Appendix B1
Civil Engineering

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UPPER MISSISSIPPI RIVER RESTORATION SYSTEM
FEASABILITY REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

HARLOW ISLAND HABITAT REHABILIATION
AND ENHANCEMENT PROJECT

MIDDLE MISSISSIPPI RIVER MILES 140.5 THROUGH 144.0
JEFFERSON COUNTY, MISSOURI

APPENDIX B1
CIVIL ENGINEERING

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1 EXISTING CONDITONS

1.1 Project Study Area and Constraints

Harlow Island is bound between approximate River Miles 140.5 and 144 on the right descending bank of the Mississippi River, approximately 5 miles south of Crystal City, in Jefferson County, Missouri. The Harlow Island project area is approximately 1,225 acres of floodplain, separated from the limestone bluff by a Mississippi River high-flow channel and perennial stream. A Burlington Northern and Santa Fe (BNSF) Railroad rail line runs adjacent to the limestone bluff, with a side-line feeding the Ameren coal power plant and limestone quarry, each located directly downstream of Harlow Island.

Figure 1-1. Limestone Bluff and Rail Line Adjacent to Harlow Island

The Island is partially leveed, as the agricultural boundary and cross-levees are breached at multiple locations. The boundary levee is relatively intact along the interior edge, which abuts two small ditches that drain the uplands upstream and downstream of the Island, respectively.

Access constraints are discussed in Section 2 of this appendix.

1.2 General Site Conditions

As is common with many islands in the Middle Mississippi River (MMR), Harlow Island appears to have been formed of sand, often around pile dikes installed in the early- to mid-1900s. After these sandbars became vegetated by willows and similar species, a "natural levee" began to form, which encouraged fine sediment deposition in the interior, forming a fine-grained upper soil layer. Harlow Island appears from historic imagery to have developed from several smaller sandbar islands, which converged into the west bank of the Mississippi prior to 1931. In the intervening years, pile dikes and similar structures extended the Island outward from the interior (leveed) portion to its full extent today, and largely filled in the backwater side channel in the island formations.

1.3 Topographic Survey Data

Topographic surveys were conducted in 2015 as one of a series of project areas under a single contract. The survey was completed by aerial Light Detection and Ranging (LiDAR) equipment by a third-party contractor with a specified Confidence of 95%. The data was collected in North American Datum of 1983 (NAD83), North American Vertical Datum of 1988 (NAVD88), Missouri State Plane East (FIPS 2401) in units of US Survey Foot.

Survey control points were not established as part of this survey, the quality control was conducted by field data collection, only. One registered National Geodetic Survey (NGS) monument is located near the project area, PID JC0266, designation U 57. This monument has not been verified since 1991, and is located near the rail tracks and the upper low-water crossing discussed in Section 2 of this document. Its estimated stability classification is C, but may still be useful in establishing control for surveys given the wide tolerances allowable for the recommended features. Control points for establishing real signal strength is low throughout much of the island, limiting the types of GPS systems that may be used during construction.

2 ACCESS, TRAFFIC CONTROL, AND SECURITY

2.1 Primary Access

The preferred access point to the Refuge is through an existing Permanent Easement from County Road AA, as discussed in Appendix D. Specific considerations for use of this access point are discussed in this section. Barring drastic changes to current conditions, this access point will be used for all land-based construction activities. Alternative access points in case of drastic changes are discussed in Section 2.2.

Harlow Island is separated from the western bank by a high-flow channel or swale of the Mississippi River. The lower end of this swale incorporates a small perennial or intermittent stream, which outlets into the Mississippi at the lower end of the Island. Existing access for site inspections and visitors to the Refuge is available over one of two Low-Water Crossings, neither of which meets preliminary visual inspections for use in construction.

The upper crossing, located near the midpoint of the island, was inherited by the USFWS with no documentation of construction methods or materials used. Visual inspection shows the foundation to be some quantity of grouted stone, over which a large concrete slab was either poured or repurposed.

Figure 2-1. Upper Low-Water Crossing

The slab is approximately 18-24 inches thick with no indication of whether or not reinforcement was used. The slab was capped with rail ties, apparently acting as a retaining wall for soil, bringing the crossing up to existing grade and forming the road surface, supplemented by river gravel. The crossing blocks approximately 90 percent of the swale channel.

The roadway feeding the upper crossing is a stem from county road AA, and has an existing rail crossing approximately 100 feet north of the county road terminus. It is composed of rail ballast at the ramps and ties over the rail lines. Weight and traffic limitations for this rail crossing are unknown, though an existing access agreement is in place, which appears to allow for use by construction equipment. Coordination with the railroad will also be necessary to ensure the crossing is properly utilized, repaired, and reinforced, if necessary.

Figure 2-2. Existing Upper Rail Crossing

If this access location is able to be utilized for construction, a hardened, at-grade form of low-water crossing will be necessary for the swale as an ephemeral or intermittent stream. This will be composed of a stone foundation over geotextile to prevent piping or undermining, and capped with suitable aggregate surfacing material. The construction costs associated with access at this location are considered as a portion of the construction contingency.

2.2 Alternative Access Options

An alternate entrance is located at the lower end of the Island from Big Hollow Road. This entrance crosses the stream with a more traditional bridged crossing, founded on concrete wing-walls with unknown subsurface reinforcement, though pilings are commonly used in these designs. The span is achieved by a series of two or more w-shape beams approximately eight inches in depth in tandem with a thin concrete slab, approximately 4 inches thick. The road surface for this crossing is also composed of soil. Additional structural assessment would be required for use of this crossing, but it is assumed that it will not be sufficient for bearing construction equipment.

Big Hollow Road leads to this access area and the boat ramp managed by the Missouri Department of Conservation (MDC) downstream of the Island at Truman Access. Big Hollow Road appears to terminate at the railroad, at which point it becomes a private driveway for the Ameren power plant, including a private bridge over the main stem rail line. The private drive loops under the bridge on the riverward side of the railroad, but then crosses the side-line rail feeding the power plant itself.

Figure 2-3. Lower Low-Water Crossing

If this crossing is to be utilized (only necessary if the Primary Access point is somehow compromised), access agreements must be coordinated with Ameren, and possibly BNSF as well. Additionally, if designated as a perennial stream, a bridged crossing will likely be required. Alternatives such as a permanent, hardened, at-grade crossing will likely be inundated more often than will be acceptable during construction, and a temporary crossing would be needed for longer than the permissible six month window. This is based on a regional-condition permit requirement that 85 percent of the bank full cross-section be open to flow, and assuming no variance may be given. Due to the shallow and wide nature of the stream at this location, as well as loading requirements for passing construction equipment, typical precast bridge sections will likely not be sufficient, and thus a custom bridge design could be required. This cost is likely too great to be considered as incorporated into the construction contingencies, should it be required.

Initial investigation suggests that the stream may be treated as intermittent, requiring only a 50 percent flow opening, and allowing for the use of culverts.

An alternative access plan would be to transport all equipment using marine plant, providing appropriate bridging apparatus to safely offload all land-based equipment, but may not result in a cost savings.

2.3 Interior Access and Temporary Features

Interior access will require off-road equipment to limit or eliminate the need to construct access roads. Interior access, staging, and stockpile areas will be designated by the contractor, except that they will be limited to the footprint of project features, designated tree clearing areas, or will otherwise be located where clearing will not be necessary. Any modifications to the site for temporary features must be returned to the existing condition, or to the design condition where appropriate, at the end of the contract.

2.4 Traffic Control Plan

A traffic control plan will be developed by the Prime Contractor for each contract per state and federal regulations and standard USACE Specifications to accommodate common traffic patterns along with trucks hauling materials to the site. No material is anticipated to be removed from the site, and river-based installation or stockpiling of stone may be possible to greatly reduce roadway traffic congestion.

Coordination with BNSF will be required for transport of equipment over the upper rail crossing to ensure no delays to rail schedule or contractor schedule, as well as for safety considerations.

2.5 Site Security Considerations

By standard USACE Specifications, the Contractor will be required to establish security of the site throughout construction, to include background checks of their employees prior to construction. After construction is complete, the USFWS will be responsible for maintaining security of the site under the auspices of their own regulations, which are separate from Army Regulations.

3 MEASURES

3.1 General Design Information

All feature designs were developed using InRoads Civil Information Modeling (CAD-CIM) software suite, from which hydraulic models were developed and quantities were calculated by area measurement or triangle volume calculation tool. Future iterations of design will be able to reuse and refine these models to better develop mass-balance estimates for haul routes, and improve constructability of the project as a whole. See Annex 1 for Project Plates.

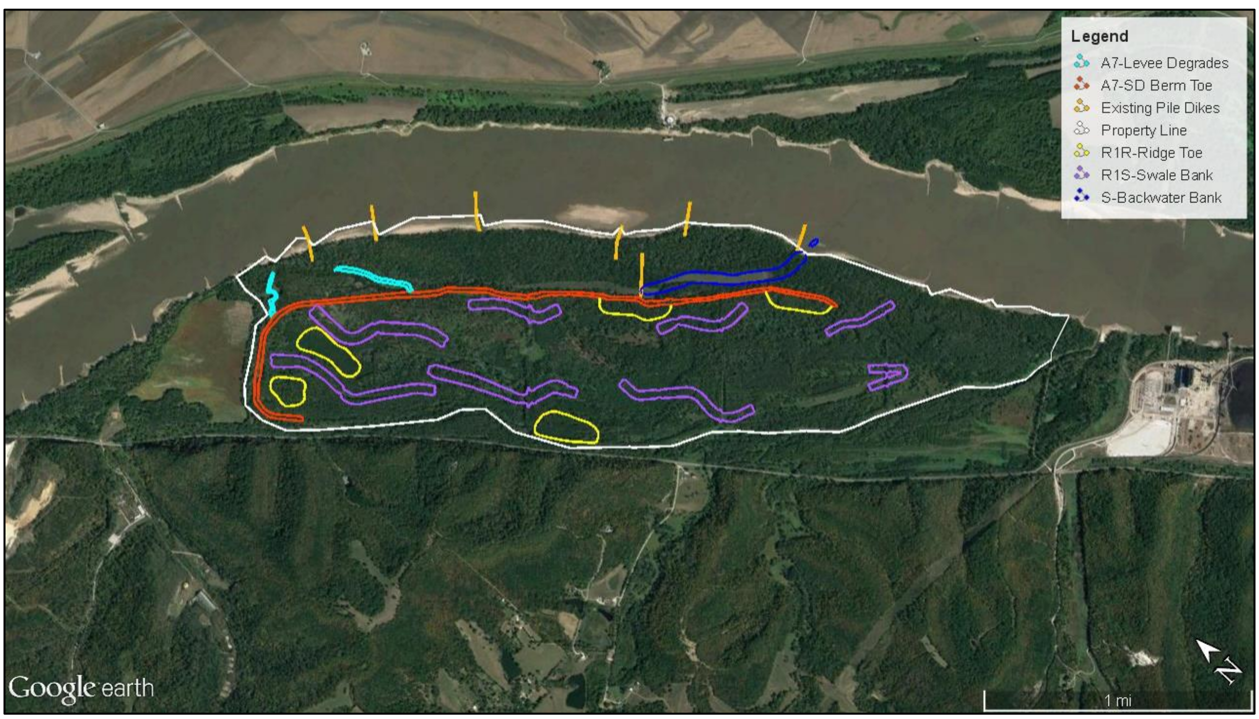

Figure 3-1. Harlow Island Proposed Feature Map

The final array of measures incorporated into the Harlow Island Feasibility-Level design include a Sediment Deflection (SD) Berm, Backwater Channel, Ridges, and Swales.

Table 1. Earthwork Quantities by Feature

Feature	Total Fill (CCY)	Total Cut (BCY)
Sediment Deflection (SD) Berm[1]	172,700	17,700
Ridge Habitat	624,500	-
Swale Wetlands[1]	-	478,700
Backwater Channel	-	414,800
Notes:		
[1]Includes necessary or incidental degrades of existing agricultural levee(s)		
Units shown are volumes in Cubic Yards prior to cut (Bank) or after fill and compaction (Compacted) are complete.		

3.2 Sediment Deflection Berm

3.2.1 Feature Basis

Sediment Deflection (SD) Berms are the term given to earthen embankment structures which resemble levees in appearance, but are open at their lowest end, allowing floodwater to enter the bermed area at low velocity. The berm's functionality was initially based on evidence available from Wilkinson Island, which has been partially leveed in some form or other since the 1920s. These levees were breached multiple times, especially during the 1993 flood and were largely abandoned after. Shallow soil sampling by hand probe and similar methods has revealed that a layer of fine soils have accreted behind the levee, attributed to backwater flooding of the leveed area. This sediment storage phenomenon was further quantified at Harlow and Wilkinson Islands using geospatial and site observations by Remo, Ryherd, Ruffner, & Therrell (2018). These fine soils, classified by the United Soil Classification System (USCS) as C or M type soils (clays and silts) provide the necessary substrate for reestablishment of bottomland hard mast species if they are able to create a sufficiently thick layer above sands and other very well drained soils. See Appendix F for more information on soil suitability for hardmast forests.

Figure 3-2. Soil Probe Sample from behind Wilkinson Island Breached Agricultural Levee

SD Berms re-create or improve these backwater settling conditions during most flood events by deflecting the direct flow of the river, thereby also deflecting the course sediment (sand) that is carried by high-velocity portions of the flow. The opening(s) at the lower end provide an indirect path for flood water to enter, carrying its highly turbid load of suspended fine sediments, which will fall out of suspension over the period of the flood, similar to the contact time of settling lagoons used in waste water treatment. Since the floodplain remains open, the sediment deflection berm will also maintain the flood-storage capacity of the Island.

Harlow Island is partially enclosed by agricultural levees which have profiles approximating a

20% Annual Chance of Exceedance (ACE) flood event (commonly referred to as a 5-Year flood). The exterior levee was constructed of nearby soil of unknown type, though stands of trees now growing on it suggest that it is of cohesive soil types classified by the United Soil Classification System (USCS) as C or M type soils (clays and silts). The existing levee system provides a foundation from which the SD Berm can be constructed, reducing the proposed construction costs. The majority of the exterior levee will be left intact, while a portion will be cleared, and material from cut features (Backwater Channel and Swales) will be used to reinforce the interior face of the upper and flank portions, raising them to the increased profile elevation, and increasing the interior slope.

During a preliminary site inspection conducted in December of 2017, several hand-driven soil probe samples were taken for visual inspection around proposed feature locations to compare with the NRCS Soil Report, Annex 2. These samples suggest that much of the upper layers of the Island are composed of clay in higher concentrations or of higher plasticity than those associated with the common loam formations identified in Annex 2, with relatively small quantities of silt. The presence of very fine grain soils predominating the Island, though likely shallow (less than five feet of depth) suggest that the existing levees are already partially functioning as a fine sediment collection system. Furthermore, soils of these types are generally suitable for construction of the ridges and berms, and will likely support hard mast forest if raised above the more frequent flooding elevations.

Figure 3-3. Tree in Leveed Portion of Harlow Island with Roots Buried by Deposited Fine Sediments

3.2.2 SD Berm Design Criteria

3.2.2.1 *Slope Stability*

The existing levees on Harlow were formed from adjacent soil materials, of the same type that will be used to reinforce and construct the SD Berm. The existing levees have fore- and backslopes of approximately 1V:3H and are largely intact, providing the basis for establishing a minimum SD Berm slope of 1V:3H. Given the low risk of failure by overtopping and seepage discussed below, the PDT has elected that no further slope stability analysis is necessary.

3.2.2.2 *Vegetation*

Unlike levees, embankment dams, and similar closed structures covered by ETL 1110-2-683 (USACE, 2014), the SD Berm is proposed to be vegetated with the same hard-mast forest tree species used for establishing Ridge Habitat. The hard-mast trees are expected to provide habitat, seed source for future forests, and hydraulic roughness once established. These benefits are expected to outweigh the potential damage from dying trees and the USFWS' reduced ability to maintain the slopes as would be required for a Flood Risk Management feature. The risks associated with these concerns were further mitigated by increasing the backslope of the SD Berm to 1V:6H. Around these plantings, a cover crop of native vegetation will be established to reduce potential erosion damage.

3.2.2.3 *Overtopping Resilience*

Overtopping forces for the SD Berm are minimal when compared to levees and dams due to their open-ended nature. At the point of overtopping, the differential head on the exterior and interior slopes is expected to be negligible, as the interior fills from the downstream end, provided in this case by the swale features, which cut through the existing levees. Additional analysis will be conducted in PED to ensure minimal overtopping velocities. To provide additional resilience, the reinforced portions will be built with a backslope of 1V:6H and the increased hydraulic roughness of the woody vegetation, helping to dissipate the overtopping energy.

