerial imagery analysis of the UMR floodplain (e.g., 2020 LCU data). This has included the following collected via drone:

- 4-band imagery (RGB + Near Infrared [~720 nm]). If multiple cameras are used, they need to have near the same resolution per pixel. Likely create a 3-band RGB mosaic and a complimentary 3-band CIR mosaic.
- 30.5 cm/pixel or better resolution.
- 30% side lap and 60% forward lap on all imagery (excluding the edges)
- Collected with global (not rolling) shutter camera(s)
- Camera flight data with per frame IMU data required for 3D processing

It is assumed that 900 acres will be surveyed. This will include test areas in Big Lake, as well as adjacent control areas. The specific locations of these sites will be identified prior to photo collection.

Task B2 – Topographic/Bathymetric Survey (Monitoring)
Rationale B2: Topobathy surveys will provide information to assess the effects of sedimentation in Big Lake. These are a lower priority item and will only be performed if USACE or partner agency staff have time and equipment available in future years.

Methodology: Collect topographic/bathymetric information to define the geometry of select areas of Big Lake. Focus areas will be D-O-1. The delta area of Catfish Slough are also a potential focus area. Perform this immediately prior to construction, and again 10 years post construction. Additional surveys further in the future (e.g., 25 years post construction) may provide further insight into long-term change, but are beyond the scope of this appendix.

Adaptive Management: If vegetation surveys identify broad conversion of aquatic celery to wild rice, and/or the topobathy surveys identify large loss of desired water depth, the interagency team will consider design modifications that would achieve the desired conditions. This could include upgrades to the sediment deflector, or other actions. Any AM related to sediment transport would be completed using USACE adaptive management funds, not sponsor O&M funds.

3.3 Sidechannel Habitat

Protect, enhance, restore, or create flowing channel habitats.

Performance Criteria C:
While this was an objective of the project, features to improve sidechannel habitat were not identified for implementation. However, rock features associated with erosion protection and the sediment deflector will provide some level of habitat features. These benefits will likely vary by season, flow conditions, etc. Agency partners had an interest in a fisheries assessment of these features and are volunteering to perform this action. Specific performance criteria have not been set. However, fisheries sampling results will be compared pre- and post-project, as well as between test and control areas, to at least generally understand potential differences in fish use of sidechannel areas as a result of rock features of the project.

Task C1 – Lotic Fish Assessment
Rationale C1: This assessment will help determine changes to the fish community in Catfish Slough as a result of rock features constructed to meet parallel project objectives.

Methodology: USACE will meet with USFWS, Wisconsin DNR and Minnesota DNR during Plans and Specs to verify the approach. The preliminary plan is for sampling via traditional boom electroshocker with sampling occurring the full length of Catfish Slough, from the sediment deflector to lower Big Lake, with an emphasis of the rock features of the project. Fisheries sampling will be conducted in an adjacent side channel control site. This could be Indian Slough, or a side channel near adjacent Robinson Lake. To the extent possible, sampling will be done twice pre-project, and twice post-project. One sampling event will be done on/around June 1st of each sampling period. The exact performance criteria will be discussed, but will likely include a comparison of species composition or community metrics, to include observations of rare fish or indicator species for rare species/communities.

Adaptive Management: None planned as project features did not directly target improvement of lotic sidechannel habitat..

3.4 Backwater Aquatic Habitat

Protect, enhance, restore, or create backwater habitats.

The draft conceptual models developed as part of Upper Mississippi River System Ecosystem Restoration Objectives report (2009) provide a variety of recommendations on performance criteria for evaluating and planning lentic fish habitat restoration. The specific criteria were developed based on the experiences of State and Federal fishery biologists as to what would be desirable to provide suitable habitat for backwater fish species.

Habitat Target D1: Increase aerial coverage of overwintering habitat areas.

Performance Criteria D:
a) Immediately after project construction, overwintering sites meet the following criteria:
  Depth: Cordwood: At least 6 acres that are 8 feet deep or greater, and 15 acres that are 4 feet or greater, inclusive of the 8 foot area. Ice Haul: 4 acres that are 8 feet deep or greater, and 11 acres that are 4 feet or greater, inclusive of the 8 foot area. We expect 40% of the dredged area to be dredged to 8 feet.
  Winter DO levels as measured at mid-depth: greater than 5mg/l
  Water temperature (winter): >1 C^0 over 75% area
  Winter current velocity less than 0.3 cm/sec over 80% of the backwater area.
  Water residence time of 5-15 days.

b) b) Within 10 years post-construction, achieve good to excellent lentic fish habitat to yield fixed site electro-fishing catch per unit effort of age 1 plus fish in overwintering sites.

- Fair - Good:
  - 100 to 200 bluegills/hour –or–
  - 50 to 100 largemouth bass/hour
- Good - Excellent:
  - 200 to 300 bluegills/hour –or–
  - 100 to 150 largemouth bass/hour
- Excellent:
  - More than 300 bluegills/hour –or–
  - More than 150 largemouth bass/hour

Task D1** – **Overwintering Site Mapping (Monitoring)

Rationale D1: This assessment will evaluate the effectiveness of project features to create overwintering fish habitat.

Methodology: A detailed map of overwintering sites meeting the depth criteria within the study area will be developed showing pre- and post-construction depths. Pre- and post-construction maps will be based on post construction surveys. Focus or priority for assessing the depth criteria will be given to D-O-1 as this is the area targeted for habitat dredging.

Figure K-1: Overwintering site locations evaluated during feasibility. Backwater areas improved through the Recommended Plan, and evaluated through this methodology include D-O-1, Big Lake and Thatcher's overwintering sites. D-O-3 is not a part of the Recommended and will not be evaluated under this plan.

Task D2 – Water Quality Sampling (Adaptive Management)
Rationale D2: The combination of these conditions are believed to be critical for defining fish overwintering sites.

Methodology: As funds are available, or as partner agencies are able, monitoring will be conducted in designated fish overwintering areas treated by the project during winter months. For hand measurements, the partner agencies will develop a sampling map based on the postconstruction bathymetry from task B1 to effectively and efficiently sample the overwintering areas. Midwinter data will be recorded using hand instruments for DO, temperature, and water velocity. DO and temperature will be collected at 0.2M below the ice, mid-depth, and 0.2M above the bottom, water velocity will be measured 0.2M below the ice. Flow data will be collected to determine whether water residence targets were achieved. Alternatively, continuous data recorders also may be deployed with periodic hand monitoring to verify logger observations. If instrumentation is not sensitive enough to detect current velocities of 0.01 feet per second, surrogate measures will be used (e.g., temperature). This data may be supplemented using data loggers that record temperature throughout the winter season. A dye study or the use of soluble materials (e.g., gypsum) may also be considered to detect flux and the presence of eddies. Assessments will be done in the years 2, 5, and 10, post-construction. Products will include maps showing sampling and dye study locations with associated sample results.

Adaptive Management: If overwintering areas are not meeting water quality criteria, the interagency team will consider design modifications that would achieve the desired conditions. Any m AM for overwintering sites would be completed using USACE adaptive management funds, not sponsor O&M funds.

Task D3 – Late Fall Electrofishing Surveys (Monitoring)
Rationale D3: Electrofishing has been an effective sampling method in the past for HREP overwintering features and can help to verify a biological response to the physical changes brought on by the project. A number of fish species congregate in locations that will serve as overwintering areas prior to ice-over conditions. This staging behavior occurs annually in the fall when water temperatures drop in the main channel below 10° C. Sampling after these temperatures have been reached can increase the likelihood of capturing fish usage and can help managers determine if additional measures should be taken to achieve the desired biological response.

Methodology: Standard boat electrofishing surveys will be conducted after fish stage to overwintering sites during late fall, when main channel water temperatures are below 10° C. Surveys will be conducted in treatment sites. Metrics will include number of fish catch-per-unit effort and size distribution. Electrofishing surveys will be conducted semi-annually by partner agencies for a period of 10 years or more. Summary reports and a five year summary report that includes all data for all species will be provided by the end of February following year 5 monitoring.

Adaptive Management: Year 6 will have a target of the “good to excellent” catch per unit effort criteria. If overwintering areas are not meeting CPUE criteria, the interagency team will consider design modifications that would achieve the desired conditions. Any AM overwintering sites would be completed using USACE adaptive management funds, not sponsor O&M funds.

Task D4 – Summer Fisheries Surveys
Rationale B4: USFWS has expressed an interest in understanding benefits of backwater improvement to species of management of concern. These include, but are not limited to, rare species and/or species of special management concern for State agencies. This effort is to try and document how improvement to backwater area D-O-1 benefits these communities. For this task, specific criteria will be developed in the future with additional collaboration.

Methodology: USACE will meet with USFWS, Wisconsin DNR and Minnesota DNR during Plans and Specs development to identify either a) specific species to sample for, or 2) indicator species that may be easier to sample in place of rare species that are difficult to collect and study. A fisheries sampling plan will be developed to evaluate response by these species/communities. This will potentially use alternative gear types to traditional electrofishing.

Preliminary discussions indicated that gears such as backpack shockers, mini fyke nets or sweep nets may provide alternative gear types to traditional electrofishing with a boom shocker. Fisheries sampling will be conducted in D-O-1 as well as at least one control sites. To the extent possible, sampling will be done twice pre-project, and twice post-project. Sampling will be done on/around June 1st and August 15th. The exact performance criteria will be discussed, but will likely include a comparison of species composition or community metrics, to include observations of rare fish or indicator species for rare species/communities.

Adaptive Management: Adaptive management measures won't be tied to this methodology.

4 Monitoring Schedule Summary

Table K-4. Monitoring Schedule Summary.

Task	Activity	Lead Agency	Years	USACE cost per event	Number of events	Total USACE Cost
A1	Tree and Invasive Monitoring	USACE	1, 3, 6	50,000	3	$150,000
B1	Aquatic Veg	USACE	TBD	$39,000	3	$117,000
B2	Topo/Bath Survey	DNRs/USACE	1, 10	0	2	0
C1	Summer Lotic Electrofish	MnDNR	2 pre- 2 post-	0	TBD	0
D1	Post-Con Surveys	USACE	1	0	1	0
D2	WQ Sampling	WiDNR	2, 5, 10	NA	3	N/A
D3	Fall Electrofish	WiDNR	2 pre- 2 post-	0	TBD	0
D4	Summer Backwater Fish	USACE	2 pre- 2 post-	$12,500	8	$101,000
	Total					**$368,000**

*Costs for B1 Aquatic Bathy are rolled into C2, Topo/Bath Survey. They will be done concurrently.

5 Monitoring and Adaptive Management Budget

5.1 Monitoring

Information collected from the monitoring tasks depicted in table 4-1 would be used to analyze the success of the of the project. If necessary, adaptive management would be used if monitoring results do not meet the criteria depicted for each task. This could include modification of existing project features, or new features constructed as part of a separate project. For budgeting purposes, the approximate overall cost for monitoring is set at 1% of total cost, or about $368,000 over the 10-year monitoring period, with all the individual tasks itemized above.

5.2 Adaptive Management

Adaptive management measures would be implemented if monitoring tasks indicate there is a need based on performance criteria. If project features are not meeting given habitat criteria, the adaptive management actions would depend on which parameters are not being met. The cost to address deficiencies in the habitat features depends on the root cause of the problem and is difficult to estimate. Active adaptive management actions for the project could include replanting trees and control of invasive species and other vegetation that competes with trees if performance criteria are not met. It could include altering the elevation of control structures that influence flow into identified backwaters. It could also be adjustments to the sediment deflector to alter sediment loading to Big Lake. For budgeting purposes, a budget for adaptive management is set at 3% of construction cost, which is about $1.1M. The actual adaptive management cost may be higher or lower.

