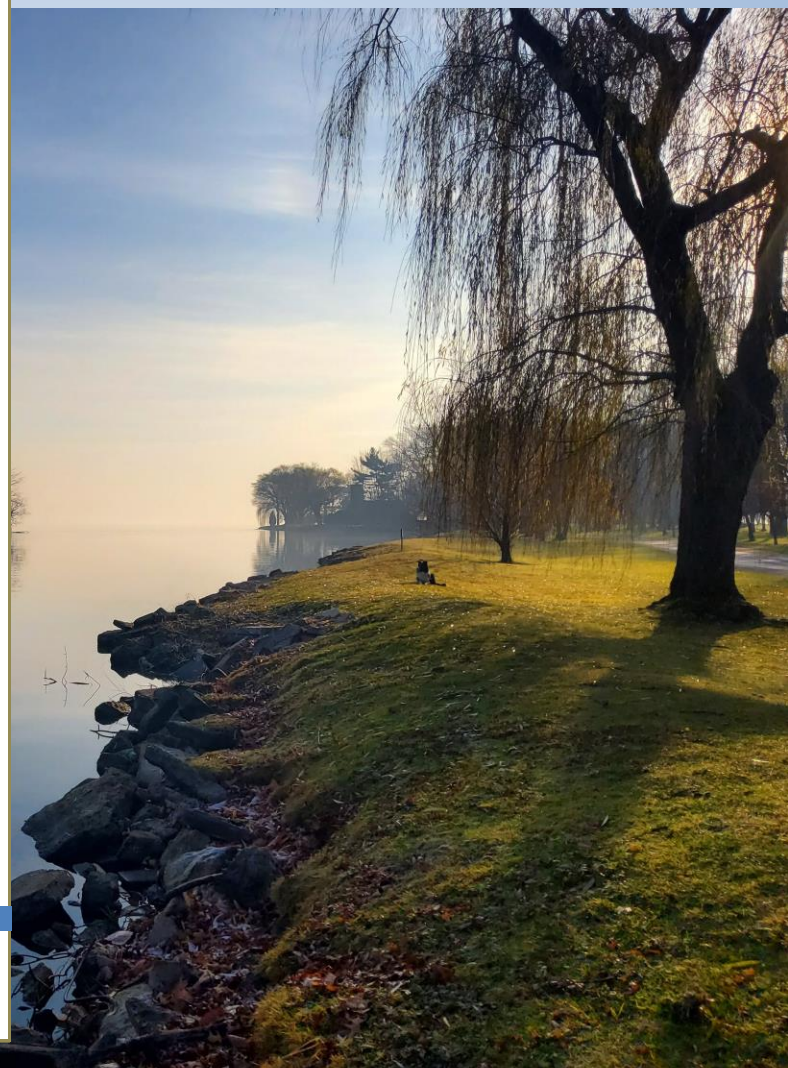
Ford Cove Restoration Feasibility Study

Summary of Pre-Construction Biological and Non-Biological Conditions

Prepared by OHM Advisors



Contents

Introduction

The Edsel and Eleanor Ford House, located at 1100 Lake Shore Road, Grosse Pointe Shores, MI, 48236, is an 87-acre complex of historic buildings, gardens, and natural areas on the shores of Lake St. Clair. Ford House, as the estate is known, was built in the 1920s as a private residence for the family of Edsel Ford – son of Henry Ford and then-president of the Ford Motor Company – but has since passed into the "benefit of the public" in keeping with the widow Eleanor Ford's wishes upon her death in 1976. Listed on the National Register of Historic Places in 1979 and designated a National Historic Landmark in 2016, the estate now serves as an art museum, a museum of the Ford House property and the Ford family, an event space, and a destination for subdued outdoor recreation.

In addition to tidy gardens and mowed parks, the Ford House grounds includes the 7-acre "Bird Island," a constructed natural area built of 80,000 cubic yards of spoils from the dredging of Ford Cove during the initial construction of the estate. Built as both a breakwater for the cove and as a bird refuge, Bird Island has become a focal point of ecological monitoring and restoration efforts at Ford House. Several rare, threatened, or special concern plant, bird, and herpetofauna species have been documented on or near the island, and the habitat potential for many others has been recognized. Early photographs of Bird Island indicate that the shoreline was once dominated by shallow beaches, but today practically all the Ford House shoreline has been armored with broken slab concrete riprap which protects the shoreline from erosion but creates a severe ecological transition that does not offer suitable habitat for many wetland and shoreline species.

On November 19, 2019, the Ford House property was identified as one of three top priorities for Michigan coastal restoration projects during the National Oceanic and Atmospheric Administration's Office of Coast Management's Great Lakes Coastal and Nearshore Habitat Assessment Workshop. The Ford Cove project seeks to restore or enhance 5.5 acres of coastal marsh, 8 acres of nearshore habitat, 4 acres of forested wetland, and roughly one mile of Lake St. Clair shoreline.

Restoration is expected to benefit native fish and herpetofauna species such as northern pike, muskellunge, smallmouth bass, largemouth bass, yellow perch, mudpuppy, eastern fox snakes, and various minnow, panfish, and percid species, as well as federal or state listed mussel species like the rayed bean, snuffbox, northern riffleshell, and purple wartyback, and resident or migratory wetland birds.

OHM Advisors ("the OHM team") in collaboration with Ford House staff, Herpetological Resource Management (HRM), Niswander Environmental, Somat Engineering, LimnoTech, and the Michigan Department of Natural Resources (MDNR) conducted a feasibility study to assess existing biological and non-biological conditions across the potential project area to inform the restoration design.

The assessment of biological conditions consisted of seven distinct investigations: a fish survey, a herpetofauna survey, a bird survey, a macroinvertebrate survey, a wetland delineation, a floristic quality assessment, and a threatened and endangered species survey. The assessment of non-biological conditions consisted of five distinct investigations: a water quality study, a geotechnical investigation and soil/sediment analysis, a bathymetric and topographic investigation, hydrodynamic modeling, and a public engagement survey. The conduct and findings of these 12 investigations are summarized below.

Summary of Biological Conditions

Fish Survey

Intent

The intent of this investigation was to establish a baseline for the size, composition, and age structure of the fish community in the waters of the potential project area to inform the restoration design and to serve as a basis for future monitoring.

Methodology

Between May and November 2021, Niswander Environmental and MDNR conducted three fish surveys in the waters of the potential project area. Two surveys, conducted by MDNR in May and November, employed electrofishing techniques along transects within Ford Cove and along the northern shore of the Ford House grounds (Figure 1, Figure 2). A third survey conducted by Niswander Environmental spanning July 20 and 22, 2022, employed seines, fyke nets, and minnow traps at sampling sites within Ford Cove and along the northern shore of the Ford House grounds in accordance with the Great Lakes Coastal Wetland Monitoring Program Standard Operating Procedure (Central Michigan University Institute for Great lakes Research, 2019a) (Figure 3). Sampling locations were characterized as being either predominantly "sheltered" (protected by Bird Island from waves and currents and relatively rich in aquatic vegetation and submerged woody debris) or "lakeward" (exposed to the full force of waves and currents prevailing in Lake St. Clair, with a bed dominated by unsorted sediments and concrete riprap).

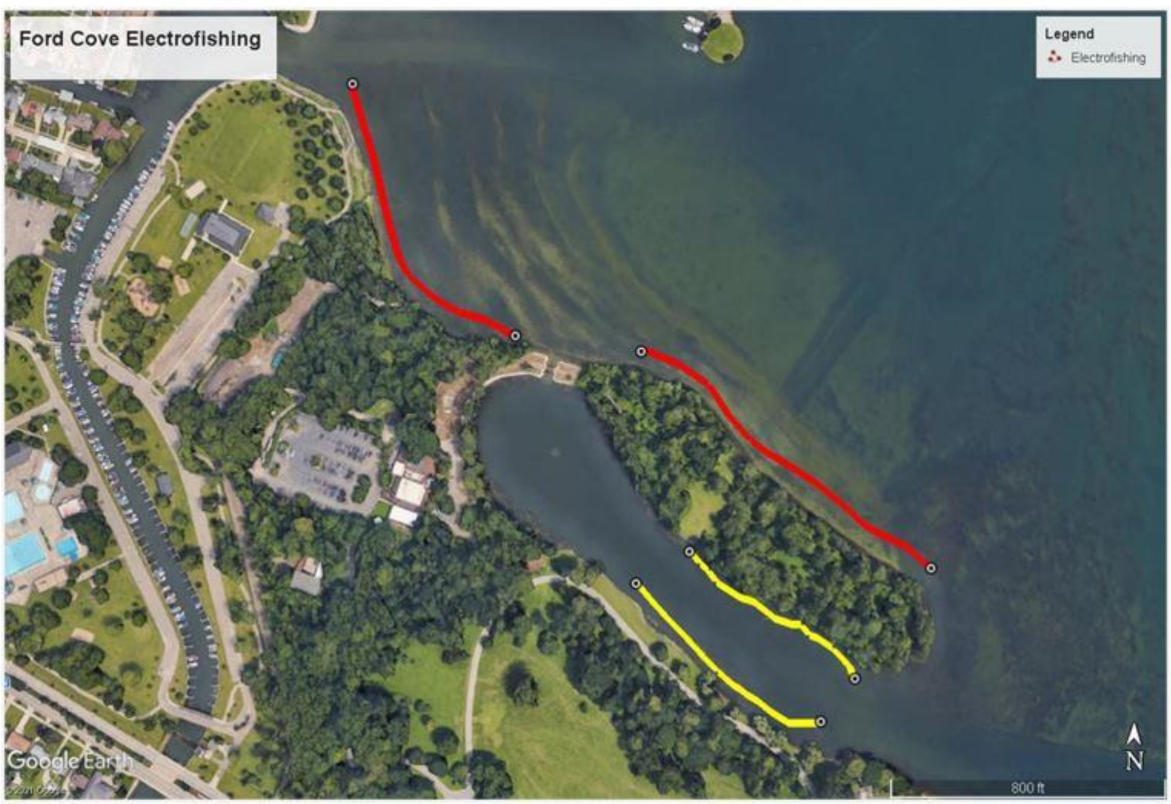


Figure 1. May 2021 electrofishing transects: lakeward in red, sheltered in yellow. Image prepared by MDNR.

Figure 2. November 2021 electrofishing transects: lakeward in red, sheltered in yellow. Image prepared by MDNR.

An example of each species encountered was photographed for reference and catalogued. Any specimen not readily identifiable was photographed and compared to accepted secondary resources for positive identification and cataloging off site. All collected fish were measured, recorded, and released alive immediately following each sampling event.

Of particular interest was the presence/abundance of northern pike (*Esox lucius*), muskellunge (*Esox masquinongy*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), and yellow perch *(Perca flavescens*). Pike, muskellunge, smallmouth bass and largemouth bass are typically considered apex predators of the nearshore environment, and their vitality depends on the robustness of the nearshore ecosystem, making them important indicator species for ecosystem health. All five species are important game fish, of commercial and cultural interest to Michigan's anglers.

Results and Discussion

In total, surveys identified 2,136 fish representing 31 species, of which 29 are native to Lake St. Clair and two are non-native (Table 1). Total catch was higher across the sheltered sites than across the lakeward sites, as was species diversity. Northern pike, muskellunge, smallmouth bass, largemouth bass, and yellow perch were all identified by one or more survey efforts, though northern pike, muskellunge and smallmouth bass were detected in very small numbers.

The greater abundance of fish and greater diversity of fish species in sheltered areas corresponded with a greater abundance of aquatic vegetation and submerged woody debris, which provide forage and shelter for many fish species, and which are known to be important for breeding. Many of the catch were young of 2021, suggesting that the waters of the potential project area constitute a functioning fish nursery.

Survey results suggest that the existing fish community benefits from the aquatic vegetation, submerged woody debris and sheltered waters within Ford Cove. Removing the concrete riprap armoring the shoreline, increasing the area of emergent wetlands, and creating shoals and sheltered sites around Bird Island will create additional habitat for our native fish, including target game fish and indicator species, contributing to the long-term health of fisheries littoral ecosystems across Lake St. Clair and the Great Lakes region.