3.2.2.4 *Seepage*

Under-seepage and through-seepage are potential failure modes in levees and dams that are caused when sufficient hydraulic head differential is achieved at weak points on the embankment. Soil variability and tree roots allow for potential weak points in the embankment that become focal points for high-energy water to penetrate, and if left unchecked, can begin eroding the soil inside the embankment in an effect known as piping. As stated, the interior of the SD Berm will be inundated to nearly the same elevation as the exterior, reducing the head differential and associated potential energy to a negligible amount, thereby removing seepage as a potential failure mode.

3.2.2.5 *Profile, Settlement and Shrinkage*

Initially, multiple elevations were considered, each corresponding to an average elevation approximating a common flood level at the associated river mile, from a 50% Annual Chance of Exceedance (ACE) flood (commonly referred to as a "2-Year" event) to a 10% ACE ("10-Year") flood. Higher profiles are anticipated to increase coarse sediment deflection, increase contact time for fine sediment settlement, and increase the amount of flood events that will provide sedimentation. The 2-Year profile was screened from consideration since the existing levee system approximates a 20% ACE ("5-Year") event, and degrading it would increase cost while decreasing benefits.

The 10-Year elevation profile was selected as providing increased opportunity for settlement of fine sediments without a high likelihood of causing a rise in adjacent 100-Year (1% Exceedance) flood elevations. The Profile Grade, based on a flow-frequency study is approximately 0.0001, ranging from elevations 397 to 399 across the length of the Island.

A settlement analysis was not completed for the SD Berm due to the low risk that settlement would induce failure. Settlement-induced failures generally occur by local settlement creating a preferential path for an overtopping event; as discussed in Section 3.2.2.3, overtopping forces are minimal for this design.

Geotechnical investigations to estimate potential shrinkage was not conducted for similar reasons to settlement analysis. Failure modes associated with shrinkage are either similar to settlement, or due to cracks in the embankment creating seepage paths. Seepage risks for the SD Berm is low, as discussed in section 3.2.2.4, and cracks are expected to be managed by the trees and other vegetation, once established.

As the profile elevations are approximated at a 10% ACE, but not tied by authorization or other requirement to a precise elevation, settlement and shrinkage changes to as-built elevation are not expected to affect system performance.

3.2.2.6 *Alignment*

The SD Berm alignment closely follows the existing exterior levee system excepting a few key locations. As its intent is to deflect the majority of flow up to a 10% ACE event, while opening up the lower end to provide flood storage and fine sediment settlement, only the upper-most and river-ward portions of the existing levee are proposed to be reinforced. The upper end of the existing levee shows signs of multiple breaches, providing evidence that it is hydraulically inefficient by cutting off portions of the Mississippi River floodway. This portion at the northern corner of the levee will be degraded and realigned. The proposed alignment utilizes wide-radius curves to smoothly conduct water around the berm.

3.3 Ridges

While suitable clay and silt soils for hard mast tree establishment are present on Harlow, and expected to continue to build over time behind the modified sediment deflection berm and levee system, a sufficient quantity of mature hard mast trees are not currently available as a seed-source for establishment of an Island-wide hard mast forest component. As such, a ridge and swale system mimicking natural riverine landforms was recommended to be constructed, on which hard mast trees could be planted and would grow to maturity while the soils build. An elevation approximating a 10% ACE event was identified by Heitmeyer (2008) as providing the best habitat for many of these species, while 20% ACE event elevation was provided as a minimum. The ridges are designed using a side slope of 1V:4H from existing grade up to the approximately 20% ACE profile, from which a shallower 1V:10H slope is used from this elevation up to the approximate 10% ACE elevation. The top will be slightly sloped to drain water, but will generally resemble a plateau to maximize the high-value area while minimizing fill quantities, which will be removed from the backwater channel and swale features.

These ridges may be constructed of a course-soil core if then capped with suitable material at a thickness of 5 feet or more, with 10 feet being preferable. The two to three ridges located at the downstream end of the Island will be constructed in this way, with the core being composed primarily of dredged material from the lower portions of the backwater channel as discussed further in Section 3.4 of this Appendix.

3.4 Backwater Channel

A Functional Analysis Value Engineering Workshop was held in July 2015, which also served as the planning and/or scoping charrette. At the planning charrette, the lack of low-velocity habitat connected to the River in this region was prioritized. Harlow Island contains an area that was once a backwater channel that has largely sedimented in. The remnant of this channel is a shallow swale system that generally follows the outside of the existing agricultural levee. The historic channel traces a path from a repaired breach section on the upper end of the Island, nearly to the confluence, with two pools that typically hold shallow water near the lower end of the Island. The alignment of the previous channel is partially disconnected by the existing levee, suggesting that the depth caused by the river's erosive forces would increase naturally if that portion of the levee were degraded. This degrade is necessary to achieve a hydraulically efficient sediment deflection berm configuration, improving its resilience and reducing stress on the river by reconnecting a portion of the floodplain.

While it is hoped that a backwater channel will form from the swale system as a result of this degrade with minimal effort, the lower portion of the theorized channel was designated to be excavated to hasten this process and create more immediate habitat, roughly 3,900 feet in length. The top several feet of the swale are fine-grained material where hand-probe samples were taken, and will be mechanically excavated to side slopes of 1V:3H. The material will be used to cap the sediment deflection berm, ridges, or create dewatering containment berms around the adjacent ridges. The remaining twenty or more feet in depth is currently estimated to be hydraulically dredged, the effluent being directed to the containment berms to form the core of the fill features. A geotechnical investigation will be required during PED to determine dredging effectiveness, design containment berms, and estimate the angle-of-repose of these soils to establish the dredge prism requirements to achieve the design width. The profile of the backwater channel will be constructed to the depth of the Navigation Program's Low-Water Reference Plane (LWRP). The dredged material will be capped with material from construction of nearby swales, as discussed in the following section of this Appendix. These swales are also expected to replace any loss of swale habitat caused by the transition to backwater fisheries habitat.

Figure 3-4. Swale Wetland, Remnant of Historic Backwater Channel

3.4.1 Control Structures

Grade control structures are proposed at relatively low elevations to arrest or manage lateral migration and promote scour locally downstream of each structure to create further depth diversity without choking off flow from the side channel. Some downcutting is expected to occur locally downstream of each structure to maintain average channel depths, and head-cutting is expected to occur to expand the channel upstream. The upper end of the structures will be over-excavated to key in the foundation and ensure the structure is not undermined. The stone must be of graded stone riprap to ensure that the stone is able to launch and self-adjust to maintain itself after scouring has occurred.

The crown or crest of the structures will be keyed approximately 20 feet into the bank lines at each side along existing grade to ensure the structure is not flanked by erosive forces. These stone keys will be choked with soil and planted with native vegetation to create a biotechnically sound and resilient transition.

3.4.1.1 *Outlet Structure and Scour Structures*

A sill-type structure will be placed near the confluence with the Mississippi after dredging is complete to control the outlet angle, width, and depth. Since this structure does not need to transition the grade, only maintain it, it will have a wide, flat crest with shallow fore- and back-slopes. It will be keyed in similarly to the upstream structures and have a similar, if narrower stilling pad downstream. Stone for structures within the dredged area will be constructed by floating plant. The stone for structures upstream of the dredge cut will likely also be delivered by barge due to access limitations. The stone will then be transported upstream by off-road trucks for land-based stone placement.

Figure TS14G–6 Top—riprap grade control structure; Bottom—subsequent launching of riprap at the grade control structure in response to advancing bed degradation and local scour

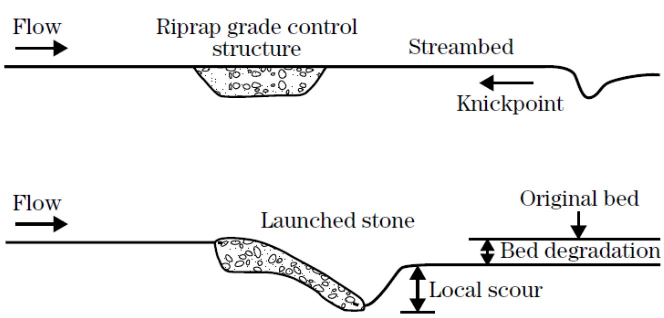

Figure 3-5. Sill-Type Grade Control Structure Concept (USDA, 2007)

Additional sill-type grade control structures may be installed, or existing structures modified to encourage desired scour and arrest lateral migration throughout the non-cut portion of the backwater. Since the backwater is very near the existing flank levee and sediment deflection berm complex, lateral migration of the backwater has the potential of damaging these features if not managed.

3.4.1.2 *Transition Structure*

After excavation is complete, it is expected that the subsequent floods will begin to erode the backwater channel further upstream, acting in the same manner as a typical hydraulic head cut. The PDT intends for this phenomenon to extend the backwater further into the Island, creating additional habitat benefit without the cost of dredging it. A grade control structure will be placed approximately 4,000 feet upstream of the cut portion of the backwater to ensure that the non-cut portion of the backwater does not erode beyond its designated limits. This structure will be placed along a stable transitional path from the existing grade down to the profile of the backwater channel at LWRP. The design of transition (upstream end) structure will be similar to rock-ramp structures, designed with a 1V:5H backslope to economically allow steady transition down from the bank down to a stilling pad of stone at the downstream toe. A much shallower backslope is recommended for in-stream versions of these structures where it is necessary to assist aquatic organisms in movement against a current (USDA, 2007), unlike this application.

3.4.2 Existing Structures

As part of the excavation, two known river training structures will have to be excavated and cut to the desired channel cross-section. The structures are located at River Miles 143.0 and 142.4, and records indicate they were constructed of stone, as discussed in Appendix B2. Many similar structures were originally established with timber piles, and later reinforced with stone. This possibility will be addressed in PED, likely by including a timber pile removal line item in the appropriate contract bid schedule as a Bid Option. These structures will be removed to the extent of the idealized channel to provide grade control, and removed stone materials will be reused to modify the remaining structure to encourage channel scouring, or construct new grade control structures.

Figure 3-6. Pile Dike near the Lower End of Harlow Island

3.4.3 Dredged Material

The Ridge features will be constructed of excavated material from the Backwater and Swale features, including the sediment currently assumed to be dredged from the Backwater. During

PED, a geotechnical investigation using vibracore sampling, borings, inspection pits, and/or other suitable methods will be conducted to verify that the subsurface material is appropriate for hydraulic dredging, or if a mechanical dredging operation will be required. If hydraulic dredging is most economical for the material found, the effluent from that operation will be placed within the footprint of the nearest ridges. Berms will be constructed by land-based equipment within the ridge footprint to create detention basins of sufficient size to be considered a Confined Disposal Facility (CDF). Testing to determine grain sizes and settlement rates will be required in PED to design the CDF cells and filter/overflow structures to ensure permit requirements are met. References for this design process include:

- Engineer Manual (EM) 1110-2-5027 – Confined Disposal of Dredged Material (USACE, 1987)
- Geotechnical Properties and Sediment Characterization for Dredged Material Models (Lee, 2001)
- Evaluation of Dredged Material Proposed for Disposal at Island, Nearshore, or Upland Confined Disposal Facilities — Testing Manual (ERDC, 2003)
- Upper Mississippi River Restoration Environmental Design Handbook (USACE, 2012)

Assumptions on dredge size will likely be made during this process, but will be specified only as an upper limit. While this limit will be that required by the CDF design, it will likely be reached as much due to draft and width restrictions within the channel as to discharge limitations within the CDF.

If investigation determines that the material is high plasticity, otherwise unsuitable for dredging, or if dredging is determined to be cost-ineffective, mechanical dredging or land-based excavation will be used to excavate the backwater. This material will be placed in containers or vehicles capable of maintaining the high water content, and will be disposed of in containment berms within the ridge footprint of similar type to the CDF discussed above.

3.5 Swales and Levee Notch

As part of the planning charrette, lateral connectivity of the Island to the River and a lack of high-value wetlands were identified as additional priorities for this project. The ridge complexes require more fill material than will be provided by excavating and dredging the backwater channel, and thus a linear borrow feature, designed to resemble natural swales were proposed. The swales will be constructed from shallow excavation of the surface soils above any sandy strata to encourage water retention. Additional suitable soils are expected to aggrade over time throughout the island, including the swale features, further reinforcing their retention capability. The swales are also designed to cut through the existing cross-levees, which is thought to provide a solution to one more of the three objectives: providing fill material, localized levee degrades to reconnect the Island to backwater effects, and providing ponding areas and other low wetland features to the Island. Additionally, a notch in the interior flank levee near the upper end of the island was recommended for consideration to reduce hydraulic head differentials for the SD Berm. This feature, and each swale at levee degrade points will be further designed in PED to include spillway design considerations utilizing EM 1110-2-160 (USACE, 1990).

Initial layouts of the swales were developed from contour lines, following Middle Mississippi River Management (Heitmeyer, 2008) design guidelines, but would result in hundreds of acres of additional tree clearing than would be necessary if narrower, slightly deeper swales were constructed. The large swale was replaced by two swales with an approximate bottom width of 80 feet, and sloped up to existing grade at approximately 1V:20H to provide a gentle, more natural transition, while making the design more constructible, and reducing the quantity of tree clearing necessary for construction. This configuration, which achieved an estimated earthwork cut and fill balance within a few thousand cubic yards (less than 1% of the total material volume), was then run through the HEC-RAS model to check hydraulic performance, primarily focused on induced flooding at the 1% ACE flood event. Minimal alterations to the SD Berm profile were required to reduce induced flooding estimates to below the 0.04 feet necessary to achieve the MVS-standard “no-rise” condition upstream.

To reduce this effect, these two swales were divided into several smaller, disconnected and more disorderly alignments in the hope of dissipating the increase in flood elevation. The first of these iterations selected portions that both pierced the cross-levees to continue meeting that objective while reducing the quantity of clearing, reducing both the temporary ecological impacts of construction and the construction costs. The swales were further disconnected, and per biologist opinion, the swales were relocated to better follow the existing low contours of the Island.

Additional considerations will be incorporated into PED for these swales, including refining the material balance, utilizing a limited geotechnical exploration to determine average soil bulk and compaction factors, ensuring that swale alignments allow for the best use of the natural contours to provide connectivity, and similarly reconnecting the floodplain to the small, perennial or intermittent streams on the Island flank.

4 CONSTRUCTION SEQUENCE AND METHODS

An estimated construction schedule was developed for the purposes of developing a reasonable cost estimate. The actual contract phasing will revisited in the early phases of PED to ensure that the most efficient sequence of work practicable will be used. The following discussion reflects additional considerations for that process.

The upper 7 to 8 feet of the Backwater Channel will be excavated mechanically along with any existing dike structures, of which only one is known to cross the channel alignment. The excavated material will be used to form containment berms on the interior of the existing levee, forming the perimeter(s) of the lowest two proposed ridges and sediment deflection (SD) berm to contain and dewater dredged material. Additional excavated material may be stockpiled for use in capping the SD Berm and Ridges, or used to construct other portions of the SD Berm, depending on the final contract sequence. The remaining portion, primarily sands, will be dredged, either in full or in part, with the dredged sediment placed as the core material for the two adjacent ridges and portion of the SD Berm. The dredged material will require time to dewater and consolidate, after which earthwork equipment will scarify the surface prior to placement of a fine-grained soil cap. Temporary filter structures composed of stone and geotextile may be required to accelerate the dewatering process.

The existing levee will be degraded at two points at the north end of the Island to improve the hydraulic performance of the reinforced sediment deflection system. After clearing and stripping of these features, the material removed from the remnant levee will be utilized in constructing the SD Berm. The remaining three Ridges and portions of the SD Berm will be constructed of material excavated from swales. Test trenches are likely to be dug at points along the swales to provide depth reference, and to determine depth of suitable material for phasing of berm construction. Sands removed from swales may only be used as core material, with a minimum cap of five feet of fine-grained soil.

Final grading and plantings are currently assumed to occur at the end of construction, except establishment of turf and cover crops at the end of each contract for erosion control. Tree plantings are commonly subcontracted to landscape specialists. Tree planting may also be completed at the end of each contract, if sufficient features are ready for planting, to justify the additional costs associated with subcontracting this work. This would begin the process of reforestation earlier in the process and provide additional time to correct any concerns with growth prior to the final contract completion.

4.1 Earthwork Methods and Estimate

Dozers or excavators may be required to break up high-plasticity clay soils for removal and placement by pan scrapers. Alternately, off-road trucks may be utilized for hauling of material, or pan scrapers may be top-loaded by excavators, likely at reduced efficiency. All fill will be semi-compacted by construction equipment to ensure a continuous soil structure while maintaining soil loose enough for trees and cover crop vegetation to take root.