6 Monitoring Roles and Responsibilities

USACE will lead the forest monitoring, the mapping of overwintering sites based on post-construction surveys, and the summer backwater fish evaluation.

Agency partners would lead the water quality sampling, lotic sidechannel electrofishing and late fall electrofishing at overwintering sites. Note that this project location is unique in that it is located in a trend pool of the LTRM Program for the UMRR. As such, this monitoring plan will be collaborated with members of that program to integrate project monitoring with the routine activities that field staff perform in lower Pool 4. Monitoring will be as fully integrated as possible to allow comparison of project data with other locations over time to maximize understanding of physical and biological trends and whether those trends are due to the project, or are more reflective of broader conditions in lower Pool 4.

7 Contingency Planning and Project Modification

Monitoring will verify the effectiveness of restoration actions, as well as rates of future sedimentation. Monitoring activities, including review of results, will be performed collaboratively between USACE and the agency partners. If restoration features are not performing as they should, the agency partners will work with the Corps to identify what can be done to rectify remaining issues through adaptive management.

8 Project Close Out

Close-out of the project would occur when the level of success of the project is determined adequate or when the maximum 10-year monitoring period has been reached. The level of success would be based on the extent to which the performance criteria have been or will be met based upon the trends for the site conditions and processes.

Additionally, project close-out will include technology transfer. This includes the dissemination of project monitoring results, analyses performed, management decisions made (Adaptive Management features or adjustments), and lessons learned. Technology transfer will occur via publications, presentations and discussions with LTRM and stakeholders, among others.

9 References

USACE, 2009. Upper Mississippi River System Ecosystem Restoration Objectives Report https://www.mvr.usace.army.mil/Portals/48/docs/Environmental/UMRR/UMRR_Ecosystem_Restoration_Objectives_2009.pdf

10 Regeneration Survey Protocol

USACE-MVP Forest Regeneration Survey Protocols, Field
Forester: A. Meier

Date: 8/4/2022

Version: 2.3

10.1 Protocols for All Surveys

10.1.1 Field Procedures

10.1.1.1 Field Equipment

- Field data collector with data dictionary and background images loaded
- Clipboard and pencil with printed datasheets (as backup)
- Site maps, preferably with planting location and orientation indicated
- Copy of original planting prescription
- Copy of monitoring prescription
- For medium intensity planting and natural regen/direct seeding surveys: height pole (can be fabricated) with marks at 1 ft., 3.72 ft. and 4.5 ft.
- For high intensity planting surveys: height pole with 1/10 foot or inch gradations
- For high intensity planting surveys: micro-dbh tape or caliper
- Logger’s tape with distance in feet on one side of the tape

10.1.2 Row Plantings

10.1.2.1 Field Equipment

- Field data collector with data dictionary and background images loaded
- Clipboard and pencil with printed datasheets (as backup)
- Site maps, preferably with planting location and orientation indicated
- Copy of original planting prescription
- For medium intensity surveys: height pole (can be fabricated) with marks at 1 ft., 3.72 ft. and 4.5 ft.
- For high intensity surveys: height pole with 1/10 foot or inch gradations
- Logger’s tape with distance in feet on one side of the tape
- Micro-dbh tape or calipers

10.1.2.2 Sampling approach

Background and data files produced in the office should be loaded onto a field GPS unit prior to leaving the office. Once in the field, follow the steps below to collect regen data:

Step 1: In the field, determine the orientation of the planting rows that you will be sampling and sample the entire planting based on this orientation. Rows may be north-south, east-west or at other bearings. Based on your selection of orientation, identify the random point nearest to the extreme corner of the planting (e.g., for a north-south planting, this would be the point closest to the northwest corner) as your first transect point. Navigate to that point, but do not worry about being exactly on the point.

Step 2: Once you have arrived at the point, look around you for the nearest planted tree. The nearest planted tree will be the first tree measured in the transect. A quick determination of the closest tree is all that is needed. Open the regen data dictionary, select the appropriate feature class (low, medium or high intensity survey) and record data for this tree.

Step 3: Once data has been collected on the first tree, continue sampling along the transect in the direction of travel, until the total number of trees per transect have been surveyed, as described in Table 1 below. The orientation of travel should remain the same as determined in Step 1, however, you may travel in either of the two cardinal directions to complete transects (i.e., in a north-south planting, transects may be completed either going north or going south, but should not be completed in an east to west orientation). It is very important to stop at each point along a transect based on the spacing of the planting and make a record of no trees in planting locations that are empty. Diagram A1 in Appendix A provides a visual representation of transect layout.

Step 4 Once the final tree has been surveyed in the transect, proceed to the nearest random point at which a transect has not been completed. Follow Steps 2 and 3 to complete the next and all subsequent transects[1].

10.1.2.3 Data collection protocols

Data should be collecting for the variables described below in Table 2.

Table 10-1. Descriptions of tree seedling measurements for row planting and random planting surveys.		
Field: ***PointTrans#***	Data type: text	Survey: All
The number of the point or transect at which tree data is collected. This number should increase sequentially with 1 being the first plot or transect sampled in a given area. This number should reset to 1 with each new survey area, but should not be duplicated within a survey area.		
Field: ***AutoID***	Data type: numeric (auto)	Survey: All
An ID number, assigned automatically to each data point collected. No data entry is required for this value.		
Field: ***TR_SP***	Data type: menu	Survey: All
Tree species, from the provided pick list. If no tree is present in the planting spot, select “no tree” from the pick list. No more data needs to be collected at the point.		
Field: ***DBH***	Data type: numeric	Survey: High Intensity
Diameter of tree at breast height. Default value is 0. For trees less than 4.5 feet tall, no data should be entered and the default value should be retained.		
Field: ***Height***	Data type: numeric	Survey: High Intensity
Total height assessed to the highest living point on the tree and perpendicular to the ground. Measurements on leaning trees should not be taken along the trunk.		
Field: ***HT_CL***[2]	Data type: menu	Survey: Medium, High Intensity
Height class assessed to the highest living point on the tree and perpendicular to the ground. Measurements on leaning trees should not be taken along the trunk.		

Height	< 2 ft. tall	2-4.5 ft. tall	4.5-10 ft tall	>10 ft tall
DD Code	< 2 ft. tall	2-4.5 ft. tall	4.5-10 ft tall	>10 ft tall
GIS Code	0	1	2	3

Field: ***COND***	Data type: menu	Survey: Medium, High Intensity

[1] If a random point falls within the transect established for another random point, a second transect should begin immediately after the first transect rather than discarding the point.
[2] HT class was adjusted from <1 ft tall and 1-4.5 ft tall in 2021 because 2 ft. tall is a better indicator of establishment than 1 ft tall.

Tree condition based on whether the tree is alive, declining or dead, the amount of growth of the most recent fully developed annual leader, and the presence or absence of basal sprouts.

Condition	Alive					Declining		Dead
Branch dieback	<10%					>10%		100%
New growth	> 6"		1" - 6"		< 1"	NA	NA	NA
Dom. leader	Present	None	Present	None	NA	NA	NA	NA
Sprouts	NA	NA	NA	NA	NA	None	Numerous	None
DD Code	A,>6", DomL	A,>6", NoDom	A,1-6",Dom	A,1-6",NoDom	A<1",NoDom	Dec,>10%DBack, NoSpr	Dec,>10%DBack, Sprout	Dead
GIS Code	1	2	3	4	5	6	7	0

Field: ***Browse***	Data type: menu	Survey: Medium, High Intensity

The percent of tree branches showing evidence of animal browsing. Default value is <10%

Branches browsed	0%	<10%	10-25%	25-50%	>50%
DD Code	0%	<10%	10-25%	25-50%	>50%
GIS Code	0	1		2	3

Field: ***Shelter***[a]	Data type: menu	Survey: Medium, High Intensity

The percent of tree branches showing evidence of animal browsing.

Shelter present	No shelter	Shelter present			
Shelter upright	NA	Yes			No
Seedling height above shelter	NA	> 1ft	< 1ft	Not above	NA
DD Code	NoShelter	ShelterUp, >1'Above	ShelterUp, <1'Above	ShelterUp, NotAbove	ShelterDown
Code	0	1	2	3	4

[a] If no shelters are present in the planting, leave this field blank

Field: ***Comment***	Data type: text	Survey: All

Miscellaneous comments, with a maximum length of 50 characters.

Field: ***Date***	Data type: Date (auto)	Survey: All

Date of data collection, assigned automatically to each data point collected. No data entry is required for this value.

Field: ***Time***	Data type: Time (auto)	Survey: All

Time of data collection, assigned automatically to each data point collected. No data entry is required for this value.

10.1.3 Random Plantings

10.1.3.1 Sampling approach

Background and data files produced in the office be loaded onto a field GPS unit prior to leaving the office. Once in the field, follow the steps below to collect regen data:

Step 1: In the field, navigate to the first of the random or grid points. Do not worry about being exactly on the point.

Step 2: Open the regen data dictionary, select the appropriate feature class (low, medium or high intensity survey), and record data for a 1/100th ac (11.8 ft. radius) plot. There may be no planted trees or multiple planted trees in a plot. If no trees are present, record this in the TR_SP field and move on to the next plot. If multiple trees are present in the plot, make sure to use the same PointTrans# for the plot.

Step 3: Upon completion of the first plot, move on to the second plot, selecting the plot nearest to the current plot. Continue through Steps 2 and 3 until data for all plots has been collected.

10.1.3.2 Data collection protocols

Data should be collected for the variables described above and in Table 2. Only trees that can reasonably be judged to have been planted should be measured. Do not record any natural regeneration unless specified in the monitoring prescription. If natural regeneration monitoring is required, follow protocols in the natural regeneration section below.

10.1.4 Natural Regeneration/Direct Seeding

10.1.4.1 Sampling approach

Background and data files produced in the office should be loaded onto a field GPS unit prior to leaving the office. Once in the field, follow the steps below to collect regen data:

Step 1: In the field, navigate to the first of the random or grid points. Do not worry about being exactly on the point.

Step 2: Open the regen data dictionary, select the appropriate feature class (stocking or tally survey), and record data for a 1/1000th ac (3.7 ft. radius) plot, measuring trees according to the appropriate natural regeneration plot protocol (described below).

Step 3: Upon completion of the first plot, move on to the second plot, selecting the plot nearest to the current plot. Continue through Steps 1-3 until data for all plots has been collected.

10.1.4.2 Data collection protocols

<u>Stocking plots</u>

For stocking plots, only the most dominant tree in the plot is recorded. All other trees are ignored. Shrubs may be recorded if they are the most dominant woody stem in the plot. Vines should not be recorded. Presence or absence of invasive plants will also be recorded. Specific data to be collected is described below in Table 3.

<u>Tally plots</u>

For tally surveys, all woody stems >1 ft tall but < 4" dbh will be measured in each plot by height class and species. Woody stems <1 ft tall will be tallied by species and categorized by number (<10 stems, 10-25 stems, 25-50 stems, > 50 stems). Presence or absence of invasive plants will also be recorded. Specific data to be collected is described below in Table 3.

Table 10-2. Descriptions of tree seedling measurements for stocking and tally natural regeneration and direct seeding surveys.