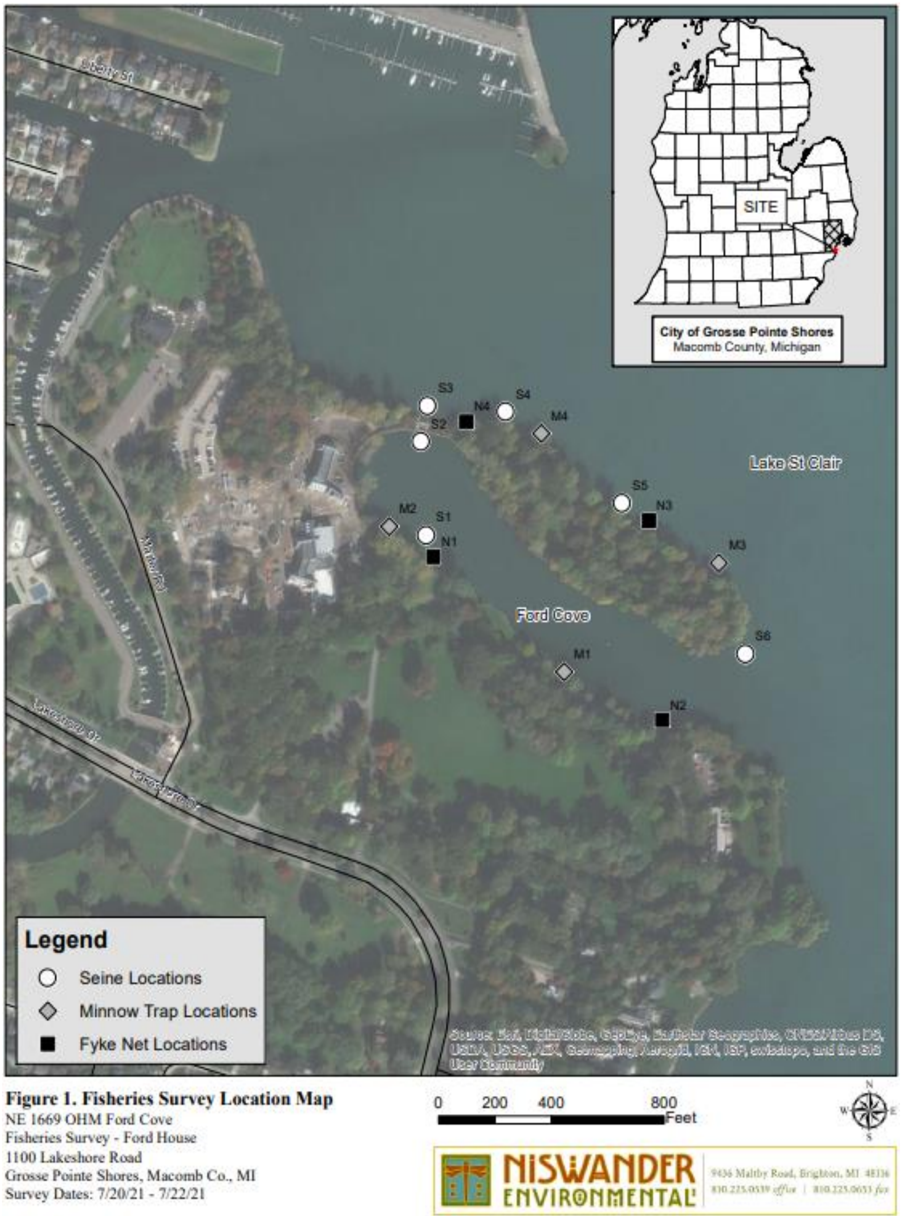


Figure 3. Sampling sites for July seine, fyke net and minnow trap survey. Image prepared by Niswander Environmental.

Table 1. Fish survey total catch, May through November, 2021.

Common Name	Scientific Name	Native to Lake St. Clair	Total	Sheltered	Lakeward
Banded Killifish	*Fundulus diaphanus*	Yes	1	1	0
Black Bullhead	*Ameiurus melas*	Yes	1	1	0
Black Crappie	*Pomoxis nigromaculatus*	Yes	3	3	0
Black Redhorse	*Moxostoma duquesnei*	Yes	1	1	0
Bluegill	*Lepomis macrochirus*	Yes	268	153	115
Bluntnose Minnow	*Pimephales notatus*	Yes	61	53	8
Bowfin	*Amia calva*	Yes	3	3	0
Brook Silverside	*Labidesthes sicculus*	Yes	210	192	18
Common Carp	*Cyprinus carpio*	No	4	3	1
Common White Sucker	*Catostomus commersonii*	Yes	1	1	0
Emerald Shiner	*Notropis atherinoides*	Yes	240	229	11
Gizzard Shad	*Dorosoma cepedianum*	Yes	1	1	0
Largemouth Bass	*Micropterus salmoides*	Yes	255	230	25
Logperch	*Percina caprodes*	Yes	4	0	4
Mimic Shiner	*Notropis volucellus*	Yes	7	7	0
Muskellunge	*Esox masquinongy*	Yes	1	1	0
Northern Hogsucker	*Hypentelium nigricans*	Yes	1	0	1
Northern Pike	*Esox lucius*	Yes	2	1	1
Pumpkinseed Sunfish	*Lepomis gibbosus*	Yes	16	11	5
Quillback	*Carpiodes cyprinus*	Yes	4	0	4
Rock Bass	*Ambloplites rupestris*	Yes	34	8	26
Round Goby	*Neogobius melanostomus*	No	102	92	10
Shorthead Redhorse	*Moxostoma macrolepidotum*	Yes	39	0	39
Smallmouth Bass	*Micropterus dolomieu*	Yes	14	7	7
Spotfin Shiner	*Cyprinella spiloptera*	Yes	64	51	13
Spottail Shiner	*Notropis hudsonius*	Yes	723	147	576
Spotted Sucker	*Minytrema melanops*	Yes	1	1	0
Walleye	*Sander vitreus*	Yes	1	1	0
White Sucker	*Catostomus commersonii*	Yes	1	1	0
Yellow Bullhead	*Ameiurus natalis*	Yes	3	3	0
Yellow Perch	*Perca flavescens*	Yes	70	61	9
Total			2,136	1,263	873

For the following supporting documents, see Appendix A:

- Attachment #1: Pictures from Michigan Department of Natural Resources May 2021 Electrofishing Effort
- Attachment #2: Niswander Environmental Field Data Sheets

Herpetofauna Survey

Intent

The intent of this investigation was to assess the size and composition of the herpetofauna community within the potential project area to inform the restoration design, anticipate potential impacts to listed species, and establish a basis for future monitoring.

Based on preliminary planning and reconnaissance investigations of historic species distributions, geographic ranges, and habitat requirements, HRM suspected that the potential project area may harbor four herpetofauna species of concern: the state threatened eastern fox snake (*Pantherophis gloydi*), state special concern mudpuppy (*Necturus maculosus*), the state threatened Blanding's turtle (*Emydoidea blandingii*), and the state special concern Butler's garter snake (*Thamnophis butleri*). The presence of listed species within the potential project area could influence the restoration design and require measures to mitigate impacts to listed species during construction.

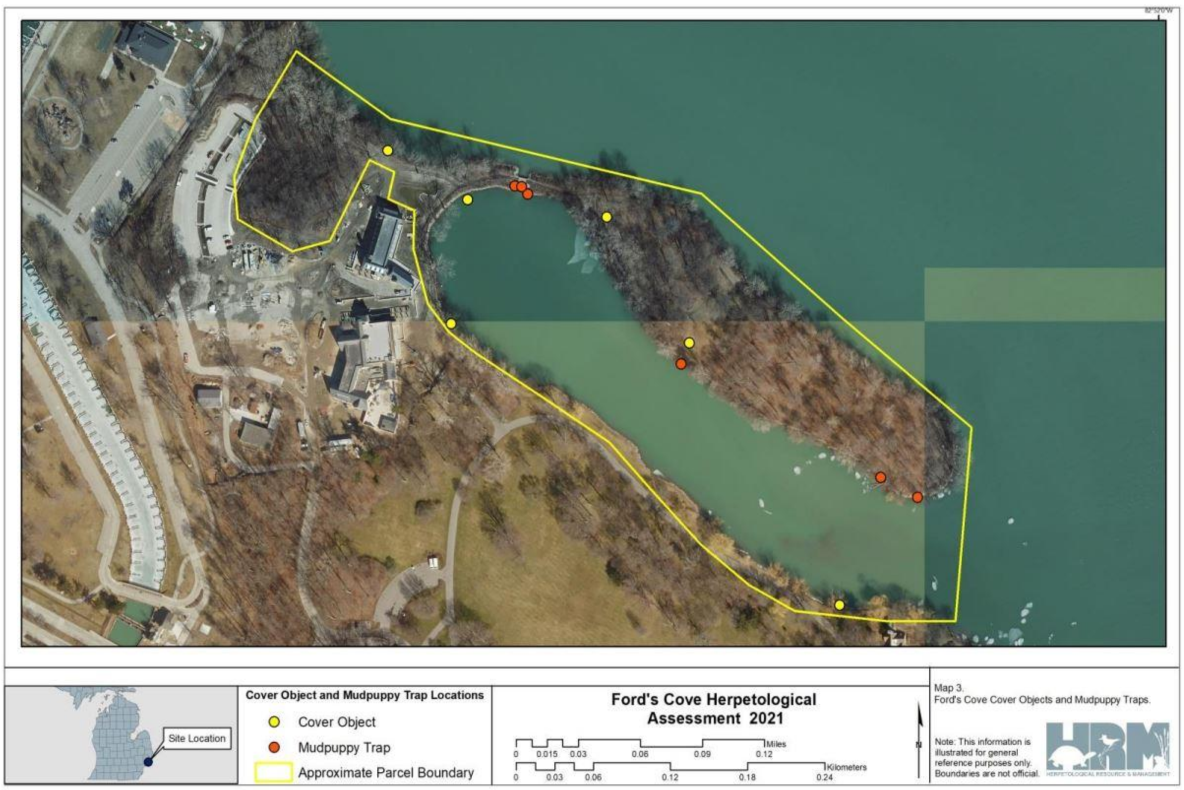


Figure 4. Locations of mudpuppy traps and artificial cover objects (ACOs). Image prepared by HRM.

Methodology

In May 2021, HRM placed baited mudpuppy traps and six artificial cover objects (ACOs) along the shore of Ford Cove (Heyer, Donnelly et al. 1994; McDiarmid, Foster et al. 2012; Graeter, Buhlmann et al. 2013) (Figure 4). Between May and August 2021, HRM and Ford House staff conducted encounter surveys for herpetofauna in addition to periodically checking and maintaining the mudpuppy traps and ACOs.

Results and Discussion

On occasion, publicly available reports of herpetofauna sightings have led to increases in poaching or harassment of herpetofauna, notably of charismatic or protected species. It is the judgment of the OHM team that the identities of two herpetofauna species observed within the potential project area ("Species A", "Species B") should be withheld from public-facing documents in order to protect these species from poaching and undue harassment. The identities of these species have been made available to project partners and relevant regulatory agencies.

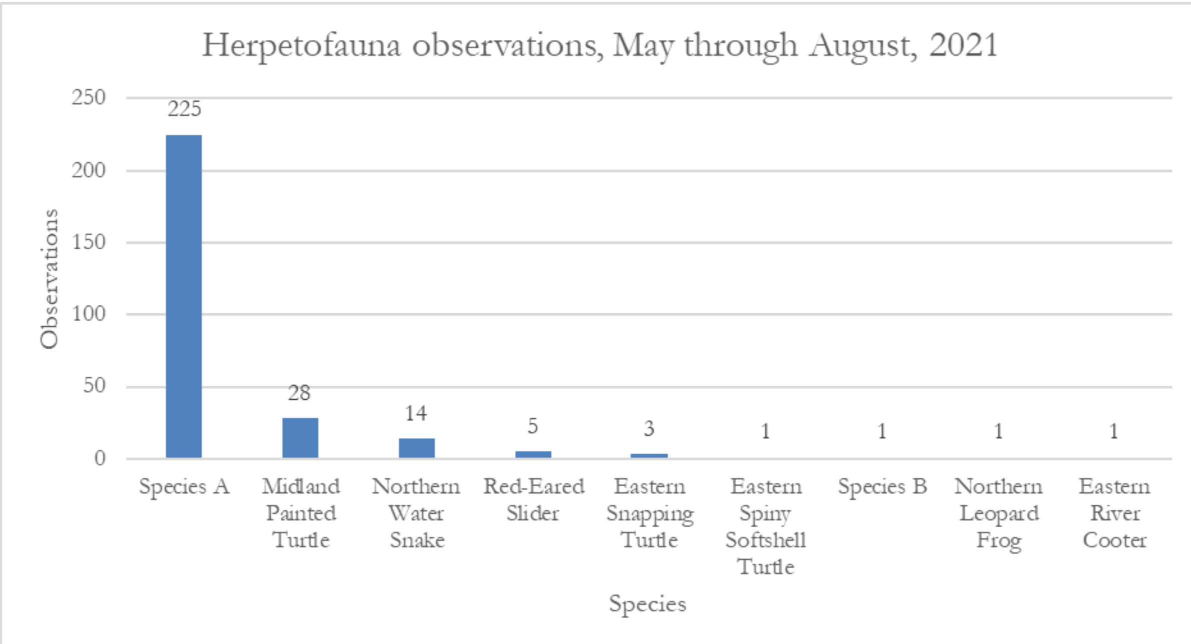


Figure 5. Herpetofauna observations, May through August 2021.

