Illinois Department of Natural Resources
CONSERVATION PLAN

(Application for an Incidental Take Authorization)
Per 520 ILCS 10/5.5 and 17 Ill. Adm. Code 1080

150-day minimum required for public review, biological and legal analysis, and permitting

PROJECT APPLICANT: Union Pacific Railroad

PROJECT NAME: Clinton Railroad Bridge Replacement Project

COUNTY: Whiteside

AMOUNT OF IMPACT AREA: approximately 9.37 acres

The 9.37 acres of river bottom impacts in Illinois comprises of the following as shown on Figure 2:

Permanent Impacts	
New bridge piers	0.13 acre
Temporary Impacts	
Rock causeway and marine trestle	5.29 acres
New pier construction workspace	0.59 acre
Existing pier demolition workspace	1.47 acres
Dredging for barge access	1.89 acres
Total	**9.37 acres**

In addition, removal of the existing bridge piers will restore approximately 0.26 acre of currently impacted river bottom for natural uses.

The incidental taking of endangered and threatened species shall be authorized by the Illinois Department of Natural Resources (IDNR) only if an applicant submits a conservation plan to the IDNR Incidental Take Coordinator that meets the following criteria:

1. A **description of the impact likely to result** from the proposed taking of the species that would be covered by the authorization, including but not limited to -

A) Identification of the **area to be affected** by the proposed action, include a legal description and a detailed description including street address, map(s), and GIS shapefile. Include an indication of ownership or control of affected property. Attach photos of the project area.

Union Pacific Railroad (UPRR) is proposing to replace its existing railroad bridge across the Mississippi River located between Clinton (Clinton County), Iowa, and Fulton (Whiteside County), Illinois. The United States Coast Guard (Coast Guard) determined that the existing swing-span bridge is an "unreasonable obstruction to free navigation" and issued an Order to Alter to UPRR as the bridge owner (see Appendix A). The Order to Alter identified the need to increase the horizontal opening for navigation purposes and set expectations for the vertical clearance of the proposed replacement structure. In Illinois, the area to be affected is located *within the Mississippi River in Section 5, Township 21N, Range 3E in Whiteside County (see Figure 1 in Appendix B). This area is within Pool 14 of the Mississippi River.*

The proposed bridge will be constructed approximately 300 feet south of the existing bridge. The existing bridge will be removed from the Mississippi River once the proposed bridge is in operation. The existing bridge is owned and operated by UPRR and the proposed bridge will be owned and operated by UPRR.

B) **Biological data** on the affected species including life history needs and habitat characteristics. Attach all pre-construction biological survey reports.

Mussel surveys were completed June 19–22, 2017, to identify the presence or absence of federally and state-listed mussel species within the Mississippi River. The survey area extended from approximately 165 feet upstream of the existing bridge to 330 feet downstream of the proposed bridge within the three channels of the Mississippi River and Cattail Slough and was coordinated with US Fish and Wildlife Service (USFWS) to ensure the extent of the survey provided adequate information on the presence of mussels, particularly downstream, to minimize impacts. Mussels were also investigated at geotechnical boring sites on August 17, 2017, and November 11, 2017.

Additional mussel surveys were completed November 1–8, 2018, to identify the presence or absence of federally and state-listed mussel species within areas where dredging may occur. The survey area included 330 feet downstream of the proposed bridge to the bottom of Little Rock Island in the second and third channels of the Mississippi River.

The findings from the surveys and investigation are included in Appendix C. Among the species found during the surveys were three state-threatened species, the butterfly (Ellipsaria lineolata), the black sandshell (Ligumia recta), and the Higgins eye pearlymussel (Lampsilis higginsii)(also federally listed), all of which are known to occur in Pool 14. One black sandshell mussel was collected from a boring site in 2017. Three butterfly mussels, eight black sandshell mussels, and one Higgins eye pearlymussel were found during the 2018 survey. The state-listed mussel species are described below. The survey and investigation activities were conducted in the Illinois and Iowa portions of the Mississippi River. This Conservation Plan presents anticipated impacts to only the Illinois-state protected mussel species in the Illinois portion of the river (see Figure 2 in Appendix B). This Conservation Plan presents best management practices, species surveys, and relocation of identified species in areas where construction is likely to affect listed species.

Butterfly Mussel

The butterfly mussel is found in large rivers in sand or gravel and is about 4 inches long. Its shell is triangular and flattened with a sharply angled posterior ridge and is yellowish brown with broken brown rays (http://wwx.inhs.illinois.edu/collections/mollusk/publications/guide/index/106).

Female butterfly mussels brood their young from August through July and then release them as glochidia. The glochidia then attach to fish gills or fins until they develop into juvenile mussels and detach to live on their own. Known hosts of glochidia of the butterfly mussel include the freshwater drum (Aplodinotus grunnieus), sunfish (Lepomis spp.) and sauger (Stizostedion canadense) (http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=IMBIV13010).

Black Sandshell Mussel

The black sandshell is found in medium to large rivers in riffles or raceways in gravel or firm sand. The shell can be up to 8 inches long and is pointed with a smooth surface. It is usually dark brown to black with a pinkish or purple nacre.
*(*http://wwx.inhs.illinois.edu/collections/mollusk/publications/guide/index/136/*).*

Black sandshell mussels also brood their young from August through July and then release them as glochidia. The glochidia then attach to fish gills or fins until they develop into juvenile mussels and detach to live on their own. Known hosts of glochidia of the black sandshell mussel include the bluegill (Lepomis macrochirus), largemouth bass (Micropterus salmoides), sauger (Stizostedion canadense), and white crappie (Pomoxis annularis).
(http://www.dnr.state.mn.us/rsg/profile.html?action=elementDetail&selectedElement=IMBIV26020).

Higgins Eye Pearlymussel

The Higgins eye pearlymussel is found in the deep part of large rivers with moderate currents in buried in the sand and gravel river bottom. The shell can be up to 4 inches long and have a rounded side and a pointed (male) or squared (female) side. It is usually yellowish brown with green rays. (https://www.fws.gov/midwest/endangered/clams/higginseye/higgins_fs.html).

Male Higgins eye pearlymussels release sperm into the river current for female Higgins eye pearlymussels to siphon and then fertilize their eggs. After fertilization, the females store the glochidia in their gills before releasing them into the current. The glochidia can attach to the gills of host fish to develop for a few weeks before detaching and settling on the river bottom where they mature into adult mussels and stay. Known hosts of glochidia of the Higgins eye pearlymussel include the largemouth bass (Micropterus salmoides), smallmouth bass (Micropterus dolomieu), freshwater drum (Aplodinotus grunniens), sauger (Stizostedion canadense), walleye (Sander vitreus), and yellow perch (Perca flavescens).
(https://www.fws.gov/midwest/endangered/clams/higginseye/higgins_fs.html).

C) **Description of project activities** that will result in taking of an endangered or threatened species, including practices and equipment to be used, a timeline of proposed activities, and any permitting reviews, such as a USFWS biological opinion or USACE wetland review. Please consider all potential impacts such as noise, vibration, light, predator/prey alterations, habitat alterations, increased traffic, etc.

Construction of the proposed project is expected to commence in 2019 and is expected to take approximately 4 years to complete. The existing bridge will remain open during construction of the new bridge and will be demolished once the new bridge has been constructed and is operational.

Following is a description of how the project will be implemented in the order in which project activities are scheduled to occur. River bottom impacts are shown on Figure 2.

Access to the Project Site and Temporary Work Stations

Temporary marine trestles, a rock causeway and improved roadways will be constructed to provide access to the project area and provide temporary work stations to construct the new bridge and demolish the existing bridge. The trestles and causeway are anticipated to be in place throughout the construction timeframe. Barges and other small watercraft will also be used to introduce equipment, supplies, and workers into the project site as well as provide a work station *for construction and demolition of the bridges. Barges will be staged along the east and west bank of the main channel of the Mississippi River and at the proposed piers. The barges will likely need to be spudded and could be spudded up to a year. In Illinois, dredging along the east bank of the main channel (west bank of Little Rock Island) may be needed to provide barge access to the project area. Dredging would occur mechanically rather than hydraulically to reduce impact to water quality. Small watercraft will be used in the second and third channels when water depth allows. Following demolition, the improved roadway, marine trestles and rock causeway will be removed. Cattail Slough will be restored to previous conditions, based on the bathymetric survey.*

Construction of the new UPRR bridge across the Mississippi River

Seven new piers in Illinois will be constructed within the Mississippi River and Cattail Slough as part of the proposed bridge. Cofferdams or a similar engineered system will first be installed surrounding the six pier locations in the second and third channels and Cattail Slough. Once cofferdams are in place, the permanent piling will be driven inside of the cofferdam and the pier constructed. Following pier construction, the cofferdam will be removed. For the one pier in Illinois in the main channel, a cofferdam will not be used and instead, casing will be advanced through the overburden to the required capacity. As the casing is being advanced, the spoils inside the casing will be excavated and hauled to an approved waste site or reused as part of the embankment as fill. Equipment used to construct the cofferdams and new piers will be located on the temporary causeway or trestles adjacent to the permanent piers. Temporary dolphins will be installed in the main channel of the river near the proposed bridge pier to provide a landing site to prepare the truss for erection. The dolphins will be installed using a barge mounted crane with an impact hammer to drive the pile. The cast in place reinforced concrete cap will be installed from the temporary trestle with support from barge mounted equipment.

Demolition of the existing UPRR bridge across the Mississippi River

Demolition of the existing UPRR bridge in Illinois is anticipated to occur between January and December 2024. These activities will occur from marine trestle (reused from the construction access) installed directly south of the existing bridge across the second and third channels of the Mississippi River. The methodology for removing the existing bridge is still being determined. Demolition will likely involve a combination of conventional mechanical and explosive demolition methods.

Up to fifty-five piers from the existing railroad bridge and the old highway 30 will be removed. Piers in the main, second and third channels and dolphins in the main channel will be removed to 15 feet below flat pool or 2 feet below mudline, whichever is deeper. Piers within Cattail Slough and piers on land will be removed to two feet below mudline. All of the in-water piers will likely be demolished using conventional claws and clamshells with a bucket between two to four cubic yards or explosives will be imbedded into the structure before detonation and debris removed from the river. A post-construction bathymetric survey will be conducted to confirm debris removal. Dredging may also be required to provide access for floating equipment.

State-listed mussels could be directly affected if they are located where the new bridge piers are to be placed or where dredging occurs or through the use of temporary work stations during construction. Habitat for the state-listed mussel species, though limited in the project area, may be temporarily affected during the placement of cofferdams and temporary work stations. Indirect impacts could occur if construction activities result in impairment to water quality.

UPRR is also obtaining a Bridge Permit from the US Coast Guard, approval under Section 408 of the Clean Water Act (CWA), a Section 404 CWA permit from the US Army Corps of Engineers, *and a floodway permit from Illinois Department of Natural Resources, Office of Water Resources. Consultation with the Illinois and Iowa State Historic Preservation Offices is occurring to ensure compliance with Section 106 of the Historic Preservation Act. Coordination is occurring with USFWS to identify measures for complying with the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and protections of the Indiana bat, northern long-eared bat, and Higgins eye pearlymussel.*

D) Explanation of the anticipated **adverse effects on listed species**;

- How will the proposed actions impact each of the species' life cycle stages?

- Describe potential impacts to individuals and the population. Include information on the species life history strategy (life span, age at first reproduction, fecundity, recruitment, survival) to indicate the most sensitive life history stages.

- Identify where there is uncertainty, place reasonable bounds around the uncertainty, and describe how the bounds were determined. For example, indicate if it is uncertain how many individuals will be taken, make a reasonable estimate with high and low bounds, and describe how those estimates were made.

Temporary stream impacts have the potential to occur as a result of in-stream work during construction. In-stream work would include installation of cofferdams and other temporary structures for construction, removal of existing piers, and construction of new piers. It is unknown at this time whether these activities will cause adverse effects on the listed species.

Listed mussel species will be relocated outside of the project area prior to construction and demolition to reduce the potential for a listed mussel to be impacted by the project (see Section 2C below for a detailed description of mussel relocation activities). Mussel relocation will not be completed at barge spudding locations outside of the relocation areas discussed in Section 2C. Potential adverse impacts to the state-listed mussel species include improper removal or relocation, sediment burial, and physical destruction. Feeding and respiratory conditions could be affected during construction, but sedimentation will be minimized so as to reduce these disruptions.

The number of possible impacted state-listed mussels is relatively accurate as they reflect the findings from the mussel surveys.

2. Measures the applicant will take to **minimize and mitigate** that impact and the **funding** that will be available to undertake those measures, including, but not limited to -

A) Plans to **minimize the area affected** by the proposed action, the estimated **number of individuals** of each endangered or threatened species that will be taken, and the **amount of habitat** affected (please provide an estimate of area by habitat type for each species).

The area affected by the proposed project was minimized through use of as much of the existing, previously disturbed transportation corridor as possible. This limits new construction on undisturbed areas to only those areas where necessary while still meeting the program objectives. Because the existing bridge must remain operational during construction of the new bridge, the new crossing could not remain on the existing alignment. However, it was located as close to the existing bridge alignment as possible considering safety and operational concerns. Because avoiding the Mississippi River was not practicable, the area of disturbance has been minimized to the area needed for construction purposes. Further, the spacing of the bridge spans have been *optimized to cost effectively minimize the number of piers required which reduces the area of work within the Mississippi River.*

Specific mussel impacts are not known at this time. No listed mussel species were identified in the Illinois portion of the Mississippi River during the 2017 field surveys at the river crossing location, but one black sandshell mussel was relocated from a geotechnical boring site in 2017, and three butterfly mussels, eight black sandshell mussels, and one Higgins eye pearlymussel were found during the 2018 survey. Because listed mussels will be relocated prior to construction, the number of affected butterfly mussels is estimated to be between one and three, the number of impacted black sandshell mussels is estimated to be between one and nine, and the number of impacted Higgins eye pearlymussels is estimated to be between one and two.

The quality of the mussel habitat in the Illinois portion of the project area where the existing and proposed bridges are located is poor to moderate. Though mussels were found in the Mississippi River and Cattail Slough, mussel habitat is poor in these locations in the project area because of the swift current in the Mississippi River channel and the sandy nature of the river bottom in Cattail Slough. Impacts in the Mississippi River channel and Cattail Slough locations of the project area total approximately 6.20 acres, including 0.07 acre of permanent impact. The quality of mussel habitat in the Willow Island East and West channels is slightly better as indicated by the slightly higher number of mussels found during the survey. Impacts in these locations of the project area total approximately 3.17 acres, including approximately 0.06 acre of permanent impacts.

B) **Plans for management of the area** affected by the proposed action that will **enable continued use** of the area by endangered or threatened species by maintaining/re-establishing suitable habitat (for example, native species planting, invasive species control, use of other best management practices, restored hydrology, etc.).

All work within the Mississippi River will be temporary. After the new piers are placed and the existing piers and temporary workspaces are removed, the substrates in which the mussels live will restore themselves through natural geofluvial processes and the channel hydrology will be restored thereby allowing the mussels to continue their use of the Mississippi River in and around the project area.

C) Description of **all measures to be implemented to avoid, minimize, and mitigate** the effects of the proposed action on endangered or threatened species.

- Avoidance measures include working outside the species' habitat.
- Minimization measures include timing work when species are less sensitive, reducing the project footprint, or relocating species out of the impact area.
- Mitigation is additional beneficial actions that will be taken for the species such as needed research, conservation easements, propagation, habitat work, or recovery planning.
- It is the **applicant's responsibility to propose mitigation measures**. IDNR expects applicants to provide species conservation benefits 5.5 times larger than their adverse impact.

1. Erosion and sediment control measures will be implemented to avoid sediment runoff into the Mississippi River. The resident engineer will provide day-to-day enforcement of implementation and maintenance of erosion control measures during construction.

2. Sedimentation countermeasures such as silt fences and/or turbidity curtains will be installed prior to the initiation of in-stream work, where the current is slow enough to allow them and where work activity warrants, to prevent re-suspended sediment from migrating downstream and affecting habitat for aquatic species. In the main channel, drilling will take place inside steel casing which eliminates turbidity as it will be a closed system. Therefore, turbidity curtains are not needed in these areas. A designated crew will inspect and maintain the countermeasures. The resident engineer will provide day-to-day enforcement of implementation and maintenance of sedimentation countermeasures during construction.

3. Worker environmental awareness training will be conducted by a qualified environmental professional contracted by UPRR prior to construction to provide the project team information regarding the protected mussel species and the avoidance, minimization and mitigation measures to be adhered to during construction.

4. Freshwater mussels will be collected from discrete locations within the action area (shown on Figure 2) and relocated by a malacologist retained by UPRR to appropriate locations outside of the project area using approved methods for handling mussels with minimal stress. Mussels, regardless of species, will be relocated once prior to construction of the new bridge and once prior to demolition of the existing bridge. The relocation site will be preapproved by IDNR. A mussel relocation plan will be developed for the project and approved by IDNR prior to conducting mussel relocations. IDNR shall review the proposed relocation site(s) and plan and respond within five (5) working days of submittal.

River bottom impacts and proposed mussel relocation areas are shown on Figure 2. Mussels will not be relocated from the entire action area. Where few mussels were observed and/or habitat is moderate to poor, field crews will be deployed to locate, collect and relocate as many mussels as possible within a given timeframe. Mussel relocation will occur within the following areas in the Illinois portion of the Mississippi River except where noted:

Prior to Construction:

1) *Six days to relocate mussels at the proposed new bridge piers plus a five-yard buffer around each pier.*
    a. *Time spent relocating mussels at the proposed new piers in the main channel of the Mississippi River may be limited due to stream flow rate at the time of relocation.*
    b. *This six-day timeframe includes relocation at proposed new bridge piers within the Iowa portion of the Mississippi River.*
2) *One day to relocate mussels in the footprint of the rock causeway within Cattail Slough.*
3) *One day to relocate mussels at the marine trestle area within the second channel.*
4) *One day to relocate mussels in the dredging area along the east bank of the main channel (west bank of Little Rock Island).*

Prior to Demolition:

1) *Five days to relocate mussels in a 10-yard buffer around the existing bridge piers and old US-30 piers in the navigational channel and a five-yard buffer around the piers in the other channels.*
    a. *Time spent relocating mussels at piers in the main channel of the Mississippi River may be limited due to stream flow rate at the time of relocation.*

b. *This five-day time frame includes area within the Iowa portion of the Mississippi River.*

Due to concerns for worker safety and limitations on visibility, no mussels will be collected from the action area within the navigation channel.

5. A mussel survey will be conducted within Pool 14 to map the habitat and distribution of mussel resources throughout the pool. Data from this study will help resource agencies track impacts from the project on mussel resources and guide future conservation efforts in Pool 14. The mussel survey is estimated to cost approximately $70,000.

6. The contractor will utilize protective measures to prevent debris from falling into the river during demolition of the existing bridge and construction of the new bridge. Should any debris enter the water, the contractor will remove that debris as soon as practicable. Construction activities will be monitored to ensure compliance with these requirements. A bathymetric survey will be conducted prior to construction and after construction to verify that any debris which has entered into the waterway has been removed.

7. The contractor will use mechanical means to conduct the dredging rather than hydraulic to reduce impacts to water quality.

D) Plans for **monitoring** the effects of the proposed actions on endangered or threatened species, such as monitoring the species' survival rates, reproductive rates, and habitat before and after construction, include a plan for follow-up **reporting to IDNR**. Monitoring surveys should be targeted at reducing the uncertainty identified in Section 1.d.

A malacologist retained by UPRR will conduct post construction follow-up at the project and mussel relocation sites within one year following construction completion. A report will be prepared to summarize the condition of mussel populations at the project and relocation sites and submitted to IDNR by December 31 of the monitoring year.

E) **Adaptive management practices** that will be used to deal with changed or unforeseen circumstances that may affect the endangered or threatened species.

- Adaptive management is a way to make decisions in the face of uncertainty by monitoring the uncertain element over time and adjusting to the new information. Adaptive management requires identifying objectives and uncertainties, thinking through a range of potential outcomes, developing triggers that will lead to different actions being taken, and monitoring to detect those triggers.
- Consider environmental variables such as flooding, drought, and species dynamics as well as other catastrophes. Management practices should include contingencies and specific triggers. Note: Not foreseeing any changes does not quality as an adaptive management plan.