Field: ***PointTrans#***	Data type: text	Survey: All

The number of the point or transect at which tree data is collected. This number should increase sequentially with 1 being the first plot or transect sampled in a given area. This number should reset to 1 with each new survey area, but should not be duplicated within a survey area.

Field: ***AutoID***	Data type: numeric (auto)	Survey: All

An ID number, assigned automatically to each data point collected. No data entry is required for this value.

Field: ***TR_SP***	Data type: menu	Survey: All

Tree species, from the provided pick list. If no tree is present in the survey spot, select "no tree" from the pick list. No more data needs to be collected at the point.

Field: ***HT_CL***[3]	Data type: menu	Survey: Medium, High Intensity

Height class assessed to the highest living point on the tree and perpendicular to the ground. Measurements on leaning trees should not be taken along the trunk.

Height	< 2 ft. tall	2-4.5 ft. tall	4.5-10 ft tall	>10 ft tall
DD Code	< 2 ft. tall	2-4.5 ft. tall	4.5-10 ft tall	>10 ft tall
GIS Code	0	1	2	3

Field: ***<2 ft Count***	Data type: menu	Survey: Tally

Count of total stems <2 ft tall, by species. Value should be assessed with a quick visual estimate.

Stems	<10	10-25	25-50	>50	No stems
DD Code	< 2 ft, <10 stems	< 2ft, 10-25 stems	<2 ft, 25-50 stems	<1 ft, >50 stems	<2 ft, no stems
GIS Code	1	2	3	4	NS

Field: ***Large stem tally***	Data type: menu	Survey: Tally

Tally of the total number of stems by size class that are greater than 1 foot tall. There may be multiple records for each species within each plot, though tallies for each combination of species and height class should be unique. Data is presented as a pick list of values from 1 to 50. If values of greater than 50 occur, note >50 and do not count any more stems.

Field: ***Browse***	Data type: menu	Survey: Medium, High Intensity

The percent of tree branches (stocking plots) or percent of trees in each species and size class (tally plots) showing evidence of animal browsing. Default value is <10%.

Branches browsed	0%	<10%	10-25%	25-50%	>50%
DD Code	0%	<10%	10-25%	25-50%	>50%
GIS Code	0	1		2	3

Field: ***INV***	Data type: menu	Survey: All

Field to record presence of common invasives within the plot. Note other species in comments.

Field: ***Comment***	Data type: text	Survey: All

Miscellaneous comments, with a maximum length of 50 characters.

Field: ***Date***	Data type: Date (auto)	Survey: All

Date of data collection, assigned automatically to each data point collected. No data entry is required.

Field: ***Time***	Data type: Time (auto)	Survey: All

Time of data collection, assigned automatically to each data point collected. No data entry is required.

Table 10-3. Number of sampling plots by acres and % sampling

Acres	100	% Area Sampled			
		10%	5%	1%	0.50%
Plot area (ac)	0.02	500	250	50	25
	0.01	1000	500	100	50
	0.004	2500	1250	250	125
	0.002	5000	2500	500	250
	0.001333	7500	3750	750	375
	0.001	10000	5000	1000	500

Acres	50	% Area Sampled			
		10%	5%	1%	0.50%
Plot area (ac)	0.02	250	125	25	12.5
	0.01	500	250	50	25
	0.004	1250	625	125	62.5
	0.002	2500	1250	250	125
	0.001333	3750	1875	375	187.5
	0.001	5000	2500	500	250

Acres	25	% Area Sampled			
		10%	5%	1%	0.50%
Plot area (ac)	0.02	125	62.5	12.5	6.25
	0.01	250	125	25	12.5
	0.004	625	312.5	62.5	31.25
	0.002	1250	625	125	62.5
	0.001333	1875	937.5	187.5	93.75
	0.001	2500	1250	250	125

Acres	10	% Area Sampled			
		10%	5%	1%	0.50%
Plot area (ac)	0.02	50	25	5	2.5
	0.01	100	50	10	5
	0.004	250	125	25	12.5
	0.002	500	250	50	25
	0.001333	750	375	75	37.5
	0.001	1000	500	100	50

[3] HT class was adjusted from <1 ft tall and 1-4.5 ft tall in 2021 because 2 ft. tall is a better indicator of establishment than 1 ft tall.

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Appendix K: Memorandum of Agreement

Lower Pool 4 Big Lake

Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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MEMORANDUM OF AGREEMENT BETWEEN THE UNITED STATES FISH AND WILDLIFE SERVICE AND THE DEPARTMENT OF THE ARMY FOR ENHANCING FISH AND WILDLIFE RESOURCES OF THE UPPER MISSISSIPPI RIVER SYSTEM BIG LAKE HREP

1 PURPOSE

The purpose of this memorandum of agreement (MOA) is to establish the relationships, arrangements, and general procedures under which the U.S. Fish and Wildlife Service (USFWS) and the Department of the Army (DOA) will operate in constructing, operating, maintaining, repairing, and rehabilitating the project for enhancement of fish and wildlife resources at Big Lake HREP (the "Big Lake project") under the Upper Mississippi River Restoration (UMRR) Program.

2 BACKGROUND

Section 1103 of the Water Resources Development Act (WRDA) of 1986, Public Law 99-662, as amended (33 U.S.C. 652) authorizes construction of measures for the purpose of enhancing fish and wildlife resources in the Upper Mississippi River System. The project area is managed by the USFWS and is on land managed as part of the Upper Mississippi River National Wildlife and Fish Refuge. Under Section 906(e) of the WRDA of 1986, Public Law 99-662 as amended (33.U.S.C. 2283(e), all construction costs of those fish and wildlife features for the Big Lake project are 100 percent Federal, and pursuant to 33 U.S.C. 652, all costs of operation and maintenance for the Big Lake project are 100 percent Federal.

3 GENERAL SCOPE

The project to be accomplished pursuant to this MOA would increase the quality and extent of floodplain forest habitat and expand overwintering habitat within the Big Lake area resulting in a gain of 147 average annual habitat units. Work includes access and overwintering dredging, a sediment deflector, four island features, four shoreline stabilization features, six rock closures, and nonstructural forest management actions.

4 RESPONSIBILITIES

A. DOA is responsible for:

1. Construction. Construction of the project features to include necessary stabilization and vegetation measures.

2. Major Rehabilitation. The Federal share of any rehabilitation of the project mutually agreed to by the DOA and the USFWS that exceeds the annual operation and maintenance requirements identified in the Integrated Feasibility Report and Environmental Assessment for the Big Lake Habitat Rehabilitation and Enhancement Project dated DATE ("Feasibility Report"), and that is needed as a result of a specific storm or flood event.

3. Construction Management. Subject to and using funds appropriated by the Congress of the United States, and in accordance with 33 U.S.C. 652 and 33 U.S.C. 2283(e), DOA will construct the project as described in the Feasibility Report applying those procedures usually followed or applied in Federal projects, pursuant to Federal laws, regulations, and policies. The USFWS will be afforded the opportunity to review and comment on modifications and amendments to the extent practicable. If the DOA encounters potential delays related to construction of the project, the DOA will promptly notify USFWS of such delays.

4. Maintenance of Records. The DOA will keep books, records, documents, and other evidence pertaining to costs and expenses incurred in connection with construction of the project to the extent and in such detail as will properly reflect total costs. The DOA shall maintain such books, records, documents, and other evidence for a minimum of three years after completion of construction of the project and resolution of all relevant claims arising therefrom, and shall make available at its offices, at reasonable times, such books, records, documents, and other evidence for inspection and audit by authorized representatives of the USFWS.

B. USFWS is responsible for:

Operation, Maintenance, and Repair: Upon completion of construction as determined by the District Engineer, St. Paul, the USFWS shall accept the project and shall operate, maintain, and repair the project as defined in the Feasibility Report, in accordance with 33 U.S.C. 652. Upon completion of construction, the DOA will develop an Operation and Maintenance Manual for the project and will provide the Manual to USFWS prior to transfer of the project to the USFWS.

5 MODIFICATION AND TERMINATION

This MOA may be modified or terminated at any time by mutual agreement of the parties. Any such modification or termination must be in writing. Unless otherwise modified or terminated, this MOA shall remain in effect for a period of no more than 50 years after initiation of construction of the project.

6 REPRESENTATIVES

The following individuals or their designated representatives shall have authority to act under this MOA for their respective parties.

USFWS: Regional Director U.S. Fish and Wildlife Service 5600 American Boulevard West, Suite 990 Bloomington, Minnesota 55437

DOA: District Engineer U.S. Army Corps of Engineers, St. Paul District 332 Minnesota Street, Suite E1500 St. Paul, Minnesota 55101

7 EFFECTIVE DATE OF MOA

This MOA shall become effective when signed by the appropriate representatives of both parties.

BY:

Eric R. Swenson, Ph.D.
Colonel
Commanding Engineer
US Army Corps of Engineers, St. Paul District

DATE: ___________________

BY:

Will Meeks
Regional Director
U.S. Fish and Wildlife Service Region 3

DATE: ___________________

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St. Paul District

Appendix L: Plates

Lower Pool 4 Big Lake Habitat Rehabilitation and Enhancement Project Feasibility Report and Integrated Environmental Assessment

Upper Mississippi River Restoration Program

May 2024

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Appendix L: Plates

TABLE OF CONTENTS

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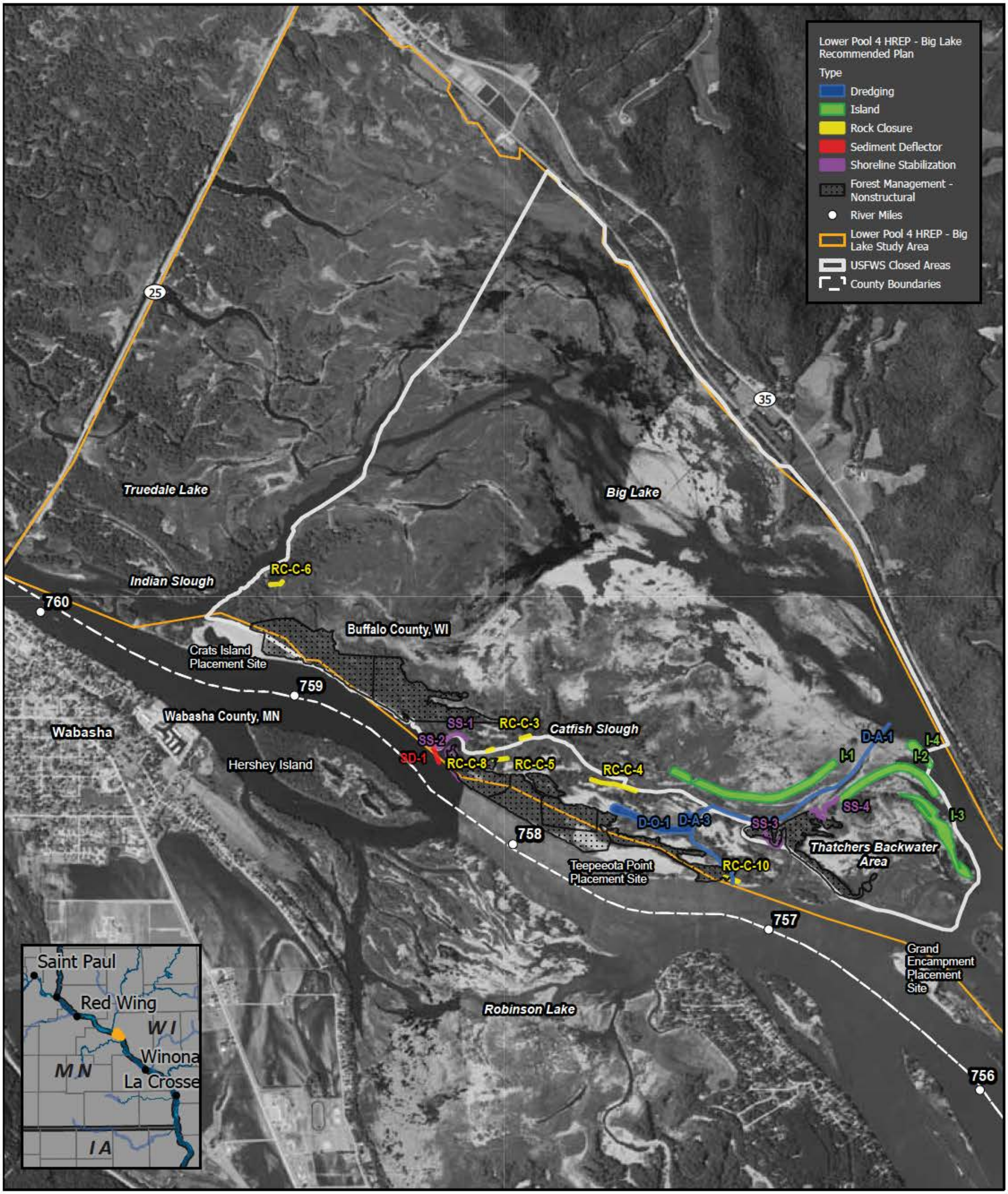