The herpetofauna survey identified 279 amphibians and reptiles representing nine species, including Species B, a state species of special concern, and the red-eared slider, a common household pet native to the American southeast but known in the Great Lakes region as a non-native pest (Figure 6, Table 2). The eastern river cooter (*Pseudemys concinna*) – another non-native introduction from farther south, presumably a former pet – was also observed, though unlike the red-eared slider the eastern river cooter is not known to compete with or displace native turtles and may help to control Eurasion milfoil (*Myriophyllum spicatum*), an invasive aquatic weed. HRM judged the potential project area to offer suitable habitat for 16 additional native herpetofauna species beyond those identified during the survey (Table 3).

Herpetofauna observations were concentrated along the banks of Ford Cove, particularly along the southern shore of Bird Island, likely due to the southern exposure, calm waters, and abundance of basking structures in this area (Figure 6). No turtle nests were discovered, though nests are typically simple and well-camouflaged and may have done undetected. The concrete riprap along the shore may be discouraging turtle species from nesting on Bird Island, as they typically build their nests in sandy or loamy soil near the water's edge.

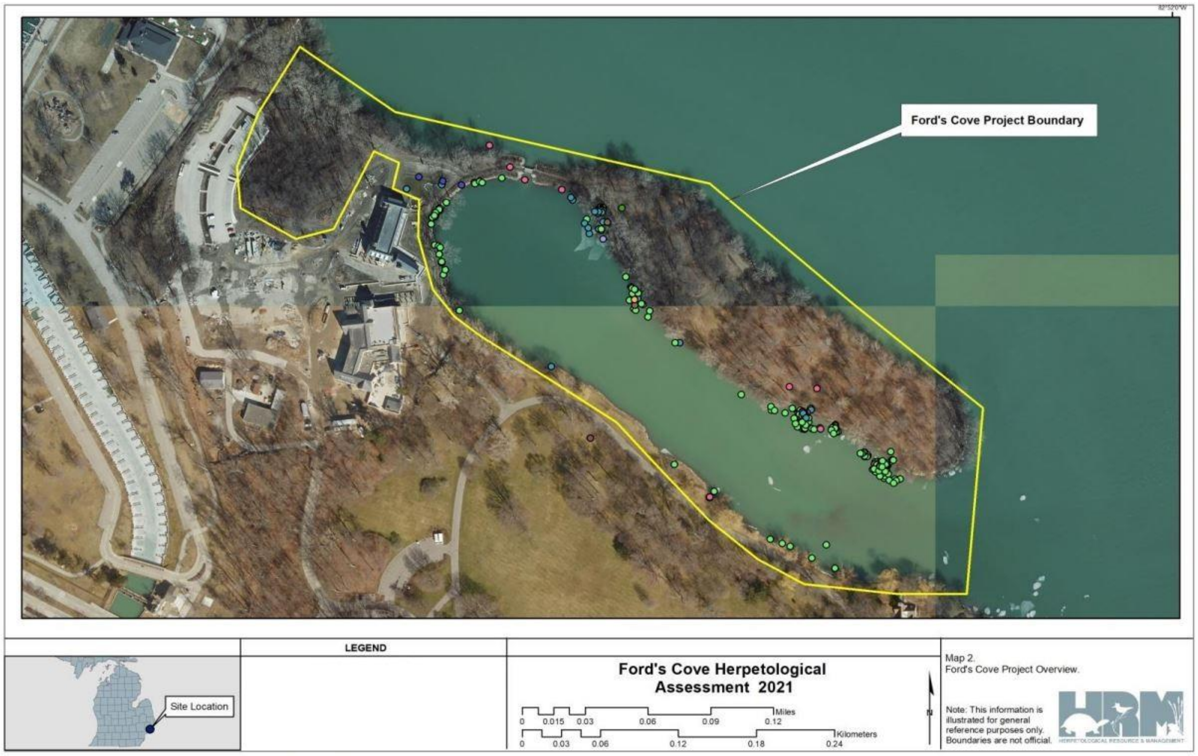


Figure 6. Locations of herpetofauna observations, May through August 2021.

Herpetofauna species evenness was low, with several species represented by only one or a few individuals. Northern water snakes (*Nerodia sipedon sipedon*) were the only snake species identified, though they appeared in abundance, notably crowding into the emergent branches of downed trees along the shore to rest and bask. Species A made up the large majority of herpetofauna observations (Figure 5, Table 2)

Unfortunately, the placement of the mudpuppy traps occurred after the seasonal peak of mudpuppy activity/visibility in the spring. Of the six ACOs, two were lost (presumably washed or blown away by storms) and a third had to be moved repeatedly due to problematic ant infestations. These setbacks could have contributed to the lack of mudpuppy observations and the lack of snake observations beneath the ACOs.

Though no observations were made of the eastern fox snake, mudpuppy, or Butler's garter snake, these species' low numbers, cryptic behavior and the possible disturbance of ACOs by curious passersby preserves the possibility that these herpetofauna species are present on Bird Island or elsewhere within the potential project area as Ford House's status as a refugia within a heavily developed and disturbed landscape increases its allure for species that may otherwise find it of only moderate value. HRM and the OHM team noted several opportunities to improve the habitat value of the site for herpetofauna (Table 4).

Table 2. Observed herpetofauna species, May through August 2021.

Herptile	Common Name	Scientific Name	Native	Observations
Frogs and Toads	Northern Leopard Frog	*Rana pipiens***	Yes	1
Snakes	Northern Water Snake	*Nerodia sipedon sipedon*	Yes	14
Turtles	Species A		Yes	225
	Species B*		Yes	1
	Eastern River Cooter	*Pseudemys concinna*	No	1
	Eastern Snapping Turtle	*Chelydra serpentina serpentina*	Yes	3
	Eastern Spiny-Softshell Turtle	*Apalone spinifera spinifera*	Yes	1
	Midland Painted Turtle	*Chrysemys picta marginata*	Yes	28
	Red-Eared Slider	*Trachemys scripta elegans*	No	5
	***State special concern** *******Rana* = *Lithobates*			

Table 3. Unobserved herpetofauna species for which suitable habitat is thought to exist.

Herptile	Common Name	Scientific Name	Native	Observed in the Past
Frogs and Toads	Bullfrog	*Rana catesbeiana****	Yes	
	Eastern American Toad	*Bufo americanus americanus*****	Yes	X
	Gray Treefrog	*Hyla versicolor/chrysoscelis*	Yes	X
	Green Frog	*Rana clamitans****	Yes	X
	Wood Frog	*Rana sylvatica****	Yes	
Salamanders	Eastern Red-Backed Salamander	*Plethodon cinereus*	Yes	
	Mudpuppy**	*Necturus maculosus*	Yes	X
Snakes	Butler's Garter Snake**	*Thamnophis butleri*	Yes	X
	Eastern Fox Snake*	*Pantherophis gloydi*	Yes	X
	Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	Yes	X
	Eastern Hognose Snake	*Heterodon platirhinos*	Yes	X
	Eastern Milk Snake	*Lampropeltis triangulum triangulum*	Yes	
	Northern Brown Snake	*Storeria dekayi dekayi*	Yes	X
	Northern Red-Bellied Snake	*Storeria occipitomaculata occipitomaculata*	Yes	
	Northern Ribbon Snake	*Thamnophis sauritus septentrionalis*	Yes	
	*State threatened **State special concern ****Rana* = *Lithobates* *****Bufo* = *Anaxyrus*			

Table 4. Herpetofauna habitat improvement techniques and objectives.

	Technique	Objective
For Herpetofauna	Provide basking logs.	Aid in thermoregulation of reptiles.
	Construct reptile hibernacula.	Allow reptiles and other wildlife to safely over winter.
	Create or enhance existing vernal pools.	Provide breeding and nursery grounds for amphibians.
	Create emergent marsh zones.	Increase water quality and provide nursery grounds for herpetofauna.
	Place small multi-branched limbs in vernal pools and marshes.	Provide adherence points for amphibian eggs and cover during mating.
	Create turtle nesting areas in key locations.	Increase recruitment and population viability of turtle populations.
	Provide mudpuppy habitat structures.	Provide refuge as well as critical breeding, nesting, and nursery sites for Mudpuppies.
	Use natural soil stabilization material.	Prevent harm to herpetofauna and other wildlife.
	Develop a habitat maintenance plan.	Maintain restored habitat areas.
For Visitors	Add interpretive signage focused on biodiversity, community composition, and restoration measures to enhance species.	Educate visitors and patrons about the community composition, efforts to restore and enhance, and ways citizens can help to keep these landscapes health and functional.
	Add interpretive signage focused on biodiversity, community composition, and restoration measures to enhance species.	Educate visitors and patrons about the community composition, efforts to restore and enhance, and ways citizens can help to keep these landscapes health and functional.

For the following supporting documents, see Appendix B:

- Attachment #1: HRM Field Notes
- Attachment #2: Catalogue of Herpetofauna Observations

Bird Survey

Intent

The intent of this investigation was to establish a baseline for the composition of the bird community across the potential project area to inform the restoration design, anticipate impacts to rare or listed species, and to serve as a basis for future monitoring.

A Rare Species Review of the potential project area from the Michigan Natural Features Inventory determined that suitable habitat for the federally and state endangered piping plover (*Charadarius melodius*) likely does not exist within 1.5 miles of the potential project area, but potential suitable migratory habitat for the federally threatened rufa red knot (*Calidris canutus rufa*) may exist (see Appendix G). For a longer discussion of the Rare Species Review, see Threatened and Endangered Species Survey, below.

In addition to the rufa red knot, the OHM team identified ten bird species for which the potential project area may offer suitable breeding habitat, including the state special concern American bittern (*Botaurus lentiginosus*), the state threatened yellow rail (*Coturnicops noveboracensis*) and common moorhen (*Gallinula chloropus*), and the state endangered king rail (*Rallus elegans*) (Table 5).

Table 5. Bird species of interest.

Common Name	Scientific Name	Protected Status
Rufa Red Knot	*Calidris canutus rufa*	Federally Threatened
Pied-billed Grebe	*Podilymbus podiceps*	
American Bittern	*Botaurus lentiginosus*	State Special Concern
Least Bittern	*Exobrychus exilis*	
Sora	*Porzana carolina*	
King Rail	*Rallus elegans*	State Endangered
Virginia Rail	*Rallus limicola*	
Black Rail	*Laterallus jamaicensis*	
Yellow Rail	*Coturnicops noveboracensis*	State Threatened
American Coot	*Fulica americana*	
Common Moorhen	*Gallinula chloropus*	State Threatened

Methodology

Between May and September 2021, the OHM team conducted four bird surveys across the potential project area. Surveys were conducted at both dusk and dawn and on dates chosen to coincide with spring migrations, fall migrations, and summer nesting. Morning surveys started ½ hour before sunrise and lasted 4 ½ hrs. Evening surveys ended ½ hour after sunset for a duration of 4 ½ hours. Each survey consisted of a one-hour alternating visual and auditory survey effort at each of four survey locations (Figure 7). Surveys were conducted in accordance with the Great Lakes Coastal Wetland Monitoring Program Standard Operating Procedure (Central Michigan University Institute for Great lakes Research, 2019c).

Figure 7. Bird survey locations, May through September 2021.

Results and Discussion

The OHM team identified 30 bird species including the state threatened bald eagle (*Haliaeetus leucocephalus*) and the state special concern common tern (*Sterna hirundo*) but did not identify any of the ten wetland bird species of interest for which the potential project area was suspected to offer suitable breeding habitat (Table 6). The absence of these species suggests that the potential project area is not currently serving as a high functioning breeding ground for wetland birds.

Table 6. Results of bird survey.