Earthwork balance quantities were made assuming soil adjustment factors to account for differences in native soil density, loose/hauled soil density, and semi-compacted fill density. The factors used in the quantities estimate are 1.2 Loose Cubic Yards (LCY) per Bank Cubic Yard (BCY) of undisturbed soil to be excavated, and 0.9 Compacted Cubic Yards (CCY) of filled material (ideally, 1 CCY = 1 BCY, as native density is assumed to be preferable for rooting vegetation). The final mass balance in PED should be conducted using values estimated from laboratory testing. A mass balance in the negative, showing excess cut material was used to be conservative.

4.2 Environmental Protection during Construction

Each contract will include USACE- and Industry-standard Specification Sections and Submittals requirements for Care of Water and Environmental Protection Plans, including Stormwater Pollution Prevention Plans (SWPPP), requiring that these plans be developed, implemented and maintained by the contractor. Preparation of these are beyond the scope of Feasibility Level Design, but the same design principles used in their successful development will be incorporated into PED.

5 REFERENCES

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UPPER MISSISSIPPI RIVER RESTORATION
HARLOW ISLAND HABITAT REHABILITATION
AND ENHANCEMENT PROJECT

INDEX OF DRAWINGS

SHT	TITLE
	GENERAL
G-001	COVER, INDEX, AND PROJECT VICINITY
	CIVIL
C-101	GENERAL PLAN
C-201	SD BERM PROFILES
C-202	SWALE AND BACKWATER CHANNEL PROFILES
C-301	TYPICAL AND KEY SECTIONS
	REFERENCE
R-701	HYDROGRAPH

B7 PROJECT VICINITY
NTS

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UPPER MISSISSIPPI RIVER RESTORATION
HARLOW ISLAND HABITAT REHABILITATION
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FEASIBILITY REPORT

COVER, INDEX, AND PROJECT LOCATION

SHEET ID
G-001

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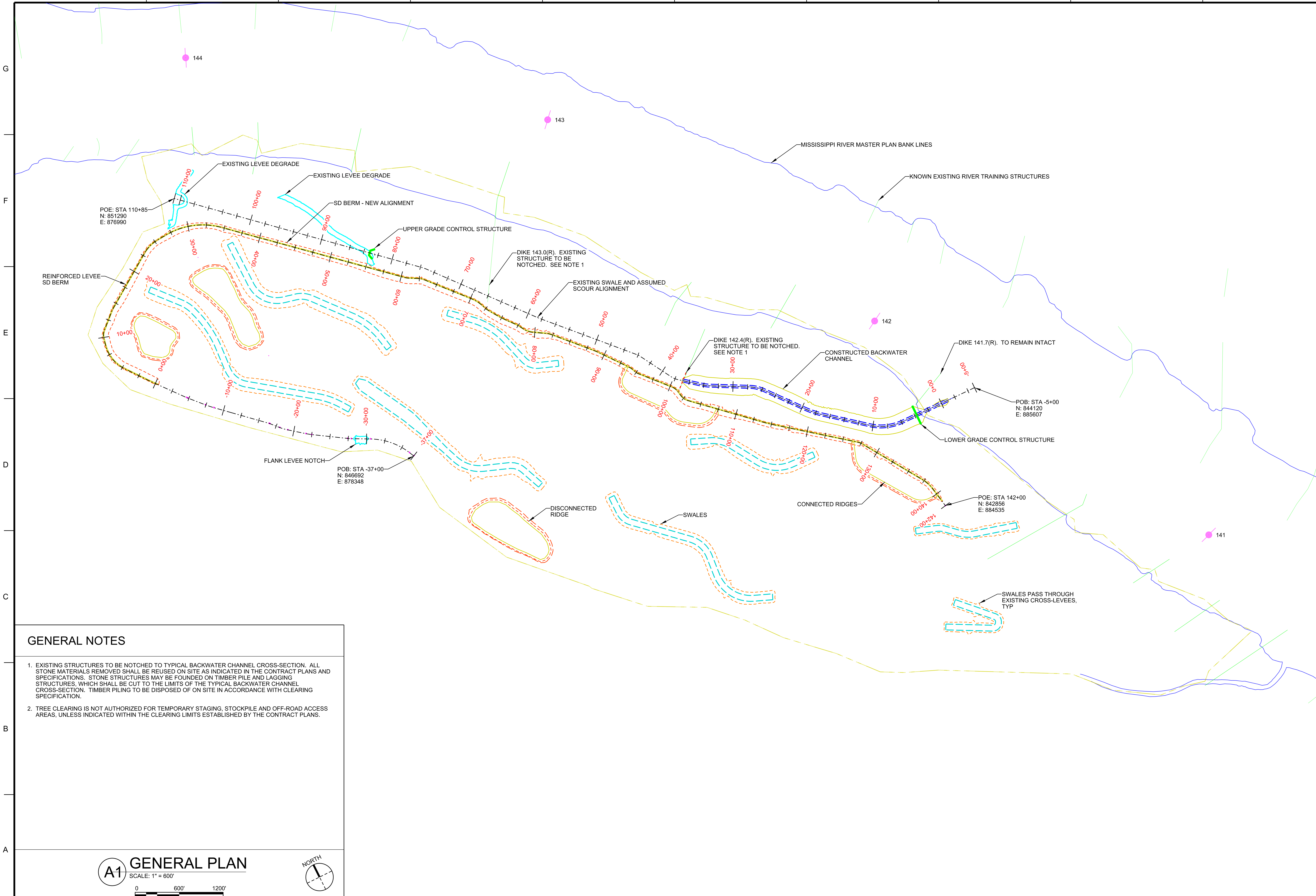

GENERAL NOTES

1. EXISTING STRUCTURES TO BE NOTCHED TO TYPICAL BACKWATER CHANNEL CROSS-SECTION. ALL STONE MATERIALS REMOVED SHALL BE REUSED ON SITE AS INDICATED IN THE CONTRACT PLANS AND SPECIFICATIONS. STONE STRUCTURES MAY BE FOUNDED ON TIMBER PILE AND LAGGING STRUCTURES, WHICH SHALL BE CUT TO THE LIMITS OF THE TYPICAL BACKWATER CHANNEL CROSS-SECTION. TIMBER PILING TO BE DISPOSED OF ON SITE IN ACCORDANCE WITH CLEARING SPECIFICATION.
2. TREE CLEARING IS NOT AUTHORIZED FOR TEMPORARY STAGING, STOCKPILE AND OFF-ROAD ACCESS AREAS, UNLESS INDICATED WITHIN THE CLEARING LIMITS ESTABLISHED BY THE CONTRACT PLANS.

A1 GENERAL PLAN
SCALE: 1" = 600'
0 600' 1200'

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GENERAL PLAN

SHEET ID
C-101

2018/05/08
2018/05/08
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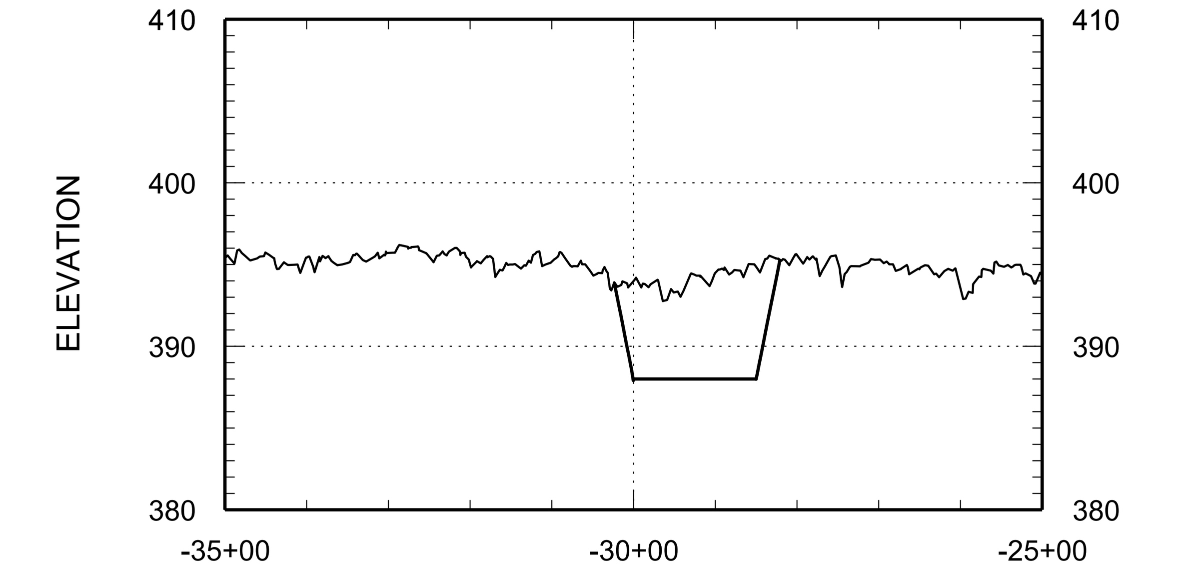
G F E D C B A



LEVEE NOTCH TYPICAL PROFILE

F8

HORIZONTAL SCALE: 1" = 200'
VERTICAL SCALE: 1" = 20'

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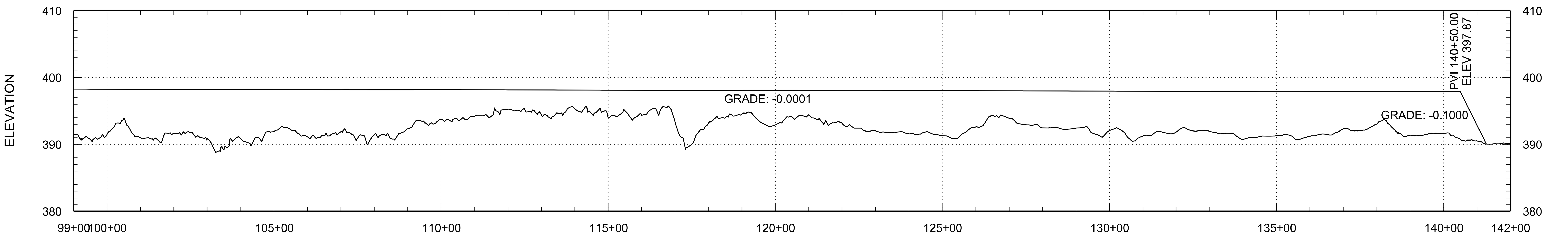
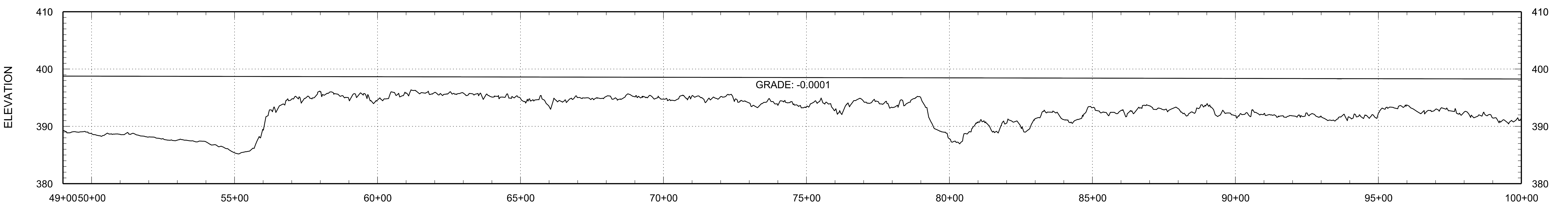
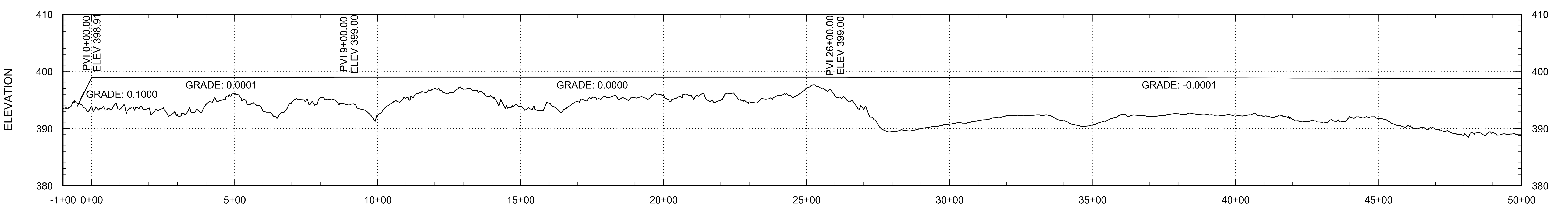
0 10' 20'







SEDIMENT DEFLECTION BERM PROFILE

A1

HORIZONTAL SCALE: 1" = 200'
VERTICAL SCALE: 1" = 20'

0 200' 400'
0 10' 20'

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SEDIMENT DEFLECTION BERM PROFILES

SHEET ID

C-201

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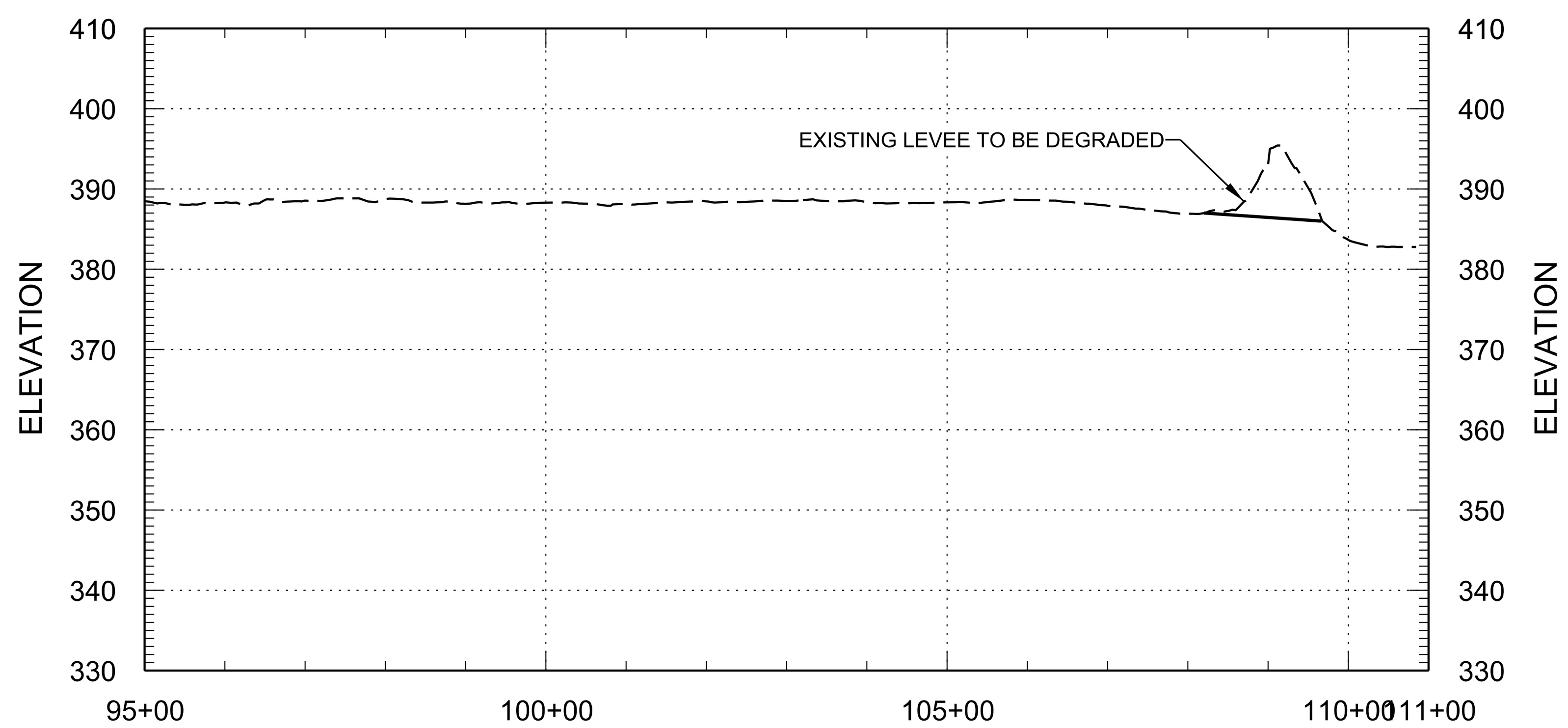