St. Paul District
GIS CENTER

US Army Corps of Engineers ®

Lower Pool 4 HREP | Big Lake | Recommended Plan Overview

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

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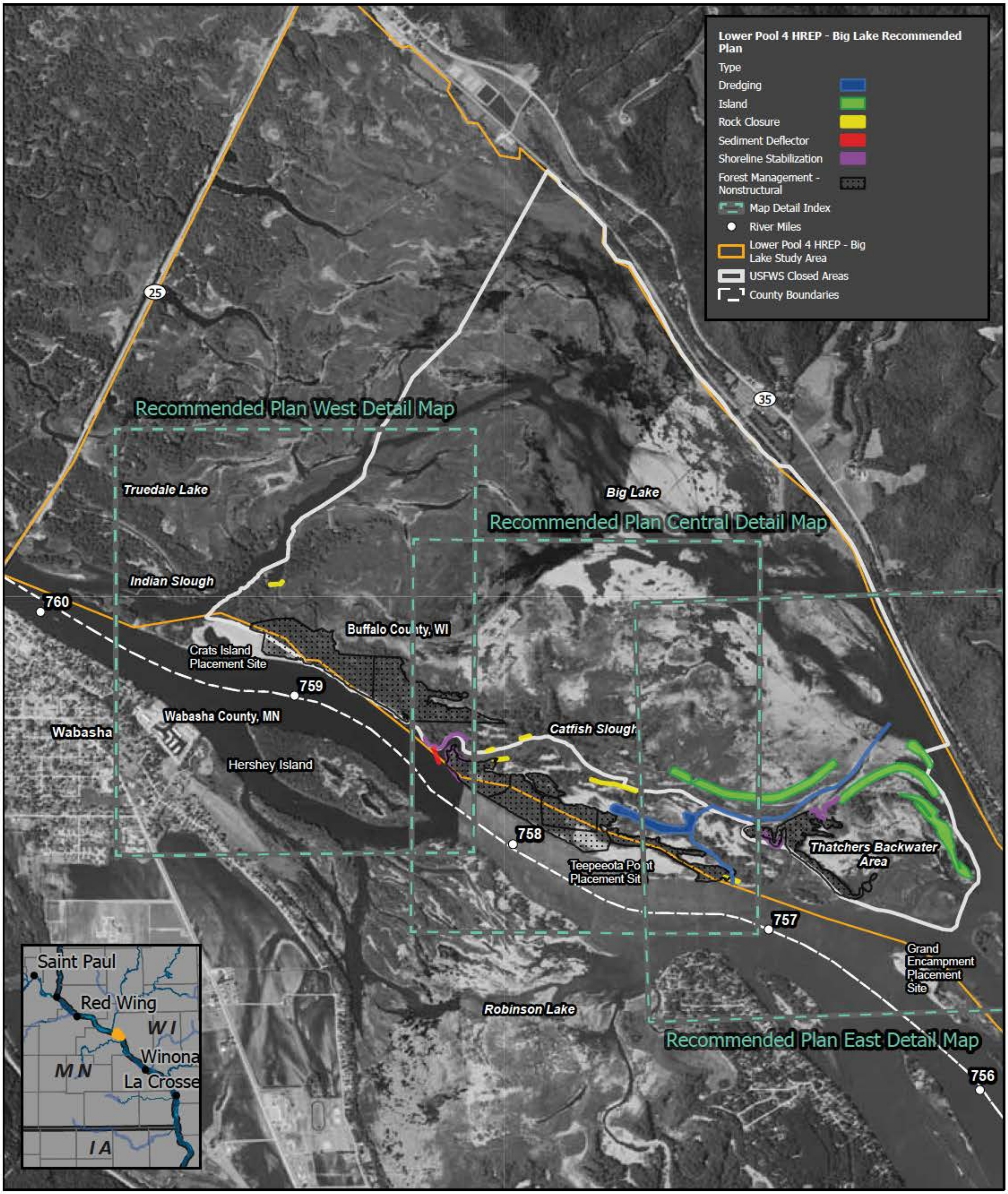

St. Paul District GIS CENTER

US Army Corps of Engineers®

Lower Pool 4 HREP | Big Lake | Recommended Plan Index Map

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

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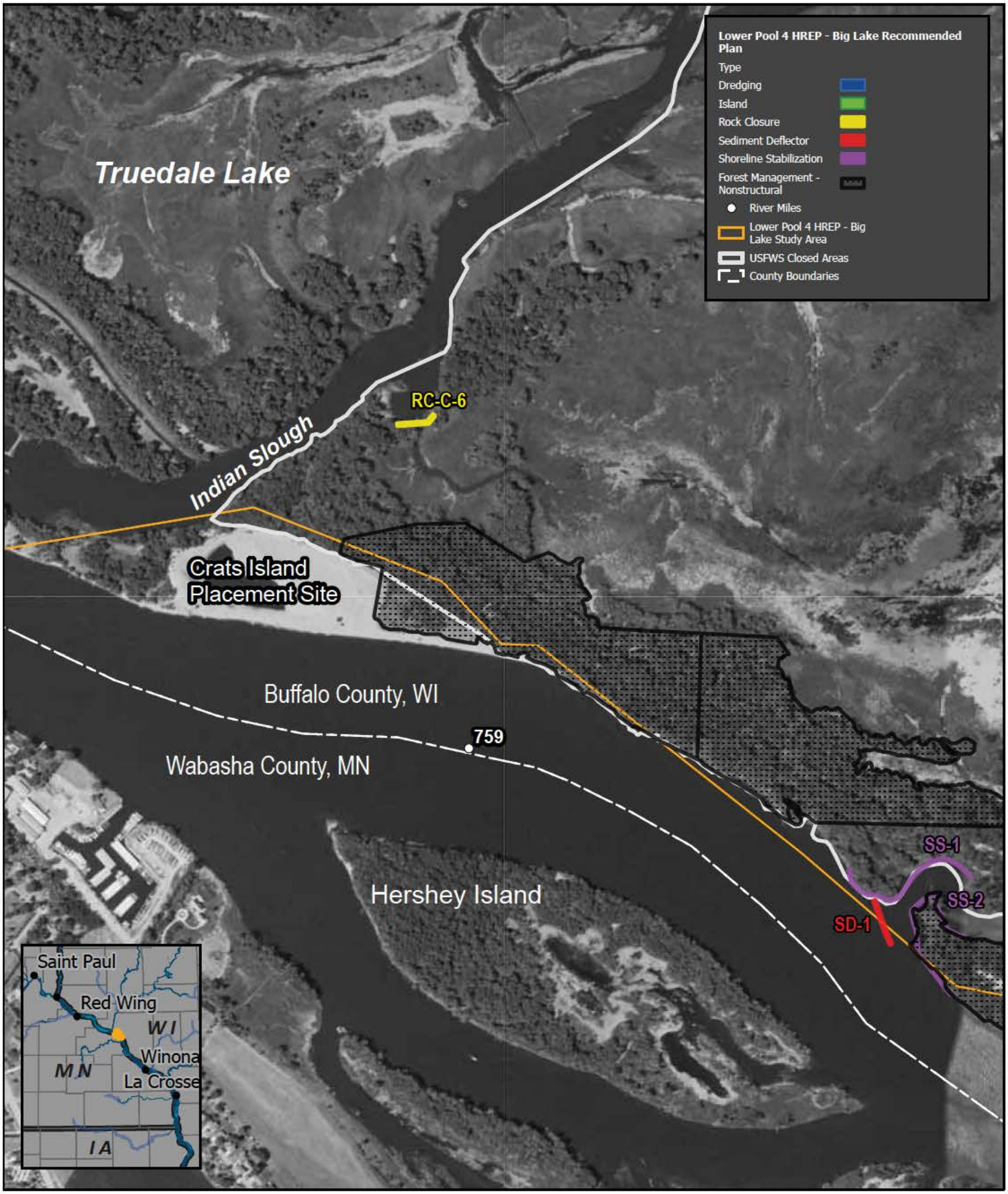