Common Name	Scientific Name	Protected Status	Observed			
			5/20/21	6/10/21	7/15/21	9/29/21
Cooper's Hawk	*Accipiter cooperii*				X	
Spotted Sandpiper	*Actitis macularius*				X	
Red-Winged Blackbird	*Agelaius phoeniceus*		X	X	X	
Wood Duck	*Aix sponsa*			X	X	X
Mallard	*Anas platyrhynchos*		X	X	X	X
Great Blue Heron	*Ardea herodias*			X	X	X
Redhead	*Aythya americana*					X
Tufted Titmouse	*Baeolophus bicolor*		X	X	X	X
Cedar Waxwing	*Bombycilla cedrorum*				X	X

Common Name	Scientific Name	Protected Status	Observed			
			5/20/21	6/10/21	7/15/21	9/29/21
Canada Goose	*Branta canadensis*		X	X	X	
Green Heron	*Butorides virescens*			X		X
Northern Cardinal	*Cardinalis cardinalis*		X	X	X	X
Chimney Swift	*Chaetura pelagica*					X
Northern Flicker	*Colaptes auratus*				X	
Ruby Crowned Kinglet	*Corthylio calendula*		X			
Blue Jay	*Cyanocitta cristata*				X	X
Bald Eagle	*Haliaeetus leucocephalus*	State threatened	X			
Baltimore Oriole	*Icterus galbula*		X	X	X	
Belted Kingfisher	*Megaceryle alcyon*			X	X	X
Great Crested Flycatcher	*Myiarchus crinitus*				X	
Double Crested Cormorant	*Nannopterum auritum*		X	X	X	X
Common Grackle	*Quiscalus quiscula*		X			X
Yellow Warbler	*Setophaga petechia*		X			
American Goldfinch	*Spinus tristis*		X	X	X	X
Common Tern	*Sterna hirundo*	State special concern	X			
European Starling	*Sturnus vulgaris*		X	X	X	
Tree Swallow	*Tachycineta bicolor*		X		X	
Carolina Wren	*Thryothorus ludovicianus*				X	
American Robin	*Turdus migratorius*		X	X	X	X
Eastern Kingbird	*Tyrannus tyrannus*		X		X	X

North American birds exhibit a great diversity of life histories and migration patterns. Many species persist locally year-round while others migrate between breeding and wintering ranges that partially overlap in central or southern North America, and still others embark on seasonal migrations of hundreds or thousands of miles between breeding grounds in central North America and wintering grounds in southern North America or South America.

Migratory birds tend to travel in broad, loosely bounded aerial corridors known as flyways. The potential project area is located within the Mississippi flyway, one of four commonly recognized major flyways over North America, and its position within the flyway and status as a coastal/wetland wildlife refuge within a highly developed and disturbed landscape suggest that it could have outsized importance as a stopover for transient, migrating species, in addition to being an important breeding ground for persistent or seasonal residents. Improving and expanding wetland areas within the potential project area will improve the habitat value for non-migratory and seasonal resident, as well as for migrating birds, which will extend the ecological value of restoration efforts far beyond the Ford House grounds.

Wetland birds require forage, protection/privacy from predators and for nesting birds, appropriate nesting materials. Removing the concrete riprap and creating a gentle transition between open water, submergent vegetation, and sandy beaches or emergent marsh, sedge meadow and shrub/scrub wetland would dramatically increase the amount of available prey and forage, provide cover for predator avoidance and physical separation from visitors, and allow nesting birds to raise their chicks undisturbed. Large snags and mature trees can be supplemented with nest boxes and nesting platforms to provide nesting habitat for larger species.

For the following supporting documents, see Appendix C:

- Attachment #1: Field Data Sheets

Macroinvertebrate Survey

Intent

The intent of this investigation was to establish a baseline for the size, composition, and disposition of the macroinvertebrate community along the shorelines of the potential project area to inform the restoration design and to serve as a basis for future monitoring.

Methodology

Macroinvertebrate samples were collected on May 20, 2021, and again on September 29, 2021, in accordance with Great Lakes Coastal Wetland Monitoring Program Standard Operating Procedure protocols (Central Michigan University Institute for Great lakes Research, 2019b).

The OHM team characterized nearshore waters as either sheltered (protected by Bird Island from waves and currents and relatively rich in aquatic vegetation and submerged woody debris) or lakeward (exposed to waves and currents prevailing in Lake St. Clair, with a bed dominated by sand and concrete riprap), and selected a single sample site for each (Figure 8). Each sampling site was subdivided into three, one-meter quadrats, approximate three meters apart, and macroinvertebrate samples collected from each using D-shaped dipnets, with special care taken to dislodge any macroinvertebrates from organic matter or substrate.

At each macroinvertebrate sampling site, water grab samples were collected and a Secchi disk used to estimate depth of visibility in support of the water quality investigation (see Water Quality Assessment, below).

Figure 8. Macroinvertebrate sampling locations, 2021.

Results and Discussion

The sheltered and lakeward sites generally yielded low populations of macroinvertebrates, reflecting a lack of vegetative detritus and organic matter in nearshore cove and lakebed sediments. Local concentrations of detritus were typically associated with increases in macroinvertebrate abundance and diversity (Table 7).

Ecological niches tend to be consistent within each macroinvertebrate class and order allowing for generalizations to be made about the likely role of each in the ecosystem.

Table 7. Results of aquatic macroinvertebrate surveys.

Common Name	Class/Order	Ecological Role*	Sheltered Sites		Lakeward Sites		Total
			5/20/21	9/28/21	5/20/21	9/28/21	
Mussel	Bivalvia	Filter feeders			1		1
Snail	Gastropoda	Herbivores, detritovores			2	1	3
True Fly	Hexapoda/ Diptera	Detritovores	2	27			29
Mayfly	Hexapoda/ Ephemeroptera	Herbivores, detritovores	1		28		29
True Bug	Hexapoda/ Hemiptera	Various, mostly herbivores			2		2
Damselfly	Hexapoda/ Odonata	Insectivores		6			6
Caddisfly	Hexapoda/ Trichoptera	Various		3		1	4
Leech	Hirudinea	Carnivores, parasites	6				6
Scud	Malacostraca/ Amphipoda	Various, mostly herbivores	2		10		12
Aquatic Sow Bug	Malacostraca/ Isopoda	Various, mostly detritovores and herbivores			1		1
Aquatic Earthworm	Oligochaeta	Detritovores	4	2	24		30
Total			15	38	68	2	123

*The ecological roles and habitat requirements of many macroinvertebrates vary dramatically between larval and adult life cycle phases; the prevailing ecological roles reported above refer only to the aquatic life cycle phase or phases of each class/order.

Aquatic macroinvertebrates play a crucial role in aquatic and wetland ecosystems. They decompose and recycle dead vegetation, regulate plant and algae populations, and provide feed for many fish, herpetofauna and bird species. Without robust populations of macroinvertebrates, ecosystems will function poorly, and other conservation efforts directed at other, more charismatic species will likely falter. For this reason, creating habitat that will support macroinvertebrate populations should be a priority for any restoration effort.

The removal of concrete riprap, the addition of woody debris and the creation of a gentle transition between open water and submergent vegetation, emergent marsh, sedge meadow and shrub/scrub wetland would dramatically improve the value of the aquatic habitat within the potential project area. Many of the macroinvertebrates in the waters surrounding the Ford House are herbivores or detritovores which benefit not only from an abundance of vegetative material but also from a mosaic of wetland types and plant communities that create many complementary ecological niches (Table 7).

For the following supporting documents, see Appendix D:

- Attachment #1: Survey Field Data Sheets
- Attachment #2: Representative Examples of Macroinvertebrate Specimens

Wetland Assessment

Intent

The intent of this investigation is to identify and characterize protected wetlands within the potential project area to inform the restoration design, anticipate impacts of construction or other restoration activities to protected wetlands, and establish a basis for future monitoring.

Methodology

In August 2021, the OHM team conducted a wetland delineation across the potential project area. The wetland investigation consisted of a desktop review and subsequent on-site wetland evaluation.

The desktop review consisted of a review of EGLE Wetlands Map Viewer aerial imagery and wetland inventory maps to identify approximate locations of potential wetlands. The EGLE Wetlands Map Viewer compiles data from the following sources (see Appendix E):

- National Wetland Inventory (NWI) maps, generated by the U.S. Fish and Wildlife Service through interpretation of topographic data and aerial photographs.
- Land cover maps generated by the Michigan Department of Natural Resources' Michigan Resource Inventory System (MIRIS), through interpretation of aerial photographs.
- Hydric soils mapped by the U.S. Department of Agriculture, Natural Resource Conservation Service (USDA NRCS).
- The desktop review also included a review of additional soil data produced by the National Cooperative Soil Survey, which were collected from the Web Soil Survey website operated by the USDA NRCS.

An on-site wetland evaluation was performed on August 2, 2021. The investigation consisted of a visual survey of the entire site to identify potential wetland field indicators, followed by formal data collection and analysis of vegetation types, hydrology indicators, and soils data within the wetland and adjacent upland areas. The data collection and analysis were performed based on the methods described in the Northcentral Northeast Regional Supplement to the 1987 USACE Wetlands Delineation Manual. Wetland boundaries were flagged in the field with pink ribbon marked "Wetland Boundary" and the flagged points were surveyed using GPS equipment with sub-foot accuracy.

Results and Discussion

The OHM team identified three wetland sites within the potential project area; for a summary of wetland properties and delineation decision criteria, see Table 8.

Wetland 1 is a wooded wetland approximately 0.06 acres in size. Surface water is present, consistent with wetland hydrology (A1, Surface Water). The dominant plant species are eastern cottonwood (*Populus deltoides*), white willow (*Salix alba*), and jewelweed (*Impatiens capensis*), consistent with a hydrophytic community. Soils are muck mineral to a depth of four inches, and sand between 4 and 15 inches (with mollusk shells in the matrix), consistent with an NRCS indicator of hydric soils (S1, Sandy Mucky Mineral).

Figure 9. Protected wetlands within the potential project area.

Wetland 2 is a wooded wetland approximately 1.25 acres in size. The soil is saturated beginning at the surface and the water table begins at a depth of eight inches, an NRCS indicator of wetland hydrology (A2, High Water Table, and A3, Saturation). The dominant plant species are American water-horehound (*Lycopus americanus*), marsh marigold (*Caltha palustris*), silver maple (*Acer saccharinum*) and green ash (*Fraxinus pennsylvanica*), consistent with a hydrophytic community. Soils are muck to a depth of 2 inches, and clay between 2 and 12 inches, with Munsell soil color and texture values consistent with an NCRS indicator of hydric soils (A11, Depleted Below Dark Surface).

Wetland 3 is a wooded wetland approximately 0.41 acres in size. The soil is saturated beginning at a depth of 5 inches, with visible drift deposits, consistent with an NCRS indicator of wetland hydrology (A3, Saturation, and B3, Drift Deposits). The dominant plant species are American elm (*Ulmus americana*), cockspur thorn (*Crataegus crus-galli)*, green ash (*Fraxinus pennsylvanica*), pin oak (*Quercus palustris*), red-osier dogwood (*Cornus sericea*), obedient plant (*Physostegia virginiana*), and calico aster (*Symphyotrichum lateriflorum*), consistent with a hydrophytic community. Soils are clay loam to a depth of 13 inches, with Munsell soil color and texture values consistent with an NCRS indicator of hydric soils (A11, Depleted Below Dark Surface).

The understanding of the OHM team is that a wetland is regulated under Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended ("Part 303"), if it meets one or more of the following criteria:

- Greater than five acres in size.
- Connected to, or located within 1,000 feet of, one of the Great Lakes or Lake St. Clair.
- Connected to, or located within 500 feet of, an inland lake, pond, river, or stream.
- Non-contiguous wetlands less than five acres in size that are on the list of rare and imperiled wetlands.
- Non-contiguous wetlands less than five acres with the documented presence of state or federal endangered or threatened species.

Based on the field investigation it was determined that the three wetlands within the potential project area are connected to, or located within 500 feet of, an inland lake, pond, river, or stream – namely, Lake St. Clair – and therefore are regulated under Part 303.

Table 8. Summary of wetland properties and delineation decision criteria.

Wetland	Type	Area (acres)	Hydrology Indicator	Hydrophytic Vegetation Indicator	Hydric Soils Indicator
1	Emergent	0.06	High Water Table (A2), Saturation (A3)	>50% of Dominant Species are OBL, FACW, or FAC	Depleted Below Dark Surface (A11)
2	Wooded	1.25	Surface Water (A1)	>50% of Dominant Species are OBL, FACW, or FAC	Sandy Mucky Mineral (S1)
3	Wooded	0.41	Saturation (A3), Drift Deposits (B3)	>50% of Dominant Species are OBL, FACW, or FAC	Depleted Below Dark Surface (A11)
TOTAL		1.72			

The OHM team also assessed the quality of, and potential restoration objectives and interventions for, each of the three protected wetlands identified during the wetland assessment.