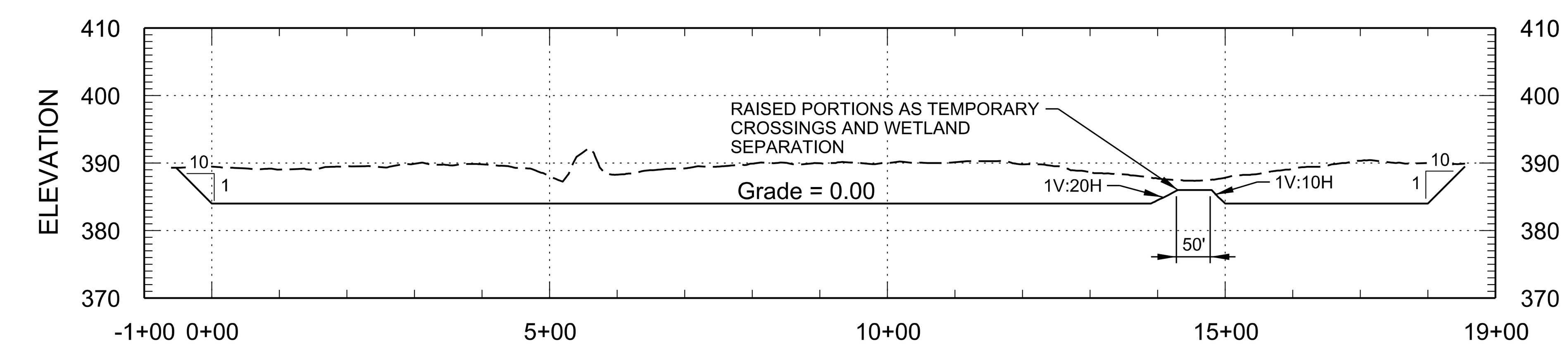

F7 TYPICAL SWALE PROFILE

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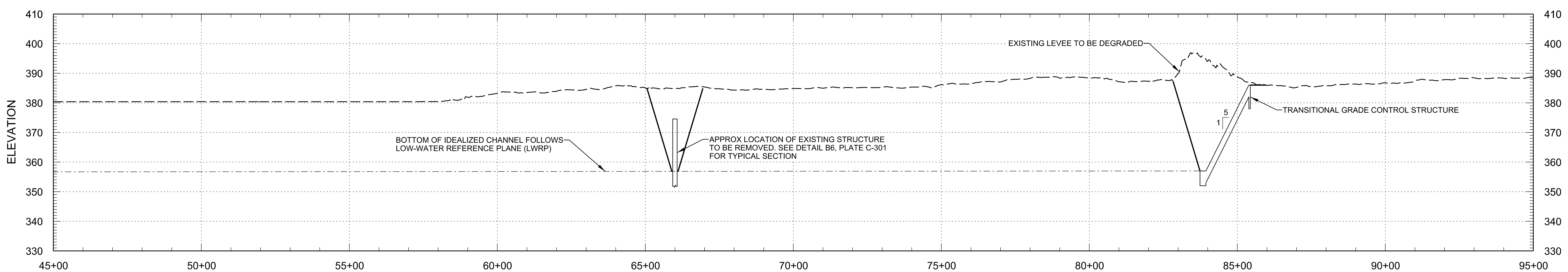

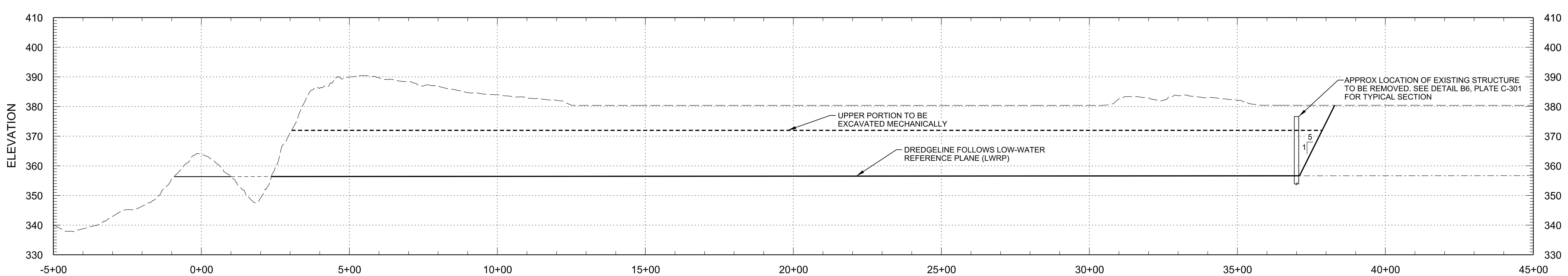

A1 BACKWATER CHANNEL PROFILE

HORIZONTAL SCALE: 1" = 200'
VERTICAL SCALE: 1" = 20'

0 200' 400'
0 10' 20'

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SWALE AND BACKWATER CHANNEL PROFILES

SHEET ID

C-202

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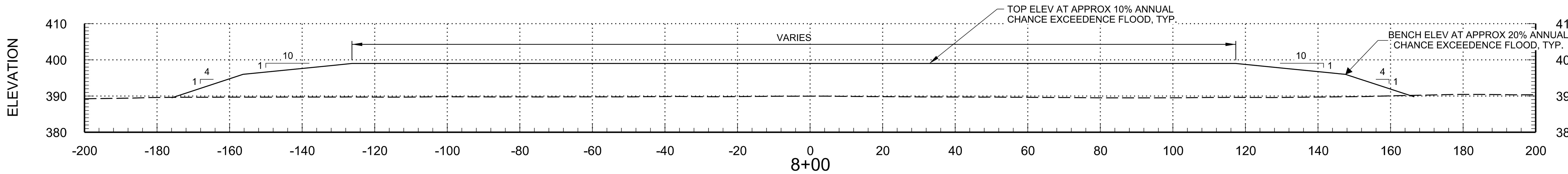

G1 RIDGE TYPICAL SECTION

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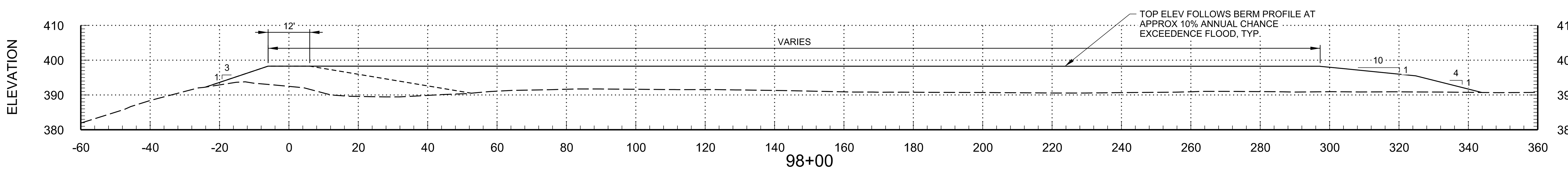

E1 SD BERM WITH ATTACHED RIDGE TYPICAL SECTION

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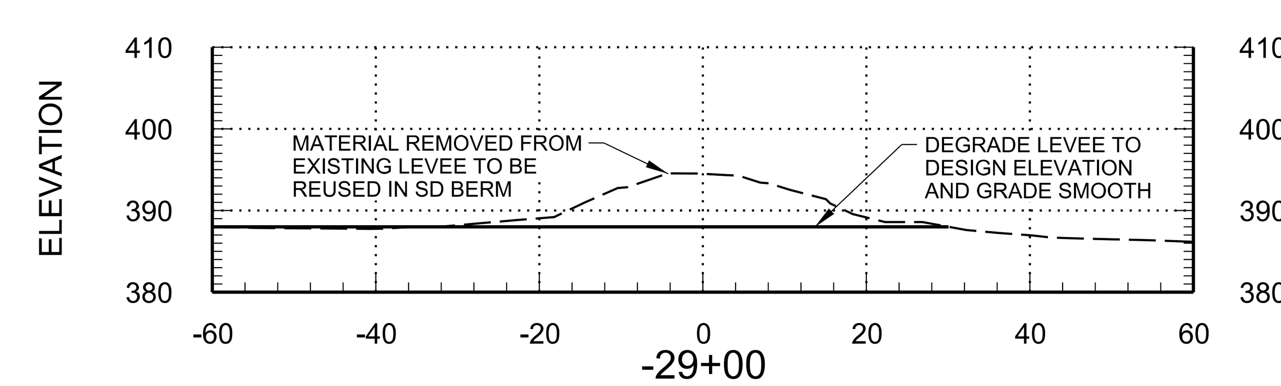

D6 LEVEE NOTCH TYPICAL SECTION

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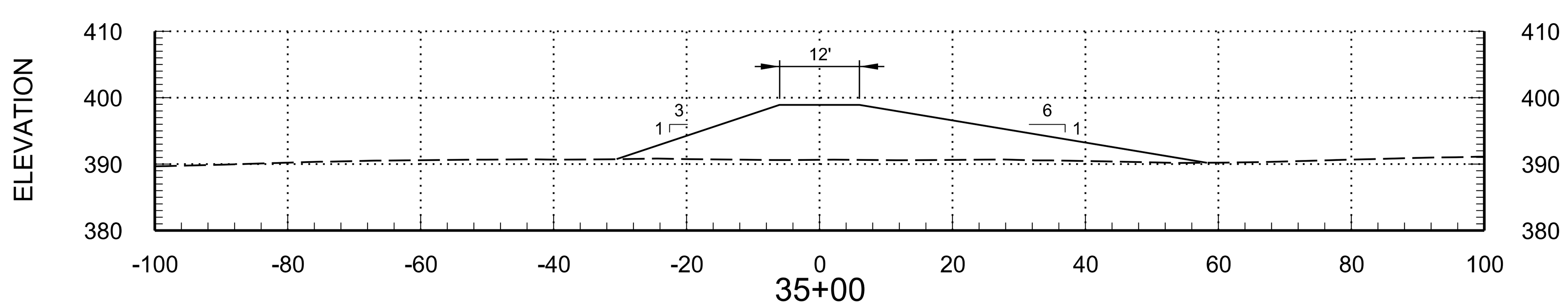

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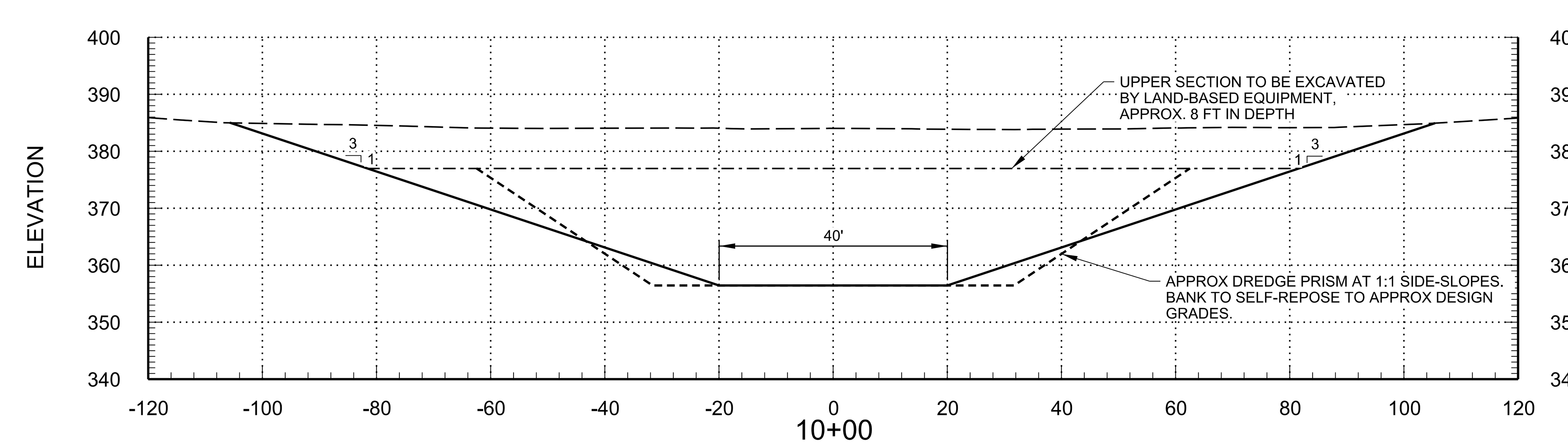

B6 BACKWATER TYPICAL SECTION

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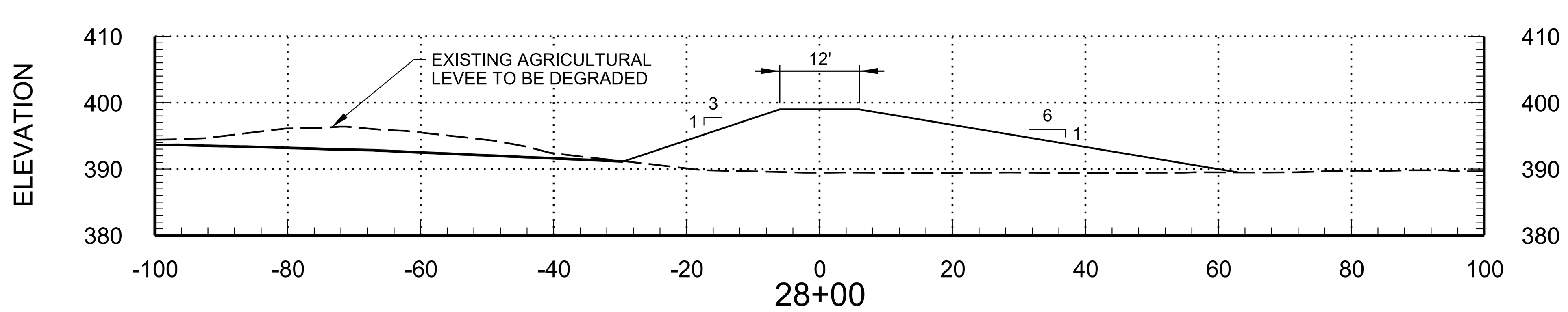

B1 SD BERM TRANSITION TYPICAL SECTION

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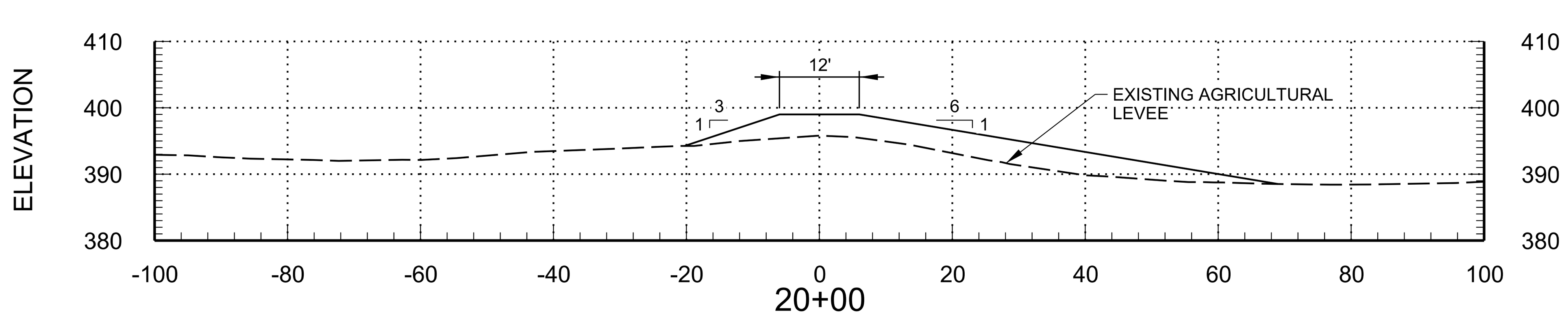

A1 REINFORCED LEVEE SD BERM TYPICAL SECTION

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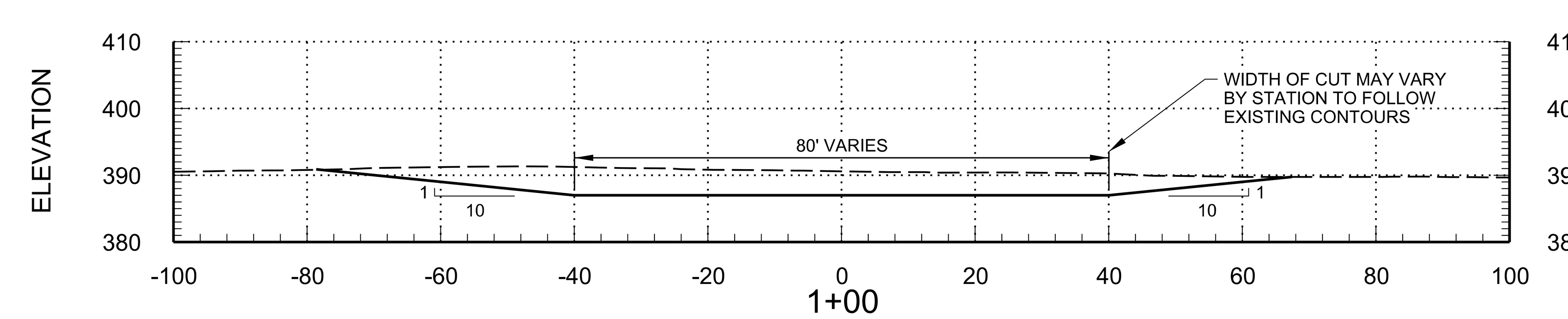

A6 SWALE TYPICAL SECTION

SCALE: 1" = 20'

SHEET NOTES

1. EXCAVATED MATERIAL TO BE REUSED AS FILL, TYP. COURSE-GRAINED SOILS USED AS CORE MATERIAL ONLY, WITH FINE-GRAIN SOIL CAP OF 5' MINIMUM THICKNESS.
2. ALL FILL OPERATIONS TO BE SEMI-COMPACTED BY CONSTRUCTION EQUIPMENT, WITH EACH LAYER SCARIFIED PRIOR TO PLACEMENT OF FOLLOWING LIFT. COMPACTION OF DREDGED MATERIAL TO BE PERFORMED ONLY AFTER MATERIAL IS DEWATERED. DREDGED MATERIAL DETENTION BERMS AND DEWATERING FILTER STRUCTURES TO BE DESIGNED IN PRECONSTRUCTION ENGINEERING AND DESIGN (PED).
3. SEDIMENT DEFLECTION (SD) BERM TO BE CONSTRUCTED ALONG EXISTING AGRICULTURAL LEVEE ALIGNMENT EXCEPT WHERE SHOWN IN PLANS.