St. Paul District GIS CENTER

US Army Corps of Engineers®

Lower Pool 4 HREP | Big Lake | Recommended Plan | West Detail

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 1,200 2,400 Feet

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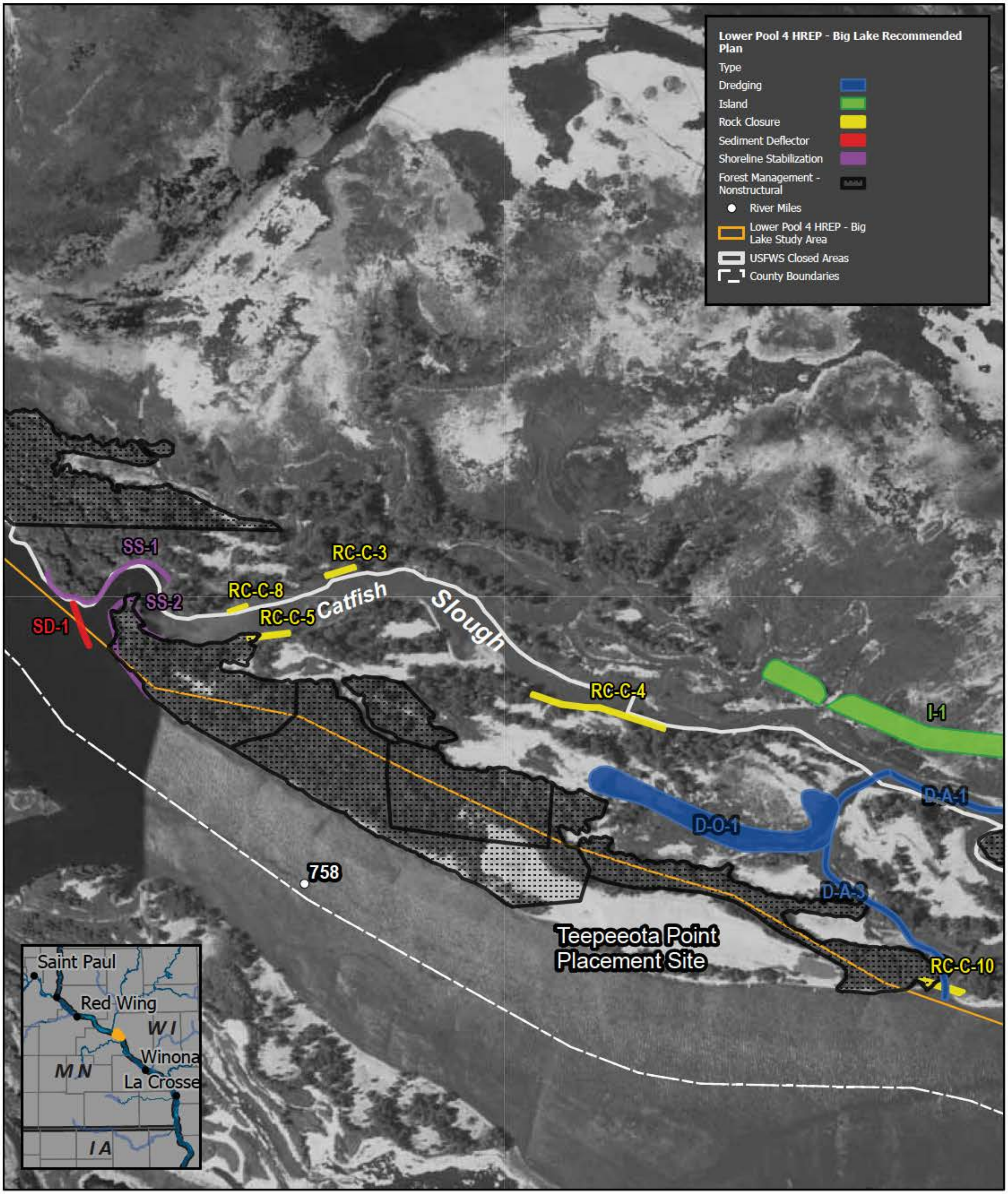

St. Paul District GIS CENTER

US Army Corps of Engineers ®

Lower Pool 4 HREP | Big Lake | Recommended Plan | Central Detail

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 1,200 2,400 Feet

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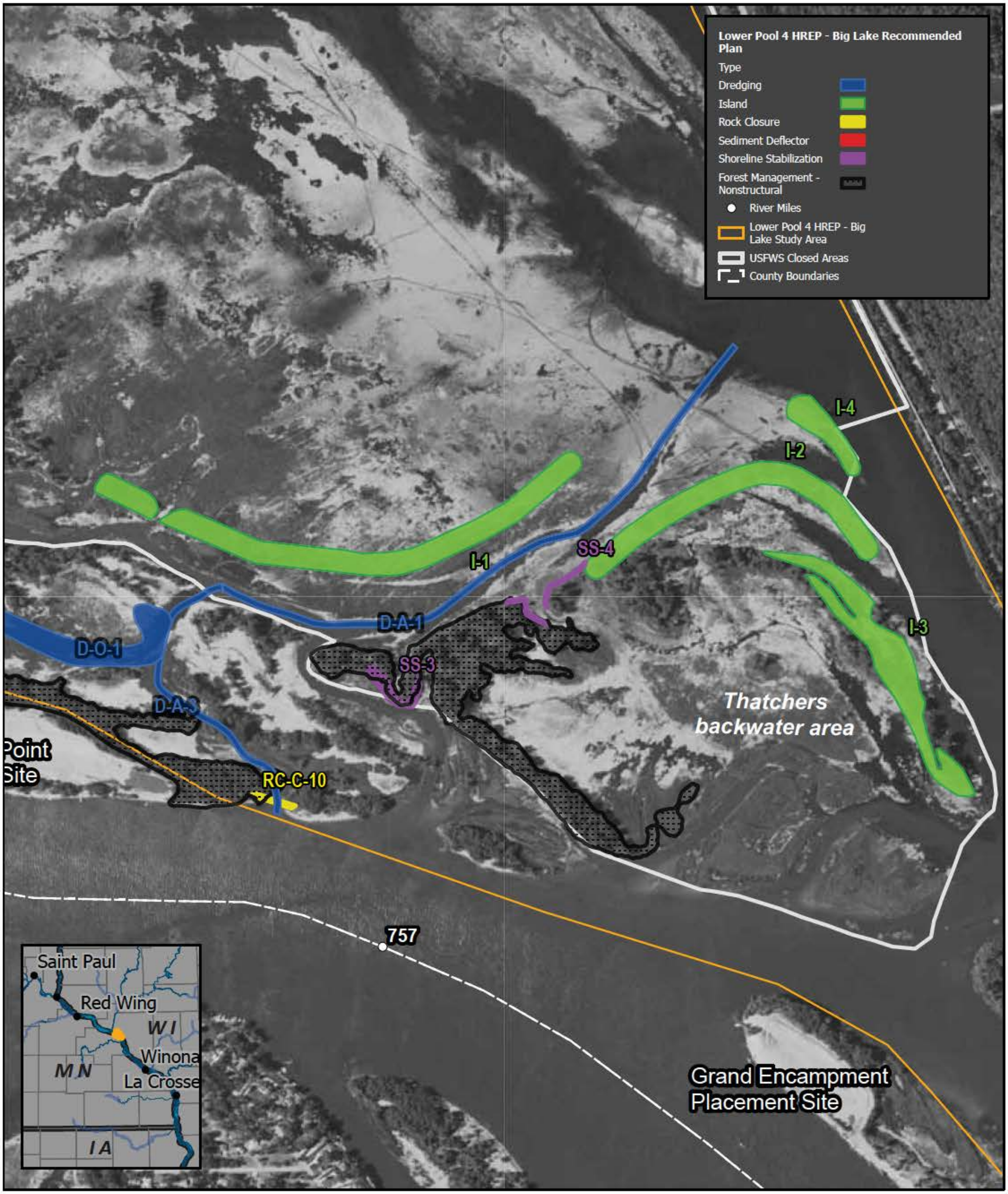

St. Paul District GIS CENTER

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Lower Pool 4 HREP | Big Lake | Recommended Plan | East Detail

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 1,200 2,400 Feet

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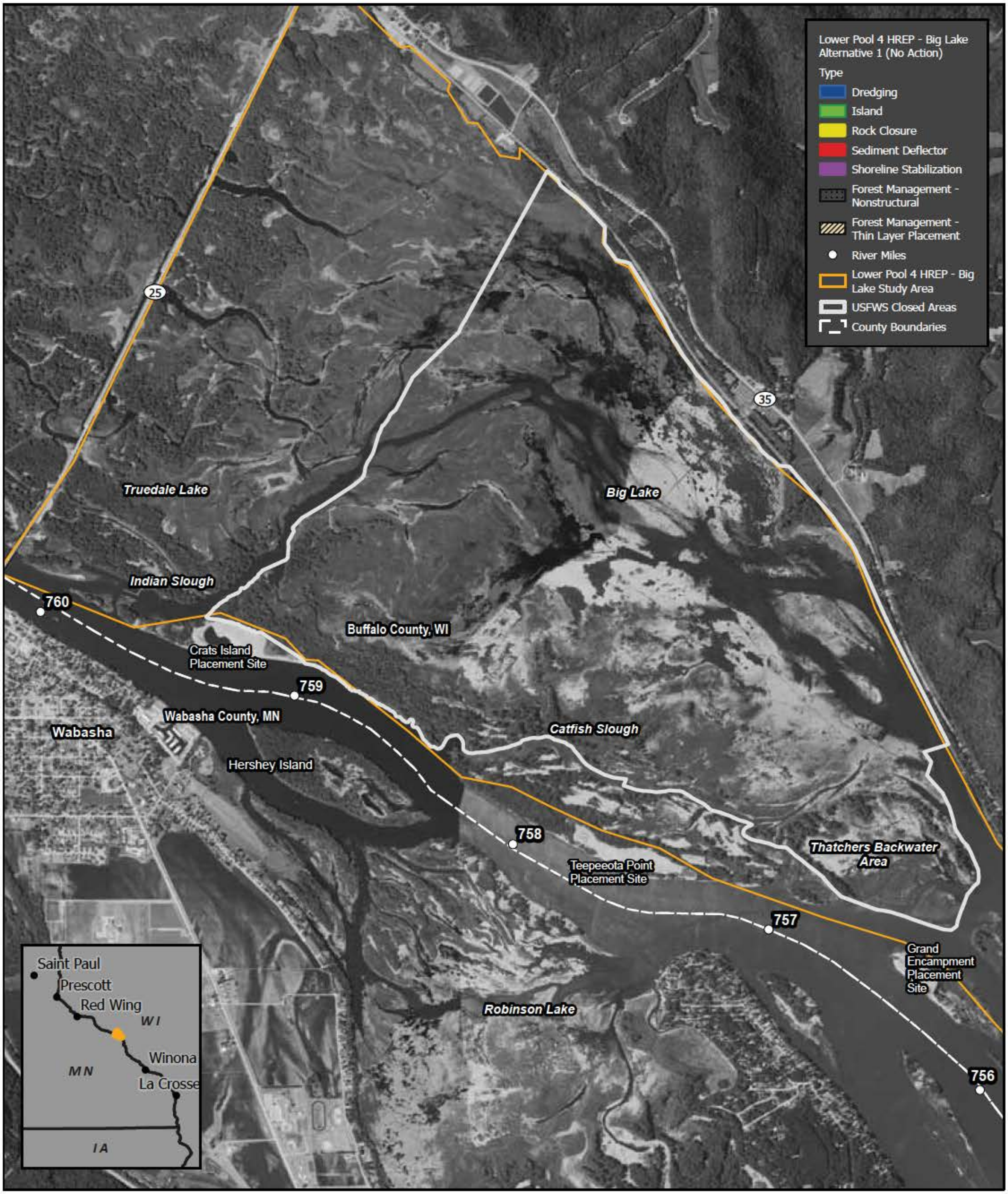

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Lower Pool 4 HREP | Big Lake | Alternative 1 (No Action)