Wetland 1 is an apparently low-quality emergent wetland consisting of early successional and introduced overstory species including eastern cottonwood (*Populus deltoides*), boxelder (*Acer negundo*), white willow (*Salix alba*) and white mulberry (*Morus alba*). The dominant herbaceous plant community consists of jewelweed (*Impatiens capensis*), and eastern poison ivy (*Toxicodendron radicans*). These herbaceous species are typical of disturbed sites and will colonize large areas, restricting the development of a more diverse plant community. This area provides great potential for improvement through the restoration process. The sites proximity to Lake St. Clair and the existing topography provides suitable conditions for the expansion and improvement of this emergent wetland. These shallow water wetlands form along the shoreline of lakes and streams and contain a variety of emergent and floating-leaved herbaceous plants including water plantains (*Alisma spp.*), sedges (*Carex spp.*), spike rushes (*Eleocharis spp.*), pond lilies (*Nuphar spp.*), and bullrushes (*Schoenoplectus spp.* and *Scirpus spp.*). These species provide ideal habitat for a variety of herpetofauna and fish species throughout their life stages as well as foraging grounds for coastal and wetland bird species. Additional topographic changes and the removal of the existing overstory provide further potential as an isolated transitional zone that could function as a nesting area for turtles.

Wetland 2 is an apparently low-quality wooded wetland consisting of a mature successional overstory dominated by silver maple (*Acer saccharinum*). The understory consists of small (0.5"-1" DBH) green ash *(Fraxinus pennsylvanica*) that will be continually stunted by attacks from the emerald ash borer (EAB). The herbaceous plant community is underdeveloped as the overstory produces heavy shade, and sporadic flooding from stormwater inputs from the surrounding parking occur throughout the growing season making it difficult for any existing vegetation to become better established. This area provides potential for establishment of a southern hardwood swamp plant community. Through selective tree removal and pruning, openings can be created in the canopy to allow for the establishment of a diversified understory and herbaceous plant community including spicebush (*Lindera benzoin*), elderberry (*Sambucus canadensis*), winterberry (*Ilex verticillata*), buttonbush (*Cephalanthus occidentalis*), marsh marigold (*Caltha palustris*), spinulose woodfern (*Dryopteris carthusiana*), cinnamon fern (*Osmunda cinnamomea*), and a variety of sedges (*Carex spp.*) This habitat improvement will encourage the establishment of amphibian species currently missing from herpetofauna surveys within the potential the restoration area.

Wetland 3 is an apparently low-quality wooded wetland consisting of a semi mature eastern cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), and pin oak (*Quercus palustris*) overstory. The understory consists of red-osier dogwood (*Cornus sericea*), hawthorn (*Crataegus s*p.) and 0.5"-1.0" DBH green ash (*Fraxinus pennsylvanica*), with larger ash trees exhibiting signs of damage and stunting from the EAB. The overstory is less dense here and improvements have been made by the Ford House landscape and woodland specialist, leading to a higher average C-value for the plant community in this wet4land than for those in the other two wetlands (see Floristic Quality Assessment, below). As is commonly the case throughout the potential project area, the riprap along the shore is a barrier to wildlife; removing the riprap and establishing a gentler topographical and ecological transition could dramatically improve the habitat value of this section of Bird Island, with its extensive frontage along the sheltered waters of Ford Cove.

For the following supporting documents, see Appendix E:

- Attachment #1: Wetland Delineation Site Map
- Attachment #2: Wetland Field Data Sheets
- Attachment #3: National Cooperative Soil Survey Map
- Attachment #4: EGLE Wetland Inventory Map

Floristic Quality Assessment

Intent

The intent of this investigation was to identify areas and drivers of higher and lower floristic quality to inform the restoration design and to serve as a basis for future monitoring.

Methodology

On August 2 and September 16, 2021, the OHM team performed a Floristic Quality Assessment (FQA) across the potential project area. The FQA assesses vascular plant species abundance and conservatism (the likelihood that a given species will be found only on undegraded or undisturbed sites) to generate a composite measure of species abundance, rarity and endemism called the Floristic Quality Index (FQI). FQAs were conducted at six sites across the potential project area and FQI was reported for each site, as well as for the potential project area overall (Figure 10, Table 9).

Figure 10. Floristic Quality Assessment survey locations.

The FQA assigns each native vascular plant species a coefficient of conservatism, also known as a "C-value", between 1 and 10, with a low value indicating a widespread, adaptable species and a high value indicating a rare or highly sensitive species; non-native species are assigned a C-value of 0. The FQI of a given site is a function of the number of identified vascular plant species and the average C-value of those species (Eq. 1). Greater species abundance and/or a higher average C-value yields a higher FQI – a higher floristic quality.

(Eq. 1)

$$\text{FQI} = \text{Average C} - \text{Value} \quad \text{X} \quad \sqrt{\text{Number of Vascular Plant Species}}$$

Results and Discussion

The average C-value across the six survey locations ranged from 1.0 to 3.5, with an average of 2.4, while the species abundance across the six survey locations ranged from 6 to 14, with 38 species identified across the potential project area. The FQI across the six survey locations ranged between 2.6 and 11.2; the FQI for the whole of the potential project area was 14.6 (Table 9).

Most remaining undeveloped lands in Michigan have FQI scores of less than 20 and have minimal significance from an ecological perspective. Areas with FQI scores greater than 35 exhibit sufficient conservatism and species richness to be floristically important and of statewide significance in Michigan. Areas with FQI scores greater than or equal to 50 are rare and represent very important elements of Michigan's biodiversity.

Though the assessed FQI scores would seem to indicate that the Ford House grounds are of minimal significance from an ecological perspective, there is potential for species dispersal from higher quality sites to lower quality areas within the potential project area.

Table 9. Summary of Floristic Quality Assessment findings.

Site	Number of Species	Percent Native	Average C-Value	FQI
1	6	100%	3.0	7.4
2	8	38%	1.3	3.5
3	14	86%	3.0	11.2
4	6	100%	3.5	8.6
5	6	100%	2.5	6.1
6	7	29%	1.0	2.6
Potential Project Area	38	71%	2.4	14.6

Floristic quality can be improved using several overlapping and mutually reinforcing strategies:

- Increasing the diversity of available habitat.
- Controlling non-native invasive species.
- Introducing or reintroducing native species.
- Supporting pollinators.

The existing riprap creates a harsh ecological transition between mesic forest and open water within which only a handful of hardy species can survive. A gradual transition from mesic forest to shrub/scrub or sedge meadow, to emergent marsh, to submergent vegetation and finally to open water offers many more ecological niches and much more suitable habitat for many more vascular plants, notably those that are not early colonizers of hardscrabble areas (generally low C-value), but rather thrive under a narrower set of mid-late succession conditions (generally moderate-to-high C-value).

Exotic invasive species like oriental bittersweet (*Celastrus orbiculatus*), multiflora rose (*Rosa multiflora*), and common privet (*Ligustrum vulgare*) can overrun communities of native plants and lead to dramatic reductions in species diversity, particularly among understory species. Controlling exotic invasives allows many more and higher C-value plant species to thrive in the long term.

Many low C-value, pioneering native species will recolonize restored areas through passive regeneration, but in cases where poorly dispersing, desirable moderate-to-high C-value species are not present in the seed bank (as is common in highly disturbed areas), active reintroduction is often the only way to ensure that they can become established. Beyond increasing species abundance in the obvious way, introduction/reintroduction also promotes a vibrant, diverse plant community that is less susceptible to diversity reducing invasions.

The reintroduction of a species whose pollinators are not present in the environment is likely to produce disappointing results. In practical terms, supporting pollinators usually means encouraging a diversity of animal-pollinated flowering plants to support pollinators throughout the growing season. Diverse plant communities will usually have many animal-pollinated plants in bloom at any given time, so there is a natural synergy between the vigor and diversity of the plant community and the vigor and diversity of the pollinator community, but in cases where few animal-pollinated flowering plants are established, thought should be given to potential gaps in pollen and nectar availability. Bird Island notably hosts several beehives, home to perhaps the best-known class of pollinators, but southern Michigan's pollinators also include hummingbirds, solitary native bees, flies, moths, butterflies, and beetles, with many plants being pollinated by only one or a few classes – or only one or a few species – of pollinators.

For the following supporting documents, see Appendix F:

- Attachment #1: Photographs of FQA Sampling Sites
- Attachment #2: Catalogue of Identified Species

Threatened and Endangered Species Survey

Intent

The intent of this investigation was to identify state or federally listed species that are known or suspected to reside or to have resided – or for which suitable habitat is thought to exist – within, or within the vicinity of, the potential project area. The findings of this investigation informed other field investigations into the presence of or suitability of habitat for listed species to inform the restoration design, anticipate potential impacts to listed species during restoration, and establish a basis for future monitoring.

Methodology

On June 14, 2021, the OHM team requested a Rare Species Review of the potential project area from the Michigan Natural Features Inventory (MNFI) (see Appendix G). The results of this review informed subsequent field investigations, detailed below.

Results and Discussion

On July 7, 2021, MNFI personnel identified ten federal and/or state listed species and two additional state species of concern for further comment regarding potential impacts from construction or other restoration activities (Table 10, Table 11). Of these twelve species, eight were judged not likely to be negatively affected by restoration efforts given the recency of historical observations (if any), the proximity of historical observations to the potential project area (if any), and the presence of suitable habitat within or near the potential project area, while four species – the snuff box (*Epioblasma triquetra*), the rayed bean (*Villosa fabalis*), rufa red knot (*Calidris canutus rufa*) and the Indiana bat (*Myotis sodalis*) – were identified for further investigation.

Table 10. State listed or special concern species identified for further comment by the MNFI.

	Common Name	Scientific Name	Protected Status	First Observation	Last Observation	Concern?
Insects	**American Bumblebee**	*Bombus pensylvanicus*	Special Concern	1957	1957	No
Fish	**Pugnose Shiner**	*Myotis septentrionalis*	State Endangered	1894	1894	No
Birds	**Peregrine Falcon**	*Falco peregrinus*	State Endangered	2014	2014	No
Mussels	**Snuff Box**	*Epioblasma triquetra*	State Endangered		1930	Yes
	Round Hickorynut	*Obovaria subrotunda*	State Endangered		1930	No
Plants	**Winged Monkey Flower**	*Mimulus alatus*	State Extirpated	1957	1957	No

Table 11. Federal listed species identified for further comment by the MNFI.

	Common Name	Scientific Name	Protected Status	Concern?
Mammals	**Indiana Bat**	*Myotis sodalis*	Federal Endangered	Yes
	Northern Long-Eared Bat	*Myotis septentrionalis*	Federal Threatened	No
Birds	**Piping Plover**	*Charadrius melodus*	Federal Endangered	No

	Common Name	Scientific Name	Protected Status	Concern?
	Rufa Red Knot	*Calidris canutus rufa*	Federal Threatened	Yes
Mussels	**Snuff Box**	*Epioblasma triquetra*	Federal Endangered	Yes
	Rayed Bean	*Villosa fabalis*	Federal Endangered	Yes
Herptiles	**Eastern Massasauga Rattlesnake**	*Sistrurus catenatus*	Federal Threatened	No

While no high-quality rufa red knot (*Calidris canutus rufa*) or Indiana bat (*Myotis sodalis*) habitat was identified within the potential project area, it is thought to exist in the vicinity of the project area. Potential impacts to these species could be mitigated by restricting construction activities during months when these species are most likely to be present (Table 12).

Table 12. Active season for threatened and endangered species with possible occurrence within the project area.

Common Name	Scientific Name	Active Season
Rufa red knot	*Calidris canutus rufa*	May-October
Indiana bat	*Myotis sodalis*	April-September

The OHM team conducted a mussel survey on August 16 and 17, 2021, to establish presence of the snuff box, the rayed bean and other native mussel species within the potential project area but did not identify live representatives of either the snuff box or the rayed bean (see Mussel Survey below).

While none of the species identified by the MNFI were observed during subsequent field investigations, a state threatened turtle was identified by Ford House staff during the herpetofauna survey effort ("Species B"; see Herpetofauna Survey, above).

Mussel Survey

Intent

The intent of this investigation was to establish a baseline for the size, composition, and disposition of the mussel community in the waters around the Ford House to inform the restoration design, gauge the risk of construction impacts and serve as a basis for future monitoring, with a specific interest in the establishing the presence and/or suitability of habitat for listed mussel species.

An MNFI Rare Species Review of the potential project area identified two federally listed endangered mussel species for which suitable habitat is thought to exist within 1.5 miles of the potential project area: the snuffbox last known occurrence in 1930, and the rayed bean, last known occurrence in 1935.

Methodology

On August 16 and 17, 2021, the OHM team conducted a mussel survey in the waters around the Ford House. A preliminary survey consisting of a visual and tactile investigation of select areas within the potential project area to identify potential mussel habitat was followed by a SCUBA reconnaissance of the nearshore environment along 23 transects running generally perpendicular to shore (Figure 11).

