**UPPER MISSISSIPPI RIVER RESTORATION**
**FEASIBILITY REPORT**
**WITH INTEGRATED ENVIRONMENTAL ASSESSMENT**

# GILEAD SLOUGH
# HABITAT REHABILITATION AND ENHANCEMENT PROJECT

**POOL 25, UPPER MISSISSIPPI RIVER MILES 246-251**
**CALHOUN COUNTY, IL**

## Appendix O: Geotechnical Engineering

US Army Corps of Engineers®
St. Louis District

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Upper Mississippi River Restoration
Leading·Innovating·Partnering

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## 1 PURPOSE AND SCOPE

This geotechnical feasibility report will discuss recommended subsurface exploration efforts for the different features, any needed testing, and anticipated analyses or activities for the Tentatively Selected Plan (TSP) of the Gilead Slough Habitat Rehabilitation and Enhancement Project (HREP), hereafter referred to as the “project”. This work is in collaboration with the U.S. Fish and Wildlife Service (USFWS).

## 2 LOCATION

The project is located on USFWS lands approximately four miles southwest of Hardin, IL in Calhoun County, IL. The project lies between approximate river miles (RM) 248 and 254 on the left descending bank of the Mississippi River. The study area limits can be seen in Figure 1.

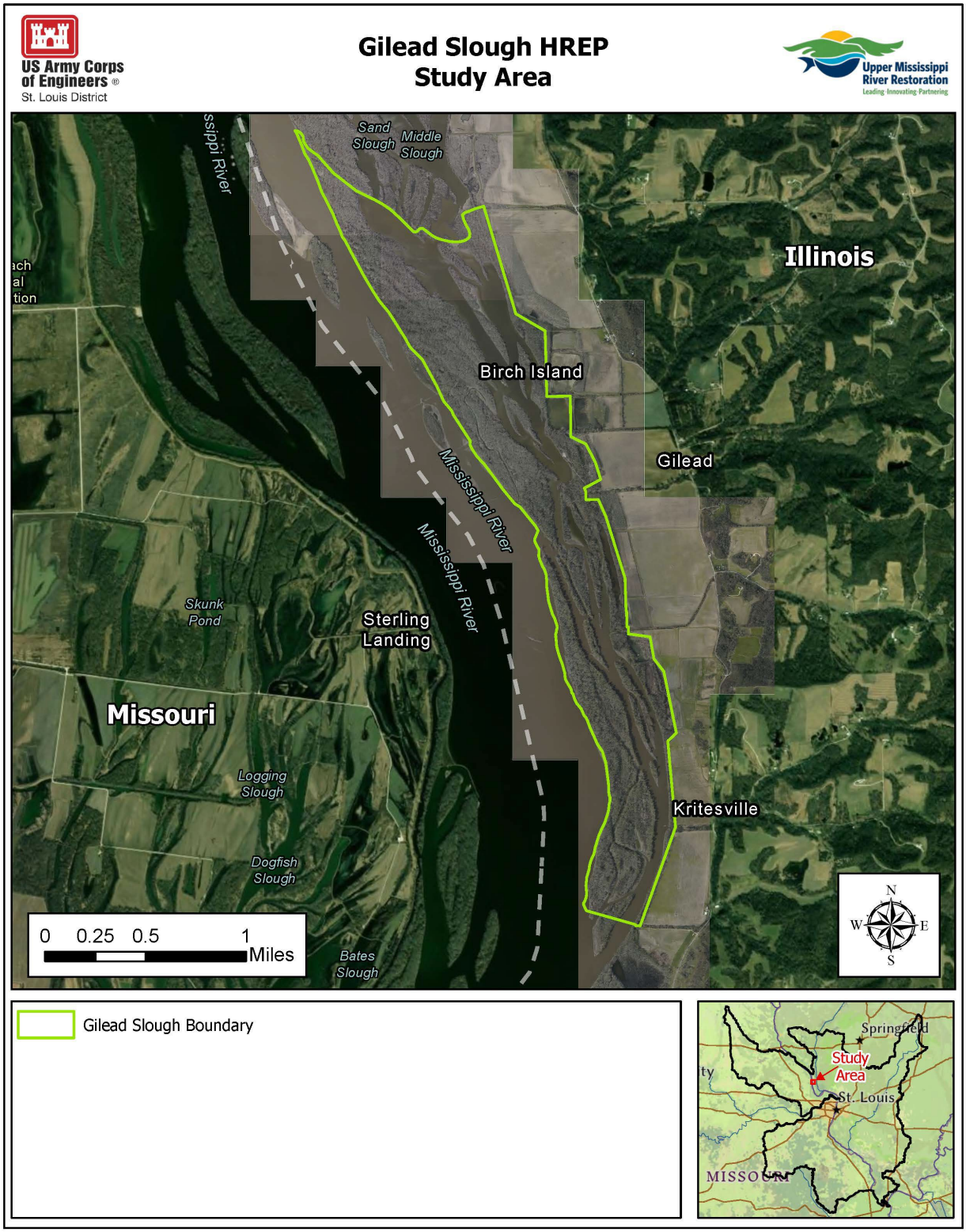


*Figure 1: Study Location Map.*

## 3 PROJECT FEATURES

Extensive sedimentation throughout the study area has led to reduced biodiversity and wildlife at the managed lands. Sedimentation of backwater habitats has resulted in reduced flow, reduced habitat depths, limited connectivity between backwater habitats, reduced aquatic vegetative cover, among others. As a result, the number of fish, mussels, migratory birds, and wildlife has decreased throughout the study area. Continued sedimentation will further compound these effects.

The project aims to reduce sedimentation of the backwater habitats to restore aquatic habitats and the native wildlife it attracts. The following alternatives were evaluated, with alternative 2, Intermediate Habitat Benefits, being the selected TSP.

1. Maximum Habitat Benefits
    a. Includes three water control structures, a pump, a side channel enhancement dike, hard points, bankline protection, scour structures, a river connection, island creation, barbs, backwater and channel dredging, road construction, gradually sloped revetment (GSR) along river bankline, and three new moist soil units with associated berms and drainage channels.
2. Intermediate Habitat Benefits