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TYPICAL AND KEY SECTIONS

SHEET ID

C-301

2018/06/18
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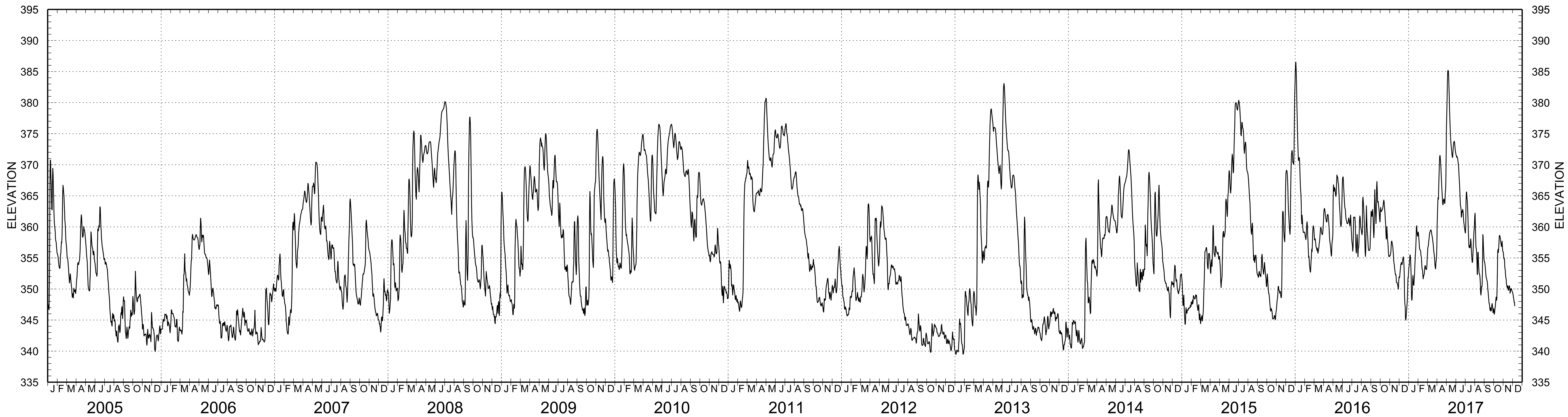

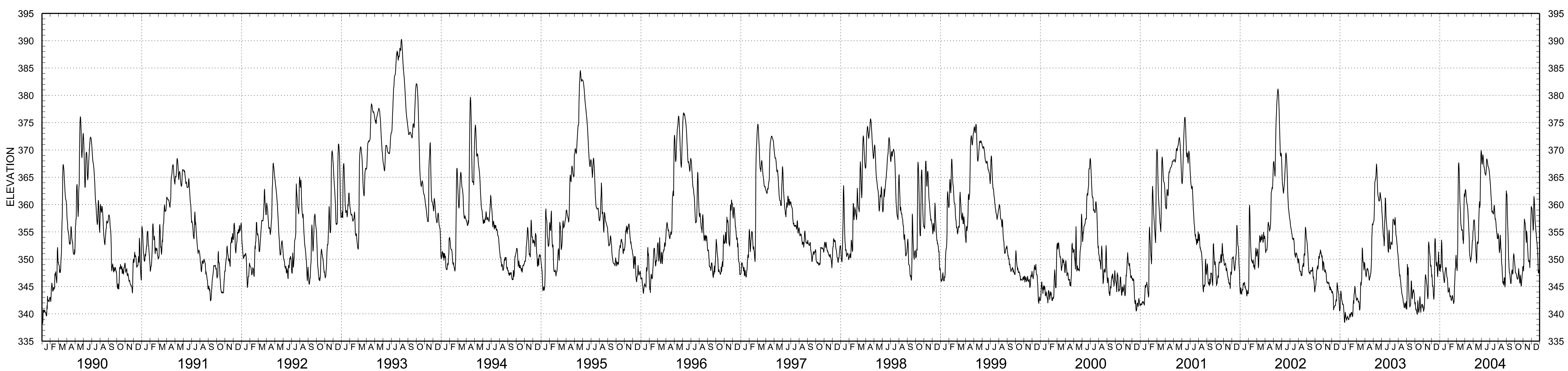

B1 HYDROGRAPHS - CHESTER GAGE

SCALE: 1" = 10'

CHESTER GAGE INFORMATION
MISSISSIPPI RIVER MILE 109.9
STAGE 0 = 340.73 FT NAVD 88
N: 449495.9
E: 2393662.6

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HYDROGRAPH

SHEET ID
R-701

United States Department of Agriculture

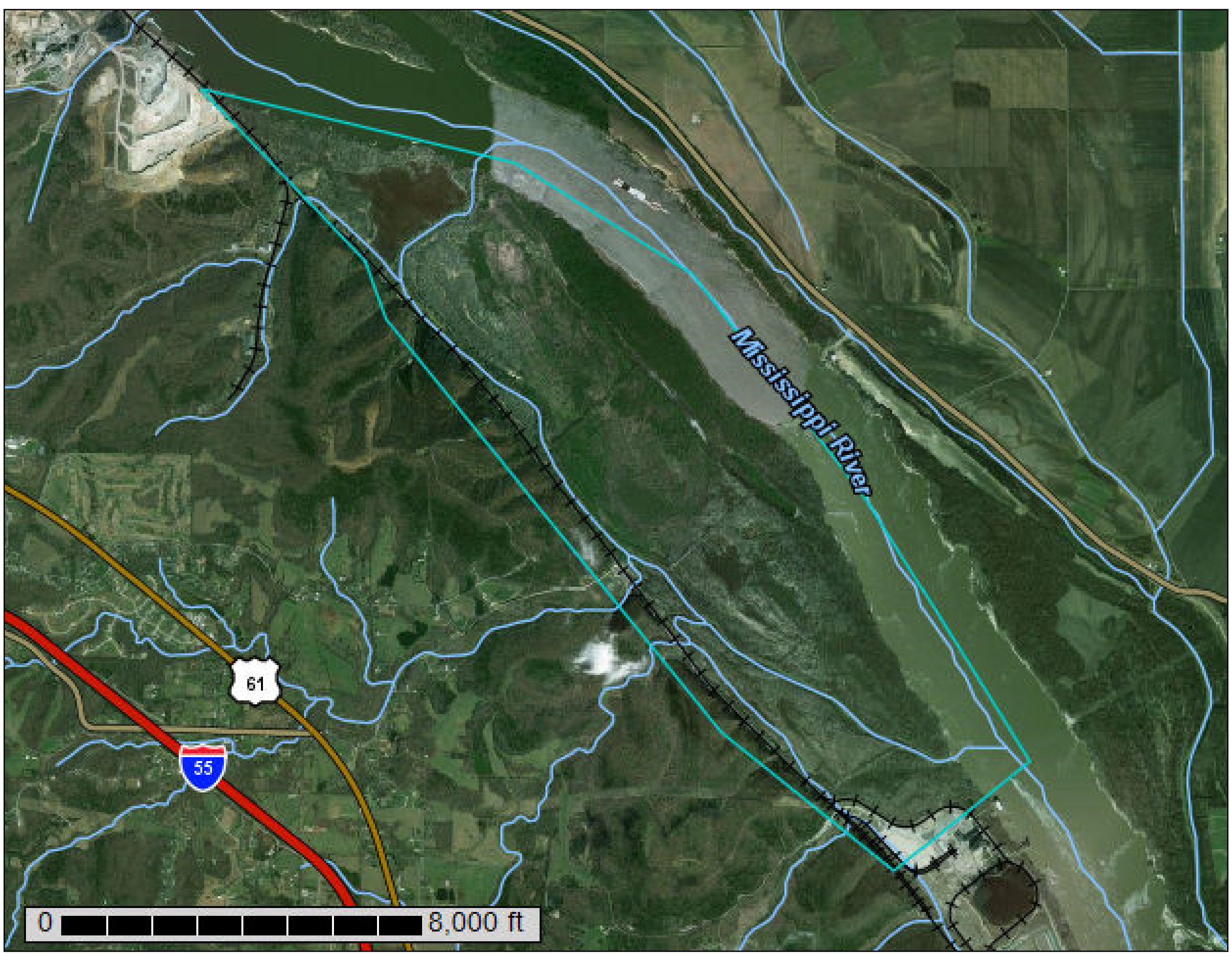
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Jefferson County, Missouri, and Monroe County, Illinois

Harlow Island



October 17, 2017

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

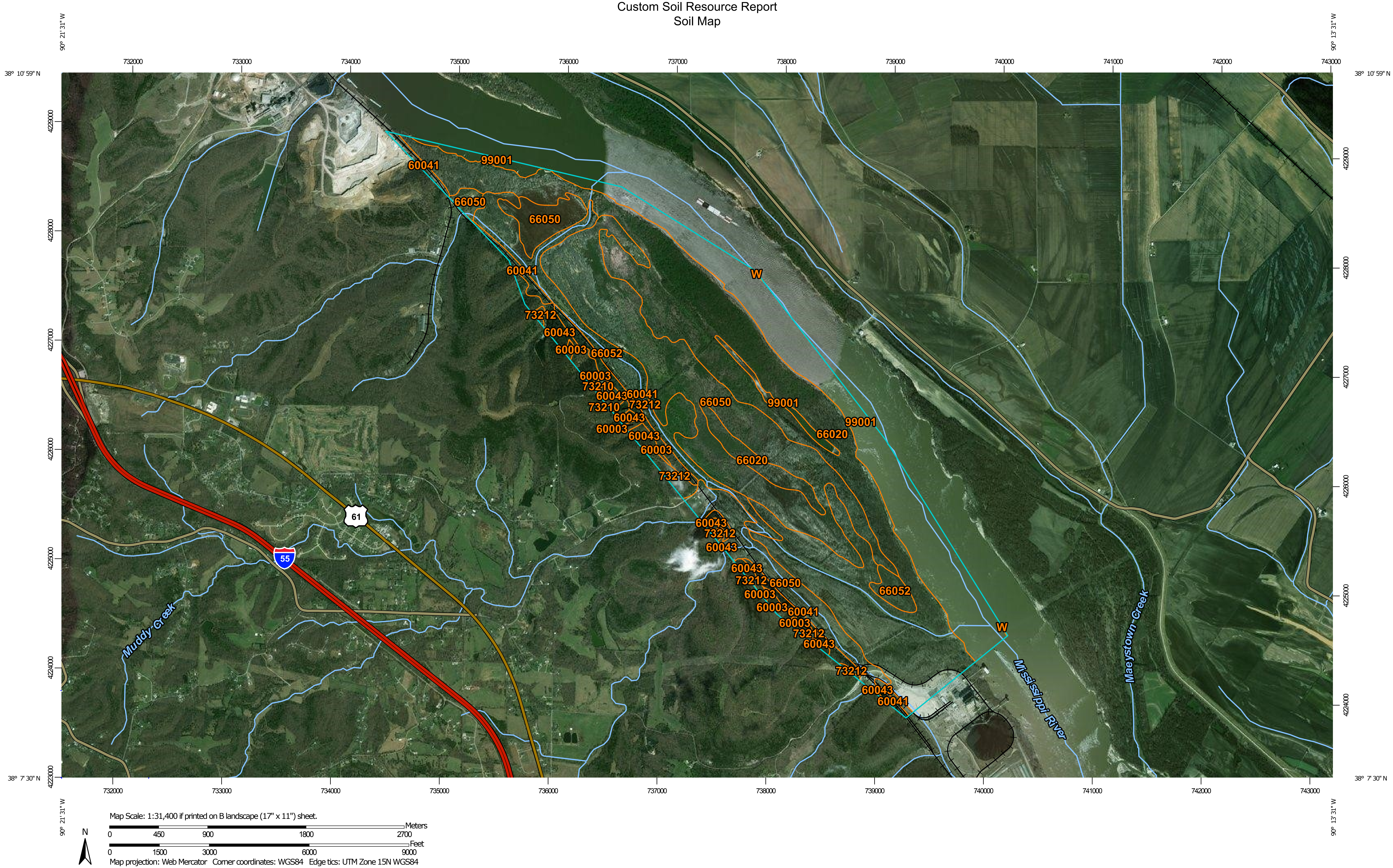
While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.


90° 21' 31" W
90° 13' 31" W
38° 10' 59" N
38° 7' 30" N
732000
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73212
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61
55
Muddy Creek
Mississippi River
Maeystown Creek
Map Scale: 1:31,400 if printed on B landscape (17" x 11") sheet.
N
0
450
900
1800
2700
Meters
0
1500
3000
6000
9000
Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Jefferson County, Missouri
Survey Area Data: Version 19, Sep 28, 2016

Soil Survey Area: Monroe County, Illinois
Survey Area Data: Version 9, Sep 16, 2016

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 27, 2015—Mar 11, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
60003	Menfro silt loam, 9 to 14 percent slopes, eroded	13.3	0.5%
60041	Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony	92.5	3.7%
60043	Menfro silt loam, 30 to 50 percent slopes	76.0	3.1%
66020	Haynie silt loam, 0 to 2 percent slopes, frequently flooded	940.6	37.9%
66050	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration	694.3	28.0%
66052	Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded	207.6	8.4%
73210	Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony	3.6	0.1%
73212	Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly	29.0	1.2%
99001	Water	423.4	17.1%
Subtotals for Soil Survey Area		**2,480.2**	**100.0%**
Totals for Area of Interest		**2,481.0**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
W	Water	0.8	0.0%
Subtotals for Soil Survey Area		**0.8**	**0.0%**
Totals for Area of Interest		**2,481.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Jefferson County, Missouri

60003—Menfro silt loam, 9 to 14 percent slopes, eroded

Map Unit Setting

National map unit symbol: 2qp0b
Elevation: 400 to 900 feet
Mean annual precipitation: 37 to 47 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 184 to 228 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Menfro and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Menfro

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess

Typical profile

Ap - 0 to 4 inches: silt loam
BE - 4 to 9 inches: silt loam
Bt1 - 9 to 35 inches: silty clay loam
Bt2 - 35 to 60 inches: silt loam

Properties and qualities

Slope: 9 to 14 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: Deep Loess Upland Woodland (F115BY001MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

60041—Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2qp13
Elevation: 800 to 1,100 feet
Mean annual precipitation: 37 to 47 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 184 to 228 days
Farmland classification: Not prime farmland

Map Unit Composition

Brussels and similar soils: 60 percent
Rock outcrop: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Brussels

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Slope alluvium

Typical profile

A - 0 to 5 inches: very channery silty clay loam
Bw1 - 5 to 35 inches: very channery silty clay
Bw2 - 35 to 60 inches: extremely channery silty clay

Properties and qualities

Slope: 35 to 90 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C

Ecological site: Talus Footslope Forest (F116AY022MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Hillslopes
Parent material: Limestone

Typical profile

R - 0 to 80 inches: unweathered bedrock

Properties and qualities

Slope: 35 to 90 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

60043—Menfro silt loam, 30 to 50 percent slopes

Map Unit Setting

National map unit symbol: 2qp15
Elevation: 400 to 900 feet
Mean annual precipitation: 37 to 47 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 184 to 228 days
Farmland classification: Not prime farmland

Map Unit Composition

Menfro and similar soils: 80 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Menfro

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loess

Typical profile

A - 0 to 4 inches: silt loam
E - 4 to 10 inches: silt loam

Bt1 - 10 to 40 inches: silty clay loam
Bt2 - 40 to 80 inches: silt loam

Properties and qualities

Slope: 30 to 50 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: Deep Loess Protected Backslope Forest (F115BY003MO), Deep Loess Exposed Backslope Woodland (F115BY043MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

66020—Haynie silt loam, 0 to 2 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2tbrj
Elevation: 350 to 730 feet
Mean annual precipitation: 33 to 47 inches
Mean annual air temperature: 50 to 57 degrees F
Frost-free period: 177 to 228 days
Farmland classification: Not prime farmland