Of these 23 transects, 10 were "sheltered" (protected by Bird Island from waves and currents and relatively rich in aquatic vegetation and submerged woody debris), spanning the breadth of Ford Cove, and 13 were "lakeward" (exposed to waves and currents prevailing in Lake St. Clair, with a bed dominated by unsorted sediments and concrete riprap), extending from the northern shore of Bird Island and the Ford House grounds. All work was performed in accordance with the Michigan Freshwater Mussel Survey Protocols and Relocation Procedures for Rivers and Streams (Hanshue et al, 2021) and under an MDNR Threatened and Endangered Species Permit (#228) and site specific MDNR Scientific Collector's Permit.

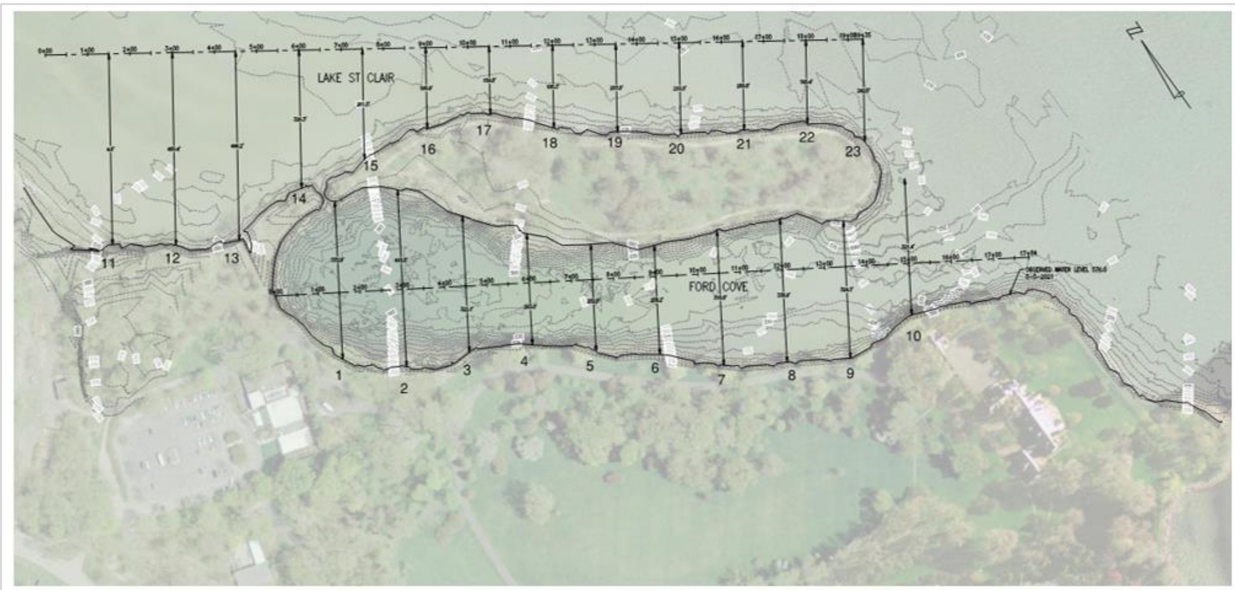


Figure 11. Mussel survey transects.

Results and Discussion

Mussel abundance in the waters around the Ford House was low. Only seven live mussels were recovered, all giant floaters (*Pyganodon grandis),* of which five were recovered from sheltered transects and two recovered from lakeward transects.

The OHM team also found weathered dead representing seven species, including the state species of concern creek heelsplitter (*Lasmigona compressa*), deertoe (*Truncilla truncata*), round pigtoe (*Pleurobema sintoxia*), and the federal endangered and state endangered threehorn wartyback (*Obliquaria reflexa*), with a particular abundance of giant floater and creek heelsplitter shells across the lakeward transects, and the greatest diversity of shells across lakeward transects 11 and 12 (Table 13, Figure 12). It is likely that shells are swept to this area by waves and currents and deposited in the shallow water.

Table 13. Results of mussel survey.

Common Name	Scientific Name	Protected Status	Transect Number (Number of Individuals and Condition)
Giant Floater	*Pyganodon grandis*		T2 (2 Live, 2 Fresh Dead), T5 (1 Live), T6 (1 Live), T8 (1 Live), T13 (1 Live) T19 (1 Live), T13-23 (many Weathered Dead)
Creek Heelsplitter	*Lasmigona compressa*	State Special Concern	T10-23 (many Weathered Dead)
Deertoe	*Truncilla truncata*	State Special Concern	T11-12 (many Weathered Dead)
Round Pigtoe	*Pleurobema sintoxia*	State Special Concern	T11-12 (2 Weathered Dead)
Threehorn Wartyback	*Obliquaria reflexa*	Federal Eendangered, State Endangered	T11-12 (2 Weathered Dead)

Common Name	Scientific Name	Protected Status	Transect Number (Number of Individuals and Condition)
Spike	*Eurynia dilatata*		T11 (1 Weathered Dead)
Black Sandshell	*Ligumia recta*	State Endangered	T11 (1 Weathered Dead)
Zebra Mussel	*Dreissena polymorpha*	Invasive	Ubiquitous (many Weathered Dead)

The presence of weathered dead of several native species (including several listed species) most likely absent from the potential project area suggests that they are present in local area and could recolonize the site given appropriate habitat.

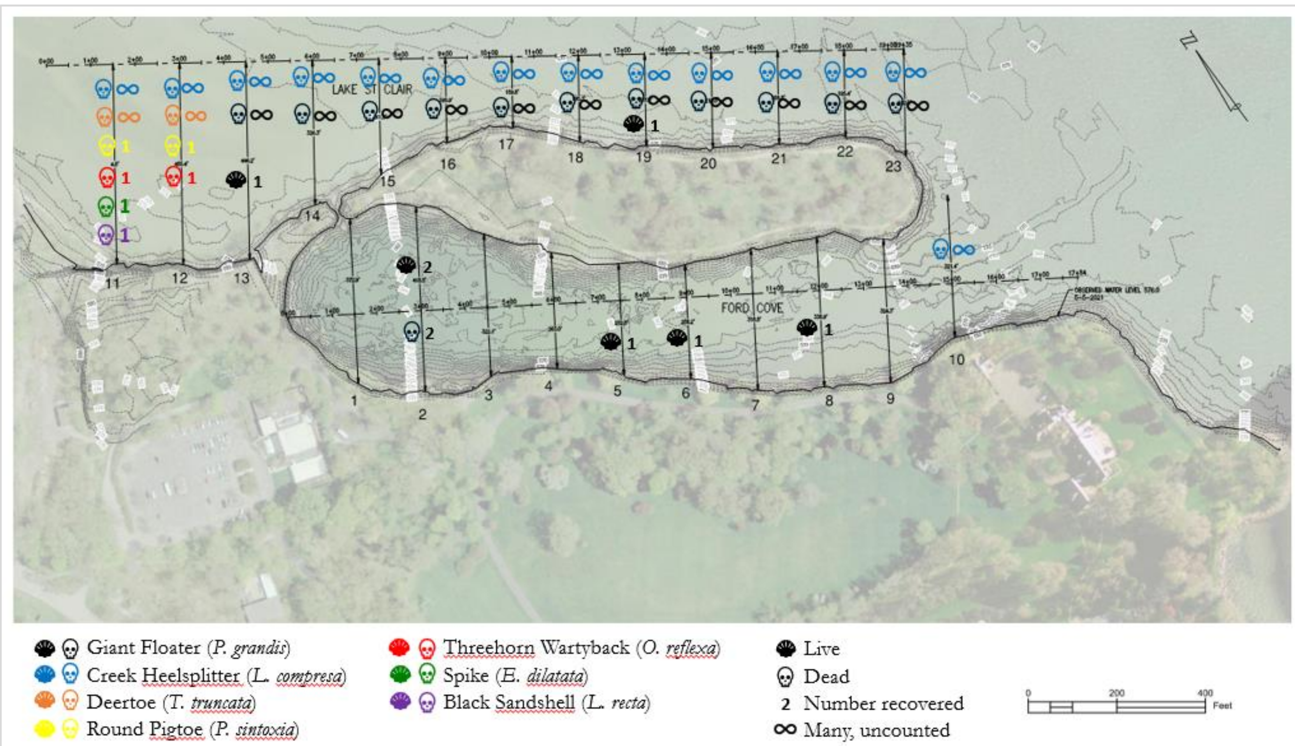


Figure 12. Results of mussel survey. Weathered dead zebra mussels (Dreissen polymorpha), a widespread invasive species, are ubiquitous throughout the potential project area but are not depicted above.

Results of water quality monitoring (see Water Quality Assessment, below) suggest that the water quality in the potential project area compares favorably to most lakes and streams in Southeast Michigan and bodes well for mussel restoration. Dissolved oxygen content is high, and the algal community (an important food source for filter-feeding bivalves) is, by implication, likely robust.

The greatest barriers to the establishment of a native mussel community within the potential project area are the sedimentation of the lakebed and cove bottom, competition from invasive zebra mussels, and the potential absence of host fish species.

At present, the steep topographical gradient and concrete riprap along the shore prevents the gradual sorting and deposition of sediments characteristic of beach/wetland environments in low-moderate wave energy environments like that along the lakeward frontage of the potential project area. Restoring areas of gravels and cobbles – mussels' preferred substrate – can be accomplished through dredging, modifications to the wave/current regime, or by the direct addition of gravels and cobbles.

Dredging is very expensive and has a large environmental impact, particularly on water quality. Where the flow regime can be modified to encourage flow to scour and sort accumulated sediments, such as at the inlet beneath Bird Island bridge, or where the shoreline can be softened and graded to allow waves and currents to scour and sort sediments, this should be done. Where modifications to the wave/flow regime are not practicable, the addition of gravels or cobbles from offsite can be considered. With dredging or the direct addition of gravels and cobbles, it is important to remember that over time, the system will tend to regress towards equilibrium with prevailing hydrodynamic and geomorphic processes, rather than retain introduced sediment or geomorphological characteristics in perpetuity. For a discussion of hydrodynamic processes within the potential project area, see Hydrodynamic Modeling, below; for a discussion of prevailing soil/sediment conditions and considerations for breakwater design, see Geotechnical and Soil/Sediment Chemistry Investigation, below.

Zebra mussels compete with native mussels for food, dissolved oxygen, and habitat; aggressive colonizers, zebra mussels are even known to directly smother native mussels beneath their own growth. Once established within a large body of water, zebra mussels are functionally impossible to eradicate, but can be managed. Fortunately, pumpkinseed sunfish, suckers, carp, round gobies, diving duck species and sea gulls have all been known to feed on zebra mussels; encouraging populations of these natural predators of zebra mussels will contribute to the success of native mussel reestablishment.

Michigan's native freshwater mussels also depend on healthy, diverse fish populations in a more direct way: the larvae of all of Michigan's native freshwater mussel species pass through a parasitic life cycle phase wherein they must encyst on the gills or fins of fish, or in the unique case of the Salamander mussel, on the gills of a mudpuppy. It is common for the free-swimming larvae (also known as glochidia) of a given mussel species to parasitize only one, or only a handful, of fish species, so there is a natural relationship between the species richness of the fish community and the likely species richness of the mussel community.

Mussels play an important role in water filtration and maintaining water quality for the whole ecosystem. That many of our native mussel species are threatened by habitat loss and the encroachment of exotic invasives like the zebra mussel makes the conservation or re-establishment of native mussels even more important.

For the following supporting documents, see Appendix G:

- Attachment #1: Rare Species Review #2945
- Attachment #2: Rare Species Review # 2945 Section 7 Comments – Macomb County
- Attachment #3: OHM Team Members Conducting Mussel Survey
- Attachment #4: Recovered Mussels (Live, Fresh Dead and Weathered Dead)

Summary of Non-Biological Conditions

Water Quality Assessment

Intent

The intent of this investigation was to assess water quality within the potential project area to inform the restoration design and establish a basis for future monitoring.

Methodology

Between May 6 and August 18, 2021, the OHM team in collaboration with LimnoTech conducted a study of water quality at the inlet between Lake St. Clair and the area sheltered by Bird Island known as Ford Cove. The sampling design was adapted from the Coastal Wetland Monitoring Program (CWMP) Sampling Protocols, following guidelines provided in CWMP Standard Operating Procedure: Water Quality Sampling and Laboratory Processing (CMU, 2019d) for all sample collection, QA/QC and processing.

In-situ water quality monitoring equipment was installed on the Bird Island bridge. This equipment consisted of a YSI EXO 2 sonde equipped with temperature, pH, conductivity, dissolved oxygen, and turbidity probes, and two Teledyne ISCO Flowlink flow meters to measure flow velocity and direction into and out of Ford Cove. As recommended in the CWMP Standard Operating Procedure for both Water Quality and Macroinvertebrate Assessments, an additional YSI EXO 2 was used to capture local water quality data at macroinvertebrate sampling sites (Figure 8) where a Secchi disk was used to estimate depth of visibility and grab samples taken for laboratory analysis.