1. Siltation during all phases of construction will be minimized through use of erosion control devices such as silt fences and/or turbidity curtains or other countermeasures to prevent runoff from entering the river and affecting habitat for protected mussel species. A designated crew will inspect and maintain silt fences/erosion structures. The resident engineer will provide day-to-day enforcement of implementation and maintenance of erosion control measures during construction. Countermeasures designed to address sediment plumes, including spill kits, will be kept at the project site for use if a sediment plume occurs, and construction crew will be trained how to handle sediment plumes.

2. If flooding is predicted to occur such that water levels will rise above the elevation of the access roads, the project team will follow the procedures described in the Emergency Action Plan (EAP) developed in compliance with Clean Water Act Section 408 approval. Procedures identified in the EAP include moving all equipment and construction materials on the riverside of the levee to the landward side of the levee and ceasing or backfilling excavated areas if sloughing or excessive seepage is observed.

3. To minimize contaminants from entering the river and increase the safety of the construction work site, construction activities will be planned to reduce the possibility of spills and falling construction debris. These methods will be written into the stormwater pollution prevention plan and construction plans. Emergency spill kits will be available to address any unforeseen contaminants entering the river and construction crew will be trained on how to use the kits.

4. As described in Section 2.C.4 above, mussels will be relocated to an appropriate location outside of the project area using approved methods for handling mussels with minimal stress.

5. UPRR will follow specifications on erosion control and water quality best management practices (BMPs). All runoff will be diverted prior to discharge into the river. Increasing retention time of runoff water will reduce sediment load and particulate/dissolved pollutants.

6. After construction is completed, cofferdams will be removed and the stream bottom, including Cattail Slough, will be restored to its approximate original condition and flow pattern, allowing for re-colonization of biota.

F) **Verification that adequate funding exists** to support and implement all minimization and mitigation activities described in the conservation plan. This may be in the form of bonds, certificates of insurance, escrow accounts, or other financial instruments adequate to carry out all aspects of the conservation plan.

This project will be self-funded by UPRR. UPRR commits to funding all costs associated with supporting and implementing all minimization and mitigation activities described in the conservation plan.

3) A description of **alternative actions** the applicant considered that would reduce take, and the reasons that each of those alternatives was not selected. A **"no-action" alternative** shall be included in this description of alternatives. Please describe the economic, social, and ecological tradeoffs of each action.

- Consideration of **alternative actions** is an important tool in conservation planning as it allows for thinking of other options and evaluating the potential outcomes in terms of all relevant objectives. However, to be useful it requires creativity in developing alternatives and systematic analysis in evaluating the alternatives.
- In evaluating alternatives, describe the economic, social, and ecological tradeoffs of each.

Alternatives for this project were developed to address the purpose and need of the project, which is to comply with the USCG's Order to Alter the existing bridge. The No-Action Alternative was considered, but because this alternative does not include altering the bridge, it does not satisfy the project's purpose and need and was dismissed. Seven Build Alternatives were considered to address the Order to Alter. The key design requirement was to allow the existing bridge to remain in place and continue to support rail traffic during the construction of the new bridge to maintain movement of freight and commerce, *minimize delays to the heavily traveled main lines between Omaha and Chicago, minimize major outages, and phase construction without disrupting stakeholders. As such, all seven Build Alternatives were located on new alignment, and considered different crossing locations (horizontal alignments) and crossing types (vertical options that include lift vs. fixed bridges at different elevations). The new alignment alternatives were generally longer than the preferred alternative and disturbed new areas of land along the Mississippi River corridor. The preferred alternative was selected based on its operational ability, navigation safety, fewer land acquisitions, lower environmental impact, and ability to significantly improve the reliability of maintaining uninterrupted barge traffic in the navigation channel and benefit roadway traffic on Illinois Route 84.*

4) Data and information to indicate that the proposed taking **will not reduce the likelihood of the survival** of the endangered or threatened species in the wild within the State of Illinois, the biotic community of which the species is a part, or the habitat essential to the species existence in Illinois.

This action is not expected to reduce the likelihood of the survival of the species for the following reasons:

- *The butterfly and black sandshell mussels are known to be widespread in the Midwest, including elsewhere in Illinois in both the Mississippi River and other rivers. The Higgins eye pearlymussel is also known to inhabit other portions of the Mississippi River and other rivers. Therefore, the project site is not the only location the species are known to inhabit. As such, if impact occurs as a result of the project, this will not impact their ability to survive elsewhere in Illinois.*
- *The state-listed mussels found at this location are considered relatively common in Pool 14 of the Mississippi River which is partially within Illinois and the Higgins eye pearlymussel is known to inhabit Pool 14,*
- *The extent of the potential mussel habitat in the Mississippi River in Illinois is much greater than the extent of the proposed project, and*
- *State-listed mussels will be relocated prior to construction by a qualified, experienced malacologist using accepted practices.*

5) An **implementing agreement**, which shall include, but not be limited to (on a separate piece of paper containing signatures):

A) Names and signatures of all participants in the execution of the conservation plan;

Patrick G. Prososki, P.E.
Manager Structure Design, UPRR

B) The obligations and responsibilities of each of the identified participants with schedules and deadlines for completion of activities included in the conservation plan and a schedule for preparation of progress reports to be provided to the IDNR;

UPRR is responsible for activities related to the Clinton Railroad Bridge Replacement Project.

UPRR will retain a malacologist prior to construction of the new bridge and prior to demolition of the existing bridge to relocate listed mussels from areas identified in Section 2C of the Conservation Plan to an appropriate location outside of the impact area.

IDNR will review the proposed relocation site(s) and plan and respond within five (5) working days of submittal.

UPRR will retain a malacologist to conduct post construction follow-up at the project and mussel relocation sites within one year following construction completion and submit a report summarizing the condition of mussel populations at these sites to IDNR by December 31 of the monitoring year.

C) Certification that each participant in the execution of the conservation plan has the legal authority to carry out their respective obligations and responsibilities under the conservation plan;

UPRR certifies that it has the authority to complete the project and carry out UPRR's obligations and responsibilities under the conservation plan.

D) Assurance of compliance with all other federal, State and local regulations pertinent to the proposed action and to execution of the conservation plan;

UPRR is coordinating with the appropriate agencies to ensure the required permits and approvals are obtained. UPRR is in the process of obtaining a Bridge Permit from the US Coast Guard, approval under Section 408 of the CWA, a Section 404 CWA permit from the US Army Corps of Engineers, and a floodway permit from Illinois Department of Natural Resources, Office of Water Resources. Consultation with the Illinois and Iowa State Historic Preservation Offices is occurring to ensure compliance with Section 106 of the Historic Preservation Act. Coordination is occurring with USFWS to identify measures for complying with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act, and protections of the federally-listed Higgins eye pearlymussel and Indiana and northern long-eared bats.

E) **Copies of any final <u>federal authorizations for a taking</u> already issued to the applicant**, if any.

Coordination with the US Fish and Wildlife Service is ongoing for the federally listed species discussed in this document. Consultation is expected to be completed in 2019.

APPENDIX A

U.S. Coast Guard Order to Alter

U.S. Department of Transportation
United States Coast Guard

Commander
Second Coast Guard District

1222 Spruce Street
St. Louis, MO 63103-2832
Staff Symbol: (ob)
Phone: 314-539-3900
Ext. 378

JRB 5-16-96

16593
16 May 1996

Mr. S.J. McLaughlin
Vice President-Engineering Services
Union Pacific Railroad
1416 Dodge Street
Omaha, NE 68179

Subj: CLINTON RAILROAD DRAWBRIDGE, MILE 518.0, UPPER MISSISSIPPI RIVER

Dear Mr. McLaughlin:

The Commandant, U. S. Coast Guard has declared the subject bridge to be an unreasonable obstruction to navigation. Enclosed is the Order to Alter issued for the bridge.

When altered, the bridge must provide a horizontal clearance of no less than 300 feet measured normal to the navigation channel and a vertical clearance of no less than 52 above the 2% flowline or 60 feet above the normal pool elevation whichever is greater, when in the open position.

Mr. Jacob Patnaik, Chief Bridge Engineering Branch for the Coast Guard will contact you in the near future concerning Truman-Hobbs program issues such as cost apportionment and the bridge alteration schedule. All other bridge issues concerning navigation, bridge lighting/marking, drawbridge operations, repairs and vessel collisions will continue to the responsibility of the Second Coast Guard District, in St. Louis, MO. These issues should be addressed to my office.

Sincerely,

ROGER K. WIEBUSCH
Bridge Administrator
By direction of the District Commander

Encl: (1) Order to Alter

U.S. Department
of Transportation

United States
Coast Guard

Commandant
U.S. Coast Guard

2100 Second Street, SW
Washington, DC 20593-0001
Staff Symbol: G-NBR/14
Phone: 202-267-0368

FEB 28 1996

ORDER TO ALTER

WHEREAS by an act of Congress approved June 21, 1940, entitled "The Truman-Hobbs Act," as amended (33 U.S.C. 511-523), the Secretary of Transportation was authorized to order the alteration of certain bridges across the navigable waters of the United States which have been determined to be unreasonable obstructions to navigation;

AND WHEREAS the Secretary of Transportation has delegated the authority of that act to the Commandant, U.S. Coast Guard, by Section 1.46(c)(3) of Title 49, Code of Federal Regulations;

AND WHEREAS, in conformity with the provisions of the Truman-Hobbs Act, notice was given to interested parties and a public hearing was held on March 28, 1995, at Clinton, Iowa, for the purpose of obtaining testimony as to whether the Clinton Railroad Drawbridge is an unreasonable obstruction to the free navigation of the Upper Mississippi River;

AND WHEREAS, after giving consideration to the testimony and the facts presented at the public hearing and to the investigations subsequently made, the Commandant has determined that the bridge, located on the Upper Mississippi River at mile 518.0, at Clinton, Iowa, is an unreasonable obstruction to navigation;

AND WHEREAS the Union Pacific Railroad is the owner of the bridge;

NOW THEREFORE, the Commandant directs the Union Pacific Railroad, to alter this bridge by reconstructing it on the same general alignment as the existing bridge subject to the following conditions:

1. The movable span shall provide a horizontal clearance of no less than 300 feet measured normal to the channel and a vertical clearance of no less than 52 feet above the two percent flowline or 60 feet above normal pool, whichever is greater, in the open position. These clearances are necessary for the reasonable needs of navigation.

2. No deviation from the approved clearances may be made either before or after completion of the structure unless the modification of said clearances has previously been submitted to and received the approval of the Commandant.

3. The proposed alteration must satisfy the requirements of all federal, state and local laws and regulations pertaining to the protection of the environment.

R E Kramek
28 February 1996

ROBERT E. KRAMEK
Admiral, U.S. Coast Guard
Commandant

APPENDIX B
Figures

LEGEND
- Clinton Railroad Bridge
- UP Railroad
- State Boundary

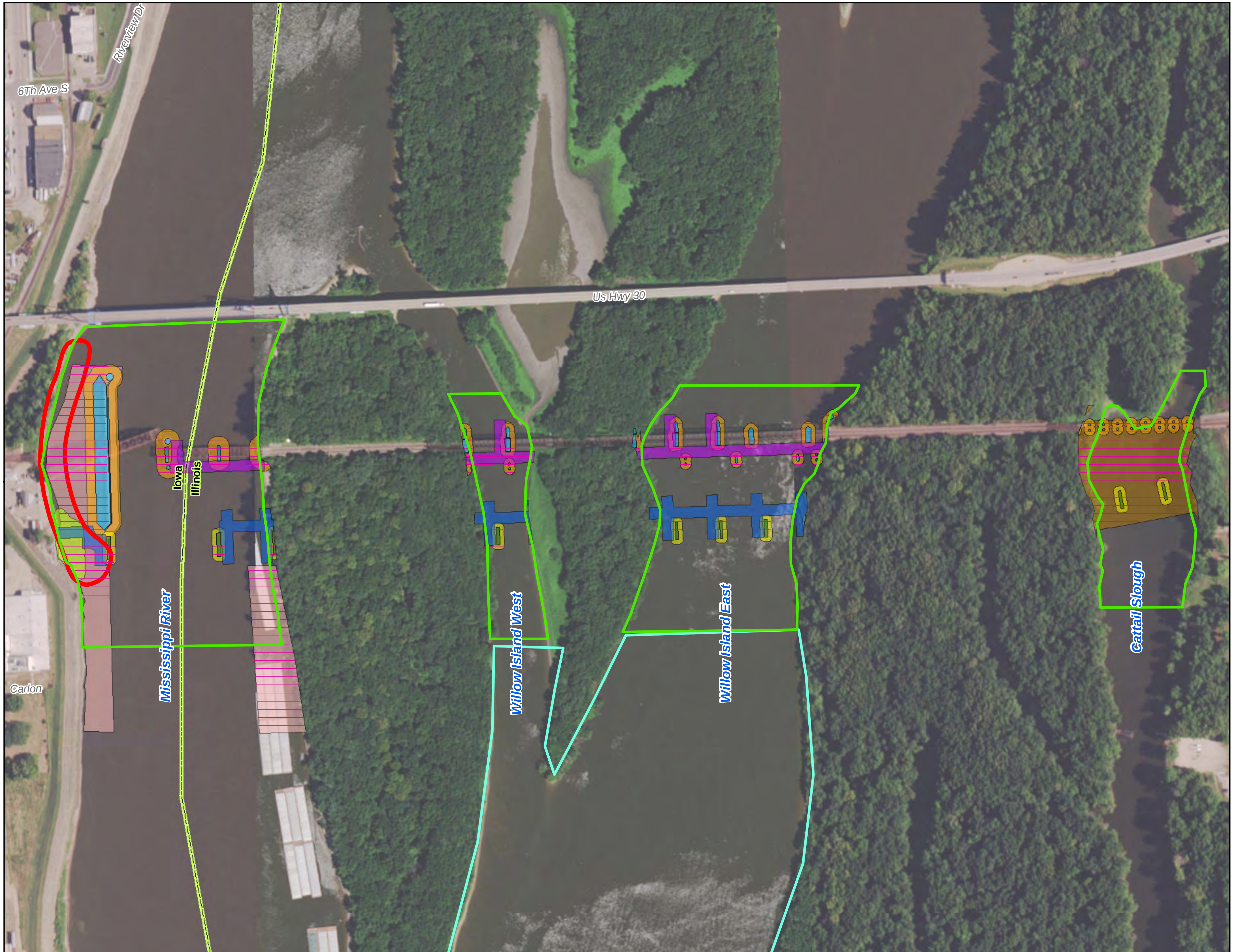
Base Map Source:
ESRI World Street Map online mapping service

0 2 4
Miles

N

FIGURE 1
Project Location Map
CLINTON RAILROAD BRIDGE REPLACEMENT
UNION PACIFIC RAILROAD COMAPNY
CLINTON COUNTY, IOWA AND WHITESIDE COUNTY, ILLINOIS

ch2m.



LEGEND

- Mussel Bed
- Mussel Relocation Area
- 2017 Mussel Survey Area
- 2018 Mussel Survey Area
- State Boundary

Mississippi River Bottom Impacts

- Trestle Footings - Existing Bridge (Temp. Impact)
- Trestle Footings - New Bridge (Temp. Impact)
- Pier - Existing Bridge (Temp. Impact)
- Pier - New Bridge (Perm. Impact)
- Embankment (Perm. Impact)
- New Pier Construction Area (Temp. Impact)
- Existing Pier Removal Area (Temp. Impact)
- Rock Causeway (Temp. Impact)
- Dredging Area (Temp. Impact)

Note:
Barges will be stagged along the right and left banks of the main channel of the Mississippi River and at the new and existing piers. Spudding of barges will add minor temporary impacts to the river bottom. Mussel relocation will not be completed at spudding locations outside of the relocation areas shown on the figure.

Base Map Source:
ESRI World Imagery online mapping service

0 350 700
Feet

N

FIGURE 2
Mississippi River Bottom Impacts

CLINTON RAILROAD BRIDGE REPLACEMENT
UNION PACIFIC RAILROAD COMAPNY
CLINTON COUNTY, IOWA AND WHITESIDE COUNTY, ILLINOIS

ch2m:

APPENDIX C

Mussel Surveys for Clinton Bridge Replacement Project

Unionid Survey in the Mississippi River for Proposed Bridge Construction at the Union Pacific Railroad Near Clinton, Iowa

Prepared for:
Union Pacific Railroad

Under contract with:
CH2M Hill

Prepared by:
Ecological Specialists

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Final Report
January 2018

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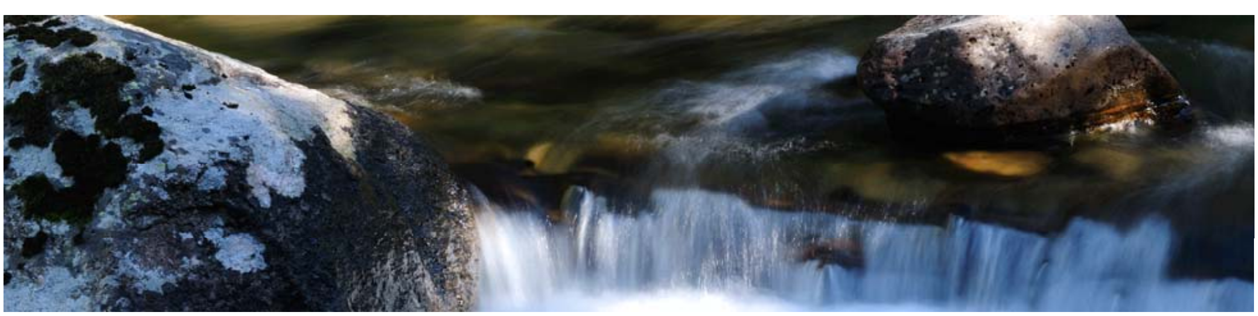

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ACKNOWLEDGMENTS
Union Pacific Railroad funded this project and Ms. Karen Munson managed the project for CH2M. Mr. Eric J. Belt of Ecological Specialists, Inc. (ESI) was the project manager, field team leader, and report author. The ESI dive team was Mr. Kendall Cranney (dive supervisor), Mr. Benjamin Dunn (diver), and Ms. Heidi Dunn (diver). Mr. David Ford assisted with field work and Ms. Heidi Dunn assisted with report preparation.

1.0 INTRODUCTION

Union Pacific Railroad (UPRR) plans on constructing a new bridge downstream (south) of the current bridge over Pool 14 the Mississippi River in Clinton, Iowa. The new structure is proposed approximately 91 m (300 ft.) downstream of the existing structure (see proposed pier locations in Figure 1-1), after which, demolition of the current bridge is planned. (Of note, the approximate pier locations are subject to change and were used for a basis of general survey locations). Two federally endangered unionids (freshwater mussels) are known to inhabit Pool 14 (*Lampsilis higginsii* and *Plethobasus cyphyus*). Historically, 40 unionid species were known live in Pool 14, 31 of which have been collected live since 1980 (Table 1-1). Of the 31, 4 are listed in as endangered or threatened Iowa and 3 in Illinois.

Information on the distribution, abundance, and species composition of unionid mussels within the bridge corridor is needed to determine if federal or state threatened or endangered mussel species may be affected by bridge construction. CH2M Hill contracted Ecological Specialists (ESI) to conduct surveys for freshwater mussels in areas potentially impacted by bridge construction and demolition. Surveys were conducted June 19 – 22, 2017. In addition to the survey, an effort to clear mussels from 5 areas for geological boring was conducted on August 17 and November 11, 2017.

2.0 METHODS

2.1 Unionid Sampling

The mussel survey area extended from approximately 50 m upstream of the existing bridge (including support structures for the swing-arm section) to 100 m downstream of the proposed new bridge. Within the survey area, a combination of quantitative and qualitative sampling techniques was used to meet the objective. The Mississippi River at the bridge crossing is comprised of 4 channels or sloughs, divided by islands; our survey area was divided into 4 sections based on physical features (Figure 1-1).