Map Unit Composition

Haynie and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Haynie

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

Ap - 0 to 7 inches: silt loam

C - 7 to 79 inches: stratified very fine sandy loam to silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very high (about 12.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B
Ecological site: Sandy/Loamy Floodplain Forest (F115BY015MO)
Hydric soil rating: Yes

Minor Components

Parkville

Percent of map unit: 10 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey Floodplain Forest (F115BY041MO)
Hydric soil rating: Yes

Sarpy

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Sandy/Loamy Floodplain Forest (F115BY015MO)
Hydric soil rating: Yes

66050—Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration

Map Unit Setting

National map unit symbol: 2tbrq
Elevation: 340 to 660 feet
Mean annual precipitation: 37 to 47 inches
Mean annual air temperature: 52 to 57 degrees F

Frost-free period: 184 to 228 days
Farmland classification: Not prime farmland

Map Unit Composition

Tice and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tice

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 16 inches: silty clay loam
Bw - 16 to 68 inches: silt loam
Bg - 68 to 79 inches: stratified loam to silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 12 to 20 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum in profile: 10 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: High (about 11.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Ecological site: Wet Floodplain Woodland (F109XY037MO)
Hydric soil rating: Yes

Minor Components

Darwin

Percent of map unit: 10 percent
Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Clayey Floodplain Forest (F115BY041MO)
Hydric soil rating: Yes

66052—Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: m8k9
Elevation: 400 to 1,650 feet
Mean annual precipitation: 37 to 47 inches
Mean annual air temperature: 52 to 57 degrees F
Frost-free period: 184 to 228 days
Farmland classification: Not prime farmland

Map Unit Composition

Waldron and similar soils: 85 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Waldron

Setting

Landform: Flood plains
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Alluvium

Typical profile

Ap - 0 to 6 inches: silty clay loam
C - 6 to 60 inches: stratified silt loam to silty clay loam to silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum in profile: 30 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: Clayey Floodplain Forest (F115BY041MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: Yes

Minor Components

Booker

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: Ponded Floodplain Prairie (R115BY042MO)
Other vegetative classification: Mixed/Transitional (Mixed Native Vegetation)
Hydric soil rating: Yes

Haynie

Percent of map unit: 5 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Loamy Floodplain Forest (F115BY031MO)
Other vegetative classification: Mixed/Transitional (Mixed Native Vegetation)
Hydric soil rating: Yes

73210—Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2vxws
Elevation: 800 to 1,200 feet
Mean annual precipitation: 39 to 49 inches
Mean annual air temperature: 54 to 59 degrees F
Frost-free period: 172 to 232 days
Farmland classification: Not prime farmland

Map Unit Composition

Goss and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Goss

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium over residuum weathered from dolomite

Typical profile

A - 0 to 3 inches: very cobbly silt loam

E - 3 to 9 inches: very gravelly silt loam
2Bt - 9 to 79 inches: very cobbly clay

Properties and qualities

Slope: 15 to 50 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: Chert Protected Backslope Forest (F116AY002MO), Chert Exposed Backslope Woodland (F116AY062MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

Minor Components

Gatewood

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Chert Dolomite Protected Backslope Forest (F116AY016MO), Chert Dolomite Exposed Backslope Woodland (F116AY048MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

Gepp

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Chert Upland Woodland (F116AY011MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

Alred

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope

Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Chert Protected Backslope Forest (F116AY002MO), Chert Exposed Backslope Woodland (F116AY062MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

Rueter

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: Chert Protected Backslope Forest (F116AY002MO), Chert Exposed Backslope Woodland (F116AY062MO)
Other vegetative classification: Trees/Timber (Woody Vegetation)
Hydric soil rating: No

73212—Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly

Map Unit Setting

National map unit symbol: 2q0qx
Elevation: 300 to 900 feet
Mean annual precipitation: 39 to 49 inches
Mean annual air temperature: 54 to 59 degrees F
Frost-free period: 172 to 232 days
Farmland classification: Not prime farmland

Map Unit Composition

Gasconade and similar soils: 55 percent
Rock outcrop: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gasconade

Setting

Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Residuum weathered from limestone

Typical profile

A - 0 to 10 inches: very channery silty clay
Bw - 10 to 13 inches: channery silty clay
R - 13 to 80 inches: bedrock

Properties and qualities

Slope: 15 to 50 percent
Percent of area covered with surface fragments: 35.0 percent
Depth to restrictive feature: 4 to 20 inches to lithic bedrock
Natural drainage class: Somewhat excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 1.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: Shallow Limestone/Dolomite Upland Glade/Woodland (R115BY009MO)
Other vegetative classification: Mixed/Transitional (Mixed Native Vegetation)
Hydric soil rating: No

Description of Rock Outcrop

Setting

Landform: Hillslopes
Parent material: Limestone

Typical profile

R - 0 to 80 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 50 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

99001—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Water

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydric soil rating: No

Monroe County, Illinois

W—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Water

Setting

Landform: Lakes, perenial streams, channels, oxbows, drainageways, rivers

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Vegetative Productivity

Vegetative productivity includes estimates of potential vegetative production for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture and rangeland. In the underlying database, some states maintain crop yield data by individual map unit component. Other states maintain the data at the map unit level. Attributes are included for both, although only one or the other is likely to contain data for any given geographic area. For other land uses, productivity data is shown only at the map unit component level. Examples include potential crop yields under irrigated and nonirrigated conditions, forest productivity, forest site index, and total rangeland production under of normal, favorable and unfavorable conditions.

Black Walnut Suitability Index (MO)

Proper site conditions are essential for suitable growth of black walnut (Juglans nigra L.) trees. Black Walnut Suitability Index ratings provide a method of rating Missouri soils based on their potential or suitability for black walnut growth.

The values for soil factors in the index are added together and then multiplied by critical factors to produce the final rating. Only factors listed under "rating reasons" are those adversely affecting the overall rating.

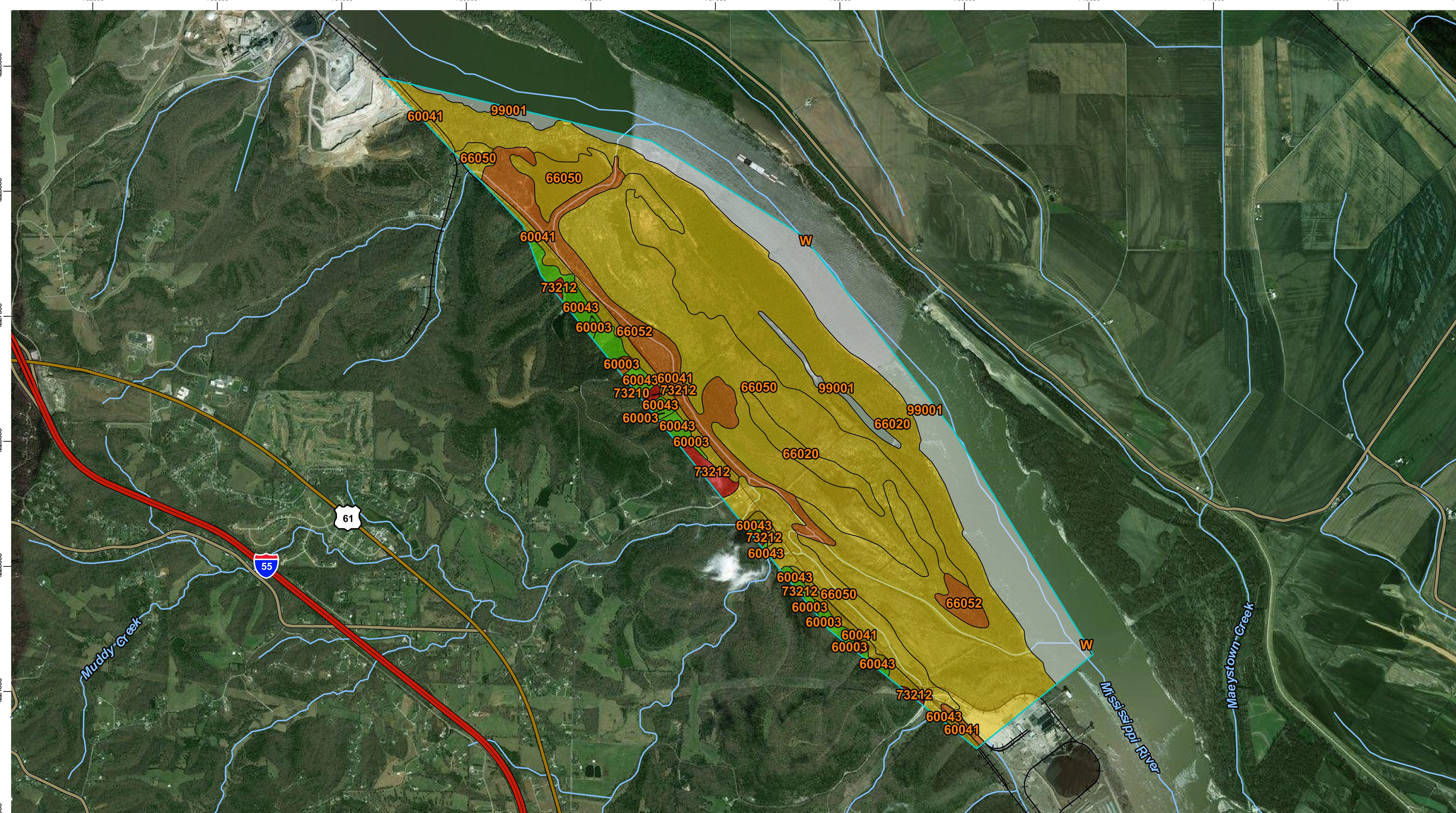
The calculated black walnut rating factor ranges from 0 to 1 with the higher values indicating better suitability. On the basis of these numeric values, the soils are grouped into suitability classes. These classes are identified as "unsuited," "poorly suited," "somewhat suited," "moderately suited," "well suited," and "very well suited."

The best suited soils for black walnut growth are very deep, moderately well drained or well drained, medium textured, slightly acid to slightly alkaline, have a high available water capacity, no rock fragments in the upper 24 inches, and are subject to brief or very brief flooding duration. Soils that are unsuited have a shallow effective rooting depth, a high water table (poor drainage), a low available water capacity, or are subject to flooding of very long duration.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen, which is displayed on the report. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the Selected Soil Interpretations report with this interpretation included from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Black Walnut Suitability Index (MO)



Map Scale: 1:31,400 if printed on B landscape (17" x 11") sheet.

Meters: 0, 450, 900, 1800, 2700

Feet: 0, 1500, 3000, 6000, 9000

N

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

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Unsuited
- Poorly suited
- Somewhat suited
- Moderately suited
- Well suited
- Very well suited
- Not rated or not available

Soil Rating Lines
- Unsuited
- Poorly suited
- Somewhat suited
- Moderately suited
- Well suited
- Very well suited
- Not rated or not available

Soil Rating Points
- Unsuited
- Poorly suited
- Somewhat suited
- Moderately suited
- Well suited
- Very well suited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Jefferson County, Missouri
Survey Area Data: Version 19, Sep 28, 2016

Soil Survey Area: Monroe County, Illinois
Survey Area Data: Version 9, Sep 16, 2016

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 27, 2015—Mar 11, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Black Walnut Suitability Index (MO)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
60003	Menfro silt loam, 9 to 14 percent slopes, eroded	Well suited	Menfro (85%)	Flood Freq: None/Rare (0.00) Landform: Backslope (0.50) pH limiting factor (0.68) Available water capacity: 8-12" (0.94)	13.3	0.5%
60041	Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony	Somewhat suited	Brussels (60%)	Frags: >15% (0.00) Flood Freq: None/Rare (0.00) Available water capacity: 3-8" (0.19) Texture: Poorly suited (0.38) Landform: Backslope (0.50)	92.5	3.7%
60043	Menfro silt loam, 30 to 50 percent slopes	Well suited	Menfro (80%)	Flood Freq: None/Rare (0.00) pH limiting factor (0.46) Landform: Backslope (0.50) Available water capacity: 8-12" (0.93)	76.0	3.1%
66020	Haynie silt loam, 0 to 2 percent slopes, frequently flooded	Somewhat suited	Haynie (85%)	Native Veg: Prairie in uplands (0.00) Flood Duration: Long (0.50) pH limiting factor (0.59) Available water capacity: 8-12" (0.97)	940.6	37.9%

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
66050	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration	Somewhat suited	Tice (90%)	Native Veg: Prairie in uplands (0.00)	694.3	28.0%
				Flood Duration: Long (0.50)		
				Watertable: 12-24" (0.59)		
				Available water capacity: 8-12" (0.96)		
66052	Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded	Poorly suited	Waldron (85%)	Native Veg: Prairie in uplands (0.00)	207.6	8.4%
				Texture: Poorly suited (0.40)		
				Flood Duration: Long (0.50)		
				pH limiting factor (0.59)		
				Watertable: 12-24" (0.63)		
73210	Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony	Poorly suited	Goss (80%)	Frags: >15% (0.00)	3.6	0.1%
				Texture: Unsuited (0.00)		
				Flood Freq: None/Rare (0.00)		
				Available water capacity: 3-8" (0.22)		
				pH limiting factor (0.32)		
			Gatewood (5%)	Texture: Unsuited (0.00)		
				Flood Freq: None/Rare (0.00)		
				Available water capacity: 3-8" (0.19)		
				Depth:35-48" (0.34)		
				Landform: Backslope (0.50)		
			Alred (5%)	Texture: Unsuited (0.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Flood Freq: None/Rare (0.00)		
				Frags: 8-15% (0.12)		
				Available water capacity: 3-8" (0.33)		
				Landform: Backslope (0.50)		
73212	Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly	Unsuited	Gasconade (55%)	Critical depth limit:<20" (0.00)	29.0	1.2%
				Critical available water capacity limit: <3" (0.00)		
				Depth: <20" (0.00)		
				Frags: >15% (0.00)		
				Texture: Unsuited (0.00)		
99001	Water	Not rated	Water (100%)		423.4	17.1%
Subtotals for Soil Survey Area					**2,480.2**	**100.0%**
Totals for Area of Interest					**2,481.0**	**100.0%**

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
W	Water	Not rated	Water (100%)		0.8	0.0%
Subtotals for Soil Survey Area					**0.8**	**0.0%**
Totals for Area of Interest					**2,481.0**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Somewhat suited	1,727.4	69.6%
Poorly suited	211.2	8.5%
Well suited	89.3	3.6%
Unsuited	29.0	1.2%
Null or Not Rated	424.1	17.1%
Totals for Area of Interest	**2,481.0**	**100.0%**

Rating Options—Black Walnut Suitability Index (MO)

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Lower

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

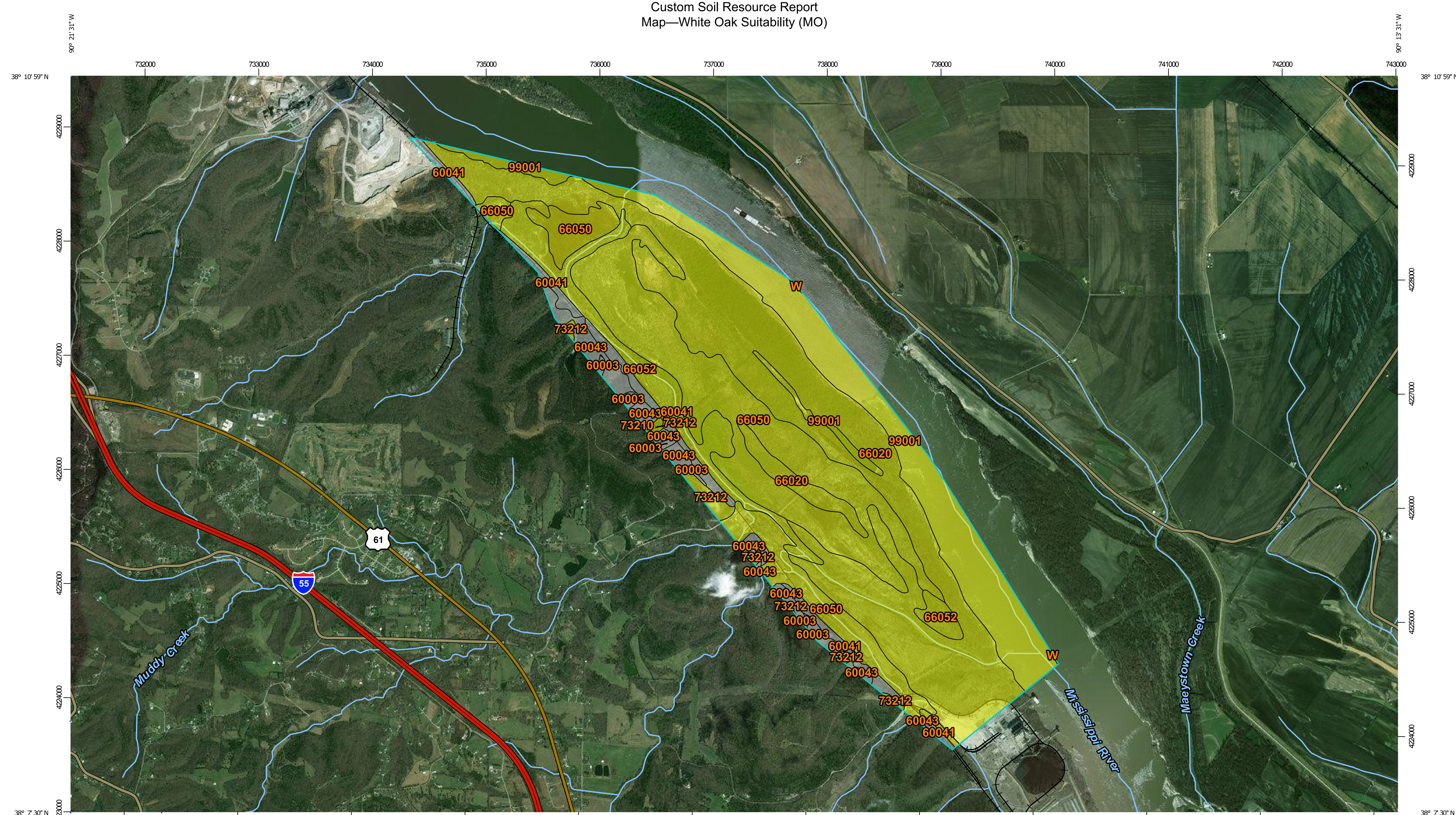
White Oak Suitability (MO)

Proper site conditions are essential for suitable growth of white oak (Quercus alba) production. White Oak Suitability ratings for Missouri soils are based on their soil's potential or suitability for white oak growth.