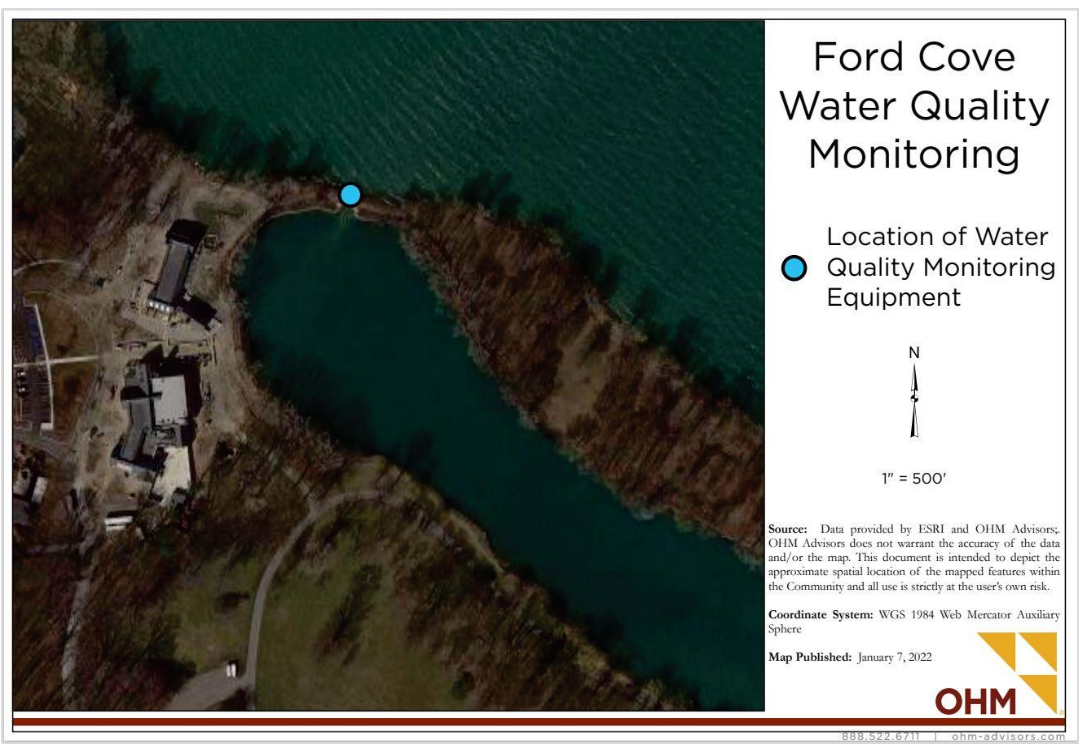


Figure 13. Location of water quality monitoring equipment.

Results and Discussion

Water quality parameters for Ford House are within expected ranges for a large limnetic system given the influence of warm surface waters from Ford Cove. Anticipated seasonal increases in water temperature, photosynthesis and aerobic respiration are consistent with observed changes in average pH, specific conductivity, dissolved oxygen content, and turbidity, as well as to changes to the timing and amplitude of daily cycles in the values of these parameters.

Table 14. Average, maximum, and minimum values for common water quality parameters. Measurements taken with an in-situ sonde at the inlet beneath Bird Island Bridge between May 6 and August 18, 2021.

Parameter	Average	Maximum	Minimum
Temperature	21.75°C	27.36°C	11.08°C
Specific Conductivity	279.25 uS/cm	400.00 uS/cm	118.00 uS/cm
Dissolved Oxygen Content, % Saturation Concentration	106.48%	171.90%	51.00%
Dissolved Oxygen Content, Absolute	9.40 mg/L	14.16 mg/L	4.23 mg/L
Turbidity	3.65 NTU	192.05 NTU	0.06 NTU

Table 15. Grab samples and spot sonde samples from macroinvertebrate sampling sites.

Sample Type	Sheltered Sample Sites		Lakeward Sample Sites	
	5/20/21*	9/29/21	5/20/21	9/29/21*
Chloride mg/L	28	23	30	19
Nitrate (mg/L)	0.17	0.38	0.23	0.29
Nitrite (mg/L)	0	0	0	0
Total Nitrogen (Nitrate+Nitrite, mg/L)	0.17	0.4	0.23	0.29
Total Phosphorus	0	0.26	0	0.089
Ammonia as N (mg/L)	0**	0.15	0**	0.15
Color (CU)	0	21	0	3
Temperature (°C)	19.83	19.2	20.58	18.16
Specific Conductivity (uS/cm)	313.3	291.5	322.5	271.1
Dissolved Oxygen (%)	121.2	87.5	125.1	101.1
pH	8.39	7.84	8.42	8.24
Turbidity (NTU)	2.03	2.04	0.8	3.86
Chlorophyll (ug/L)	6.52	3.09	1.12	2.85
*Indicates location where a duplicate sample was analyzed. **Test outsourced, detention limit 0.15 mg/L rather than normal 0.02 mg/L.				

Temperature

Observed water temperatures were consistent with the anticipated seasonal increase in average water temperature and the anticipated daily cycling of water temperature (Figure 14). Changes to water temperature typically correlated with changes in ambient air temperature, but at some delay and with much lower amplitude. Daily high water temperatures typically occurred between 5:00 PM and 7:00 PM; low water temperatures typically occurred between 6:00 AM and 8:00 AM. In some instances, these general patterns were dampened or overwhelmed by storm events or by countervailing changes in ambient air temperature. The amplitude of daily cycling in water temperature changed little between late spring and late summer (Figure 15, Figure 16).

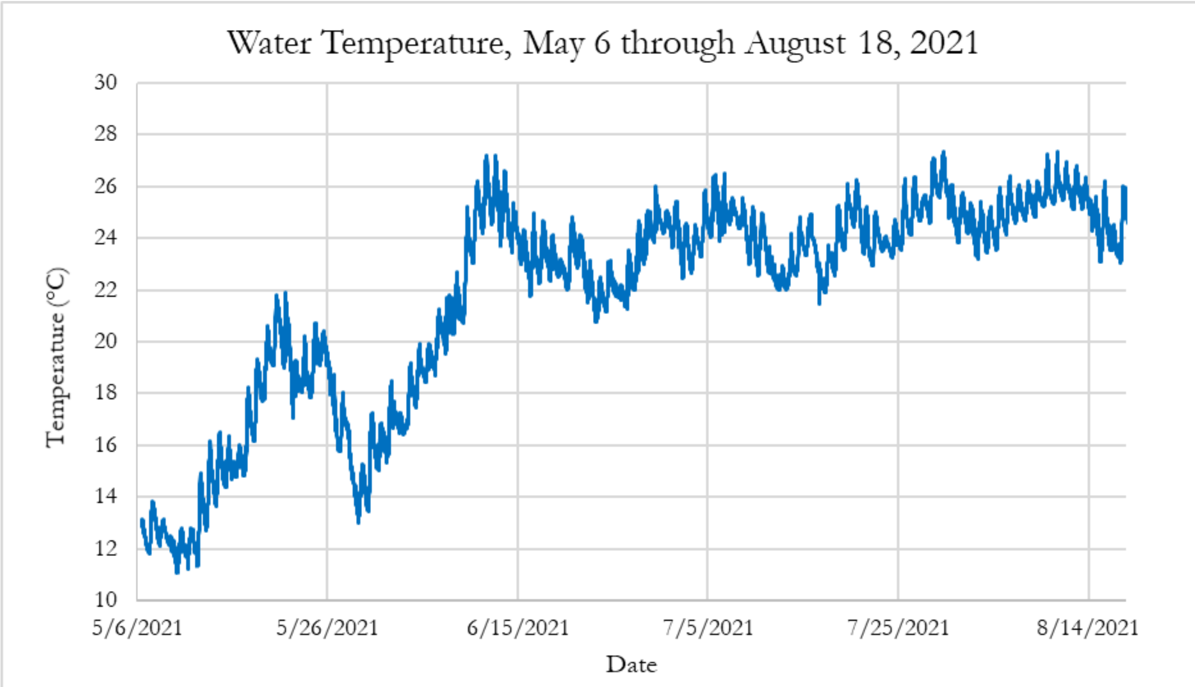


Figure 14. Water temperature between May 6 through August 18, 2021.

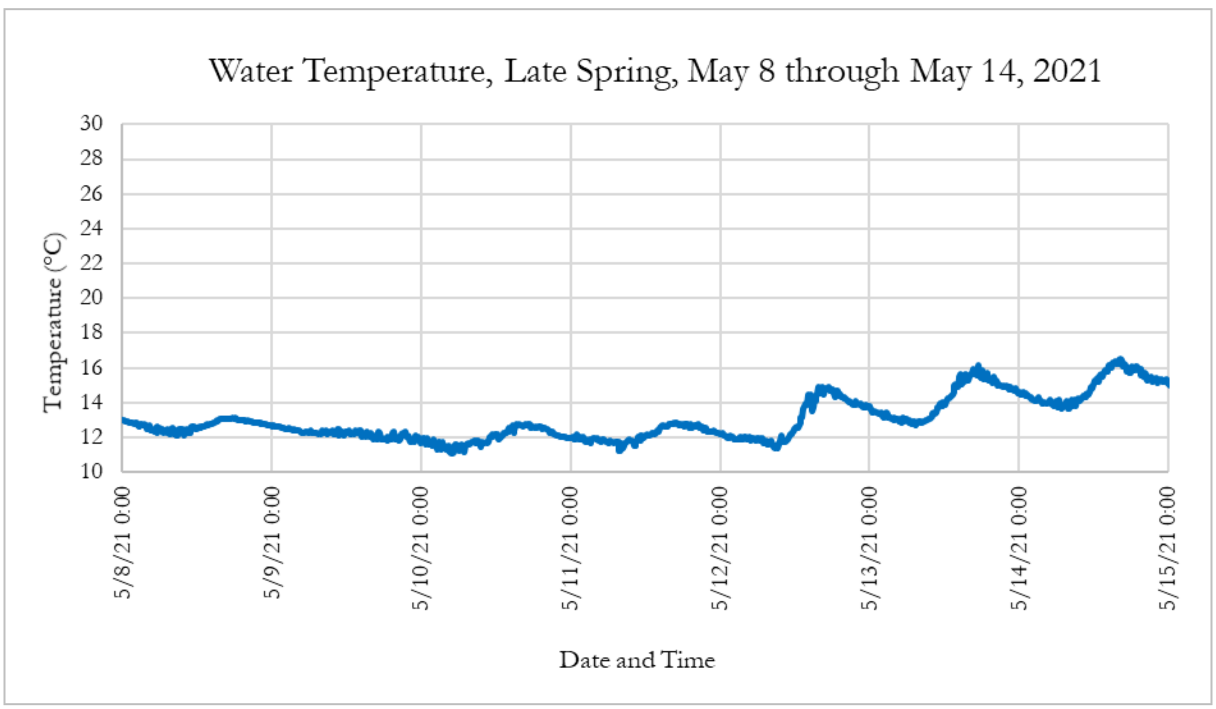


Figure 15. Water temperature between May 8 and May 14, 2021, representative of late spring.