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

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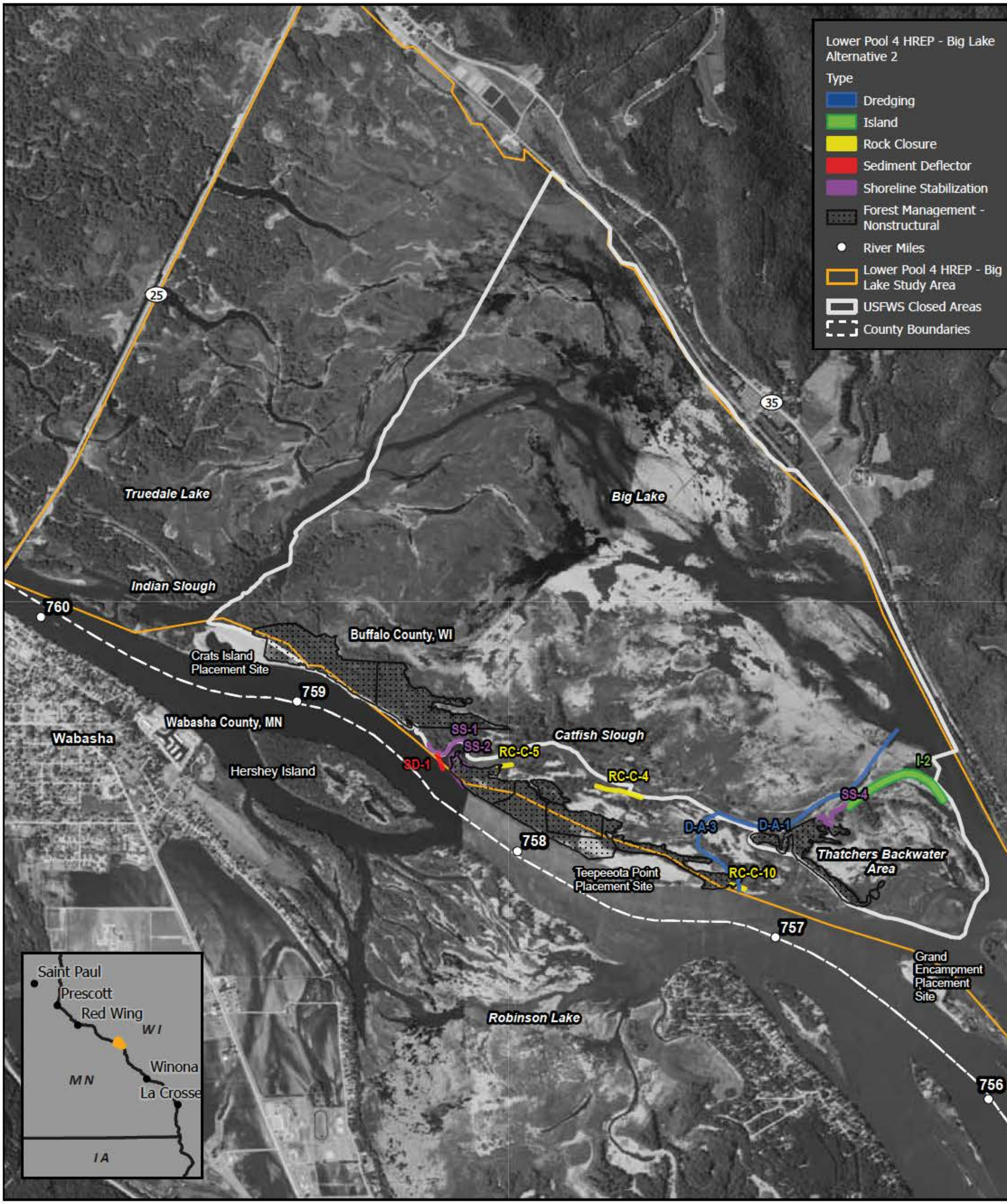

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Lower Pool 4 HREP | Big Lake | Alternative 2

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

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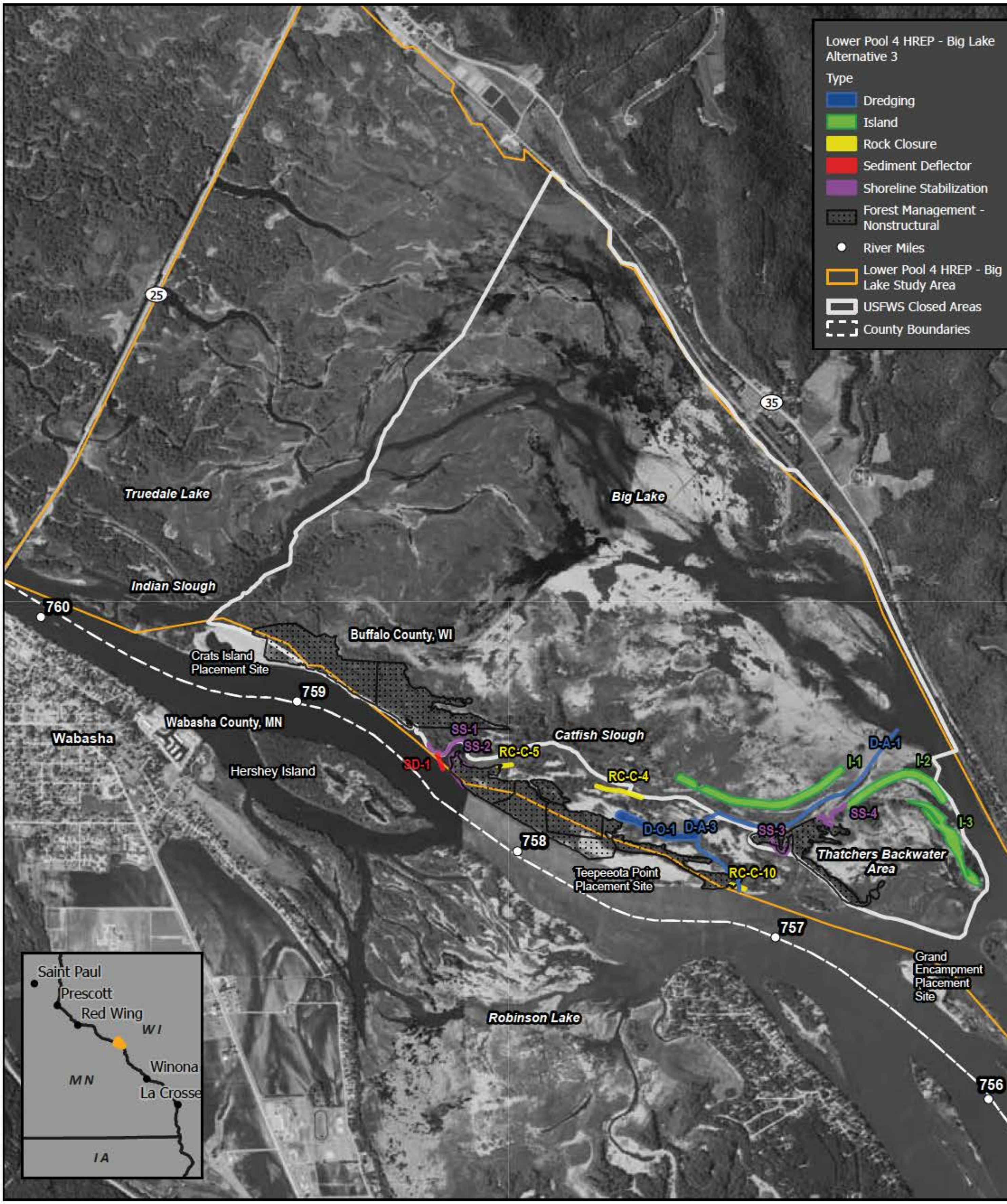

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Lower Pool 4 HREP | Big Lake | Alternative 3

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjb8 9/29/2023 10:50 AM
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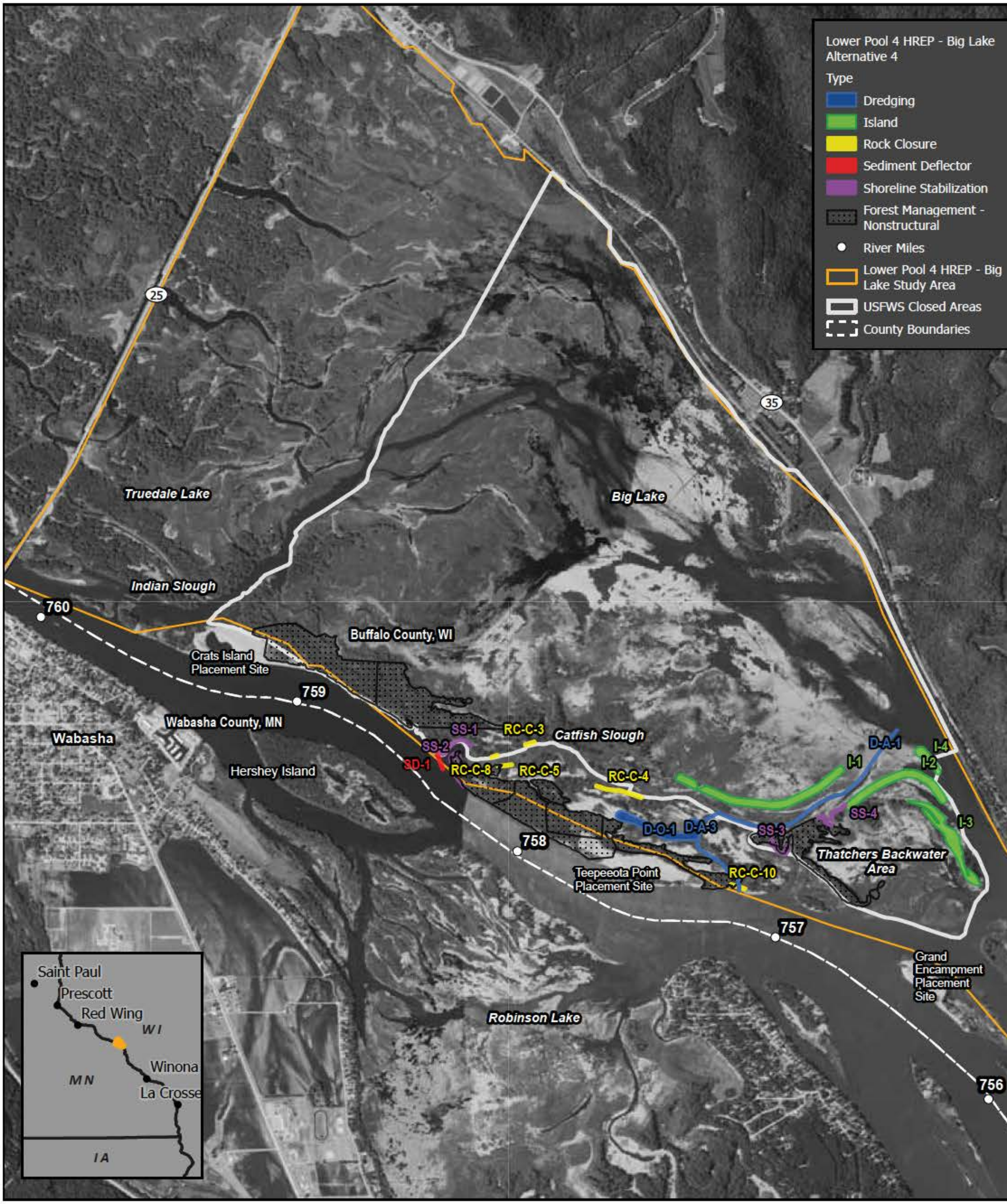

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Lower Pool 4 HREP | Big Lake | Alternative 4