Quantitative samples were used to determine mussel distribution and density within the areas described above. The number of samples collected from each area followed the methodology and sampling effort approved by Iowa and Illinois DNR that ESI used for the I-74 Bridge replacement survey and Biological Assessment at Quad Cities (No. of samples = 0.0012 x area in m^2 + 11). A three-random start design (Strayer and Smith, 2003) was used; this allows for calculation of a confidence interval for density and population estimates, as well as provides information on mussel distribution. Each sample location was recorded with GPS. For each sample, the diver excavated all substrate within a 0.25 m^2 quadrat into an attached mesh bag (6 mm mesh). Substrate was sieved through 12 and 6 mm sieves and all unionids retrieved from the sample. All collected unionids were identified to species, measured (length in mm), and aged (external annuli count). Zebra mussel infestation was also recorded. At least one individual of each species was photographed, and at least one dead shell of each species was retained (as available) as a voucher. Unionids were released near their original collection location; endangered species were hand placed in the substrate. At each quadrat location, the diver also visually estimated substrate composition (Wentworth scale), and depth was recorded with a depth pole in areas <2 m and a pneumofathometer in areas >2 m deep. Depths and substrates for each quantitative sample are presented in Appendix A.

Not all areas were accessible for sampling as increased depths and flows in the channel within the Main Channel and Willow Island East areas created unsafe diving conditions in this part of the river. Therefore, fewer quadrats were sampled than proposed (see table) and qualitative sampling could not be conducted at the proposed Pier 1 and 2 sites. Sampling in the unsampled areas is likely to be unsafe under any conditions as low water would increase flows and higher water would increase both flows and depth. Therefore, no further sampling is possible. However, it is likely these areas do not harbor suitable unionid habitat as they are likely all sand.

Survey Area	Description	Approx. Area (m^2)	No. Quadrats Proposed	No. Quadrats Sampled
Area A	Main Channel	79,000	105	54
Area B	Willow Island West	16,000	29	29
Area C	Willow Island East	47,000	67	59
Area D	Sunfish Slough	23,000	37	37

Qualitative sampling (timed searches) was used to delineate the mussel bed located along the Iowa bank and at all but two proposed pier construction locations due to unsafe diving conditions. Qualitative sampling consisted of a diver collecting as many unionids as possible (concentrating on rare species) within a 5-minute interval. Samples were retrieved after 5 minutes, and all unionids identified and counted as ≤5 years old or >5 years old. A total of 29 qualitative samples were collected. One was collected at Piers 5, 6, 8, and 9 and two were collected at Piers 3, 4, 7, and 10. To increase the probability of finding rarer species and confirm the extent of the mussel bed, an additional 17 qualitative samples were collected within the mussel bed along the Iowa bank.

Prior to collecting geological boring samples, 8 sites were cleared of mussels. Each site was either marked with a buoy by the boring field crew, or navigated to via a GPS coordinate. At least 10 min. of sampling within a 1 m diameter around the boring site was conducted. Unionids were recorded to species and moved upstream to an area of similar habitat, outside of direct boring impact.

2.2 Data Analysis

Since a mussel bed was observed, metrics were calculated for potential use in future analysis and comparison to other mussel beds. Metrics used are from a Mussel Community Assessment Tool (MCAT) currently being developed for the Upper Mississippi River (Dunn et al., 2016). Metrics used from this tool are:

- % tribe Lampsilini ([no. of individuals in the tribe Lampsilini/total no. of individuals]*100)
- % FD (no. FD/[no. live + no. FD]*100)
- % juveniles ([no. young (≤5 external annuli)/no. live]*100)
- abundance at 75th quartile (density[no. live/m^2] > X in 25% of the samples)
- species evenness (Pielou's evenness; Shannon Wiener diversity (H)/Hmax)
- tribe evenness (Pielou's evenness; Shannon Wiener diversity (H)/Hmax)
- rarefaction richness at 100 individuals (ES_100) calculated using EstimateS (Colwell, 2013)

Another metric calculated is similar an MCAT metric, but modified per Iowa DNR by adding *Leptodea fragilis* and *Pyganodon grandis*:

- % tolerant species ([no. of *Amblema plicata* + *Quadrula quadrula* + *Obliquaria reflexa* + *Leptodea fragilis* + *Pyganodon grandis*/total no. of individuals]*100).

3.0 RESULTS AND DISCUSSION

3.1 Main Channel

The Main Channel area as a whole harbored few unionids, with the channel being mostly sand, however, a mussel bed was observed between the Iowa bank and the swing bridge wall (Figure 3-1). A total of 183 live unionids of 17 species were found within both quantitative and qualitative samples (Table 3-1) within the entire Main Channel area. One of these species (*Ellipsaria lineolata* [n=3]) is listed as threatened in Iowa and Illinois and one (*Ligumia recta* [n=22]) threatened in Illinois, however these species are relatively common in Pool 14. No federally listed species were collected. No unionids were collected in qualitative searches of Pier 3. Diving was unsafe at Piers 1 and 2 due to depth and flow, however substrate in all surrounding areas (with less depth and flow) was homogeneous sand and no mussels were found. Estimated density throughout the area was 4.2±2.2 unionids/m^2 (Table 3-2). Depths throughout the main channel in sampled areas ranged from 1.2 to 13.1 m and averaged 5.3 m. Based on the few samples collected within the thalweg, the substrate appeared to be mostly sand. Along the west bank of Little Rock Island, substrate was mostly sand with some silt and clay near the bank, and cobble and gravel further riverward. Substrate within the western side of the site was variable, with silt and clay at the upstream end and more cobble and boulder downstream (Figure 3-2a). Only 2 live unionids were collected outside of the mussel bed. Therefore, to more accurately evaluate the unionid community within the mussel bed discovered along the Iowa bank, data from within the Iowa Bank Bed (IBB) is presented separately as a subset of the Main Channel area as a whole.

The Iowa Bank Bed (IBB) harbored a moderately dense and diverse mussel community. Substrate in this area was a more heterogeneous stable substrate mix and more conducive to unionid mussels. Within the IBB, 17 live species were collected and density averaged 8.5±3.8 unionid/m^2 (Table 3-3). Most community metrics calculated for this bed fell within the fair range compared to other Upper Mississippi River mussel beds (Dunn et al., 2016). Abundance at the 75th Quartile (highest density part of the bed; 12/m^2), species richness (15), % juveniles (recruitment; 40.0%), and % tolerant species (40.0%) metrics were fair compared to other Upper Mississippi River beds (Table 3-3). Species evenness (0.85) fell in the good MCAT range. However, mortality (20.3%) and tribe evenness (0.70) fell in the poor MCAT range (Table 3-3).

3.2 Willow Island West

The Willow Island West survey area harbored marginal unionid habitat and a unionid community dominated by juveniles of common species. Habitat within the Willow Island West survey area was not generally ideal for unionids, as homogeneous sand was the most abundant substrate type and does not provide stable substrate for establishing a stable unionid community. Depths ranged from 2.1 to 4.3 m, averaging 2.9 m. Substrate was typically sand towards the middle of the channel and sand, clay, and silt towards the banks (Figure 3-2a). A total of 40 live unionids of 11 species were collected in quantitative and qualitative samples within the survey area (Table 3-1). Of the 40 live collected, 21 were collected during the two 5-minute qualitative searches at Pier 4. Quantitative samples provided a density estimate of 2.6±1.3 unionids/m^2, with 88.9% being juveniles (Table 3-2). Mortality was 17.4% and no listed species were observed. Unionids were scattered throughout the area, with more being encountered near the banks (Figure 3-1) within the more stable clay substrate.

3.3 Willow Island East

Unionids were scattered throughout the Willow Island East survey area at a relatively low density due to the primarily sand substrate. This channel was deep, averaging 6.1 m and ranging from 1.2 to 11.0 m (Figure 3-2b). Substrate was primarily sand (74.6% average) with silt, clay, and gravel interspersed. A total of 32 live unionids of 8 species were collected (Table 3-1), 11 of which were collected in qualitative samples at Piers 5, 6, and 7. Estimated density from quantitative samples was 1.2±0.8 unionids/m^2, with juvenile mussels comprising 70.6% (Table 3-2). Mortality was 15.0% and no listed species were observed. The scattered few unionids collected and sandy substrate suggests a patchy distribution with no definitive mussel bed.

3.4 Sunfish Slough

Substrate was mostly silt within the Sunfish Slough survey area, which is not typically favorable unionid habitat, and consequently, few unionids were collected. Silt averaged 66.8% in substrates recorded, but some clay was also observed in each sample (Figure 3-2b). Depths were shallower compared to the other survey areas, averaging 3.8 m and ranging from 1.5 m near the upstream reaches to 6.1 m towards the middle. A total of 13 live unionids of 4 common species were collected in both quantitative and qualitative samples, 6 of which were in quantitative samples and 7 of which were collected within qualitative searches at Piers 8, 9, and 10 (Table 3-1). Density averaged 0.6±0.6 unionids/m^2 with 50.0% being juveniles (Table 3-2).

3.5 Boring Sites

A total of 56 live unionids of 12 species were collected and moved upstream and out of the area of direct boring impacts. Only 3 live were found at the two Main Channel sites (Figure 1-1) and none were found at B-20 and B-26, 1 was found at B-19, and 3 were found at B-25 (Table 3-4). The most (n = 47) were found at B-31 within the Willow Island West site. Eight (8) species were collected there, with the majority (73.2%) being juveniles. At the two boring sites in Willow Island East (B-34 and B-35), 1 and 4 live, respectively, were collected (Table 3-4). One *L. recta* (IL threatened) was found and relocated from B-35.

4.0 CONCLUSIONS

Within all four sampled areas, the Iowa Bank Bed was the only area harboring a relatively significant and apparently stable unionid community. Community metrics were generally fair compared to other beds in the Upper Mississippi (Dunn et al., 2016). Although two species listed as state threatened, *E. lineolata* (IA and IL) and *L. recta* (IL), were collected, these species are considered relatively common in Pool 14 of the Mississippi River (Kelner, 2011).

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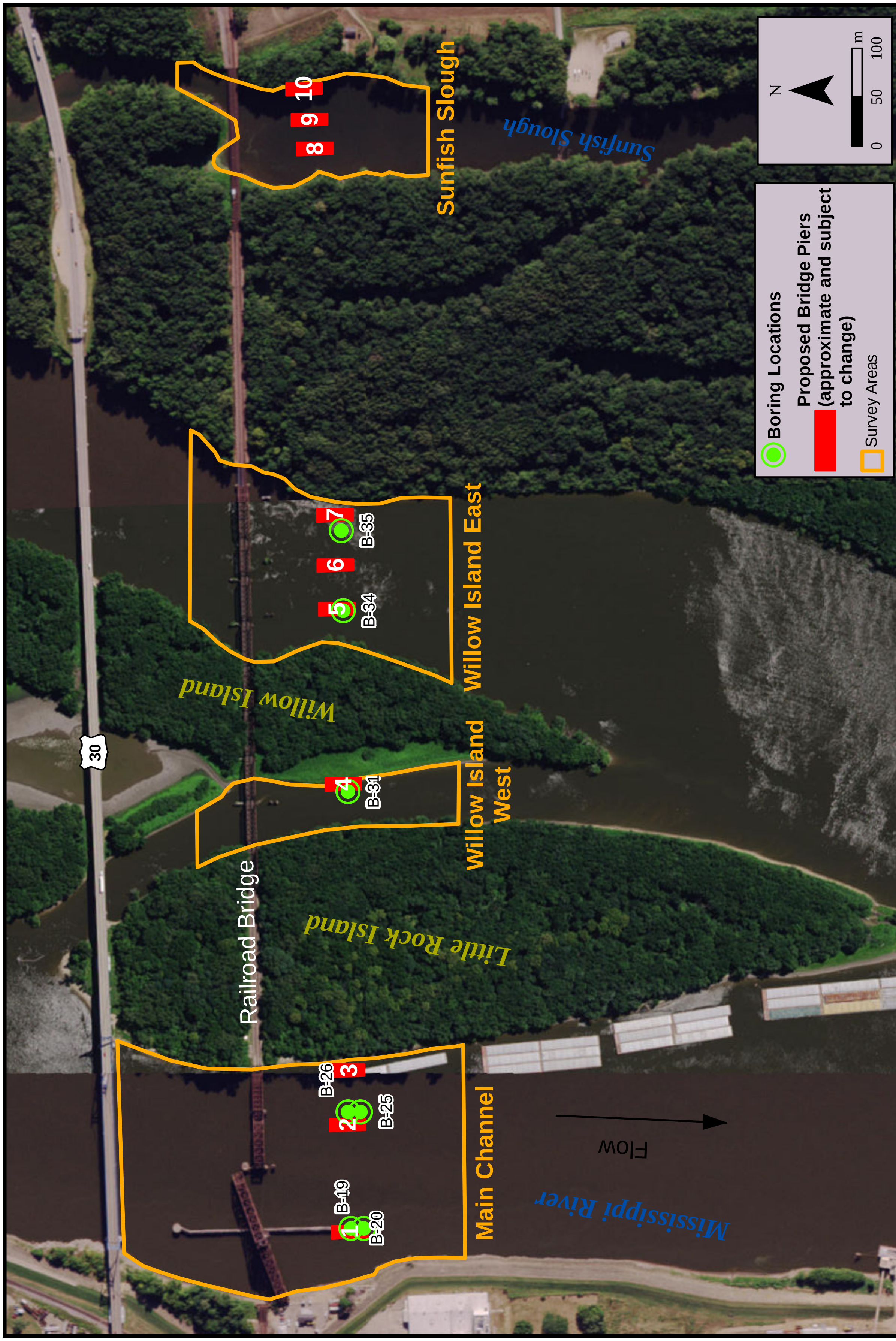

Figure 1-1. Unionid sample areas, Mississippi River near Clinton, Iowa.

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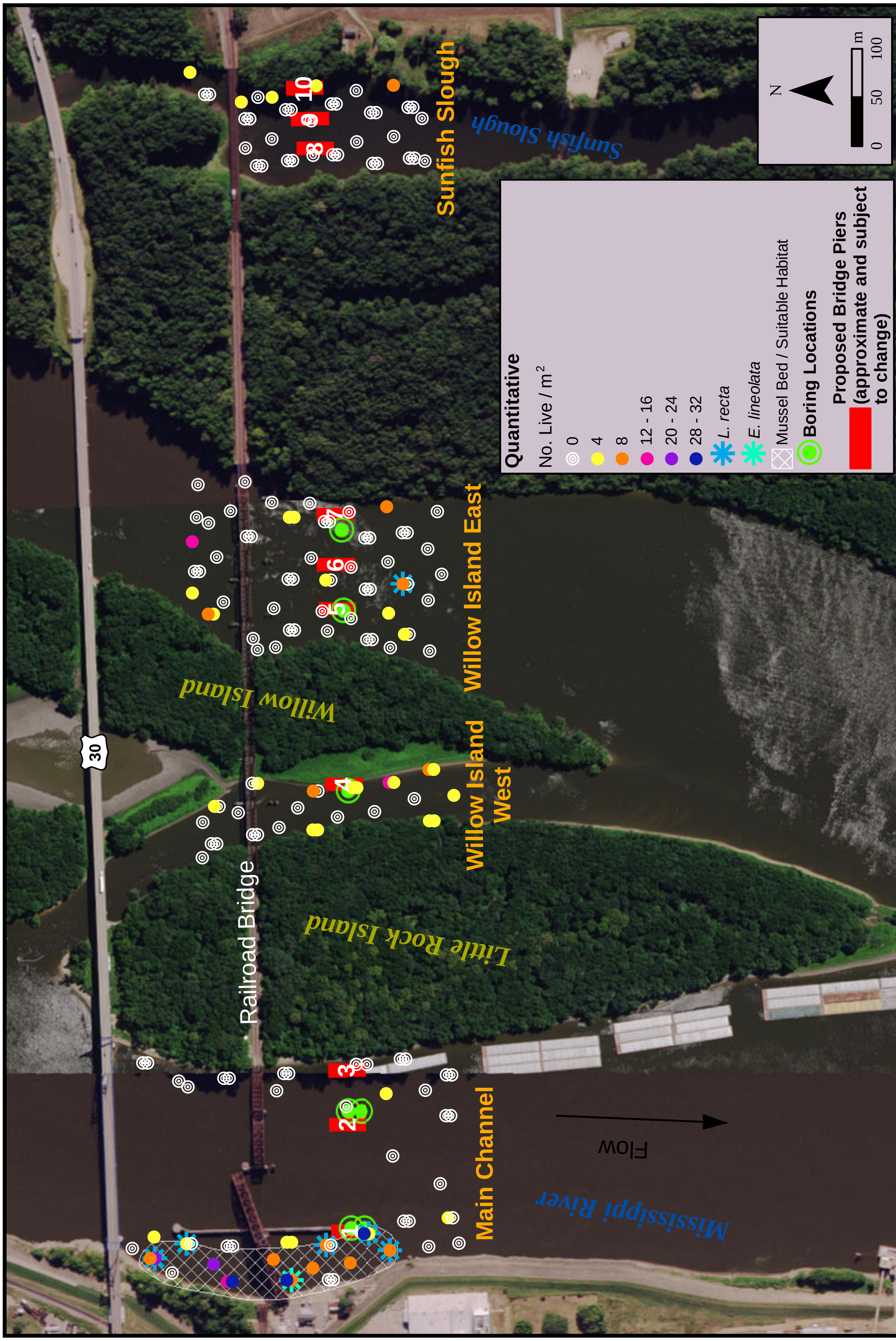

Figure 3-1. Unionid distribution, Mississippi River near Clinton, Iowa.

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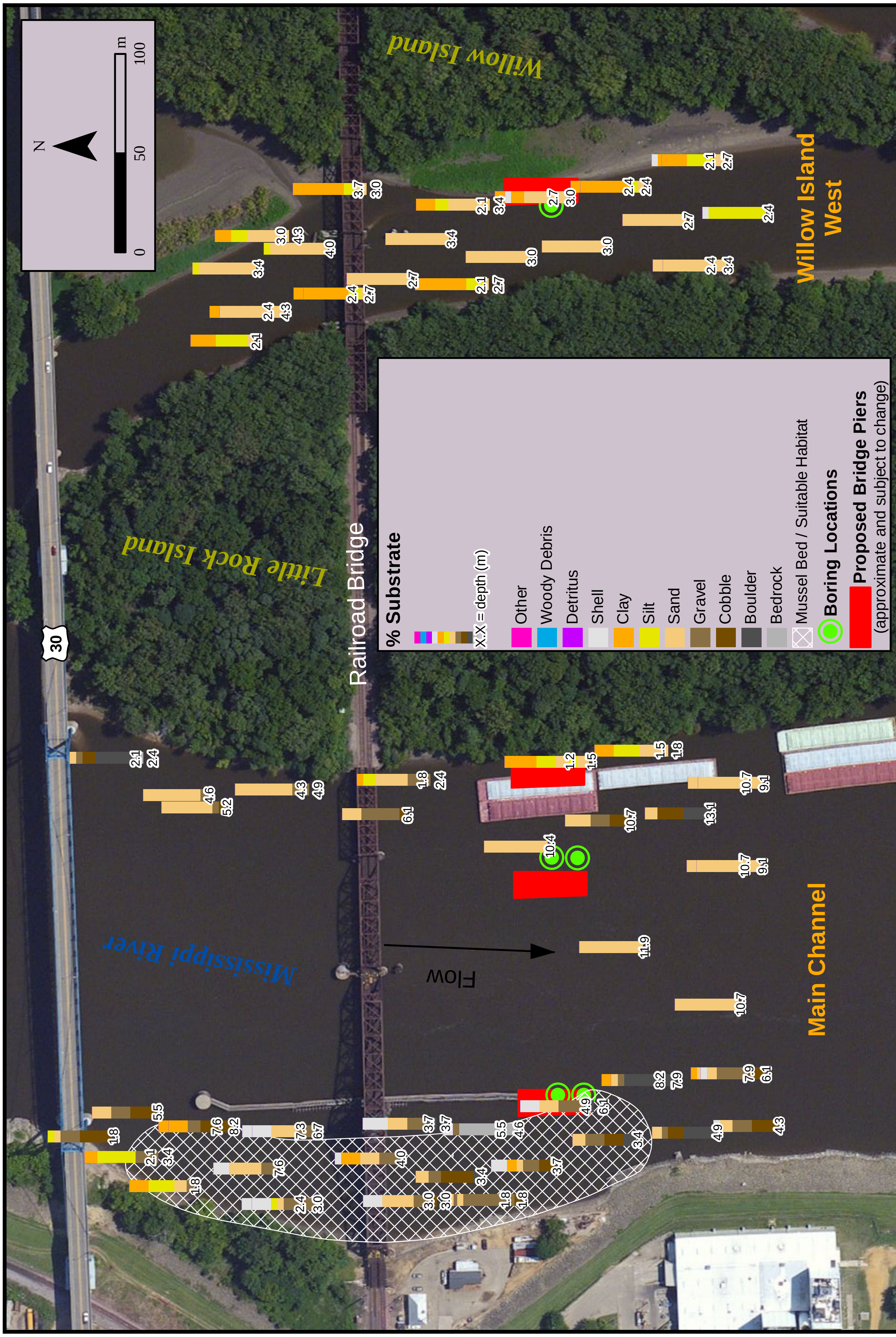

Figure 3-2a. Unionid habitat, Mississippi River near Clinton, Iowa.