    a. Includes three water control structures, scour structures, hard points, barbs, backwater and channel dredging, island creation, three new moist soil units with associated berms and drainage channels, road construction, and GSR along river bankline.
3. Minimum Habitat Benefits
    a. Includes scour structures, barbs, island creation, and backwater and channel dredging.

## 4 SITE GEOLOGY

The project area for Gilead Slough is located along the left descending bank of the Mississippi River Pool 25 between river miles 248 – 256 in Calhoun County, Illinois between Hamburg and Gilead, Illinois. The project area is located on the USGS 7.5-min Hamburg, IL and Foley, MO-IL quadrangle maps. The project areas are located in an area of alluvium and open water sloughs adjacent to bedrock uplands that form a divide between the Mississippi and Illinois Rivers. The uplands are characterized by steeply dissected ridges.

The project area is in a regional complex structural system related to the Ozark Uplift. The Gilead Slough is approximately 1-mile north of the Cap au Gres Faulted Flexure/Lincoln Fold, which is the dominant structural feature in the area. Rocks are generally sloped depending on the structural features but are oriented vertically at the terminal ends of the Cap au Gres Faulted Flexure, and faults with 30 to 40 feet of displacement are associated with the Cap au Gres Faulted Flexure (Seid & Devera, 2008). Near the center of the Cap au Gres Faulted Flexure and north of the structural feature, the rocks dip more gently. Movement on the flexure appears to not extend into

formations younger than the Pennsylvanian. Anticlines and synclines associated with the Cap au Gres Faulted Flexure and Lincoln Fold underly or are adjacent to the project area.

Gilead Slough overlies the Gilead Anticline which parallels the Hardin Syncline to the east. The Hardin Syncline is a structurally enclosed feature with 250 feet of negative relief in about 0.5 mile. The Gilead Anticline is bounded by the Hardin Syncline to the east and the Kritesville Syncline to the southwest. The Kritesville Syncline is an open syncline with approximately 50 feet of relief in approximately 0.5 mile.

The regional bedrock at the project site dips shallowly to the northeast with approximately 1 degree of slope, but the rocks dip more steeply where interrupted by the smaller anticlines and synclines (Rubey, 1952; Seid, Breeden, & Kenderes, 2016). Near the Gilead Anticline and Hardin Syncline the rocks can dip up to 10 degrees to the northeast in these northwest-southeast trending structural features (Reinertsen, et al. 1994).