The values for specific soil properties are evaluated and rated based upon the most restrictive soil property/properties for white oak growth.

The calculated white oak ratings range from 0 to 1. The higher the values the better the suitability. On the basis of these numeric values, the soils are grouped into suitability classes. Soils are rated as "Well Suited on protected slopes otherwise suited," "Suited on protected slopes otherwise poorly suited," "Poorly Suited," " Very Poorly Suited," or "Not Rated." The best suited soils for white oak growth are very deep, moderately well drained or well drained, medium textured, and slightly acid to slightly alkaline, have a high available water capacity, and have no rock fragments in the upper 24 inches. Also, the best suited soils are on protected slopes that face north or east, away from direct sunlight.

Onsite investigations are needed to validate these interpretations and to confirm the identity of the soil on a given site.



Map Scale: 1:31,400 if printed on B landscape (17" x 11") sheet.

N

Meters: 0, 450, 900, 1800, 2700

Feet: 0, 1500, 3000, 6000, 9000

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not Rated
- Very Poorly Suited
- Poorly Suited
- Suited on protected slopes otherwise poorly suited
- Well Suited on protected slopes otherwise suited
- Not rated or not available

Soil Rating Lines

- Not Rated
- Very Poorly Suited
- Poorly Suited
- Suited on protected slopes otherwise poorly suited
- Well Suited on protected slopes otherwise suited
- Not rated or not available

Soil Rating Points

- Not Rated
- Very Poorly Suited
- Poorly Suited
- Suited on protected slopes otherwise poorly suited
- Well Suited on protected slopes otherwise suited
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Jefferson County, Missouri
Survey Area Data: Version 19, Sep 28, 2016

Soil Survey Area: Monroe County, Illinois
Survey Area Data: Version 9, Sep 16, 2016

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 27, 2015—Mar 11, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—White Oak Suitability (MO)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
60003	Menfro silt loam, 9 to 14 percent slopes, eroded	Well Suited on protected slopes	Menfro (85%)		13.3	0.5%
60041	Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony	Suited	Brussels (60%)	AWC 8 cm - 15 cm (0.42)	92.5	3.7%
				pH = 4.5 - 5.49 or 6.49 to 7.0 (0.50)		
60043	Menfro silt loam, 30 to 50 percent slopes	Suited	Menfro (80%)	pH = 4.5 - 5.49 or 6.49 to 7.0 (0.71)	76.0	3.1%
66020	Haynie silt loam, 0 to 2 percent slopes, frequently flooded	Poorly Suited	Haynie (85%)	brief-very long (0.00)	940.6	37.9%
				Occasional, Frequent, Very Frequent (0.00)		
				pH = 4.5 - 5.49 or 6.49 to 7.0 (0.10)		
			Parkville (10%)	brief-very long (0.00)		
				Occasional, Frequent, Very Frequent (0.00)		
				pH = <4.49 or >7.09 (0.00)		
				Water Table < 60 cm (0.00)		
			Sarpy (5%)	brief-very long (0.00)		
				Occasional, Frequent, Very Frequent (0.00)		
				pH = <4.49 or >7.09 (0.00)		
66050	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration	Poorly Suited	Tice (90%)	brief-very long (0.00)	694.3	28.0%
				Water Table < 60 cm (0.00)		
			Darwin (10%)	brief-very long (0.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Water Table < 60 cm (0.00)		
66052	Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded	Poorly Suited	Waldron (85%)	brief-very long (0.00)	207.6	8.4%
				Occasional, Frequent, Very Frequent (0.00)		
				Water Table < 60 cm (0.00)		
				pH = 4.5 - 5.49 or 6.49 to 7.0 (0.10)		
			Booker (5%)	brief-very long (0.00)		
				Occasional, Frequent, Very Frequent (0.00)		
				Water Table < 60 cm (0.00)		
				pH = 4.5 - 5.49 or 6.49 to 7.0 (0.90)		
			Haynie (5%)	brief-very long (0.00)		
				Occasional, Frequent, Very Frequent (0.00)		
				pH = 4.5 - 5.49 or 6.49 to 7.0 (0.10)		
73210	Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony	Suited	Goss (80%)	pH = 4.5 - 5.49 or 6.49 to 7.0 (0.51)	3.6	0.1%
			Gepp (5%)	pH = 4.5 - 5.49 or 6.49 to 7.0 (0.61)		
			Alred (5%)	pH = 4.5 - 5.49 or 6.49 to 7.0 (0.91)		
			Rueter (5%)	pH = 4.5 - 5.49 or 6.49 to 7.0 (0.61)		
73212	Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly	Poorly Suited	Gasconade (55%)	AWC <8 cm (0.00)	29.0	1.2%
			Rock outcrop (25%)	AWC <8 cm (0.00)		
				pH = <4.49 or >7.09 (0.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
99001	Water	Poorly Suited	Water (100%)	AWC <8 cm (0.00)	423.4	17.1%
				Frost Free Days = <145 days (0.00)		
				Precip < 76 cm (0.00)		
				pH = <4.49 or >7.09 (0.00)		
Subtotals for Soil Survey Area					**2,480.2**	**100.0%**
Totals for Area of Interest					**2,481.0**	**100.0%**

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
W	Water	Poorly Suited	Water (100%)	AWC <8 cm (0.00)	0.8	0.0%
				Frost Free Days = <145 days (0.00)		
				Precip < 76 cm (0.00)		
				pH = <4.49 or >7.09 (0.00)		
Subtotals for Soil Survey Area					**0.8**	**0.0%**
Totals for Area of Interest					**2,481.0**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Poorly Suited	2,295.6	92.5%
Suited	172.0	6.9%
Well Suited on protected slopes	13.3	0.5%
Totals for Area of Interest	**2,481.0**	**100.0%**

Rating Options—White Oak Suitability (MO)

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Water Management

Water Management interpretations are tools for evaluating the potential of the soil in the application of various water management practices. Example interpretations include pond reservoir area, embankments, dikes, levees, and excavated ponds.

Embankments, Dikes, and Levees

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. Embankments that have zoned construction (core and shell) are not considered. The soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the suitability of the undisturbed soil for supporting the embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

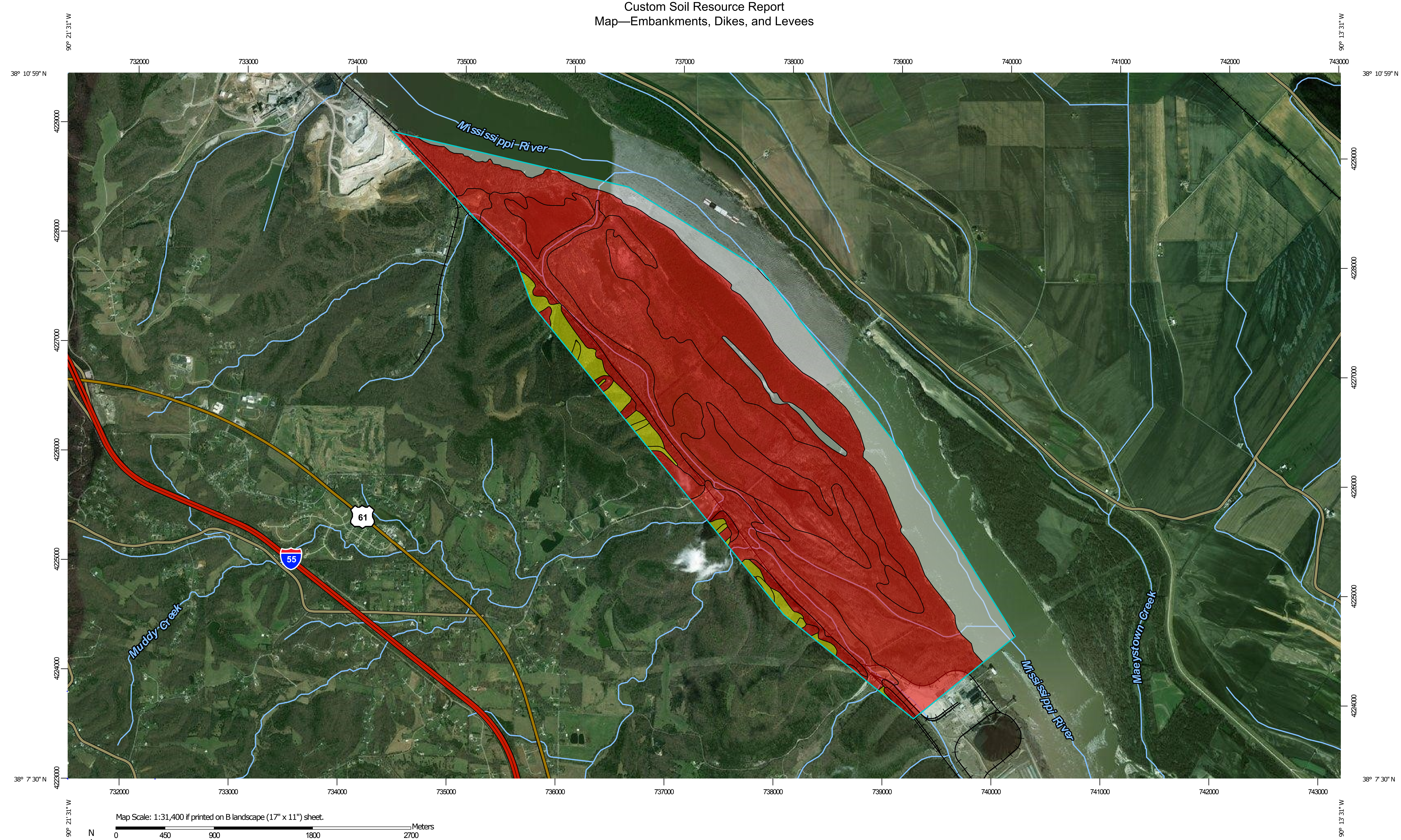
The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Embankments, Dikes, and Levees



Map Scale: 1:31,400 if printed on B landscape (17" x 11") sheet.

N

Meters: 0 450 900 1800 2700

Feet: 0 1500 3000 6000 9000

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Jefferson County, Missouri
Survey Area Data: Version 19, Sep 28, 2016

Soil Survey Area: Monroe County, Illinois
Survey Area Data: Version 9, Sep 16, 2016

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 27, 2015—Mar 11, 2017

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MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Embankments, Dikes, and Levees

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
60003	Menfro silt loam, 9 to 14 percent slopes, eroded	Somewhat limited	Menfro (85%)	Dusty (0.07)	13.3	0.5%
60041	Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony	Very limited	Brussels (60%)	Large stones (1.00)	92.5	3.7%
				Hard to pack (0.50)		
				Dusty (0.07)		
60043	Menfro silt loam, 30 to 50 percent slopes	Somewhat limited	Menfro (80%)	Dusty (0.07)	76.0	3.1%
66020	Haynie silt loam, 0 to 2 percent slopes, frequently flooded	Very limited	Haynie (85%)	Piping (1.00)	940.6	37.9%
				Dusty (0.05)		
			Parkville (10%)	Depth to saturated zone (1.00)		
				Piping (1.00)		
				Dusty (0.09)		
			Sarpy (5%)	Seepage (1.00)		
				Piping (1.00)		
66050	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration	Very limited	Tice (90%)	Depth to saturated zone (1.00)	694.3	28.0%
				Dusty (0.07)		
			Darwin (10%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		
				Hard to pack (0.60)		
				Dusty (0.07)		
66052	Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded	Very limited	Waldron (85%)	Depth to saturated zone (1.00)	207.6	8.4%
				Hard to pack (0.50)		
				Dusty (0.07)		
			Booker (5%)	Ponding (1.00)		
				Depth to saturated zone (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Hard to pack (1.00)		
				Dusty (0.07)		
			Haynie (5%)	Piping (1.00)		
				Dusty (0.05)		
73210	Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony	Very limited	Goss (80%)	Hard to pack (1.00)	3.6	0.1%
				Large stones (0.45)		
				Dusty (0.07)		
			Gatewood (5%)	Hard to pack (1.00)		
				Depth to saturated zone (0.95)		
				Thin layer (0.66)		
				Dusty (0.07)		
			Gepp (5%)	Hard to pack (1.00)		
				Dusty (0.07)		
			Alred (5%)	Hard to pack (1.00)		
				Dusty (0.07)		
73212	Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly	Very limited	Gasconade (55%)	Thin layer (1.00)	29.0	1.2%
				Dusty (0.07)		
99001	Water	Not rated	Water (100%)		423.4	17.1%
Subtotals for Soil Survey Area					**2,480.2**	**100.0%**
Totals for Area of Interest					**2,481.0**	**100.0%**

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
W	Water	Not rated	Water (100%)		0.8	0.0%
Subtotals for Soil Survey Area					**0.8**	**0.0%**
Totals for Area of Interest					**2,481.0**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Very limited	1,967.5	79.3%
Somewhat limited	89.3	3.6%
Null or Not Rated	424.1	17.1%

Rating	Acres in AOI	Percent of AOI
Totals for Area of Interest	**2,481.0**	**100.0%**

Rating Options—Embankments, Dikes, and Levees

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

Soil Physical Properties

Soil Physical Properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

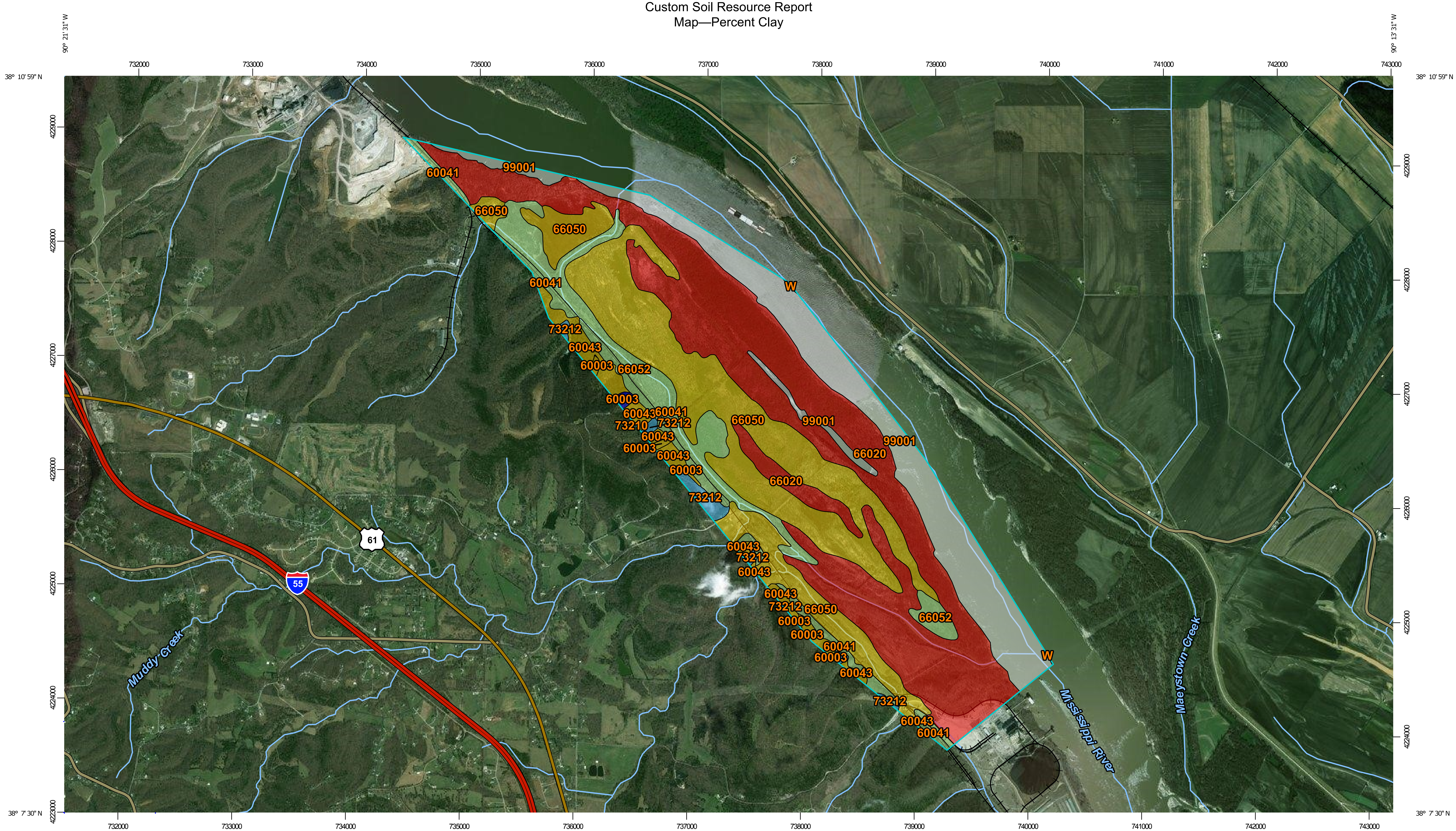
Percent Clay

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. The estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Most of the material is in one of three groups of clay minerals or a mixture of these clay minerals. The groups are kaolinite, smectite, and hydrous mica, the best known member of which is illite.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Map—Percent Clay



Map Scale: 1:31,400 if printed on B landscape (17" x 11") sheet.