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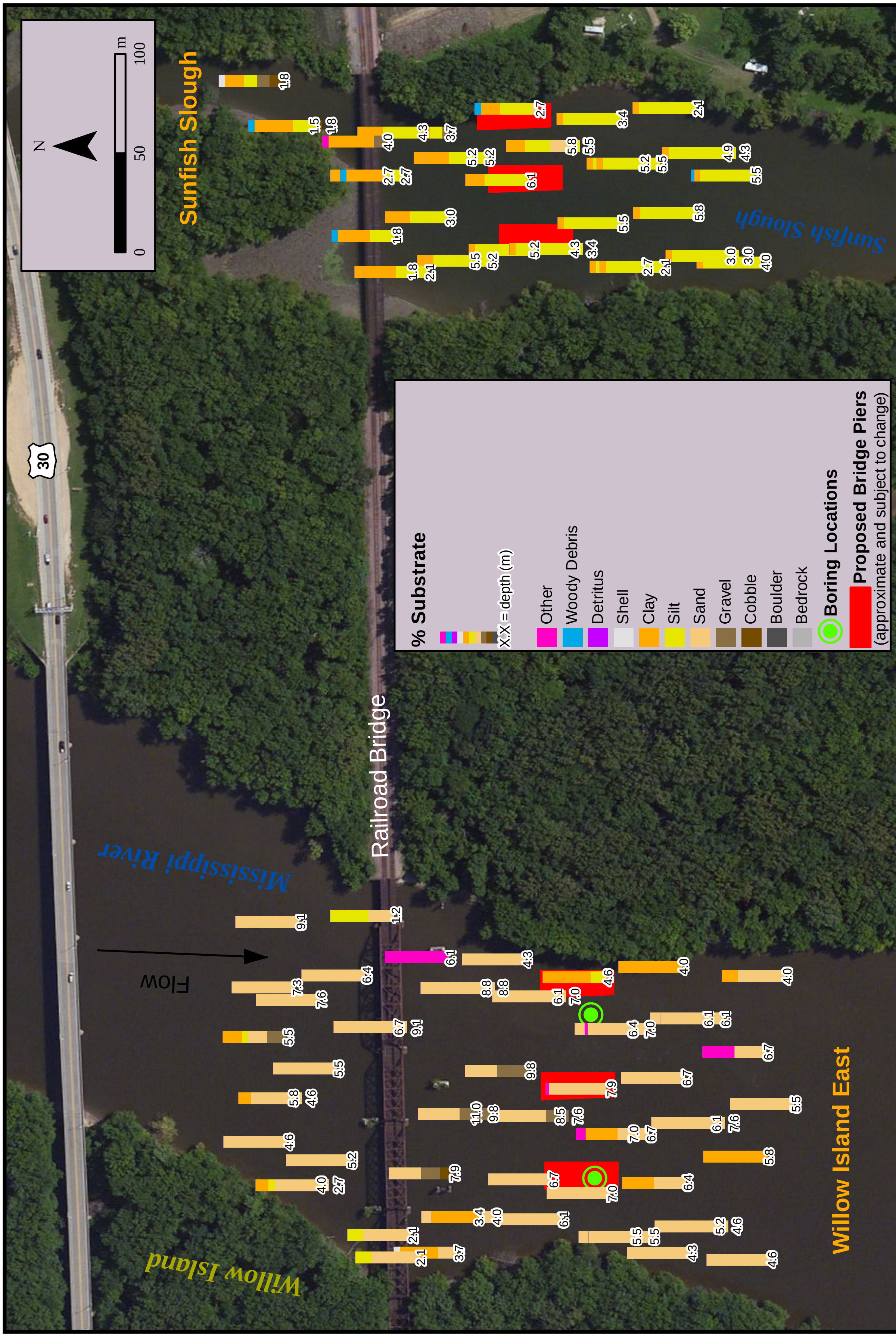

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Figure 3-2b. Unionid habitat, Mississippi River near Clinton, Iowa.

Table 1-1. Unionid species reported from Mississippi River, Pool 14.

Species	Status[1]	Kelner 2011 [2]	ESI 2013	ESI 2014	ESI 2015	ESI 2016[3]
Margaritifieridae						
Cumberlandia monodonta	FE	H	SF	–	–	–
Amblemini						
Amblema plicata		A	L	L	L	L
Pleurobemini						
Elliptio crassidens	ILE	H	SF	–	–	–
Elliptio dilatata	ILT	R	WD	–	–	–
Fusconaia ebena		H	WD	–	WD	WD
Fusconaia flava		C	L	L	L	L
Plethobasus cyphyus	FE	R	SF	–	–	–
Pleurobema sintoxia	IAE	R	SF	–	–	–
Quadrulini						
Cyclonaias tuberculata	IAT, ILT	H	WD	–	WD	-
Megalonaias nervosa		C	L	L	L	L
Quadrula metanevra		R	L	L	L	WD
Quadrula nodulata		R	L	–	L	L
Quadrula p. pustulosa		C	L	L	L	L
Quadrula quadrula		C	L	L	L	L
Tritogonia verrucosa	IAE	H	WD	–	–	–
Lampsilini						
Actinonaias ligamentina		C	L	–	–	L
Ellipsaria lineolata	IAT, ILT	C	L	L	L	L
Epioblasma triquetra	FE	H	–	–	–	–
Lampsilis cardium		C	L	L	L	L
Lampsilis higginsii	FE	R	L	L	L	L
Lampsilis siliquoidea		R	L	–	WD	-
Lampsilis teres	IAE	R	L	–	L	L
Leptodea fragilis		R	L	L	L	L
Ligumia recta	ILT	C	L	L	L	L
Obliquaria reflexa		A	L	L	L	L
Obovaria olivaria		C	L	L	L	L
Potamilus alatus		C	L	L	L	L
Potamilus capax	FE	H	WD	–	–	–
Potamilus ohiensis		R	L	–	L	-
Toxolasma parvus		R	L	L	L	WD
Truncilla donaciformis		R	L	–	L	L
Truncilla truncata		C	L	–	L	L
Anodontini						
Anodonta suborbiculata		H	L	–	–	–
Arcidens confragosus		R	L	L	L	L
Lasmigona c. complanata		R	L	L	L	L
Lasmigona compressa	IAT	H	–	–	–	–
Lasmigona costata		R	SF	–	–	–
Pyganodon grandis		R	L	L	WD	L
Strophitus undulatus	IAT	R	L	–	FD	-
Utterbackia imbecillis		R	L	–	FD	L
Live species		31	28	18	22	22
FD, WD, & SF species		9	10	–	6	3
Total species		40	38	18	28	25

L = Live, D = Dead, FD = Fresh Dead, WD = Weathered Dead, SF = Sub Fossil

[1]FE = Federal Endangered (USFWS, 2017), IAE = IA Endangered, IAT = IA Threatened (IADNR, 2017) ILE = IL Endangered, ILT = IA Threatened (IESPB, 2015)

[2]A = Abundantly taken in most samples, C = Common, taken in most samples; can make up a large portion of samples, R = Rare, does not usually appear in sample collections, populations are small either naturally or have declined and may or may not be near extirpation, H = Records of occurrence but no live collections have been documented since 1980.

[3]ESI, 2017

Table 3-1. Unionids collected by sample area, Mississippi River, Clinton, Iowa.

		Main Channel / Mussel Bed				Willow Island West				Willow Island East				Sunfish Slough			
Tribe	Species	Quan.[1]	Qual.[2]	Total	%	Quan.	Qual.[1]	Total	%	Quan.	Qual.[1]	Total	%	Quan.	Qual.[1]	Total	%
Amblemini	*Amblema plicata*	19	52	71	38.8	6	10	16	40.0	10	1	11	34.4	2	2	4	30.8
Pleurobemini	*Fusconaia ebena*	SF	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Fusconaia flava	1	6	7	3.8	0	2	2	5.0	2	0	2	6.3	0	0	0	0.0
	Plethobasus cyphyus	SF	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Pleurobema sintoxia	SF	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Quadrulini	*Megalonaias nervosa*	2	2	4	2.2	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Quadrula metanevra	SF	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Quadrula nodulata	0	0	0	0.0	3	0	3	7.5	0	0	0	0.0	0	0	0	0.0
	Quadrula p. pustulosa	2	0	2	1.1	0	1	1	2.5	1	1	2	6.3	0	0	0	0.0
	Quadrula quadrula	0	2	2	1.1	1	0	1	2.5	0	0	0	0.0	2	2	4	30.8
	Tritogonia verrucosa	SF	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Lampsilini	*Actinonaias ligamentina*	SF	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Ellipsaria lineolata	1	2	3	1.6	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Lampsilis cardium	5	18	23	12.6	0	0	0	0.0	0	4	4	12.5	0	0	0	0.0
	Leptodea fragilis	4	3	7	3.8	0	0	0	0.0	0	1	1	3.1	1	1	2	15.4
	Ligumia recta	5	17	22	12.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Obliquaria reflexa	8	9	17	9.3	4	6	10	25.0	6	3	9	28.1	0	0	0	0.0
	Obovaria olivaria	0	7	7	3.8	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Potamilus alatus	0	4	4	2.2	0	1	1	2.5	1	1	2	6.3	0	0	0	0.0
	Potamilus ohiensis	0	0	0	0.0	0	1	1	2.5	1	0	1	3.1	0	0	0	0.0
	Toxolasma parvus	FD	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Truncilla donaciformis	4	0	4	2.2	3	0	3	7.5	0	0	0	0.0	0	0	0	0.0
	Truncilla truncata	1	0	1	0.5	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
Anodontini	*Arcidens confragosus*	0	1	1	0.5	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Lasmigona c. complanata	0	3	3	1.6	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Pyganodon grandis	0	0	0	0.0	1	0	1	2.5	0	0	0	0.0	1	2	3	23.1
	Strophitus undulatus	SF	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
	Utterbackia imbecillis	5	0	5	2.7	1	0	1	2.5	0	0	0	0.0	0	0	0	0.0
	Total	57	126	183	100.0	19	21	40	100.0	21	11	32	100.0	6	7	13	100.0
No. Live Species		12	13	17		7	6	11		6	6	8		4	4	4	

[1]L = Live, D = Dead, FD = Fresh Dead, WD = Weathered Dead, SF = Sub Fossil

[2]Qualitative includes searches in the mussel bed (Main Channel) and pier searches.

Table 3-2. Unionid community characteristics by sample area, Mississippi River, Clinton, Iowa.

Metric[1]	Main Channel / Mussel Bed	Willow Island West	Willow Island East	Sunfish Slough
Density[2]	4.2±2.2	2.6±1.3	1.2±0.8	0.6±0.6
No. Live	57	19	17	6
No. Live Species	17	11	8	2
Tribes				
% Amblemini	38.8	40.0	34.4	30.8
% Pleurobemini	3.8	5.0	6.3	0.0
% Quadrulini	4.4	12.5	6.3	30.8
% Lampsilini	48.1	37.5	53.1	15.4
% Anodontini	4.9	5.0	0.0	23.1
Tribe Evenness	0.74	0.81	0.23	0.83
Species Evenness	0.85	0.75	0.89	0.98
Abundance at 75th Quartile[3]	8	4	0	0
Species Richness (ES_50)[4]	12	n/a	n/a	n/a
Mortality (% Freshly Dead)	19.7	17.4	15.0	33.3
% Juveniles	59.6	88.9	70.6	50.0
% Tolerant Species[5]	54.4	63.2	76.2	100.0

[1]Metrics based on quantitative data only, except No. Live Species

[2]No. live unionids/m^2

[3]Density = Ave. no. live unionids/m^2 ± 2 Standard Errors (SE)

[4]ES_50 = rarefaction species richness estimated at the collection of 50 individuals

[5]*Amblema plicata*, *Leptodea fragilis*, *Pyganodon grandis*, *Quadrula quadrula*, and *Obliquaria reflexa*

Table 3-3. Unionid community characteristics in the Iowa Bank Bed, Mississippi River, Clinton, Iowa.

		Quantitative		Qualitative		Total	
Tribe	Species	No. Live	%	No. Live	%	No. Live	%
Amblemini	*Amblema plicata*	18	32.7	52	41.3	70	38.7
Pleurobemini	*Fusconaia flava*	1	1.8	6	4.8	7	3.9
Quadrulini	*Megalonaias nervosa*	2	3.6	2	1.6	4	2.2
	Quadrula nodulata	FD	0.0	0	0.0	0	0.0
	Quadrula p. pustulosa	2	3.6	0	0.0	2	1.1
	Quadrula quadrula	FD	0.0	2	1.6	2	1.1
Lampsilini	*Ellipsaria lineolata*	1	1.8	2	1.6	3	1.7
	Lampsilis cardium	4	7.3	18	14.3	22	12.2
	Leptodea fragilis	4	7.3	3	2.4	7	3.9
	Ligumia recta	5	9.1	17	13.5	22	12.2
	Obliquaria reflexa	8	14.5	9	7.1	17	9.4
	Obovaria olivaria	FD	0.0	7	5.6	7	3.9
	Potamilus alatus	0	0.0	4	3.2	4	2.2
	Truncilla donaciformis	4	7.3	0	0.0	4	2.2
	Truncilla truncata	1	1.8	0	0.0	1	0.6
Anodontini	*Arcidens confragosus*	0	0.0	1	0.8	1	0.6
	Lasmigona c. complanata	0	0.0	3	2.4	3	1.7
	Utterbackia imbecillis	5	9.1	0	0.0	5	2.8
	Total	55	100.0	126	100.0	181	100.0

	Quantitative	Qualitative	Total
Density[1]	8.5±3.8		
No. Live	55	126	181
No. Live Species	12	13	17
Tribes			
% Amblemini	32.7	41.3	38.7
% Pleurobemini	1.8	4.8	3.9
% Quadrulini	7.3	3.2	4.4
% Lampsilini	49.1	47.6	48.1
% Anodontini	9.1	3.2	5.0

Metrics[2]	Value	Score Based on MCAT Quality Ranges
Tribe Evenness	0.70	Poor (<0.719)
Species Evenness	0.85	Good (>0.780)
Abundance at 75th Quartile[3]	12	Fair (8 to 13)
Species Richness (ES_100)[4]	15	Fair (11.5 to 15.7)
Mortality (% Freshly Dead)	20.3	Poor (>6.7)
% Juveniles	40.0	Fair (19.8 to 49.3)
% Tolerant Species MCAT	47.3	Fair (38.3 to 62.7)
% Tolerant Species[5]	54.5	

[1]Density = Ave. no. live unionids/m^2 ± 2 Standard Errors (SE)

[2]Metrics based on quantitative data only, except species richness

[3]No. live unionids/m^2

[4]ES_100 = rarefaction species richness estimated at the collection of 100 individuals

[5]*Amblema plicata*, *Leptodea fragilis*, *Pyganodon grandis*, *Quadrula quadrula*, and *Obliquaria reflexa*

Table 3-4. Unionids relocated from within boring sites, Mississippi River, Clinton, Iowa.

Tribe	Species	Boring Site							Total
		B-19	B-20	B-25	B-26	B-31	B-34	B-35	
Amblemini	*Amblema plicata*	0	0	1	0	29	0	1	31
Pleurobemini	*Fusconaia flava*	0	0	0	0	1	0	0	1
Quadrulini	*Quadrula p. pustulosa*	0	0	0	0	4	0	0	4
	Quadrula quadrula	0	0	0	0	1	0	0	1
Lampsilini	*Lampsilis cardium*	1	0	1	0	0	0	0	2
	Ligumia recta	0	0	0	0	0	0	1	1
	Obliquaria reflexa	0	0	1	0	9	0	1	11
	Obovaria olivaria	0	0	0	0	1	0	0	1
	Potamilus ohiensis	0	0	0	0	1	0	0	1
	Truncilla donaciformis	0	0	0	0	0	0	1	1
Anodontini	*Lasmigona c. complanata*	0	0	0	0	1	0	0	1
	Pyganodon grandis	0	0	0	0	0	1	0	1
	Total	1	0	3	0	47	1	4	56
No. Species		1	0	3	0	8	1	4	12
% Juveniles		100.0	0.0	66.7	0.0	74.5	100.0	50.0	73.2

Appendix A. Depths (m) and substrate recorded at quantitative samples.

Site	Replicate	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Main Channel	1	1.8	0	0	50	30	10	10	0	0	0	0	0
	2	2.1	0	0	0	20	0	60	20	0	0	0	0
	3	3.4	0	0	0	50	40	10	0	0	0	0	0
	4	1.8	0	0	0	10	20	40	30	0	0	0	0
	5	7.6	0	0	50	20	0	0	30	0	0	0	0
	6	8.2	0	0	50	20	0	0	30	0	0	0	0
	7	7.6	0	0	0	25	50	0	0	25	0	0	0
	8	7.3	0	0	0	40	20	0	0	40	0	0	0
	9	6.7	0	0	0	30	40	0	0	30	0	0	0
	10	2.4	0	0	0	30	40	0	0	30	0	0	0
	11	3.0	0	0	0	50	10	10	0	30	0	0	0
	12	4.0	0	0	0	30	30	0	30	10	0	0	0
	13	3.7	0	0	0	30	30	0	0	40	0	0	0
	14	3.7	0	20	40	20	10	0	0	10	0	0	0
	15	13.1	0	40	40	0	20	0	0	0	0	0	0
	16	10.7	0	0	0	0	100	0	0	0	0	0	0
	17	10.4	0	0	0	0	100	0	0	0	0	0	0
	18	10.7	0	0	30	30	40	0	0	0	0	0	0
	19	10.7	0	0	0	0	100	0	0	0	0	0	0
	20	9.1	0	0	0	0	100	0	0	0	0	0	0
	21	9.1	0	0	0	0	100	0	0	0	0	0	0
	22	10.7	0	0	0	0	100	0	0	0	0	0	0
	23	11.9	0	0	0	0	100	0	0	0	0	0	0
	24	3.0	0	0	0	20	50	0	0	30	0	0	0
	25	3.0	0	0	50	25	25	0	0	0	0	0	0
	26	3.4	0	10	50	20	20	0	0	0	0	0	0
	27	1.8	0	0	10	80	10	0	0	0	0	0	0
	28	1.8	0	0	10	80	10	0	0	0	0	0	0
	29	5.5	0	50	0	10	15	0	0	25	0	0	0
	30	4.6	90	0	0	10	0	0	0	0	0	0	0
	31	3.7	0	0	25	25	10	0	15	25	0	0	0
	32	4.9	0	0	0	40	30	0	0	30	0	0	0
	33	6.1	0	70	0	20	10	0	0	0	0	0	0
	34	3.4	0	20	30	30	20	0	0	0	0	0	0
	35	8.2	0	50	10	20	0	0	20	0	0	0	0
	36	7.9	0	80	0	10	10	0	0	0	0	0	0
	37	4.9	0	50	25	10	15	0	0	0	0	0	0
	38	7.9	0	0	50	25	15	0	10	0	0	0	0
	39	6.1	0	0	25	50	15	0	0	10	0	0	0
	40	4.3	0	0	40	30	20	0	0	10	0	0	0

Appendix A. Depths (m) and substrate recorded at quantitative samples.