The uplands adjacent to the alluvial deposits generally consist of the following formations in descending order and range of thicknesses:

- Quaternary
  - Peoria/Roxana Silts (0-30 ft thick)
  - Peyton/Cahokia Formations (colluvium/alluvial fan deposits 0-35 ft thick)
  - Cahokia/Henry Formations (alluvium 0->100 feet thick)
- Tertiary (Pliocene-Pleistocene)
  - Grover Gravel (0-30 ft thick)
- Mississippian
  - Burlington Limestone (130-170 ft thick)
  - Chouteau Limestone (20-40 ft thick)
  - Hannibal (New Albany) Shale (40-120 ft thick)
- Devonian
  - Louisiana Limestone (3-18 ft thick)
  - Saverton Formation (siltstone 1-10 ft thick)
  - Grassy Creek Shale (1-25 ft thick)
  - Sylamore Sandstone (0-2 ft thick)
  - Cedar Valley Limestone (9-25 ft thick)
- Silurian
  - Joliet Limestone (10-65 ft thick)
  - Kankakee Limestone (10-25 ft thick)
  - Bowling Green Limestone (10-25 ft thick)
- Ordovician
  - Maquoketa Shale (95-150 ft thick)
  - Kimmswick Limestone (75-120 ft thick)

The uplands are generally covered by loess, which overlies Grover Gravel deposits from an ancestral Mississippi River. The Grover Gravel is present on the ridge tops and may be reworked in younger colluvial and alluvial deposits. The alluvium of Mississippi River is adjacent to colluvial deposits and bedrock of the uplands. Colluvium with gravel sourced from the adjacent rock formations or Tertiary Grover Gravel located on the uplands is interbedded with silt from the loess overlying the uplands. The colluvium forms fans or terraces located along the bedrock uplands. The lowest bedrock exposed at the edge of the alluvium in the project area is the Makquoketa Shale (Devera, 2010; Seid, Breeden, & Kenderes, 2016).

The alluvium near Red's Landing and Gilead Slough is generally characterized as a fining upward sequence from cobbles to silty clay. Water well borings in the alluvium reportedly had approximately 25 to 30 feet of silty clay overlying sand and cobbles at depth. The borings were terminated at depths ranging from 65 to 75 feet. The static water level was reported at a depth within 5 feet of the ground surface. The colluvium near the rock outcrops appears to be finer grained to the termination depth of the borings above bedrock. Kimmswick Limestone likely underlies the alluvium in the project area.

# 5 TENTATIVELY SELECTED PLAN FEATURES

## 5.1 Water Control Structures

Three new water control structures (WCS) will be constructed to allow for water level management at Moist Soil Units (MSU). These WCS will be aluminum culverts with stoplogs. Minimal geotechnical design is anticipated for these. Coordination with the structural engineer is anticipated regarding soil properties. Coordination with materials engineer may also be necessary for bedding material. Design of these structures should be in accordance with EM 1110-2-2902.

## 5.2 Hard Points and Barbs

There is minimal geotechnical design effort anticipated for these features.

## 5.3 Island Creation

There is minimal geotechnical design anticipated for this feature. Constructing such a feature in an open river channel would involve placing soil or dredged material at the bottom of the river channel and building it up to the desired elevation. Should settlement be observed, additional material would be placed to bring the features back up to the desired elevation.

## 5.4 Gradual Slope Revetment and Scour Structures

These features are typically constructed of stones. Minimal geotechnical design is anticipated. A Materials Engineer would be able to aid in stone sizing and materials selection.

## 5.5 MSU Creation

Moist Soil Units, or MSU for short, are habitat management units which can be independently operated and managed from one another for different types of wildlife. Three new MSUs will be created. Two of them, North and South, will require berm construction. The three proposed water control structures will be located at these MSU for ponding water. Management in Middle MSU will be achieved solely by means of the proposed water control structure at that location and does not require berm construction. Channels will be excavated at each MSU to direct water towards the WCS. Some regrading may also be necessary at the North MSU for increased storage capacity.

### 5.5.1 Subsurface Exploration

North MSU and South MSU will require berm construction along the perimeter. The berms will approximately be 5 to 6 feet high. It is recommended to drill a borehole every 500 feet. This would yield three borings along the north berm alignment, and three along the south berm alignment. Accessibility should be taken into consideration when planning subsurface exploration activities. The areas pond water and are wooded. Tree clearing may need to be completed prior to drilling. A site visit to the North MSU revealed that the soils are soft and easy to become stuck in. An old, wooded road could possibly be used to reach the North MSU location, but the trees may impede access and operations. Access to South MSU is also limited. It is bounded by a slough to the west and private property to the east. A private road from Mississippi River Road leads straight to this area but would require an easement to use.