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjh8 9/29/2023 10:52 AM
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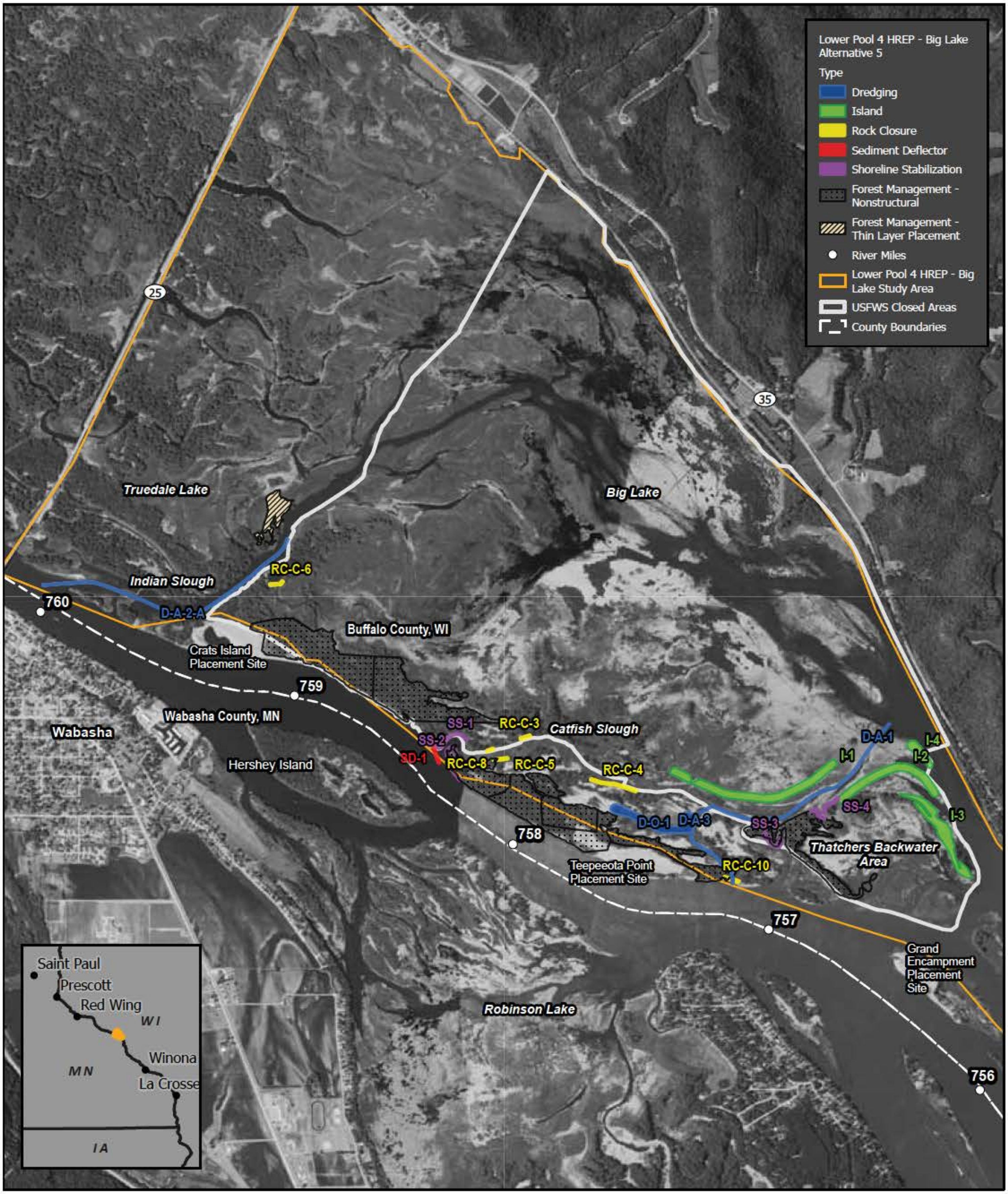

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Lower Pool 4 HREP | Big Lake | Alternative 5

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjh8 9/29/2023 10:30 AM
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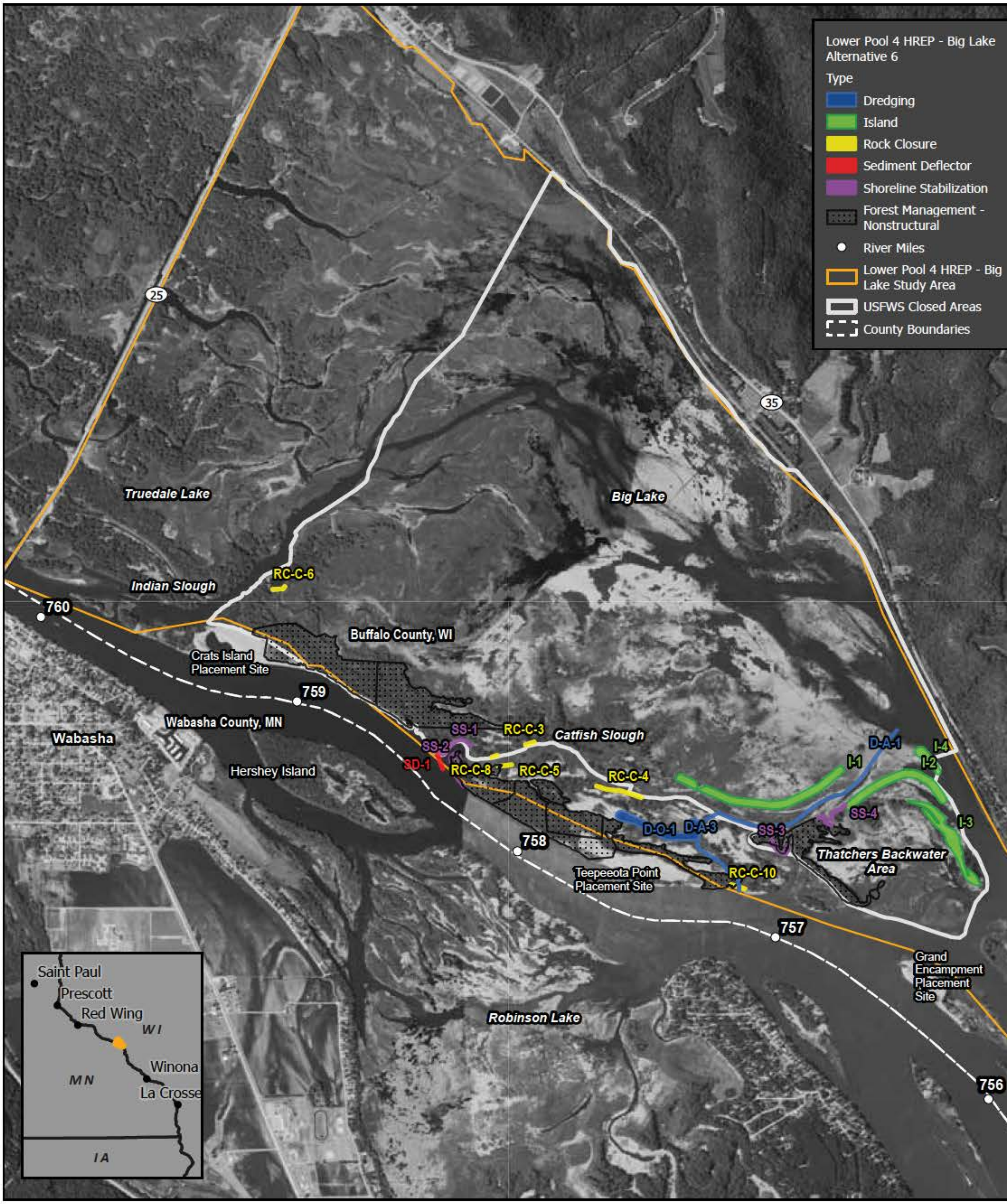

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Lower Pool 4 HREP | Big Lake | Alternative 6

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjh8 9/29/2023 10:55 AM
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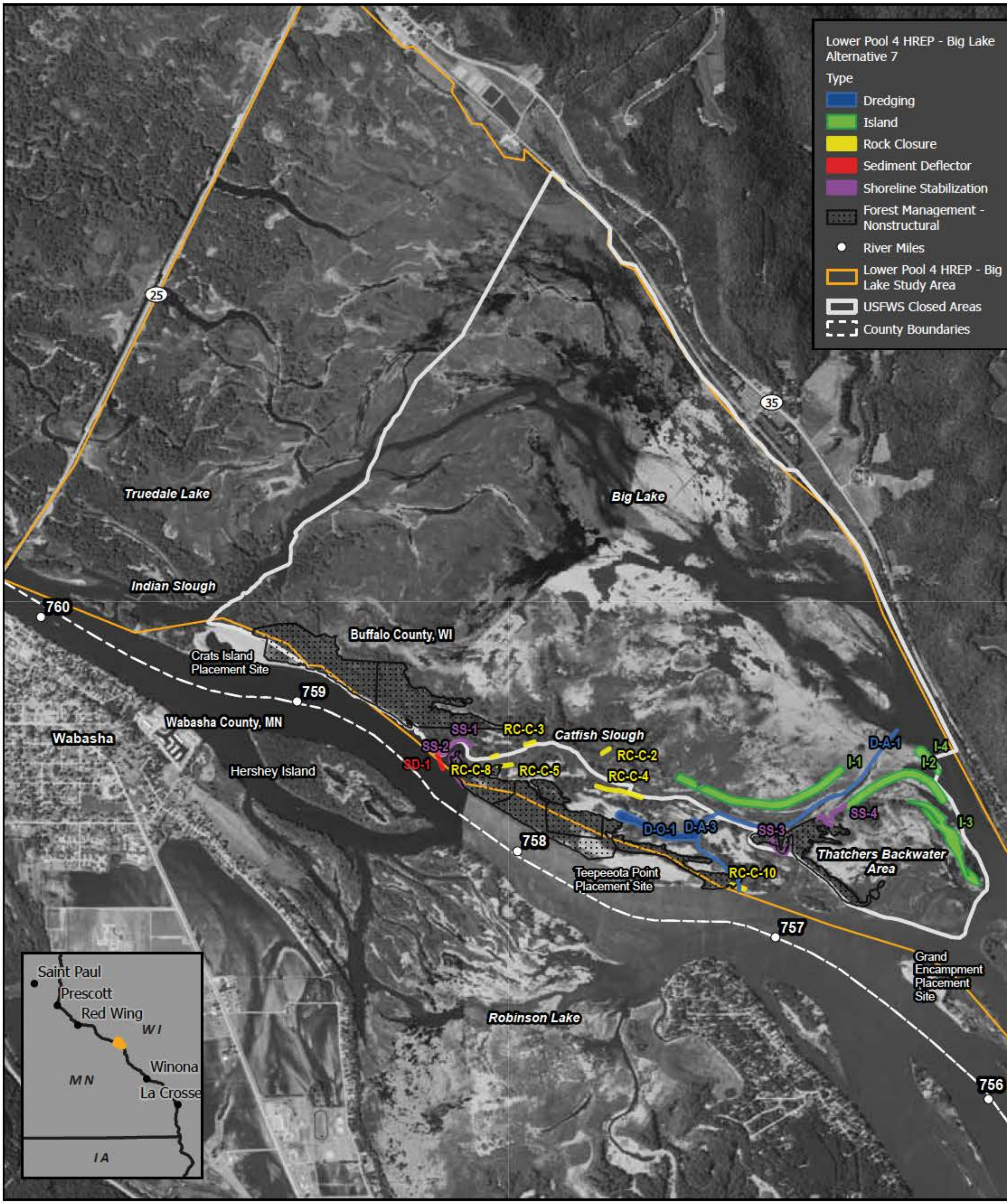

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Lower Pool 4 HREP | Big Lake | Alternative 7