Site	Replicate	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Main Channel	41	1.2	0	0	0	0	20	30	50	0	0	0	0
(cont.)	42	1.5	0	0	0	0	20	40	40	0	0	0	0
	43	1.5	0	0	0	0	30	40	30	0	0	0	0
	44	1.8	0	0	0	0	20	30	50	0	0	0	0
	45	1.8	0	0	0	20	50	20	10	0	0	0	0
	46	2.4	0	0	0	20	30	20	30	0	0	0	0
	47	2.1	0	60	20	10	10	0	0	0	0	0	0
	48	2.4	80	0	10	10	0	0	0	0	0	0	0
	49	4.6	0	0	0	10	90	0	0	0	0	0	0
	50	5.2	0	0	10	10	80	0	0	0	0	0	0
	51	4.3	0	0	0	10	90	0	0	0	0	0	0
	52	4.9	0	0	0	10	90	0	0	0	0	0	0
	53	6.1	0	0	10	60	30	0	0	0	0	0	0
	54	5.5	0	0	40	30	30	0	0	0	0	0	0
Main Channel Average		5.3	3.1	8.3	12.5	20.9	35.6	5.7	7.3	6.4	0.0	0.0	0.0
Willow Island	1	2.1	0	0	0	0	10	50	40	0	0	0	0
West	2	2.4	0	0	0	0	75	0	25	0	0	0	0
	3	4.3	0	0	0	0	100	0	0	0	0	0	0
	4	3.4	0	0	0	0	90	10	0	0	0	0	0
	5	3.0	0	0	0	0	50	25	25	0	0	0	0
	6	4.3	0	0	0	0	90	10	0	0	0	0	0
	7	4.0	0	0	0	0	90	10	0	0	0	0	0
	8	2.4	0	0	0	0	50	25	25	0	0	0	0
	9	2.7	0	0	0	0	10	20	70	0	0	0	0
	10	2.7	0	0	0	0	100	0	0	0	0	0	0
	11	3.4	0	0	0	0	100	0	0	0	0	0	0
	12	3.0	0	0	0	0	25	25	50	0	0	0	0
	13	3.7	0	0	0	0	0	20	80	0	0	0	0
	14	2.1	0	0	0	0	0	20	80	0	0	0	0
	15	2.7	0	0	0	0	10	20	70	0	0	0	0
	16	2.1	0	0	0	0	50	20	30	0	0	0	0
	17	3.4	0	0	0	0	50	20	30	0	0	0	0
	18	3.0	0	0	0	0	100	0	0	0	0	0	0
	19	2.7	0	0	0	0	0	30	70	0	0	0	0
	20	3.0	0	0	0	0	70	0	20	10	0	0	0
	21	3.0	0	0	0	0	100	0	0	0	0	0	0
	22	2.4	0	0	0	0	10	10	80	0	0	0	0
	23	2.4	0	0	0	0	10	10	80	0	0	0	0
	24	2.7	0	0	0	0	100	0	0	0	0	0	0
	25	2.4	0	0	0	0	100	0	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at quantitative samples.

Site	Replicate	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
	26	3.4	0	0	0	0	100	0	0	0	0	0	0
	27	2.4	0	0	0	0	0	90	0	10	0	0	0
	28	2.1	0	0	0	0	30	30	30	10	0	0	0
	29	2.7	0	0	0	0	20	40	40	0	0	0	0
Willow Island West Average		2.9	0.0	0.0	0.0	0.0	53.1	16.7	29.1	1.0	0.0	0.0	0.0
Willow Island	1	9.1	0	0	0	0	100	0	0	0	0	0	0
East	2	5.5	0	0	0	30	30	10	30	0	0	0	0
	3	4.6	0	0	0	0	100	0	0	0	0	0	0
	4	4.0	0	0	0	0	70	10	20	0	0	0	0
	5	2.7	0	0	0	0	10	20	70	0	0	0	0
	6	3.7	0	0	0	0	30	0	60	10	0	0	0
	7	7.9	0	0	20	30	50	0	0	0	0	0	0
	8	4.6	0	0	0	0	100	0	0	0	0	0	0
	9	5.2	0	0	0	0	100	0	0	0	0	0	0
	10	4.6	0	0	0	0	100	0	0	0	0	0	0
	11	4.3	0	0	0	0	100	0	0	0	0	0	0
	12	5.5	0	0	0	0	100	0	0	0	0	0	0
	13	5.5	0	0	0	0	100	0	0	0	0	0	0
	14	6.1	0	0	0	0	100	0	0	0	0	0	0
	15	6.1	0	0	0	0	100	0	0	0	0	0	0
	16	3.4	0	0	0	0	100	0	0	0	0	0	0
	17	4.0	0	0	0	0	25	0	75	0	0	0	0
	18	6.1	0	0	0	0	100	0	0	0	0	0	0
	19	6.1	0	0	0	0	100	0	0	0	0	0	0
	20	4.0	0	0	0	0	75	0	25	0	0	0	0
	21	4.6	0	0	0	0	0	25	75	0	0	0	0
	22	4.0	0	0	0	0	0	0	100	0	0	0	0
	23	4.3	0	0	0	0	100	0	0	0	0	0	0
	24	5.5	0	0	0	0	100	0	0	0	0	0	0
	25	5.8	0	0	0	0	0	0	100	0	0	0	0
	26	6.1	0	0	0	0	100	0	0	0	0	0	0
	27	7.6	0	0	0	0	100	0	0	0	0	0	0
	28	6.7	0	0	0	0	50	0	0	0	0	0	50
	29	6.7	0	0	0	0	100	0	0	0	0	0	0
	30	6.4	0	0	0	0	50	0	50	0	0	0	0
	31	7.0	0	0	0	0	75	0	0	0	0	0	25
	32	6.7	0	0	0	0	50	0	50	0	0	0	0
	33	6.4	0	0	0	0	100	0	0	0	0	0	0
	34	5.8	0	0	0	0	0	0	0	0	0	0	0
	35	4.6	0	0	0	0	80	0	20	0	0	0	0

Appendix A. Depths (m) and substrate recorded at quantitative samples.

Site	Replicate	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	36	5.5	0	0	0	0	100	0	0	0	0	0	0
East (cont.)	37	7.3	0	0	0	0	100	0	0	0	0	0	0
	38	7.6	0	0	0	0	100	0	0	0	0	0	0
	39	6.4	0	0	0	0	100	0	0	0	0	0	0
	40	6.7	0	0	0	0	100	0	0	0	0	0	0
	41	9.1	0	0	0	0	100	0	0	0	0	0	0
	42	1.2	0	0	0	0	40	60	0	0	0	0	0
	43	2.1	0	0	0	0	75	25	0	0	0	0	0
	44	6.1	0	0	0	0	0	0	0	0	0	0	100
	45	5.2	0	0	0	0	100	0	0	0	0	0	0
	46	6.1	0	0	0	0	100	0	0	0	0	0	0
	47	11.0	0	50	0	0	50	0	0	0	0	0	0
	48	9.8	0	0	0	50	50	0	0	0	0	0	0
	49	6.7	0	0	0	0	100	0	0	0	0	0	0
	50	7.0	0	0	0	0	100	0	0	0	0	0	0
	51	7.0	0	0	0	0	95	0	0	0	0	0	5
	52	7.9	0	0	0	5	90	0	0	0	0	0	5
	53	7.0	0	0	0	0	100	0	0	0	0	0	0
	54	7.0	0	0	0	0	25	25	50	0	0	0	0
	55	8.8	0	0	0	0	100	0	0	0	0	0	0
	56	8.8	0	0	0	0	100	0	0	0	0	0	0
	57	9.8	0	0	0	50	50	0	0	0	0	0	0
	58	8.5	0	0	0	20	80	0	0	0	0	0	0
	59	7.6	0	0	0	25	50	0	25	0	0	0	0
Willow Island East Average		6.1	0.0	0.8	0.3	3.6	74.6	3.0	12.7	0.2	0.0	0.0	3.1

Appendix A. Depths (m) and substrate recorded at quantitative samples.

Site	Replicate	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Sunfish Slough	1	1.8	0	0	20	20	0	20	30	10	0	0	0
	2	1.5	0	0	0	0	0	30	60	0	0	10	0
	3	1.8	0	0	10	0	0	30	60	0	0	0	0
	4	4.0	0	0	0	20	0	0	70	0	0	0	10
	5	4.3	0	0	0	0	0	60	40	0	0	0	0
	6	3.7	0	0	0	10	0	20	60	0	0	10	0
	7	2.7	0	0	0	10	10	30	50	0	0	0	0
	8	2.7	0	0	0	0	0	30	60	0	0	10	0
	9	1.8	0	0	0	0	0	40	50	0	0	10	0
	10	1.8	0	0	0	0	0	50	50	0	0	0	0
	11	2.1	0	0	0	0	0	50	50	0	0	0	0
	12	3.0	0	0	0	0	0	60	40	0	0	0	0
	13	5.2	0	0	0	0	0	60	40	0	0	0	0
	14	5.2	0	0	0	0	0	60	40	0	0	0	0
	15	2.7	0	0	0	0	10	50	30	0	0	10	0
	16	5.8	0	0	0	0	30	40	30	0	0	0	0
	17	6.1	0	0	0	0	0	70	30	0	0	0	0
	18	5.5	0	0	0	0	0	70	30	0	0	0	0
	19	5.2	0	0	0	0	0	90	10	0	0	0	0
	20	5.2	0	0	0	0	0	90	10	0	0	0	0
	21	4.3	0	0	0	0	0	90	10	0	0	0	0
	22	3.4	0	0	0	0	0	90	10	0	0	0	0
	23	5.5	0	0	0	0	0	90	10	0	0	0	0
	24	5.5	0	0	0	0	0	90	10	0	0	0	0
	25	3.4	0	0	0	0	0	90	10	0	0	0	0
	26	5.2	0	0	0	0	0	90	10	0	0	0	0
	27	5.5	0	0	0	0	0	90	10	0	0	0	0
	28	2.7	0	0	0	0	0	90	10	0	0	0	0
	29	2.1	0	0	0	0	0	90	10	0	0	0	0
	30	5.8	0	0	0	0	0	90	10	0	0	0	0
	31	2.1	0	0	0	0	0	90	10	0	0	0	0
	32	4.9	0	0	0	0	0	90	10	0	0	0	0
	33	4.3	0	0	0	0	0	90	10	0	0	0	0
	34	5.5	0	0	0	0	0	85	10	0	0	5	0
	35	3.0	0	0	0	0	0	90	10	0	0	0	0
	36	3.0	0	0	0	0	0	85	10	0	0	5	0
	37	4.0	0	0	0	0	0	90	10	0	0	0	0
Sunfish Slough Average		3.8	0.0	0.0	0.8	1.6	1.4	66.8	27.3	0.3	0.0	1.6	0.3

Unionid Survey in the Mississippi River for Proposed Dredging and Staging Related to Bridge Construction at the Union Pacific Railroad Near Clinton, Iowa

Prepared for:
Union Pacific Railroad

Under contract with:
Jacobs

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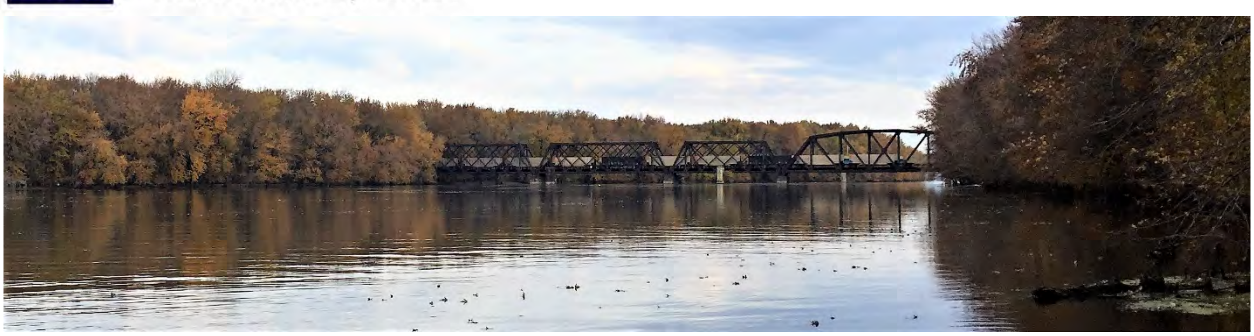

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APPENDICES

1.0 INTRODUCTION

Union Pacific Railroad (UPRR) plans on constructing a new bridge downstream (south) of the current bridge over Pool 14 of the Mississippi River in Clinton, Iowa. The new structure is proposed approximately 91 m (300 ft.) downstream of the existing structure (see proposed pier locations in Figure 1-1), after which, demolition of the current bridge is planned. (Of note, the approximate pier locations presented in this report are subject to change and were used for a basis of general survey locations in 2017). Two federally endangered unionids (freshwater mussels) are known to inhabit Pool 14 (*Lampsilis higginsii* and *Plethobasus cyphyus*). Historically, 40 unionid species were known live in Pool 14, 31 of which have been collected live since 1980 (Table 1-1). Of the 31, 4 are listed in as endangered or threatened Iowa and 3 in Illinois.

In 2017, Ecological Specialists (now EcoAnalysts) conducted a unionid survey near the existing bridge and proposed new bridge alignment to characterize the unionid assemblages present within bridge construction and demolition impact areas. A unionid bed was found along the Iowa bank at the bridge crossing, with 2 state listed species (*Ellipsaria lineolata* and *Ligumia recta*) and no federally listed species (Table 1-1). This year's (2018) survey areas were immediately downstream of 2017's study (ESI, 2018) and within ADM's Camanche Terminal Barge Facility where barge staging and dredging are proposed (Figure 1-1).

Information on the distribution, abundance, and species composition of unionid mussels within the areas where bridge construction activity is planned is needed to determine if federal or state threatened or endangered (T&E) mussel species may be affected by proposed bridge construction activities. Jacobs contracted EcoAnalysts to conduct surveys for freshwater mussels in areas potentially impacted by dredging and barge staging. Surveys were conducted November 2 – 8, 2018.

2.0 METHODS

Originally four study areas were proposed for unionid surveys: Right Main Channel, Left Main Channel, Willow Island (Secondary Channel), and ADM Barge Facility (Figure 1-1). However, because of high flows and falling water temperatures during the survey, the Main Channel sites could not be safely surveyed in 2018.

Semi-quantitative sampling along transects was conducted within the Willow Island site. The objective of semi-quantitative sampling was to determine unionid distribution within the study area. Thirty (30) transects of lengths varying from 50 – 200 m were established to cover the area. A total of 427 samples (10 m sections) were collected in the Willow Island site. To easier identify transect locations, the site was divided into 4 subsites: Willow Island Right Upstream (WIRU), Willow Island Left Upstream (WILU), Willow Island Right Downstream (WIRD), and Willow Island Left (WIL). For each transect, a diver traversed the line collecting unionids within one meter on one side of the transect by searching tactually through the substrate, removing loose debris, and fanning fine sediment. Each 10 m section was considered a separate sample and unionids from that section were placed in a bag and brought to the surface for processing. All collected unionids were processed and returned to the river bottom. At each 10 m point, the diver provided visual/tactual assessment of substrate type (Wentworth scale, Wentworth 1922), and depth was recorded with a pneumometer (Appendix A). The start and end point of each transect was recorded with GPS.

Semi-quantitative sampling revealed unionids at the toe of Willow Island and along the left descending bank within the Willow Island site. To increase probability of finding more species, these areas were investigated with qualitative sampling. Qualitative sampling was also employed to survey the ADM site. Qualitative sampling entailed a diver searching the substrate in a zig-zag pattern to cover the entire survey area. While moving along the bottom, mussels were searched for visually and tactually and placed in a mesh bag to be held before processing. Percent substrate constituents and water depth was recorded for each sample and mussels were processed. For the ADM site, 32, 5 min. searches were conducted throughout the study area. Within the Willow Island site, 12 were collected along the bank within the WIL subsite and 12 were collected just downstream of the toe of Willow Island.

For processing, live unionids were counted, and up to 30 of each species were aged (external annuli count) and measured (length in mm). Species names followed Williams et al., 2017. Freshly dead unionids (with or without tissue, nacre shiny, valves still intact, periostracum present; likely dead less than one year) were counted and noted as adults or juveniles. Weathered (no tissue, nacre chalky, valves may or may not be intact, periostracum present; animal likely dead more than one year) or subfossil shells (entire shell chalky, valves not intact, no periostracum; animal dead many years to decades) were noted as present. Live unionids were returned to the river near their collection point. At least one individual of each species was photographed (Appendix B). Each live state or federal listed species (T&E) was aged, measured (length, width, and height in mm), and photographed and hand-placed back into the substrate. Appendix C lists T&E species characteristics and sample where collected.

3.0 RESULTS AND DISCUSSION

Unionids were found in both the ADM Barge Facility site and Willow Island site. No federal or state listed species were collected and are not likely present in the ADM site since habitat there is marginal for most unionid species. However, one federal and three state T&E species were collected within the Willow Island site. Habitat within the Willow Island site was mostly sandy, but suitable habitat was found in areas within 30 m of the bank and downstream of the toe of Willow Island.

3.1 ADM Barge Facility

Being mostly silt or clay rather than a heterogenous mix of substrate sizes, which is typically the preferred substrate type for most unionid species, habitat was marginal for unionids within the ADM Barge Facility Site. Substrate was generally mostly silt or mostly clay, with some coarser substrate near the banks. Clay was more prevalent upstream and silt downstream (Figure 3-1). Depths ranged from 0.9 to 6.4 m, averaged 4.4 m, and were less at the mouth of the facility (Figure 3-1).

A total of 118 live unionids of 13 species were collected within the ADM Barge Facility site (Table 3-1). No federal or state listed species were collected. The majority (77.1%) were juveniles and most were thin-shelled species (*Potamilus alatus*, *Potamilus ohiensis*, and *Pyganodon grandis*). Most unionids were collected in the downstream half of the site (excluding the mouth) where silt was more prevalent (Figure 3-2). Results suggest this area does not harbor a stable, reproducing unionid assemblage, but one of transient juveniles of thin-shelled species more adapted for silty substrate.

3.2 Willow Island Site / Secondary Channel Site

The majority of the Willow Island Site was dominated by sand, while silt and clay were found near the banks. Depths ranged from 0.3 to 5.8 m (Figure 3-3) and averaged 3.4 m. Most of the substrate consisted of sand (Figure 3-4). Clay and silt were common within 30 – 40 m from the banks as was woody debris. Deposits of unionid shell material were also encountered scattered throughout the site (Figure 3-4).

A total of 995 live unionids of 20 species were collected within the Willow Island site, including one federally endangered (*Lampsilis higginsii*) and three state listed (*Ellipsaria lineolata*, *Lampsilis teres*, and *Ligumia recta*) species (Table 3-1). Two listed species, *Ellipsaria lineolata* (threatened in Iowa and Illinois) and *L. recta* (threatened in Illinois), are both relatively common in Pool 14 (Table 1-1). Although several species were collected, most were represented by few individuals. The unionid assemblage was dominated by three species, one of which, *Amblema plicata*, comprised over half (51.7%) of all live unionids collected (Table 3-1). Combined with the next two most common species, *Lampsilis cardium* (19.6%), and *Obliquaria reflexa* (8.9%), these 3 species comprised 80.2% of unionids collected live. Recruitment within semi-quantitative samples ranged from 9.7 to 41.7% and was highest within WIRU, with 41.7% of live unionids collected along transects being ≤ 5 years of age (Table 3-1).

Unionids, including listed species, were generally found within 30 m from banks where more silt and clay were present, and were sparse towards the center of the channel and at transects WIRD 4 – 7 and WIL 15 and 16 (Figure 3-5) where sand was the dominant substrate type. Two areas of higher unionid abundance were identified and further sampled with qualitative searches: one at the toe of Willow Island, and the other along the left descending bank of the site (Figure 3-5). During qualitative searches, one *L. higginsii* was collected within the area at the toe of Willow Island (Figure 3-6). Catch per unit effort (CPUE) was similar among subsites within the Willow Island site, with semi-quantitative CPUE ranging from 0.8 to 1.7 unionids / 10 m^2. CPUE was also similar between qualitative samples at WIL (17.6 unionids / 5 min.) and

WILU (15.8 unionids / 5 min.; Table 3-1). Results suggest two areas within the Willow Island site support a relatively species-rich and reproducing unionid assemblage that harbor federal and/or state listed species.

4.0 CONCLUSION

Data from this study demonstrate the presence of unionid assemblages at both the ADM Barge Facility site and the Willow Island Site. Within the ADM Barge Facility, most unionids were collected within the southern (downstream) half. At the Willow Island Site, unionids were generally restricted to within 30 m from the banks. No listed species were collected within the ADM Barge Facility, however, one federal and three state listed species were collected within the Willow Island Site. Although *L. higginsii* (federally endangered) and *L. teres* (Iowa endangered) are rare within Pool 14 of the Mississippi River, *E. lineolata* and *L. recta* are relatively common (Kelner, 2011).