Based on water well drilling logs obtained from the Illinois State Geological Survey website, the clay blanket is estimated to be roughly 30 ft thick. Samples of the clay blanket should be collected using Shelby tube sampler switching to SPT jar samples once in the aquifer sands below. It is recommended to collect Shelby tube samples on 5-foot centers for 30 feet, then SPT samples on 5-foot centers from 30 to 80 feet in depth.

### 5.5.2 Lab Testing

Shelby tube samples collected from the blanket should be tested for moisture contents, Atterberg limits, and USCS classifications. Unconsolidated-Undrained (UU), Consolidated-Undrained (CU), and consolidation tests should be performed on select samples. Special attention should be given to low-strength fine-grained soils which should be prioritized for strength and consolidation testing. Grain size distributions and moisture contents should be determined for any sand samples.

### 5.5.3 Soil Properties

For each stratigraphic layer, shearlines will need to be developed along with the following soil properties:

- In-situ moisture content (mc)
- Soil cohesion of fine-grained soils (c)

- Effective friction angle ($\phi'$)
- Saturated unit weight ($\gamma_{sat}$)
- Dry unit weight ($\gamma_{dry}$)
- Permeability (k)
- Compression and Recompression Indices ($C_c$ and $C_r$, respectively)

### 5.5.4 Geotechnical Analyses

The following geotechnical analyses are anticipated:

- Total settlement calculations
- Slope stability
- Seepage analysis

## 5.6 Road Construction

The new road will connect the existing road at the Middle WCS to North MSU and its associated WCS. There is minimal geotechnical design effort anticipated for this feature.

## 5.7 Backwater and Channel Dredging

There is minimal geotechnical effort anticipated for the dredging activities. However, dredged material is anticipated to be used as borrow soils for the construction of various features, most notably the MSU berms. Samples of the dredged material should be collected to aid in design. However, overwater drilling and sampling is more expensive than land-based drilling. Vibracore sampling was identified as a viable alternative to traditional drilling for collecting representative samples of the dredge material along the proposed dredging locations. This sampling method would allow for earlier material identification, thus reducing risks and advancing design. Current sampling is underway with results expected to be incorporated into the Recommended Plan. Moisture content and Atterberg limits will be determined for each sample. The Atterberg limits will help in classifying the soils at the dredging locations.

Coming from the bottom of the sloughs, these soils will be highly saturated. Prior to use in construction, they will need to be dried out. Drying soils to the desired moisture content is more difficult than increasing moisture and is a time-dependent process. Impacts to budget and schedule should be considered. Specifications will need to be written for the use of dredged materials.

The risk of a later classification of the dredged material is that classifications would have to be assumed. These assumptions should be verified once dredging commences. If the assumptions are wrong, the geotechnical design would need to be revised. Specifications may also need to constrain dredge material to certain assumed classifications.

Dredging involves a prior regulatory and environmental permitting process that may be lengthy. Possible impacts to schedule should be considered. If possible, an option is to

begin the permitting process prior to commencement of Preconstruction Engineering and Design (PED), then dredging the material and stockpiling it. The dredged material can then be tested, and the design made with the actual soil classification and properties of the soil.

## 6 DATA NEEDS

- Design elevations for the MSU berms.
- Ground surface elevation profiles along berm alignments.
- Bathymetry data for the slough adjacent to the berms.
- Select cross sections of the berms.

## 7 RECOMMENDATIONS

- Request historical geotechnical data at the study area.
- Include a Materials Engineer as a PDT member to aid in riprap and revetment design, stone sizing, bank protection design, bedding stone, and bank stabilization design.
- Using dredge spoils as borrow material introduces risks to the design by assuming soil classifications and properties and may necessitate a design revision. Additionally, impacts to budget and schedule should be considered consistent with the discussion in Section 5.7. Considering that the main need for borrow soils are the MSU berms, it may be cost effective to source needed borrow for these features elsewhere given their limited length and height. A borrow source can be identified within the project boundaries or brought in from an external source. Additional costs may need to be weighed against the risk presented by using dredge spoils.
- Begin permitting and dredging activities as soon as possible. Samples can be collected from the stockpiled dredge soils and tested for their classification. The earlier the spoils can be verified, the lesser the impact to the design and the more the risk can be bought down.

# 8 REFERENCES


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