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjh8 9/29/2023 10:57 AM
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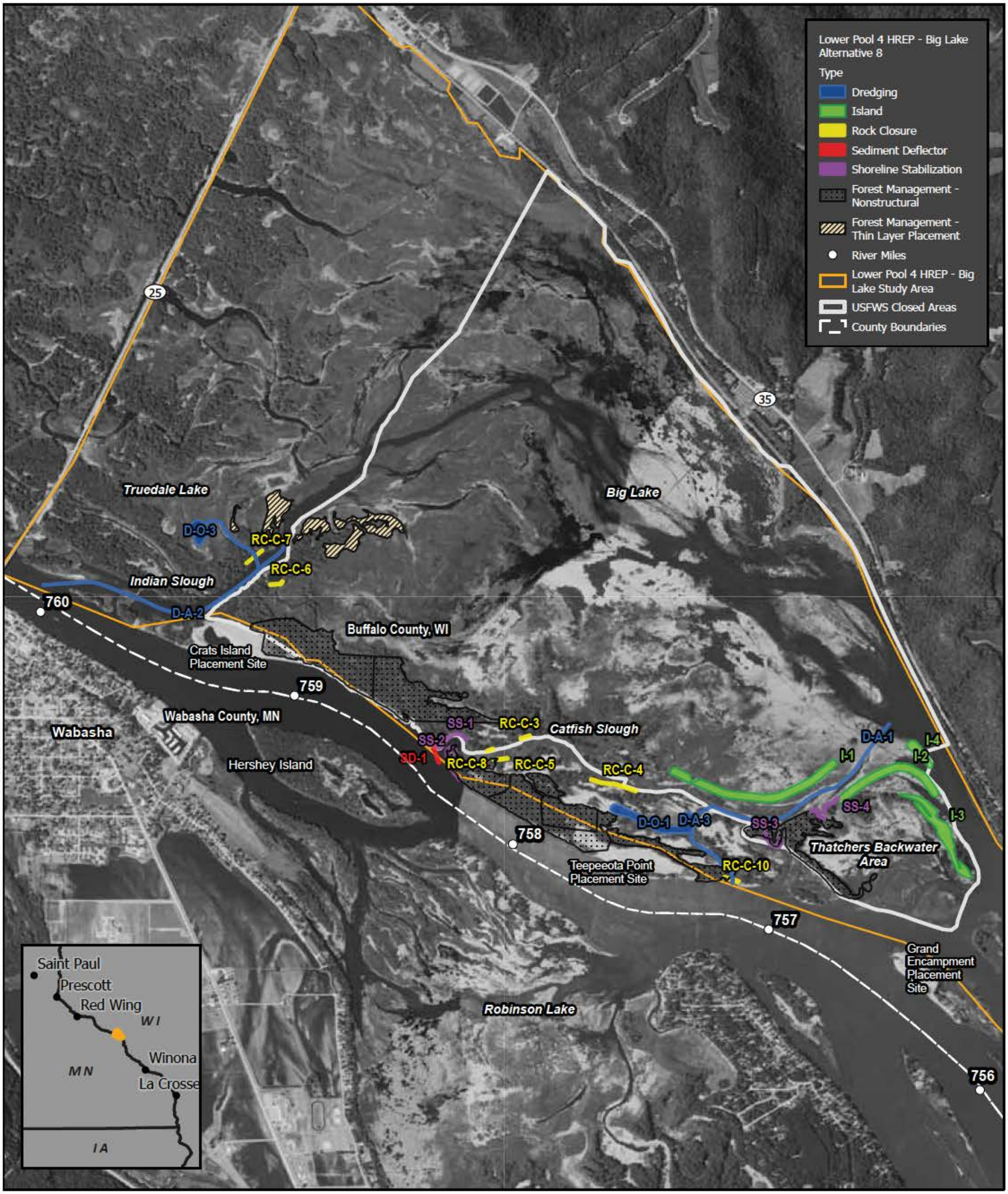

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Lower Pool 4 HREP | Big Lake | Alternative 8

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjh8 9/29/2023 10:25 AM
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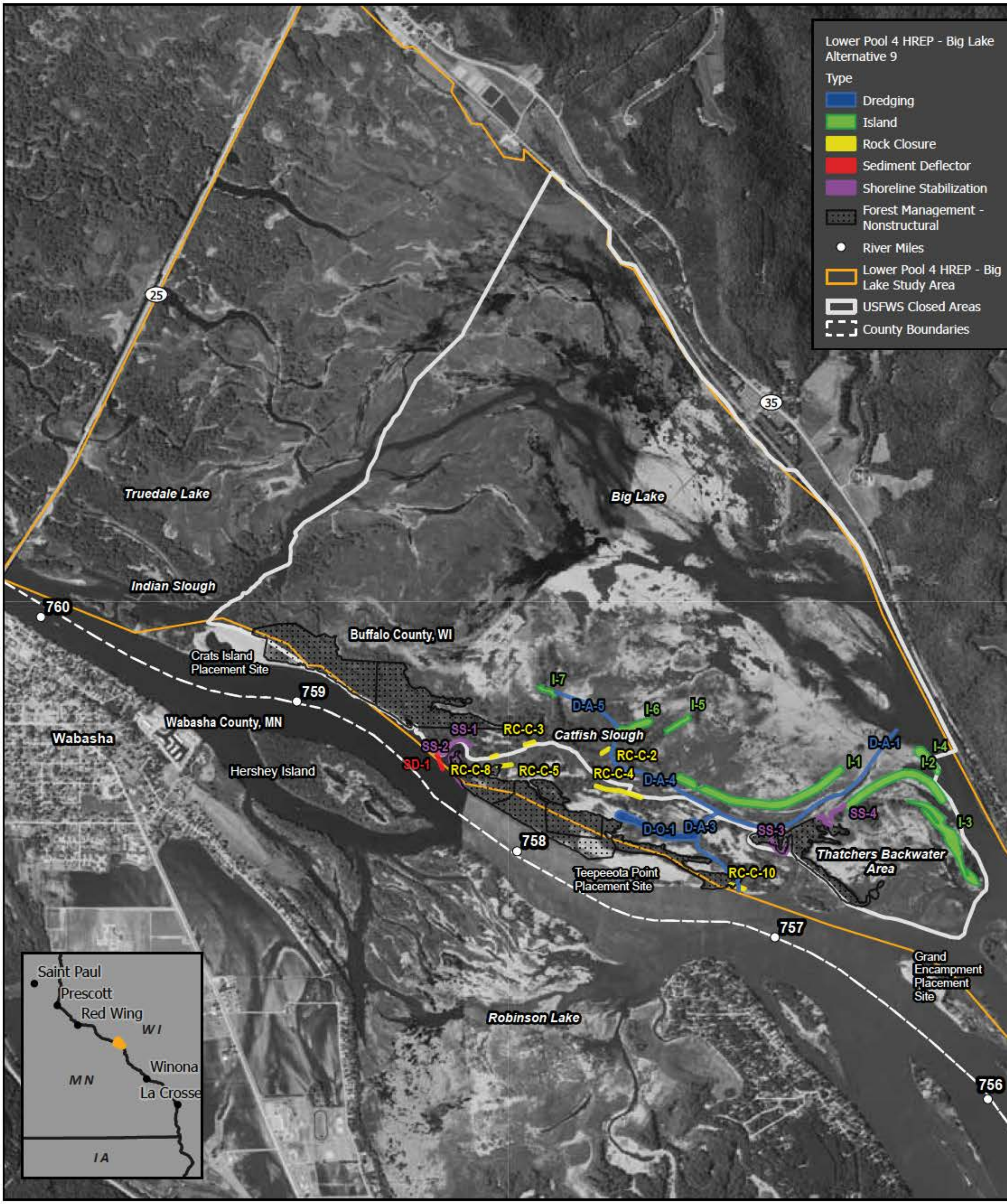

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Lower Pool 4 HREP | Big Lake | Alternative 9

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjh8 9/29/2023 11:01 AM
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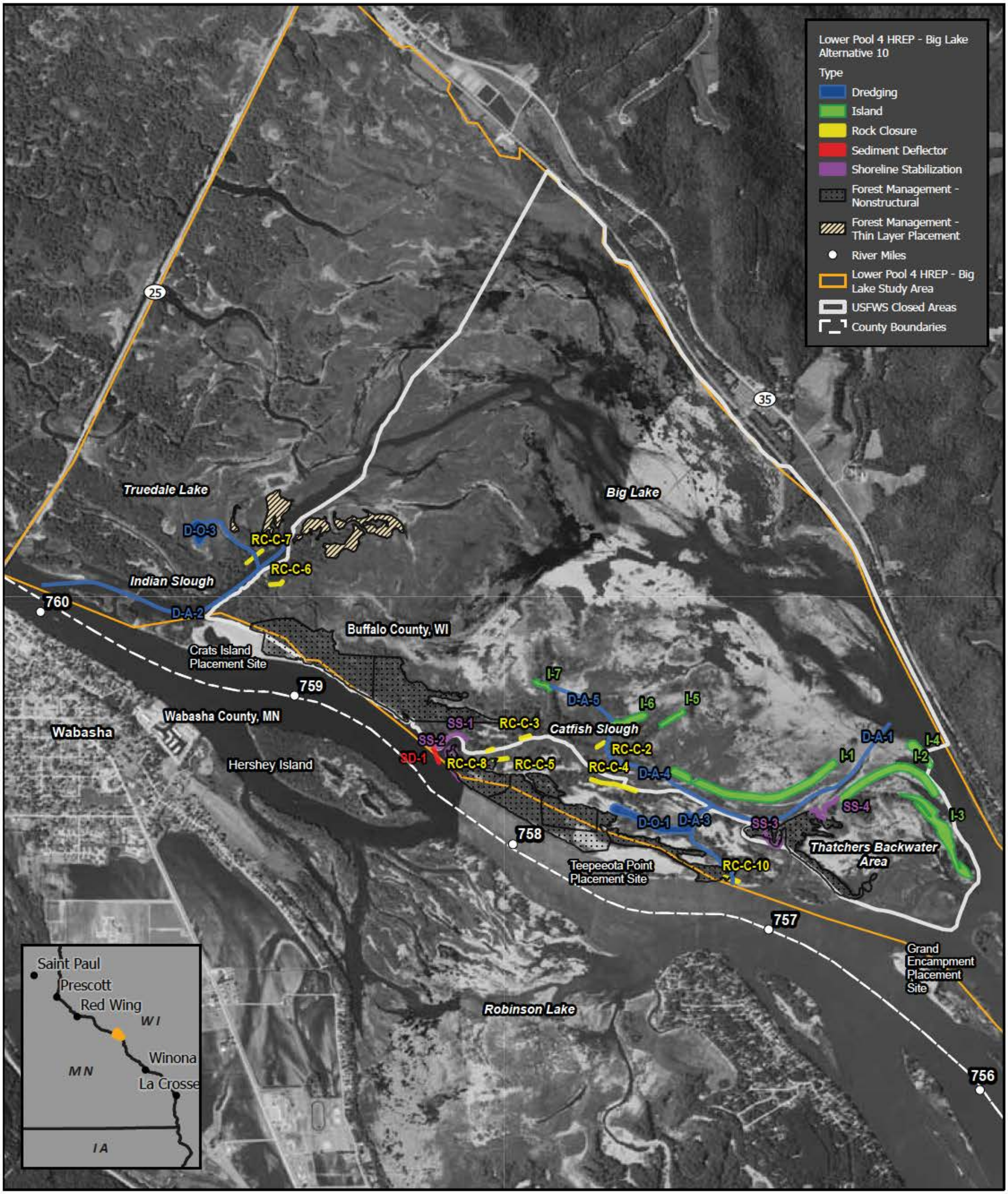

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Lower Pool 4 HREP | Big Lake | Alternative 10

Base Image: WI FSA NAIP 8/5/2022 (Greyscale)

0 3,500 7,000 Feet

N

Created by: b6pdkjh8 9/29/2023 10:23 AM
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