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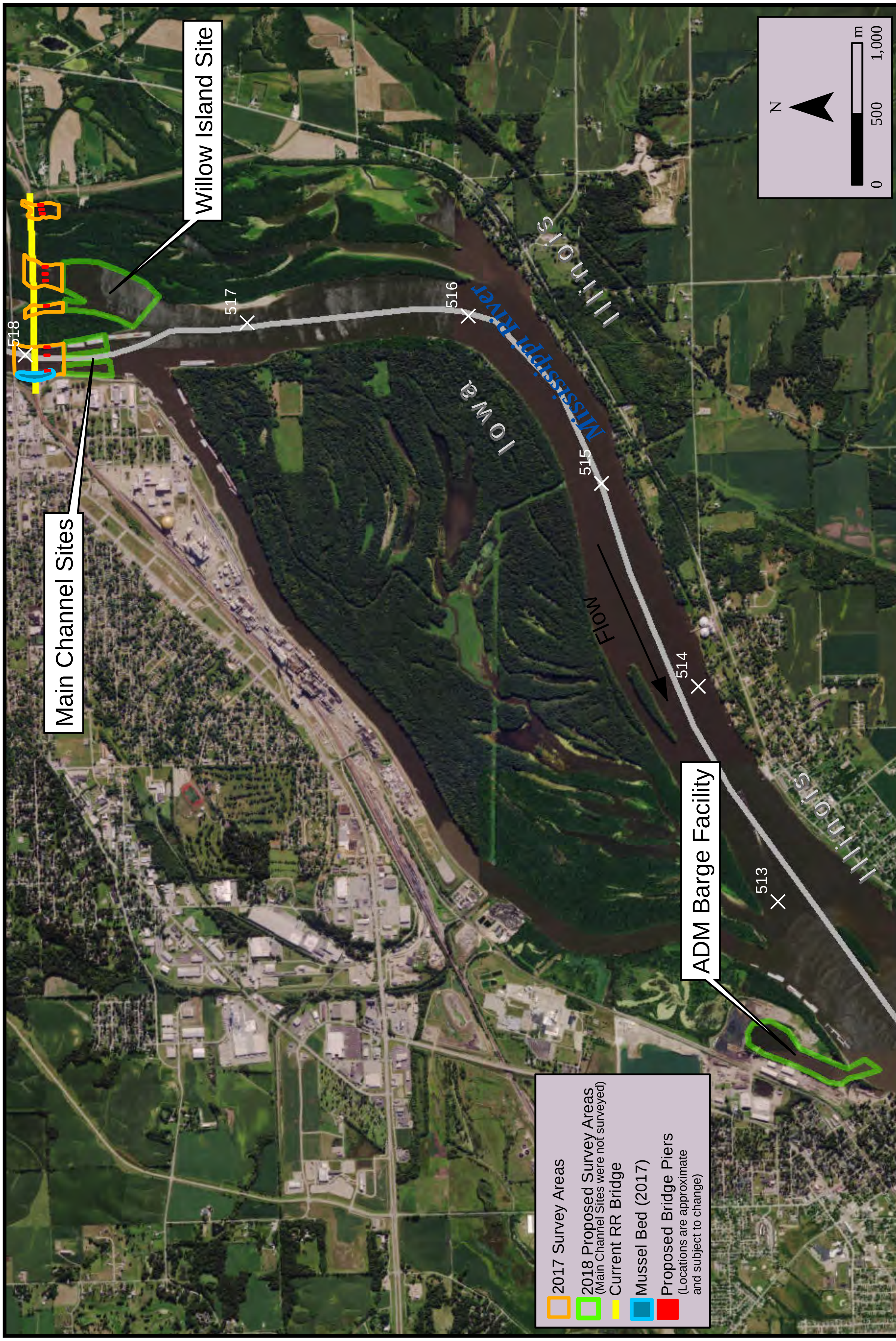

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Figure 1-1. Unionid survey areas, Mississippi Pool 14, 2017 and 2018.

Figure 3-1. Depths and substrate, ADM Barge Facility Site, Camanche, Iowa, November 2018.

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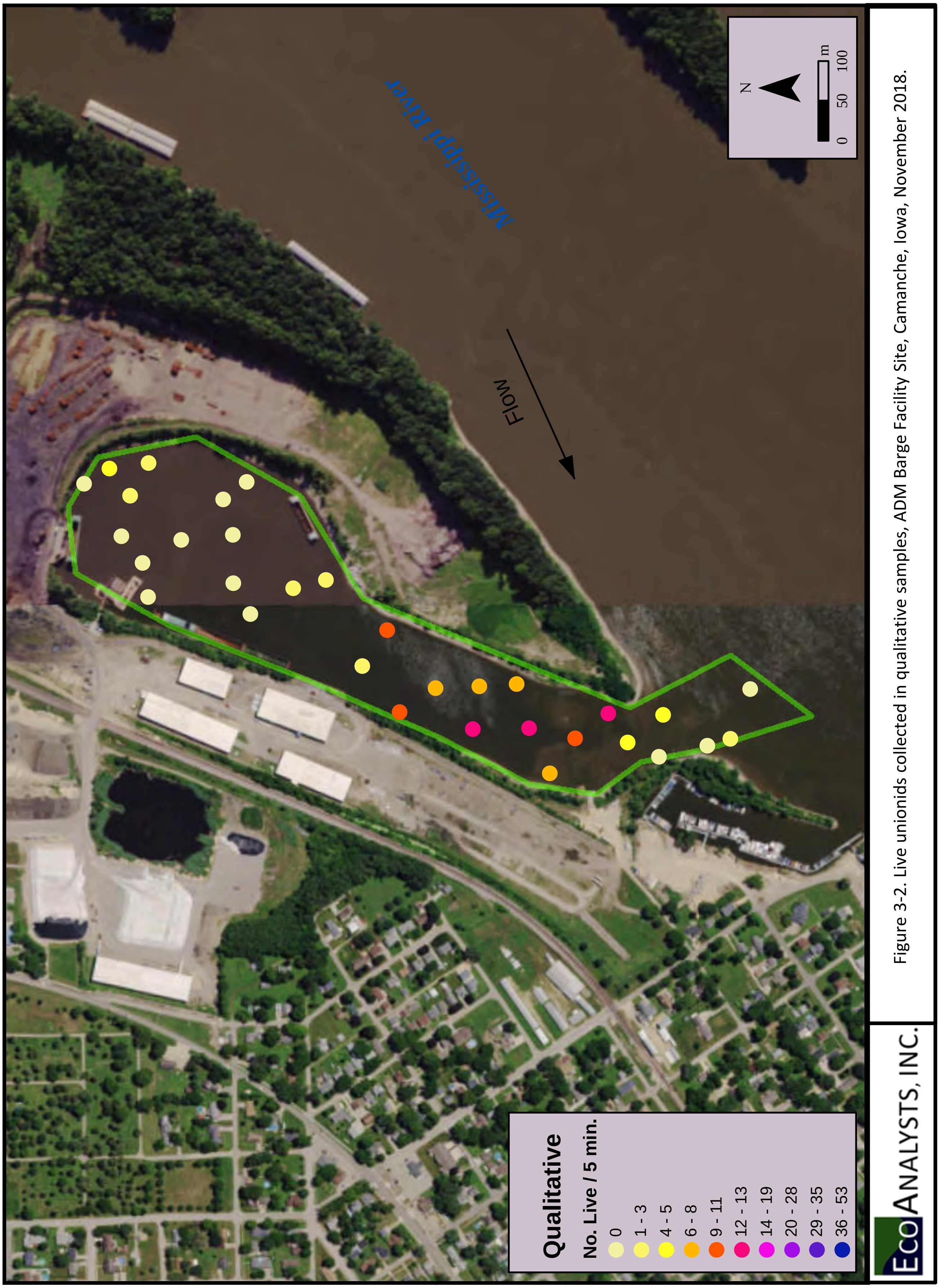

Figure 3-2. Live unionids collected in qualitative samples, ADM Barge Facility Site, Camanche, Iowa, November 2018.

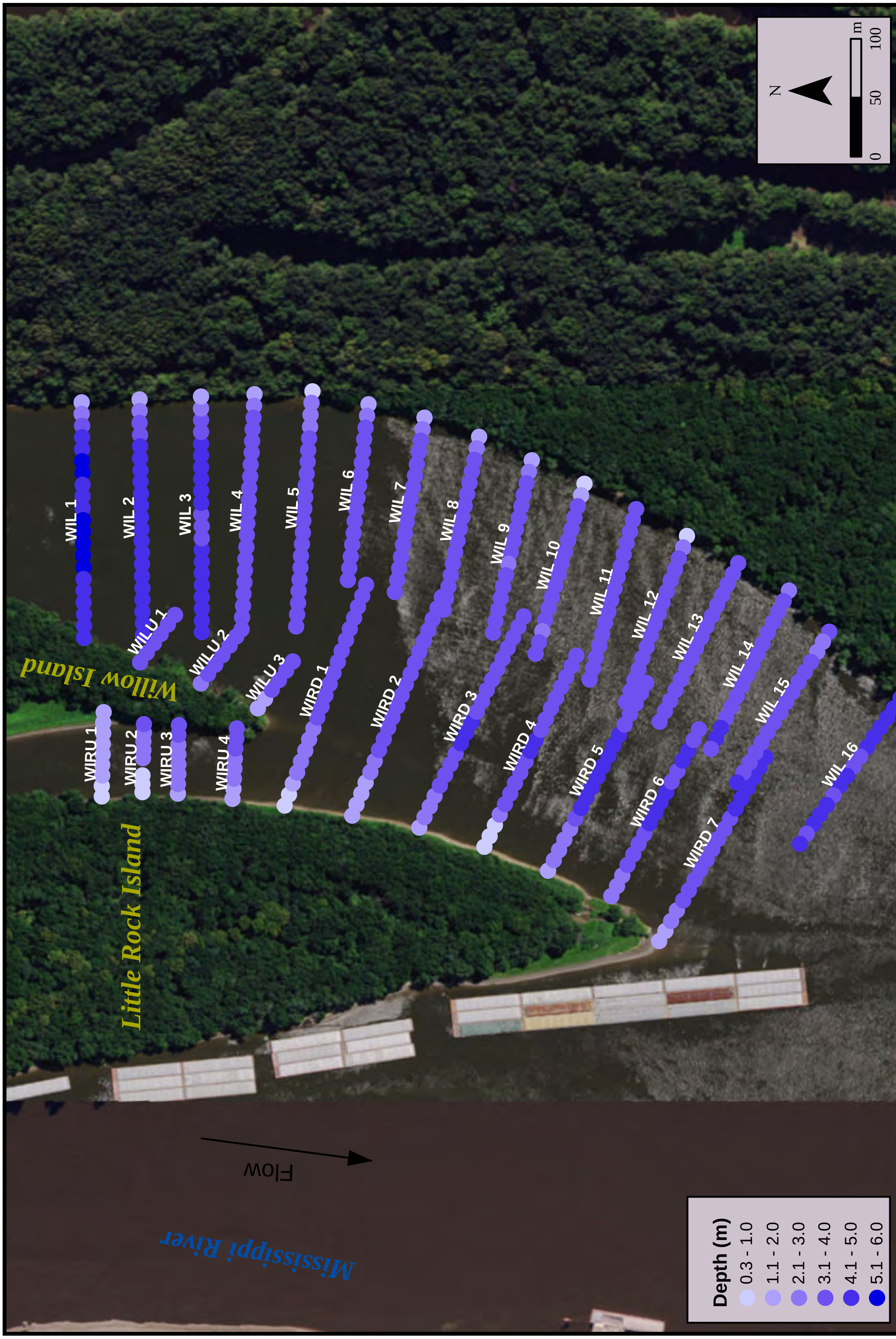

Figure 3-3. Depths along semi-quantitative transect samples, Willow Island Site, Clinton, Iowa, November 2018.

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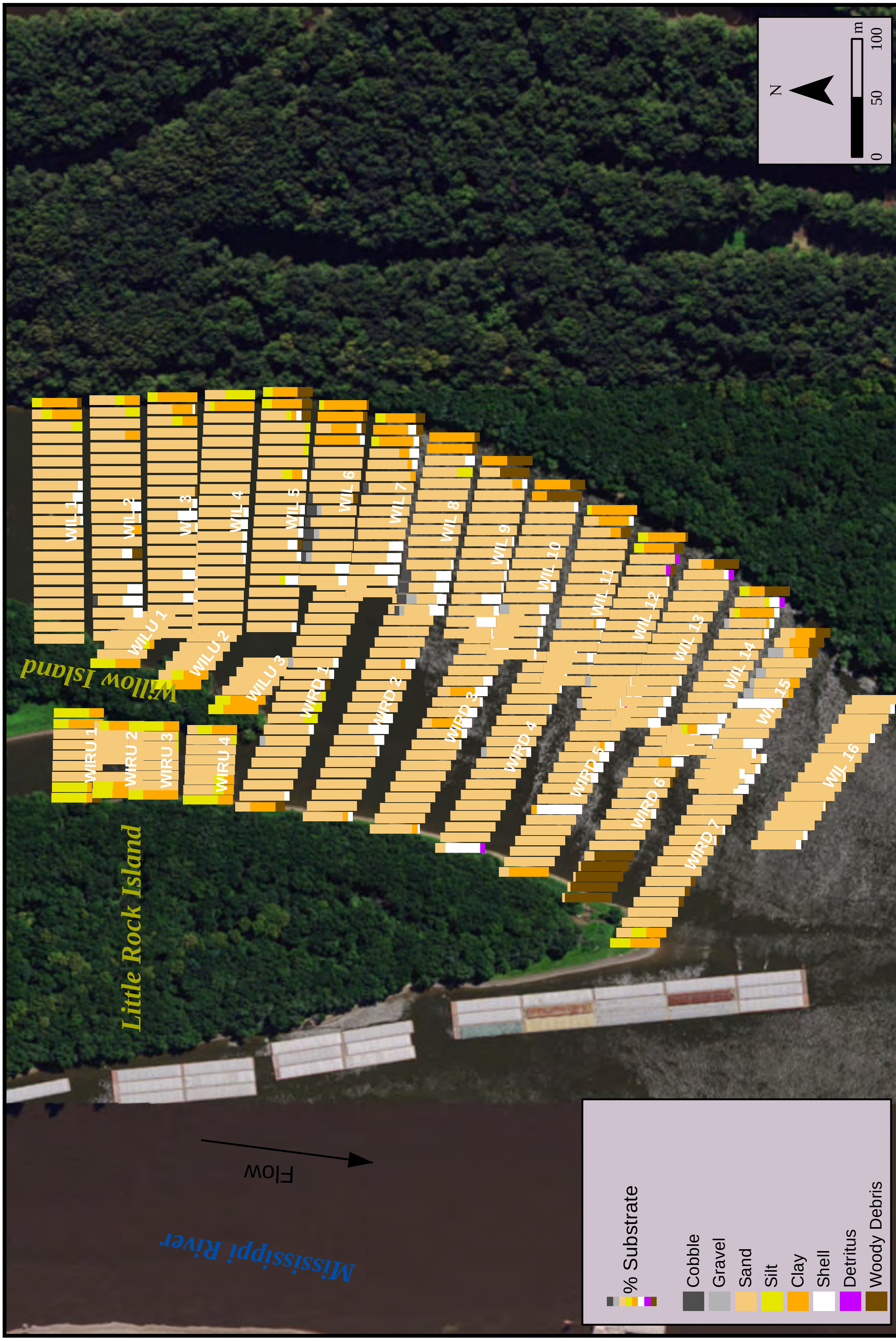

Figure 3-4. Substrate along semi-quantitative transect samples, Willow Island Site, Clinton, Iowa, November 2018

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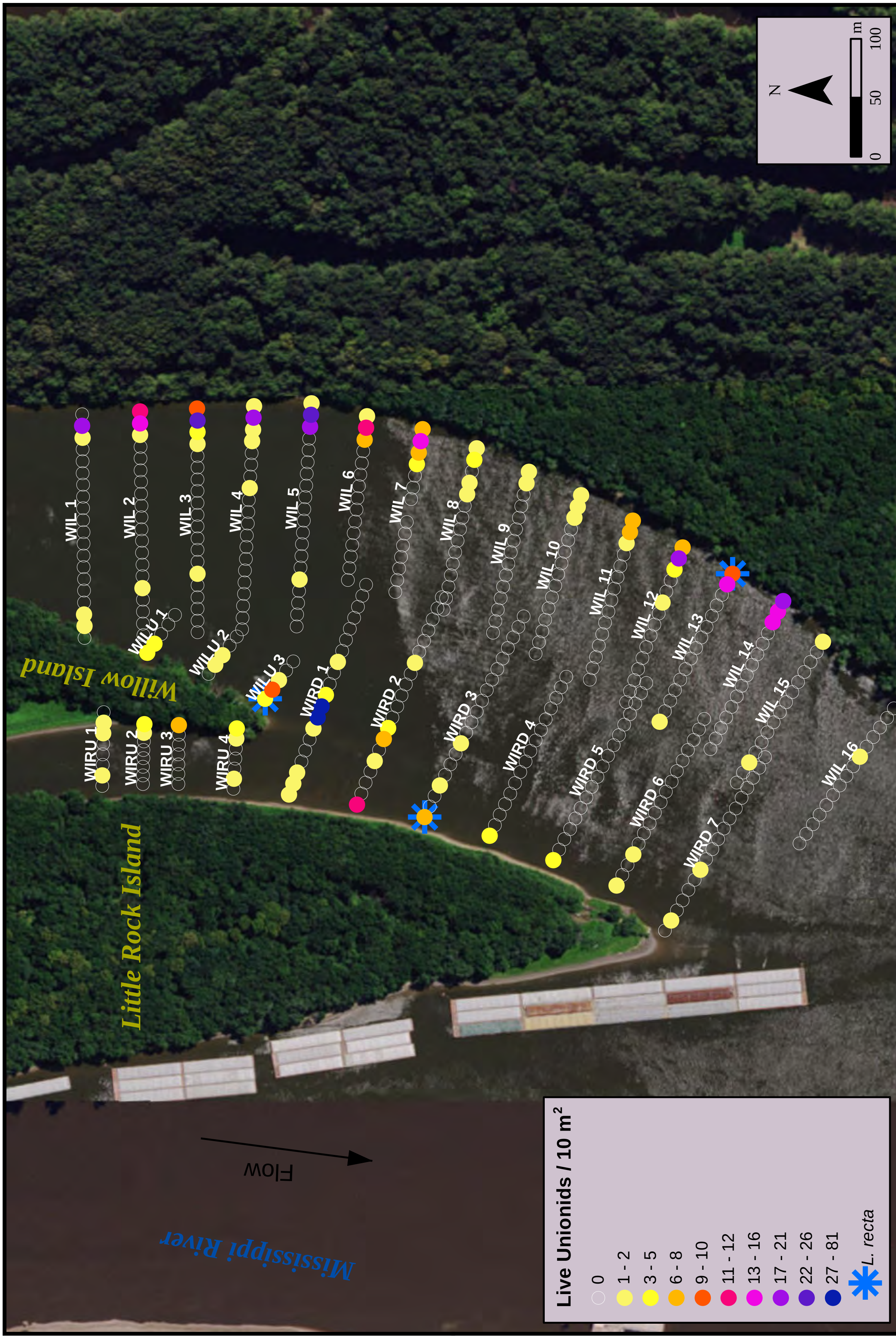

Figure 3-5. Live unionids collected along semi-quantitative transect samples, Willow Island Site, Clinton, Iowa, November 2018.