Meters: 0, 450, 900, 1800, 2700

Feet: 0, 1500, 3000, 6000, 9000

N

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

<= 7.7

> 7.7 and <= 26.6

> 26.6 and <= 41.7

> 41.7 and <= 49.5

> 49.5 and <= 61.6

Not rated or not available

Soil Rating Lines

<= 7.7

> 7.7 and <= 26.6

> 26.6 and <= 41.7

> 41.7 and <= 49.5

> 49.5 and <= 61.6

Not rated or not available

Soil Rating Points

<= 7.7

> 7.7 and <= 26.6

> 26.6 and <= 41.7

> 41.7 and <= 49.5

> 49.5 and <= 61.6

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Soil Survey Area: Jefferson County, Missouri
Survey Area Data: Version 19, Sep 28, 2016

Soil Survey Area: Monroe County, Illinois
Survey Area Data: Version 9, Sep 16, 2016

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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Date(s) aerial images were photographed: Mar 27, 2015—Mar 11, 2017

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MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Percent Clay

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
60003	Menfro silt loam, 9 to 14 percent slopes, eroded	25.3	13.3	0.5%
60041	Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony	41.7	92.5	3.7%
60043	Menfro silt loam, 30 to 50 percent slopes	26.6	76.0	3.1%
66020	Haynie silt loam, 0 to 2 percent slopes, frequently flooded	7.7	940.6	37.9%
66050	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration	23.7	694.3	28.0%
66052	Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded	41.3	207.6	8.4%
73210	Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony	61.6	3.6	0.1%
73212	Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly	49.5	29.0	1.2%
99001	Water		423.4	17.1%
Subtotals for Soil Survey Area			**2,480.2**	**100.0%**
Totals for Area of Interest			**2,481.0**	**100.0%**

Map unit symbol	Map unit name	Rating (percent)	Acres in AOI	Percent of AOI
W	Water		0.8	0.0%
Subtotals for Soil Survey Area			**0.8**	**0.0%**
Totals for Area of Interest			**2,481.0**	**100.0%**

Rating Options—Percent Clay

Units of Measure: percent

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Depth Range (Weighted Average)

Top Depth: 0

Bottom Depth: 120

Units of Measure: Inches

Soil Qualities and Features

Soil qualities are behavior and performance attributes that are not directly measured, but are inferred from observations of dynamic conditions and from soil properties. Example soil qualities include natural drainage, and frost action. Soil features are attributes that are not directly part of the soil. Example soil features include slope and depth to restrictive layer. These features can greatly impact the use and management of the soil.

Hydrologic Soil Group

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

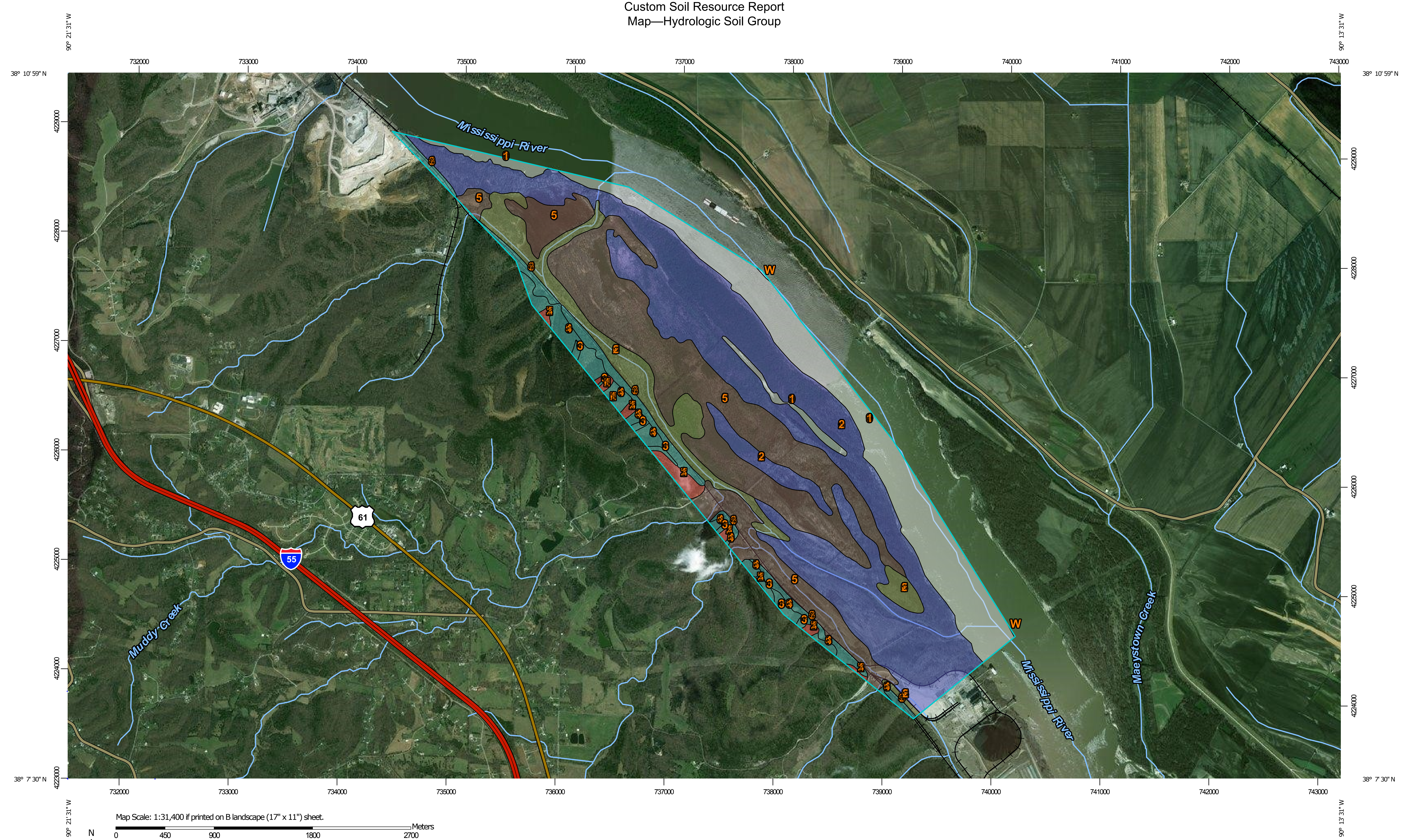
Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Map—Hydrologic Soil Group



Map Scale: 1:31,400 if printed on B landscape (17" x 11") sheet.

N

Meters: 0 450 900 1800 2700

Feet: 0 1500 3000 6000 9000

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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Soil Survey Area: Monroe County, Illinois
Survey Area Data: Version 9, Sep 16, 2016

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MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
60003	Menfro silt loam, 9 to 14 percent slopes, eroded	C	13.3	0.5%
60041	Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony	C	92.5	3.7%
60043	Menfro silt loam, 30 to 50 percent slopes	C	76.0	3.1%
66020	Haynie silt loam, 0 to 2 percent slopes, frequently flooded	B	940.6	37.9%
66050	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration	B/D	694.3	28.0%
66052	Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded	C/D	207.6	8.4%
73210	Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony	D	3.6	0.1%
73212	Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly	D	29.0	1.2%
99001	Water		423.4	17.1%
Subtotals for Soil Survey Area			**2,480.2**	**100.0%**
Totals for Area of Interest			**2,481.0**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
W	Water		0.8	0.0%
Subtotals for Soil Survey Area			**0.8**	**0.0%**
Totals for Area of Interest			**2,481.0**	**100.0%**

Rating Options—Hydrologic Soil Group

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Ecological Site Assessment

Individual soil map unit components can be correlated to a particular ecological site. The Ecological Site Assessment section includes ecological site descriptions, plant growth curves, state and transition models, and selected National Plants database information.

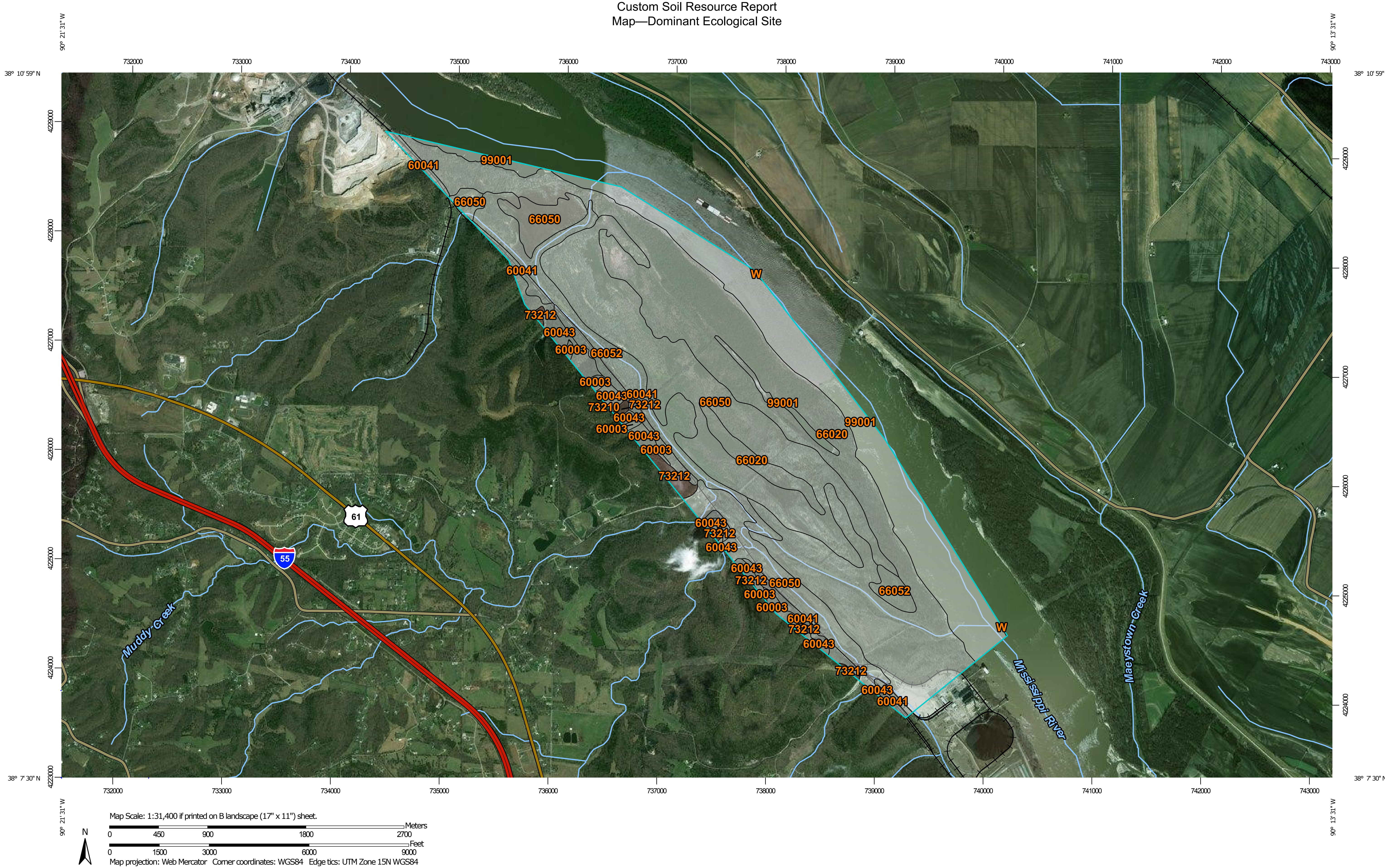
All Ecological Sites — Rangeland

An "ecological site" is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time; a characteristic hydrology, particularly infiltration and runoff, that has developed over time; and a characteristic plant community (kind and amount of vegetation). The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. For example, the hydrology of the site is influenced by development of the soil and plant community. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species or in total production.

An ecological site name provides a general description of a particular ecological site. For example, "Loamy Upland" is the name of a rangeland ecological site. An "ecological site ID" is the symbol assigned to a particular ecological site.

The map identifies the dominant ecological site for each map unit, aggregated by dominant condition. Other ecological sites may occur within each map unit. Each map unit typically consists of one or more components (soils and/or miscellaneous areas). Each soil component is associated with an ecological site. Miscellaneous areas, such as rock outcrop, sand dunes, and badlands, have little or no soil material and support little or no vegetation and therefore are not linked to an ecological site. The table below the map lists all of the ecological sites for each map unit component in your area of interest.

Map—Dominant Ecological Site



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

R115BY009MO

Not rated or not available

Soil Rating Lines

R115BY009MO

Not rated or not available

Soil Rating Points

R115BY009MO

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 1:24,000.

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Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Ecological Sites by Map Unit Component

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
60003	Menfro silt loam, 9 to 14 percent slopes, eroded	Menfro (85%)		13.3	0.5%
60041	Brussels-Rock outcrop complex, 35 to 90 percent slopes, extremely stony	Brussels (60%)		92.5	3.7%
		Rock outcrop (20%)			
60043	Menfro silt loam, 30 to 50 percent slopes	Menfro (80%)		76.0	3.1%
66020	Haynie silt loam, 0 to 2 percent slopes, frequently flooded	Haynie (85%)		940.6	37.9%
		Parkville (10%)			
		Sarpy (5%)			
66050	Tice silty clay loam, 0 to 2 percent slopes, frequently flooded, long duration	Tice (90%)		694.3	28.0%
		Darwin (10%)			
66052	Waldron silty clay loam, 0 to 2 percent slopes, frequently flooded	Waldron (85%)		207.6	8.4%
		Booker (5%)	R115BY042MO — Ponded Floodplain Prairie		
		Haynie (5%)			
73210	Goss very cobbly silt loam, 15 to 50 percent slopes, extremely stony	Goss (80%)		3.6	0.1%
		Alred (5%)			
		Gatewood (5%)			
		Gepp (5%)			
		Rueter (5%)			
73212	Gasconade-Rock outcrop complex, 15 to 50 percent slopes, rubbly	Gasconade (55%)	R115BY009MO — Shallow Limestone/ Dolomite Upland Glade/Woodland	29.0	1.2%
		Rock outcrop (25%)			
99001	Water	Water (100%)		423.4	17.1%
Subtotals for Soil Survey Area				**2,480.2**	**100.0%**
Totals for Area of Interest				**2,481.0**	**100.0%**

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
W	Water	Water (100%)		0.8	0.0%
Subtotals for Soil Survey Area				**0.8**	**0.0%**

Map unit symbol	Map unit name	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
Totals for Area of Interest				**2,481.0**	**100.0%**

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