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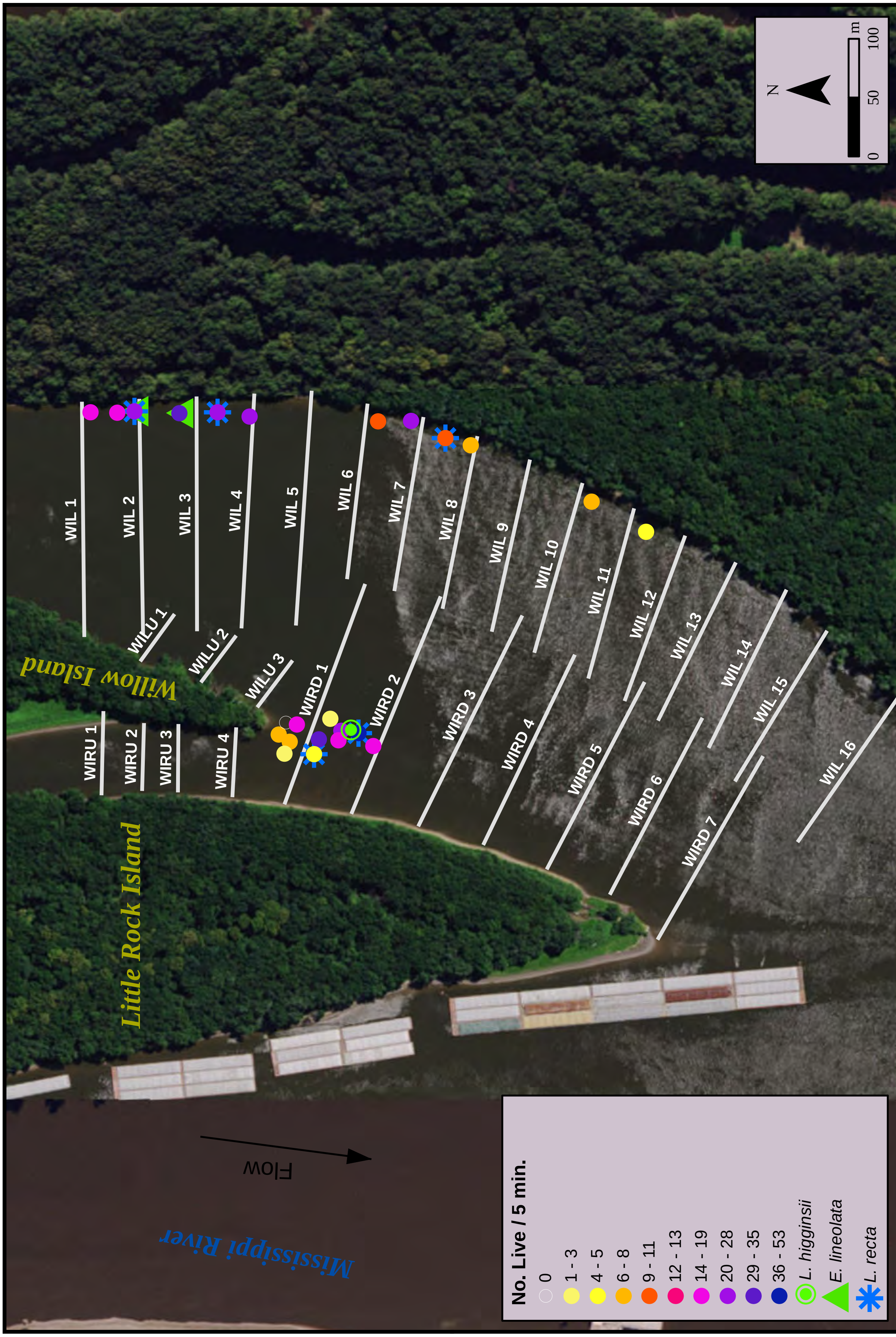

Figure 3-6. Live unionids collected in qualitative samples, Willow Island Site, Clinton, Iowa, November 2018.

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Table 1-1. Unionid species reported from Mississippi River Pool 14.

Species	Status[1]	Kelner 2011 [2]	ESI 2013	ESI 2014	ESI 2015	ESI 2016[3]	ESI 2017[4]
Margaritifieridae							
Margaritifera monodonta	FE	H	SF	–	–	–	–
Amblemini							
Amblema plicata		A	L	L	L	L	L
Pleurobemini							
Elliptio crassidens	ILE	H	SF	–	–	–	–
Eurynia dilatata	ILT	R	WD	–	–	–	–
Fusconaia flava		C	L	L	L	L	L
Plethobasus cyphyus	FE	R	SF	–	–	–	SF
Pleurobema sintoxia	IAE	R	SF	–	–	–	SF
Reginaia ebenus		H	WD	–	WD	WD	SF
Quadrulini							
Cyclonaias tuberculata	IAT, ILT	H	WD	–	WD	-	-
Cyclonaias nodulata		R	L	–	L	L	L
Cyclonaias pustulosa		C	L	L	L	L	L
Megalonaias nervosa		C	L	L	L	L	L
Quadrula quadrula		C	L	L	L	L	L
Theliderma metanevra		R	L	L	L	WD	SF
Tritogonia verrucosa	IAE	H	WD	–	–	–	SF
Lampsilini							
Actinonaias ligamentina		C	L	–	–	L	SF
Ellipsaria lineolata	IAT, ILT	C	L	L	L	L	L
Epioblasma triquetra	FE	H	–	–	–	–	–
Lampsilis cardium		C	L	L	L	L	L
Lampsilis higginsii	FE	R	L	L	L	L	-
Lampsilis siliquoidea		R	L	–	WD	-	-
Lampsilis teres	IAE	R	L	–	L	L	-
Leptodea fragilis		R	L	L	L	L	L
Ligumia recta	ILT	C	L	L	L	L	L
Obliquaria reflexa		A	L	L	L	L	L
Obovaria olivaria		C	L	L	L	L	L
Potamilus alatus		C	L	L	L	L	L
Potamilus capax	FE	H	WD	–	–	–	–
Potamilus ohiensis		R	L	–	L	–	–
Toxolasma parvum		R	L	L	L	WD	FD
Truncilla donaciformis		R	L	–	L	L	L
Truncilla truncata		C	L	–	L	L	L
Anodontini							
Anodonta suborbiculata		H	L	–	–	–	–
Arcidens confragosus		R	L	L	L	L	L
Lasmigona complanata		R	L	L	L	L	L
Lasmigona compressa	IAT	H	–	–	–	–	–
Lasmigona costata		R	SF	–	–	–	–
Pyganodon grandis		R	L	L	WD	L	L
Strophitus undulatus	IAT	R	L	–	FD	-	SF
Utterbackia imbecillis		R	L	–	FD	L	L
Live species		31	28	18	22	22	19
FD, WD, & SF species		9	10	–	6	3	8
Total species		40	38	18	28	25	27

L = Live, D = Dead, FD = Fresh Dead, WD = Weathered Dead, SF = Sub Fossil

[1]FE = Federal Endangered (USFWS, 2018), IAE = IA Endangered, IAT = IA Threatened (IADNR, 2018), ILE = IL Endangered, ILT = IL Threatened (IESPB, 2015)

[2]A = Abundantly taken in most samples, C = Common, taken in most samples; can make up a large portion of samples, R = Rare, does not usually appear in sample collections, populations are small either naturally or have declined and may or may not be near extirpation, H = Records of occurrence but no live collections have been documented since 1980.

[3]ESI, 2017; [4]ESI, 2018

Table 3-1. Live unionids collected by site, Mississippi River Pool 14, November 2018.

	ADM	Mississippi River Secondary Channel / Willow Island Site							
	Barge Facility	WIL		WILU		WIRD	WIRU	Total	
Species by Tribe	Qualitative	Qualitative	Semi-Quan.	Qualitative	Semi-Quan.	Semi-Quan.	Semi-Quan.	No. Live	%
Amblemini									
Amblema plicata	16	133	121	118	12	116	14	514	51.7
Pleurobemini									
Fusconaia flava	2	0	24	0	0	6	0	30	3.0
Quadrulini									
Cyclonaias nodulata	0	0	2	0	0	2	1	5	0.5
Cyclonaias pustulosa	0	3	10	6	1	3	0	23	2.3
Quadrula quadrula	6	11	11	8	0	4	0	34	3.4
Total	**6**	**14**	**23**	**14**	**1**	**9**	**1**	**62**	**6.2**
Lampsilini									
Ellipsaria lineolata [IAT, ILT]	0	3	0	0	0	0	0	3	0.3
Lampsilis cardium	1	34	79	36	5	37	4	195	19.6
Lampsilis higginsii [FE]	0	0	0	1	0	0	0	1	0.1
Lampsilis teres [IAE]	0	0	0	0	1	0	0	1	0.1
Leptodea fragilis	9	4	4	0	0	0	0	8	0.8
Ligumia recta [ILT]	0	2	2	2	1	1	0	8	0.8
Obliquaria reflexa	1	12	63	2	0	10	2	89	8.9
Obovaria olivaria	0	3	11	5	3	2	1	25	2.5
Potamilus alatus	40	1	5	1	0	1	0	8	0.8
Potamilus ohiensis	15	2	4	0	0	2	1	9	0.9
Toxolasma parvum	2	0	1	0	0	0	0	1	0.1
Truncilla donaciformis	1	0	0	0	0	1	1	2	0.2
Total	**69**	**61**	**169**	**47**	**10**	**54**	**9**	**350**	**35.2**
Anodontini									
Arcidens confragosus	0	0	1	3	1	5	0	10	1.0
Lasmigona complanata	1	1	7	5	0	3	0	16	1.6
Pyganodon grandis	23	2	6	3	0	2	0	13	1.3
Utterbackia imbecillis	1	0	0	0	0	0	0	0	0.0
Total	**25**	**3**	**14**	**11**	**1**	**10**	**0**	**39**	**3.9**
Total No. Live	**118**	**211**	**351**	**190**	**24**	**195**	**24**	**995**	**100.0**
Total Live Species	**13**	**13**	**16**	**12**	**7**	**15**	**7**	**20**	
Effort	**32 X 5 min.**	**12 X 5 min.**	**265 - 10m^2**	**12 X 5 min.**	**15 - 10m^2**	**117 - 10m^2**	**30 - 10m^2**		
Recruitment (% ≤5 y.)	**77.1**	**12.8**	**33.0**	**2.1**	**16.7**	**9.7**	**41.7**	**18.1**	
CPUE (No. Live / 5 min. or 10 m^2)	**3.7**	**17.6**	**1.3**	**15.8**	**1.6**	**1.7**	**0.8**		

IAT = Iowa Threatened, ILT = Illinois Threatened, FE = Federally Endangered, IAE = Iowa Endangered

Appendix A. Depths (m) and substrate recorded at each sample.

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL1-0	1.2	0	0	0	0	0	20	70	0	0	10	0
	WIL1-1	2.1	0	0	0	0	20	20	60	0	0	0	0
	WIL1-2	4.0	0	0	0	0	80	20	0	0	0	0	0
	WIL1-3	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL1-4	4.9	0	0	0	0	100	0	0	0	0	0	0
	WIL1-5	5.2	0	0	0	0	100	0	0	0	0	0	0
	WIL1-6	4.9	0	0	0	0	100	0	0	0	0	0	0
	WIL1-7	4.9	0	0	0	0	90	0	0	10	0	0	0
	WIL1-8	4.9	0	0	0	0	80	0	0	20	0	0	0
	WIL1-9	4.9	0	0	0	0	90	0	0	10	0	0	0
	WIL1-10	5.8	0	0	0	0	95	0	0	5	0	0	0
	WIL1-11	5.8	0	0	0	0	100	0	0	0	0	0	0
	WIL1-12	5.5	0	0	0	0	100	0	0	0	0	0	0
	WIL1-13	5.5	0	0	0	0	100	0	0	0	0	0	0
	WIL1-14	4.9	0	0	0	0	100	0	0	0	0	0	0
	WIL1-15	4.9	0	0	0	0	100	0	0	0	0	0	0
	WIL1-16	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL1-17	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL1-18	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL1-19	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL1-20	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL2-0	1.8	0	0	0	0	50	20	30	0	0	0	0
	WIL2-1	2.7	0	0	0	0	70	30	0	0	0	0	0
	WIL2-2	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL2-3	4.0	0	0	0	0	70	0	30	0	0	0	0
	WIL2-4	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL2-5	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL2-6	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL2-7	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL2-8	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL2-9	4.6	0	0	0	0	80	0	0	20	0	0	0
	WIL2-10	4.9	0	0	0	0	95	0	0	5	0	0	0
	WIL2-11	4.9	0	0	0	0	80	0	20	0	0	0	0
	WIL2-12	4.9	0	0	0	0	100	0	0	0	0	0	0
	WIL2-13	4.9	0	0	0	0	60	0	0	20	0	20	0
	WIL2-14	4.9	0	0	0	0	100	0	0	0	0	0	0
	WIL2-15	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL2-16	4.6	0	0	0	0	70	0	0	30	0	0	0
	WIL2-17	4.6	0	0	10	0	50	0	0	40	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL2-18	4.6	0	0	0	0	80	0	0	20	0	0	0
(cont.)	WIL2-19	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL2-20	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL3-0	1.5	0	0	0	0	0	20	80	0	0	0	0
	WIL3-1	2.4	0	0	0	0	50	0	40	5	0	5	0
	WIL3-2	3.4	0	0	0	0	50	20	30	0	0	0	0
	WIL3-3	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL3-4	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-5	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-6	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-7	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-8	4.3	0	0	0	0	95	0	0	0	0	5	0
	WIL3-9	4.0	0	0	0	0	90	0	0	10	0	0	0
	WIL3-10	4.0	0	0	0	0	60	0	0	40	0	0	0
	WIL3-11	4.0	0	0	0	0	95	0	0	5	0	0	0
	WIL3-12	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL3-13	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-14	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-15	4.6	0	0	0	0	70	0	0	30	0	0	0
	WIL3-16	4.6	0	0	0	0	95	0	0	5	0	0	0
	WIL3-17	4.3	0	0	0	0	70	0	0	30	0	0	0
	WIL3-18	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-19	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL3-20	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL4-0	1.5	0	0	0	0	40	60	0	0	0	0	0
	WIL4-1	2.4	0	0	0	0	10	10	80	0	0	0	0
	WIL4-2	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-3	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-4	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL4-5	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL4-6	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-7	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-8	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-9	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-10	4.0	0	0	0	0	90	0	0	10	0	0	0
	WIL4-11	3.7	0	0	0	0	85	0	0	15	0	0	0
	WIL4-12	3.7	0	0	0	0	90	0	0	10	0	0	0
	WIL4-13	3.7	0	0	0	0	90	0	0	10	0	0	0
	WIL4-14	4.0	0	0	0	0	95	0	0	5	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL4-15	4.0	0	0	0	0	100	0	0	0	0	0	0
(cont.)	WIL4-16	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-17	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-18	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-19	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL4-20	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL5-0	0.6	0	0	0	0	0	20	50	0	0	30	0
	WIL5-1	1.8	0	0	0	0	0	20	60	0	0	20	0
	WIL5-2	2.7	0	0	0	0	50	10	10	10	0	20	0
	WIL5-3	2.7	0	0	0	0	90	10	0	0	0	0	0
	WIL5-4	2.7	0	0	0	0	90	10	0	0	0	0	0
	WIL5-5	3.0	0	0	0	0	90	10	0	0	0	0	0
	WIL5-6	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL5-7	3.4	0	0	0	0	50	20	20	10	0	0	0
	WIL5-8	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL5-9	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL5-10	3.4	0	0	0	0	90	0	0	10	0	0	0
	WIL5-11	3.7	0	0	0	0	90	0	0	10	0	0	0
	WIL5-12	3.4	0	0	0	0	90	0	0	10	0	0	0
	WIL5-13	3.4	0	0	0	0	70	0	0	20	0	10	0
	WIL5-14	3.4	0	0	0	0	90	0	0	10	0	0	0
	WIL5-15	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL5-16	3.7	0	0	0	0	60	10	0	30	0	0	0
	WIL5-17	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL5-18	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL5-19	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL5-20	3.0	0	0	0	0	90	0	0	10	0	0	0
	WIL6-0	1.5	0	0	0	0	0	10	85	0	0	5	0
	WIL6-1	2.1	0	0	0	0	0	0	90	0	0	10	0
	WIL6-2	3.0	0	0	0	0	30	0	50	10	0	10	0
	WIL6-3	3.4	0	0	0	0	0	0	90	10	0	0	0
	WIL6-4	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL6-5	3.7	0	0	5	0	95	0	0	0	0	0	0
	WIL6-6	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL6-7	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL6-8	3.7	0	0	10	0	80	0	0	0	0	10	0
	WIL6-9	3.7	0	0	20	10	70	0	0	0	0	0	0
	WIL6-10	3.7	0	0	10	0	90	0	0	0	0	0	0
	WIL6-11	3.7	0	0	20	10	70	0	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL6-12	3.7	0	0	20	0	80	0	0	0	0	0	0
(cont.)	WIL6-13	3.4	0	0	10	10	80	0	0	0	0	0	0
	WIL6-14	3.7	0	0	0	0	70	0	0	30	0	0	0
	WIL6-15	3.7	0	0	0	0	80	0	0	20	0	0	0
	WIL7-0	1.2	0	0	0	0	0	20	60	0	0	20	0
	WIL7-1	2.7	0	0	0	0	0	0	70	15	0	15	0
	WIL7-2	3.4	0	0	0	0	0	15	70	10	0	5	0
	WIL7-3	3.7	0	0	0	0	60	0	20	20	0	0	0
	WIL7-4	3.7	0	0	0	0	80	0	10	10	0	0	0
	WIL7-5	4.0	0	0	0	0	90	0	10	0	0	0	0
	WIL7-6	4.0	0	0	10	0	90	0	0	0	0	0	0
	WIL7-7	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL7-8	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL7-9	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL7-10	3.0	0	0	5	0	95	0	0	0	0	0	0
	WIL7-11	3.0	0	0	0	0	70	0	0	30	0	0	0
	WIL7-12	3.0	0	0	0	0	70	0	0	30	0	0	0
	WIL7-13	3.0	0	0	0	0	50	0	0	50	0	0	0
	WIL7-14	3.7	0	0	0	0	80	0	0	20	0	0	0
	WIL7-15	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL8-0	1.2	0	0	0	0	0	0	90	0	0	10	0
	WIL8-1	2.4	0	0	0	0	0	0	90	0	0	10	0
	WIL8-2	3.0	0	0	0	0	80	0	0	20	0	0	0
	WIL8-3	3.0	0	0	0	0	70	30	0	0	0	0	0
	WIL8-4	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL8-5	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL8-6	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL8-7	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL8-8	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL8-9	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL8-10	3.4	0	0	5	0	95	0	0	0	0	0	0
	WIL8-11	3.7	0	0	5	0	90	0	0	5	0	0	0
	WIL8-12	3.4	0	0	20	0	50	0	0	30	0	0	0
	WIL8-13	3.4	0	0	20	0	50	0	0	30	0	0	0
	WIL8-14	3.0	0	0	20	20	40	0	0	20	0	0	0
	WIL8-15	3.4	0	0	10	10	50	0	0	30	0	0	0
	WIL9-0	1.2	0	0	0	0	0	0	50	0	0	50	0
	WIL9-1	2.4	0	0	0	0	40	0	0	0	0	60	0
	WIL9-2	3.4	0	0	0	0	70	0	20	10	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL9-3	3.4	0	0	0	0	100	0	0	0	0	0	0
(cont.)	WIL9-4	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL9-5	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL9-6	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL9-7	3.4	0	0	0	0	95	0	0	5	0	0	0
	WIL9-8	2.7	0	0	0	0	100	0	0	0	0	0	0
	WIL9-9	2.4	0	0	0	0	95	0	0	5	0	0	0
	WIL9-10	3.0	0	0	0	0	95	0	0	5	0	0	0
	WIL9-11	3.0	0	0	0	0	95	0	0	5	0	0	0
	WIL9-12	3.0	0	0	0	0	60	0	0	40	0	0	0
	WIL9-13	3.0	0	0	0	0	90	0	0	10	0	0	0
	WIL9-14	3.0	0	0	0	0	60	0	0	40	0	0	0
	WIL9-15	3.0	0	0	0	0	95	0	0	5	0	0	0
	WIL10-0	0.6	0	0	0	0	0	0	70	0	0	30	0
	WIL10-1	1.2	0	0	0	0	0	0	30	0	0	70	0
	WIL10-2	3.7	0	0	0	0	90	0	0	10	0	0	0
	WIL10-3	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL10-4	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL10-5	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL10-6	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL10-7	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL10-8	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL10-9	3.0	0	0	0	0	90	0	0	10	0	0	0
	WIL10-10	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL10-11	3.0	0	0	0	20	60	0	0	20	0	0	0
	WIL10-12	2.7	0	0	0	0	90	0	0	10	0	0	0
	WIL10-13	2.7	0	0	0	0	90	0	0	10	0	0	0
	WIL10-14	3.0	0	0	0	0	95	0	0	5	0	0	0
	WIL10-15	3.0	0	0	0	0	95	0	0	5	0	0	0
	WIL11-0	1.8	0	0	0	0	0	10	90	0	0	0	0
	WIL11-1	3.7	0	0	0	0	30	0	60	10	0	0	0
	WIL11-2	3.7	0	0	0	0	60	0	20	0	0	20	0
	WIL11-3	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL11-4	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL11-5	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL11-6	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL11-7	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL11-8	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL11-9	3.0	0	0	0	0	100	0	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL11-10	3.4	0	0	0	10	65	0	5	20	0	0	0
(cont.)	WIL11-11	3.0	0	0	0	0	95	0	0	5	0	0	0
	WIL11-12	3.4	0	0	0	0	95	0	0	5	0	0	0
	WIL11-13	3.4	0	0	0	0	80	0	0	20	0	0	0
	WIL11-14	3.4	0	0	0	0	90	0	0	10	0	0	0
	WIL11-15	3.7	0	0	0	0	95	0	0	5	0	0	0
	WIL12-0	0.9	0	0	0	0	0	20	75	0	0	5	0
	WIL12-1	2.4	0	0	0	0	0	20	60	0	0	20	0
	WIL12-2	3.0	0	0	0	0	90	0	0	0	10	0	0
	WIL12-3	3.7	0	0	0	0	80	0	0	0	10	10	0
	WIL12-4	4.0	0	0	0	0	90	0	0	5	0	5	0
	WIL12-5	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL12-6	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL12-7	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL12-8	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL12-9	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL12-10	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL12-11	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL12-12	3.4	0	0	0	0	95	0	0	5	0	0	0
	WIL12-13	3.7	0	0	0	10	80	0	0	10	0	0	0
	WIL12-14	3.7	0	0	0	0	90	0	0	10	0	0	0
	WIL12-15	3.7	0	0	0	10	75	0	0	10	5	0	0
	WIL13-0	3.0	0	0	0	0	25	0	25	0	0	50	0
	WIL13-1	4.0	0	0	0	0	80	0	0	10	10	0	0
	WIL13-2	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL13-3	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL13-4	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL13-5	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL13-6	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL13-7	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL13-8	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL13-9	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL13-10	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL13-11	3.4	0	0	0	0	95	0	0	5	0	0	0
	WIL13-12	3.4	0	0	0	0	90	0	0	10	0	0	0
	WIL13-13	3.7	0	0	0	0	85	0	0	15	0	0	0
	WIL13-14	4.0	0	0	0	0	85	0	0	15	0	0	0
	WIL13-15	4.0	0	0	0	0	75	0	0	25	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL14-0	2.1	0	0	0	0	0	20	30	0	0	50	0
(cont.)	WIL14-1	3.7	0	0	0	0	60	10	0	20	10	0	0
	WIL14-2	3.4	0	0	0	0	10	10	70	10	0	0	0
	WIL14-3	4.0	0	0	0	10	75	0	5	10	0	0	0
	WIL14-4	4.0	0	0	0	0	85	0	5	10	0	0	0
	WIL14-5	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL14-6	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL14-7	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL14-8	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL14-9	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL14-10	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL14-11	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL14-12	4.0	0	0	0	0	80	0	0	20	0	0	0
	WIL14-13	4.3	0	0	0	0	20	10	20	50	0	0	0
	WIL14-14	3.7	0	0	0	0	90	0	0	10	0	0	0
	WIL14-15	3.7	0	0	0	0	95	0	0	5	0	0	0
	WIL15-0	2.7	0	0	0	0	30	0	40	0	0	30	0
	WIL15-1	2.7	0	0	0	0	30	0	40	0	0	30	0
	WIL15-2	1.8	0	0	0	30	20	0	30	0	0	20	0
	WIL15-3	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL15-4	3.7	0	0	0	20	80	0	0	0	0	0	0
	WIL15-5	3.4	0	0	0	10	70	0	20	0	0	0	0
	WIL15-6	2.7	0	0	0	20	70	0	10	0	0	0	0
	WIL15-7	3.4	0	0	0	0	0	0	0	90	0	10	0
	WIL15-8	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL15-9	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIL15-10	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL15-11	3.0	0	0	0	0	60	0	0	40	0	0	0
	WIL15-12	3.0	0	0	0	0	90	0	0	10	0	0	0
	WIL15-13	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL15-14	3.4	0	0	0	0	90	0	0	10	0	0	0
	WIL15-15	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIL16-0	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL16-1	4.6	0	0	0	0	90	0	0	10	0	0	0
	WIL16-2	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL16-3	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL16-4	4.9	0	0	0	0	90	0	0	10	0	0	0
	WIL16-5	4.0	0	0	0	0	100	0	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIL16-6	4.0	0	0	0	0	100	0	0	0	0	0	0
(cont.)	WIL16-7	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL16-8	4.3	0	0	0	0	90	0	0	5	0	5	0
	WIL16-9	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIL16-10	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIL16-11	4.3	0	0	0	0	90	0	0	5	0	5	0
	WIL16-12	4.6	0	0	0	0	100	0	0	0	0	0	0
	WIL16-13	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIL16-14	4.0	0	0	0	0	90	0	0	10	0	0	0
	WIL16-15	4.6	0	0	0	0	90	0	0	10	0	0	0
	WILU1-0	3.0	0	0	0	0	0	50	50	0	0	0	0
	WILU1-1	3.7	0	0	0	0	100	0	0	0	0	0	0
	WILU1-2	3.7	0	0	0	0	80	10	10	0	0	0	0
	WILU1-3	3.7	0	0	0	10	90	0	0	0	0	0	0
	WILU1-4	4.0	0	0	0	10	90	0	0	0	0	0	0
	WILU1-5	4.0	0	0	0	0	100	0	0	0	0	0	0
	WILU2-0	2.4	0	0	0	0	0	40	60	0	0	0	0
	WILU2-1	4.0	0	0	0	0	25	25	50	0	0	0	0
	WILU2-2	4.0	0	0	0	0	100	0	0	0	0	0	0
	WILU2-3	4.0	0	0	0	0	100	0	0	0	0	0	0
	WILU2-4	4.0	0	0	0	0	100	0	0	0	0	0	0
	WILU2-5	4.0	0	0	0	0	100	0	0	0	0	0	0
	WILU3-0	1.2	0	0	0	0	0	30	70	0	0	0	0
	WILU3-1	1.8	0	0	0	0	0	30	70	0	0	0	0
	WILU3-2	3.4	0	0	0	0	100	0	0	0	0	0	0
	WILU3-3	3.4	0	0	0	0	100	0	0	0	0	0	0
	WILU3-4	3.4	0	0	0	0	100	0	0	0	0	0	0
	WILU3-5	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-0	0.6	0	0	0	0	30	0	50	0	0	20	0
	WIRD1-1	0.9	0	0	0	0	90	0	0	10	0	0	0
	WIRD1-2	1.5	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-3	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-4	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-5	2.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-6	2.7	0	0	0	10	90	0	0	0	0	0	0
	WIRD1-7	2.7	0	0	0	0	90	0	0	10	0	0	0
	WIRD1-8	3.4	0	0	0	0	70	30	0	0	0	0	0
	WIRD1-9	3.4	0	0	0	0	80	20	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIRD1-10	3.7	0	0	0	0	90	10	0	0	0	0	0
(cont.)	WIRD1-11	3.7	0	0	0	0	80	0	0	10	0	10	0
	WIRD1-12	3.7	0	0	0	0	90	0	0	10	0	0	0
	WIRD1-13	3.7	0	0	0	10	80	0	0	10	0	0	0
	WIRD1-14	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-15	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-16	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-17	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-18	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-19	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD1-20	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-0	1.5	0	0	0	0	80	0	10	10	0	0	0
	WIRD2-1	1.5	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-2	1.5	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-3	1.8	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-4	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-5	2.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-6	3.0	0	0	0	0	95	0	0	5	0	0	0
	WIRD2-7	3.7	0	0	0	0	80	0	0	20	0	0	0
	WIRD2-8	4.0	0	0	0	0	60	0	0	40	0	0	0
	WIRD2-9	3.7	0	0	0	0	80	0	0	20	0	0	0
	WIRD2-10	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-11	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-12	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-13	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-14	3.7	0	0	0	0	70	0	10	20	0	0	0
	WIRD2-15	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-16	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-17	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-18	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD2-19	3.4	0	0	0	0	80	0	0	20	0	0	0
	WIRD2-20	3.0	0	0	0	0	70	0	0	30	0	0	0
	WIRD3-0	1.5	0	0	0	0	85	0	10	5	0	0	0
	WIRD3-1	2.1	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-2	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-3	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-4	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-5	3.0	0	0	0	0	100	0	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIRD3-6	3.4	0	0	0	0	100	0	0	0	0	0	0
(cont.)	WIRD3-7	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-8	4.3	0	0	0	0	95	0	0	5	0	0	0
	WIRD3-9	4.3	0	0	0	0	80	0	10	10	0	0	0
	WIRD3-10	4.0	0	0	0	0	20	0	60	20	0	0	0
	WIRD3-11	4.0	0	0	0	0	80	0	0	20	0	0	0
	WIRD3-12	4.0	0	0	0	0	95	0	0	5	0	0	0
	WIRD3-13	4.0	0	0	0	0	25	0	50	25	0	0	0
	WIRD3-14	4.0	0	0	0	0	80	0	0	20	0	0	0
	WIRD3-15	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-16	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-17	3.7	0	0	0	0	70	0	0	30	0	0	0
	WIRD3-18	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-19	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD3-20	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-0	2.1	0	0	0	0	20	0	0	70	10	0	0
	WIRD4-1	2.1	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-2	2.1	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-3	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-4	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-5	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-6	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-7	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-8	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-9	4.3	0	0	0	10	80	0	0	10	0	0	0
	WIRD4-10	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-11	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-12	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-13	3.4	0	0	0	0	95	0	0	5	0	0	0
	WIRD4-14	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-15	3.7	0	0	0	0	95	0	0	5	0	0	0
	WIRD4-16	3.7	0	0	0	0	95	0	0	5	0	0	0
	WIRD4-17	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD4-18	3.4	0	0	0	0	95	0	0	5	0	0	0
	WIRD5-0	1.5	0	0	0	0	20	0	80	0	0	0	0
	WIRD5-1	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-2	2.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-3	2.7	0	0	0	0	100	0	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIRD5-4	2.7	0	0	0	0	100	0	0	0	0	0	0
(cont.)	WIRD5-5	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-6	4.3	0	0	0	0	0	0	10	90	0	0	0
	WIRD5-7	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-8	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-9	4.6	0	0	0	0	85	0	0	15	0	0	0
	WIRD5-10	4.6	0	0	0	0	70	0	10	20	0	0	0
	WIRD5-11	4.6	0	0	0	0	80	0	0	20	0	0	0
	WIRD5-12	4.6	0	0	0	0	70	0	10	20	0	0	0
	WIRD5-13	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-14	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-15	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-16	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD5-17	4.0	0	0	0	0	85	0	0	15	0	0	0
	WIRD5-18	4.0	0	0	0	0	95	0	0	5	0	0	0
	WIRD6-0	2.4	0	0	0	0	5	0	0	0	0	95	0
	WIRD6-1	2.7	0	0	0	0	5	0	0	0	0	95	0
	WIRD6-2	2.7	0	0	0	0	5	0	0	0	0	95	0
	WIRD6-3	3.0	0	0	0	0	5	0	0	0	0	95	0
	WIRD6-4	3.0	0	0	0	0	20	0	0	0	0	80	0
	WIRD6-5	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD6-6	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD6-7	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIRD6-8	4.3	0	0	0	0	90	0	0	10	0	0	0
	WIRD6-9	4.3	0	0	0	0	95	0	0	0	0	5	0
	WIRD6-10	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD6-11	4.0	0	0	0	0	95	0	0	0	0	5	0
	WIRD6-12	4.3	0	0	0	0	95	0	0	0	0	5	0
	WIRD6-13	4.3	0	0	0	0	50	0	25	25	0	0	0
	WIRD6-14	4.0	0	0	0	0	70	0	0	30	0	0	0
	WIRD6-15	4.0	0	0	0	0	85	0	0	15	0	0	0
	WIRD6-16	3.7	0	0	0	0	80	0	0	20	0	0	0
	WIRD6-16	3.4	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-0	1.2	0	0	0	0	0	40	60	0	0	0	0
	WIRD7-1	1.8	0	0	0	0	30	30	40	0	0	0	0
	WIRD7-2	2.1	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-3	2.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-4	3.0	0	0	0	0	90	0	0	0	0	10	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIRD7-5	3.0	0	0	0	0	90	0	0	0	0	10	0
(cont.)	WIRD7-6	3.4	0	0	0	0	90	0	0	0	0	10	0
	WIRD7-7	3.7	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-8	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-9	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-10	3.7	0	0	0	0	90	0	0	5	0	5	0
	WIRD7-11	3.7	0	0	0	0	95	0	0	5	0	0	0
	WIRD7-12	4.0	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-13	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-14	4.3	0	0	0	0	100	0	0	0	0	0	0
	WIRD7-15	4.3	0	0	0	0	70	0	0	30	0	0	0
	WIRD7-16	4.9	0	0	0	0	80	0	0	20	0	0	0
	WIRD7-17	4.3	0	0	0	0	90	0	0	10	0	0	0
	WIRD7-18	4.0	0	0	0	0	90	0	0	10	0	0	0
	WIRU1-0	0.3	0	0	0	0	0	70	10	0	0	20	0
	WIRU1-1	0.3	0	0	0	0	0	70	10	0	0	20	0
	WIRU1-2	1.8	0	0	0	0	80	10	0	0	0	10	0
	WIRU1-3	1.8	0	0	0	0	100	0	0	0	0	0	0
	WIRU1-4	1.8	0	0	0	0	100	0	0	0	0	0	0
	WIRU1-5	1.8	0	0	0	0	100	0	0	0	0	0	0
	WIRU1-6	1.8	0	0	0	0	100	0	0	0	0	0	0
	WIRU1-7	1.2	0	0	0	0	0	30	70	0	0	0	0
	WIRU1-8	0.6	0	0	0	0	0	70	30	0	0	0	0
	WIRU2-0	0.9	0	0	0	0	0	40	60	0	0	0	0
	WIRU2-1	0.9	0	0	0	0	0	40	60	0	0	0	0
	WIRU2-2	0.9	0	0	0	0	100	0	0	0	0	0	0
	WIRU2-4	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRU2-5	2.1	0	0	0	0	100	0	0	0	0	0	0
	WIRU2-6	2.7	0	0	0	0	95	5	0	0	0	0	0
	WIRU2-7	2.7	0	0	0	0	95	5	0	0	0	0	0
	WIRU2-8	3.0	0	0	0	0	10	20	70	0	0	0	0
	WIRU3-0	1.8	0	0	0	0	0	30	70	0	0	0	0
	WIRU3-1	2.1	0	0	0	0	100	0	0	0	0	0	0
	WIRU3-2	2.7	0	0	0	0	100	0	0	0	0	0	0
	WIRU3-3	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRU3-4	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRU3-5	2.4	0	0	0	0	95	5	0	0	0	0	0
	WIRU3-6	3.0	0	0	0	0	95	5	0	0	0	0	0

Appendix A. Depths (m) and substrate recorded at each sample.

Site	Sample	Depth (m)	% Bedrock	% Boulder	% Cobble	% Gravel	% Sand	% Silt	% Clay	% Shell	% Detritus	% Woody Debris	% Other
Willow Island	WIRU3-7	2.4	0	0	0	0	0	70	30	0	0	0	0
(cont.)	WIRU4-0	1.8	0	0	0	0	0	70	30	0	0	0	0
	WIRU4-1	1.8	0	0	0	0	60	20	20	0	0	0	0
	WIRU4-2	2.1	0	0	0	0	60	20	20	0	0	0	0
	WIRU4-3	2.1	0	0	0	0	100	0	0	0	0	0	0
	WIRU4-4	2.4	0	0	0	0	100	0	0	0	0	0	0
	WIRU4-5	3.0	0	0	0	0	100	0	0	0	0	0	0
	WIRU4-6	3.0	0	0	0	0	90	10	0	0	0	0	0
	WIRU4-7	3.0	0	0	0	0	20	30	50	0	0	0	0
ADM Facility	ADM-1	3.4	0	0	15	0	70	0	0	15	0	0	0
	ADM-2	3.0	0	0	0	0	90	10	0	0	0	0	0
	ADM-3	3.7	0	0	0	0	60	40	0	0	0	0	0
	ADM-4	6.1	0	0	0	0	50	0	40	0	0	10	0
	ADM-5	6.1	0	0	0	0	0	0	100	0	0	0	0
	ADM-6	6.1	0	0	5	0	0	0	90	0	0	5	0
	ADM-7	4.9	0	0	15	15	60	0	10	0	0	0	0
	ADM-8	6.4	0	0	0	0	0	0	95	5	0	0	0
	ADM-9	5.5	0	0	0	0	0	0	90	0	0	10	0
	ADM-10	4.9	0	0	0	0	5	0	90	0	0	5	0
	ADM-11	6.1	0	0	0	0	0	0	100	0	0	0	0
	ADM-12	6.4	0	0	0	0	5	0	90	0	0	5	0
	ADM-13	5.5	0	0	70	15	15	0	0	0	0	0	0
	ADM-14	6.1	0	0	0	0	0	0	100	0	0	0	0
	ADM-15	5.2	0	0	0	0	0	0	100	0	0	0	0
	ADM-16	4.6	0	0	0	0	0	70	30	0	0	0	0
	ADM-17	6.1	0	0	0	0	0	60	30	0	0	10	0
	ADM-18	2.1	0	0	0	10	60	30	0	0	0	0	0
	ADM-19	4.9	0	0	0	0	0	70	20	0	0	10	0
	ADM-20	4.9	0	0	0	0	0	30	70	0	0	0	0
	ADM-21	4.6	0	0	0	0	0	60	20	0	0	20	0
	ADM-22	5.2	0	0	0	20	0	50	30	0	0	0	0
	ADM-23	4.6	0	0	0	0	0	70	30	0	0	0	0
	ADM-24	2.1	0	0	0	0	0	50	30	0	0	20	0
	ADM-25	4.6	0	0	0	0	0	70	30	0	0	0	0
	ADM-26	1.8	0	0	0	0	0	70	30	0	0	0	0
	ADM-27	4.6	0	0	0	0	0	30	70	0	0	0	0
	ADM-28	0.9	0	0	0	0	0	60	20	0	0	20	0

Appendix B. Photographs of unionid species.


Amblema plicata


Fusconaia flava


Cyclonaias nodulata


Cyclonaias pustulosa


Quadrula quadrula


Ellipsaria lineolata


Lampsilis cardium


Lampsilis higginsii

Lampsilis teres

Leptodea fragilis

Ligumia recta

Ligumia recta

Ligumia recta

Ligumia recta

Ligumia recta

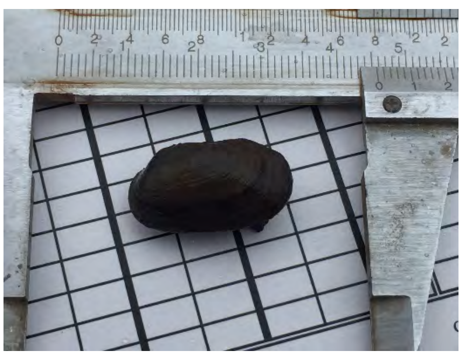
Ligumia recta


Obliquaria reflexa


Obovaria olivaria


Potamilus alatus


Potamilus ohiensis


Toxolasma parvum


Truncilla donaciformis


Arcidens confragosus


Lasmigona complanata


Pyganodon grandis


Utterbackia imbecillis

Appendix C. Listed species characteristics.

Appendix C. Listed species characteristics.

Species	Sample	Age (annuli count)	Length (mm)	Height (mm)	Width (mm)	Sex
Ellipsaria lineolata	WIL Qual3	6	63	49	24	Male
Ellipsaria lineolata	WIL Qual3	7	35	49	27	Male
Ellipsaria lineolata	WIL Qual4	7	69	52	26	Male
Lampsilis higginsii	WILU Qual24	13	78	67	52	Female Gravid
Ligumia recta	WIL13-1	16	144	62	45	Male
Ligumia recta	WIRD3-1	14	133	56	38	Female Gravid
Ligumia recta	WILU3-2	14	134	56	39	Male
Ligumia recta	WIL Qual3	14	117	56	43	Female Gravid
Ligumia recta	WIL Qual5	14	139	58	38	Male
Ligumia recta	WIL Qual9	15	138	59	40	Male
Ligumia recta	WILU Qual18	14	142	61	39	Male
Ligumia recta	WILU Qual23	11	127	57	37	Male