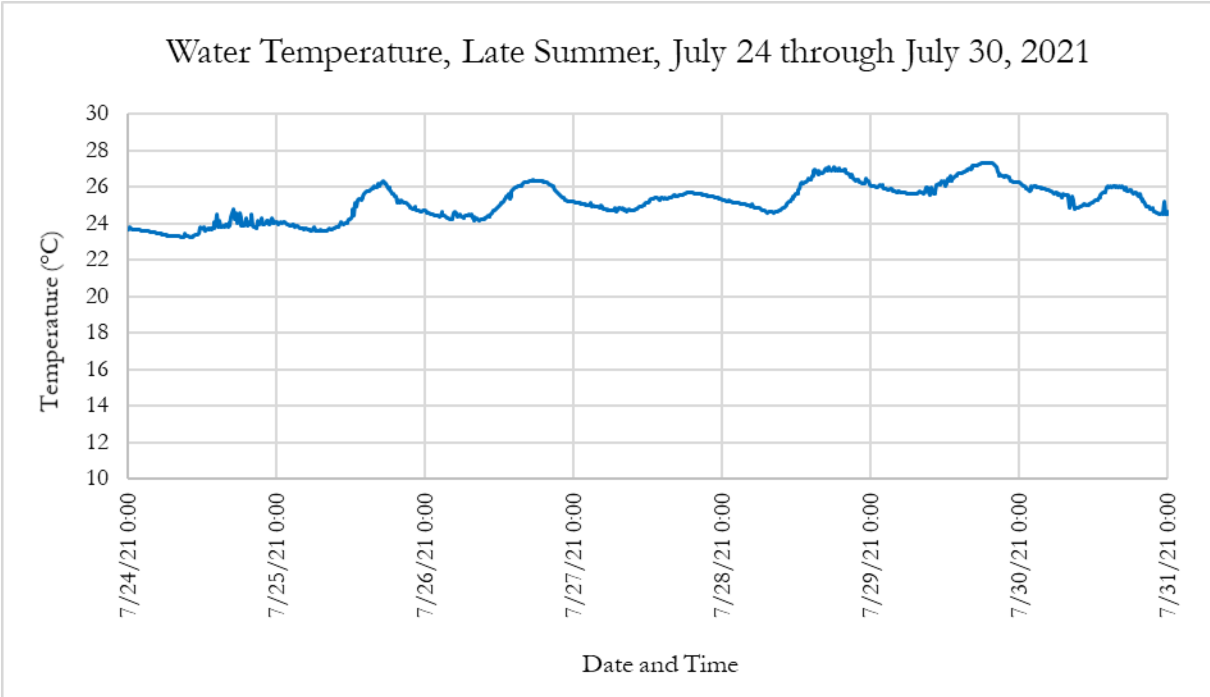


Figure 16. Water temperature between July 24 and July 30, 2021, representative of late summer.

Specific Conductivity

Specific conductivity (expressed in µS/cm, or microsiemens per centimeter) is a measure of the capacity of water to pass an electric current. Specific conductivity is influenced by the concentration of dissolved inorganic ionic compounds ("DIIC")—commonly, salts—which, in solution, readily conduct electricity.

The specific conductivity of large limnetic systems is influenced most strongly by watershed geology. Higher water temperatures also increase specific conductivity, though the effect is not large enough to produce clear daily cycling or seasonal patterns (Figure 17, Figure 18, Figure 19).

In healthy bodies of fresh water that can support most fish and other aquatic organisms, specific conductivity typically ranges between 150 and 500 µS/cm; all observations of specific conductivity at the inlet beneath Bird Island Bridge fell within this range (Table 15). Values greater than 500 µS/cm may indicate concentrations of salt or other pollutants high enough to stress freshwater organisms. A handful of abrupt changes in specific conductivity, apparent in Figure 17, are suspected to have been caused by influxes of pollutants or stormwater, which can temporarily change concentrations of DIIC, especially in shallow littoral waters which are heavily influenced by surface runoff.

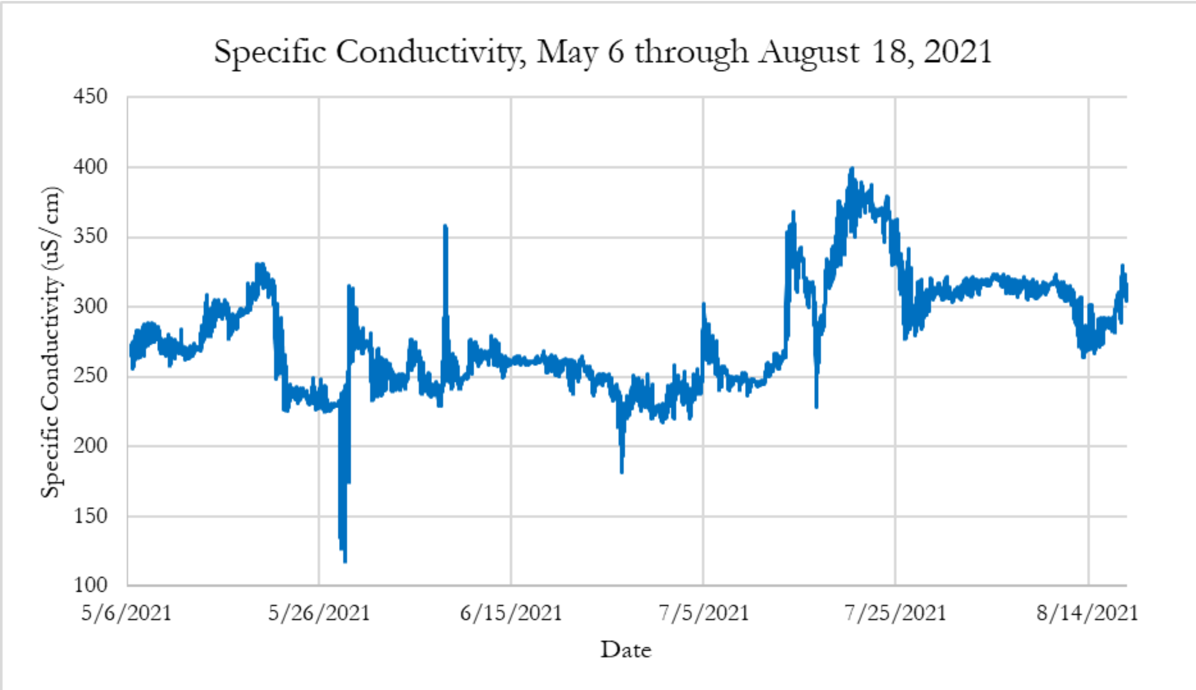


Figure 18. Specific conductivity between May 6 and August 18, 2021.

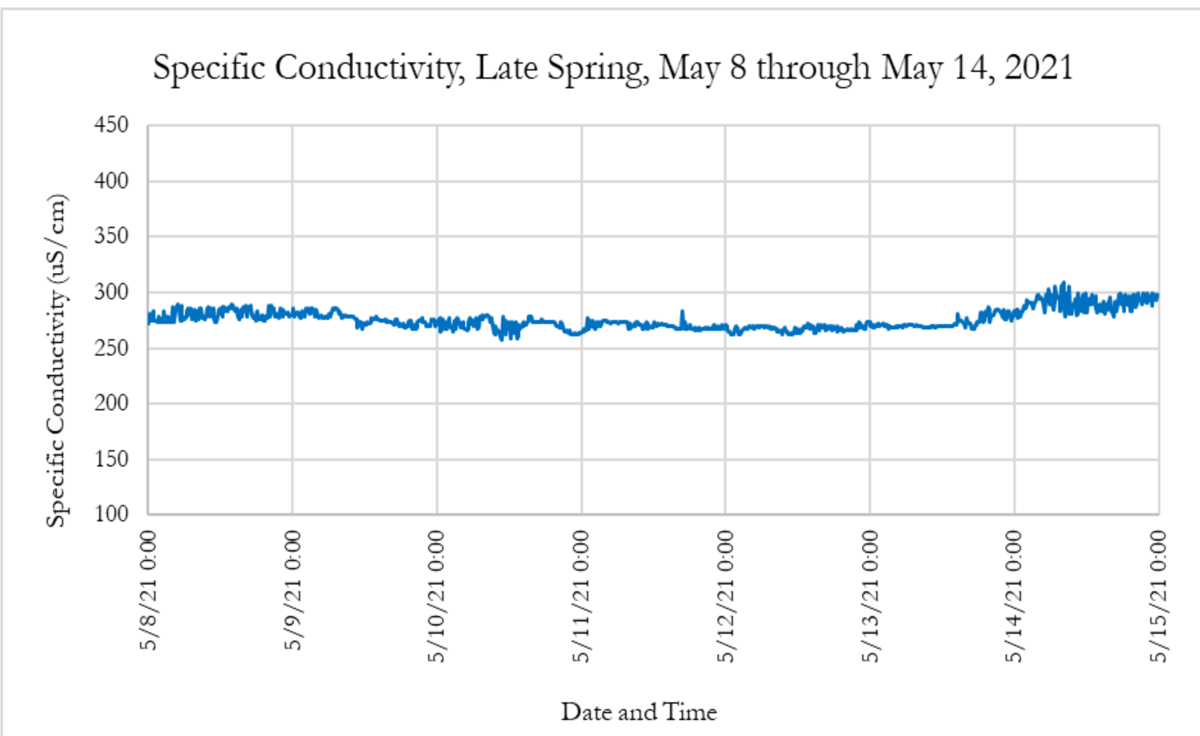


Figure 17. Specific conductivity between May 8 and May 14, 2021, representative of late spring.

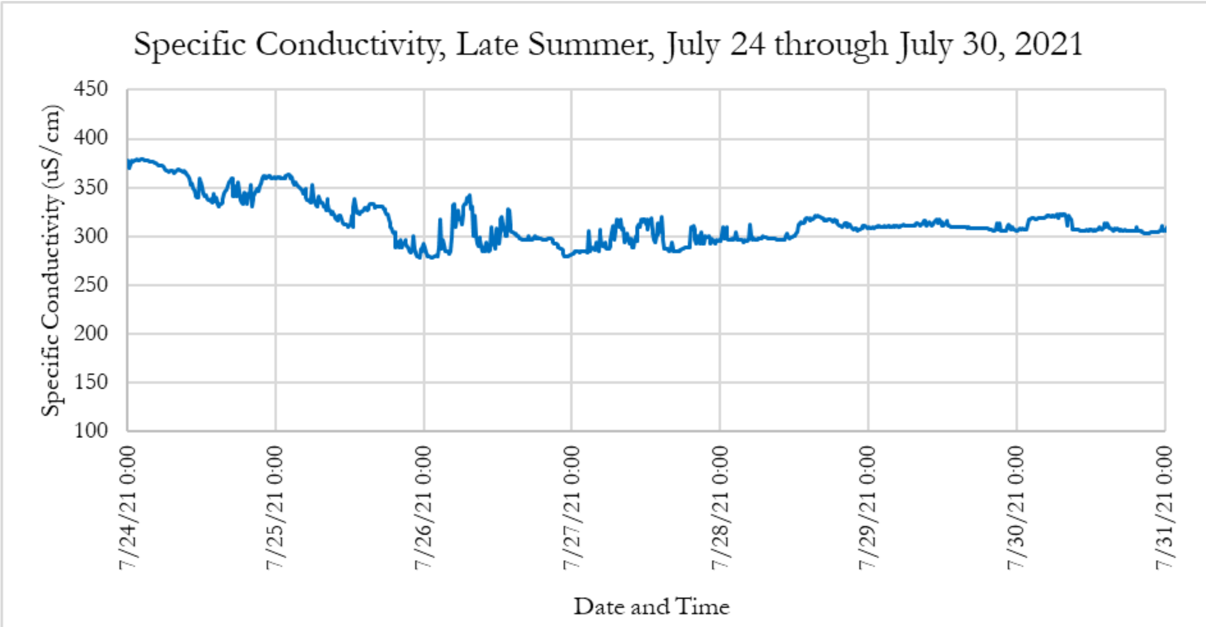


Figure 19. Specific conductivity between July 24 and July 30, 2021, representative of late summer.

Acidity (pH)

Given a volume of pure water, a small proportion of water molecules (H_2O) will naturally "ionize" or decompose into ions: negatively charged OH^- (hydroxide) and positively charged H^+, which quickly associates with another water molecule to form H_3O^+ (hydronium).

$$2H_2O \rightleftharpoons H_2O + H^+ + OH^- \rightleftharpoons H_3O^+ + OH^- \qquad \text{(Eq. 2)}$$

In pure water the concentration of OH^- (denoted by $[OH^-]$) is equal to the concentration of H_30^+, by convention expressed as H^+ (and denoted as $[H^+]$)—roughly one of each per 10,000,000 molecules of water.

In impure water, compounds that bind to H^+ ions or donate additional H^+ ions change the concentration of H^+ ions. The concentration of H^+ ions is more colloquially expressed as "acidity" and reported in terms of "power [or potential] of hydrogen," or "pH". Because changes in $[H^+]$ commonly span many orders of magnitude, acidity is expressed on a logarithmic scale as a unitless value between 0 and 14. On the pH scale, each increment of 1.0 represents a ten-fold difference in H^+ concentration.

$$pH = -\log\,[H^+] \qquad \text{(Eq. 3)}$$

Pure water, with an $[H^+]$ of 1/10,000,000, is said to have a pH of 7.0.

$$pH_{(pure\ water)} = -\log\left[\frac{1}{10{,}000{,}000}\right] = 7.0 \qquad \text{(Eq. 4)}$$

Solutions in which the concentration of H^+ ions is greater than 1/10,000,000 will have a pH of less than 7.0, and are said to be acidic.

$$pH_{(orange\ juice)} \approx -\log\left[\frac{1}{3{,}000}\right] \approx 3.5 \qquad \text{(Eq. 5)}$$

Solutions in which the concentration of H^+ ions is less than 1/10,000,000 will have a pH of greater than 7.0, and are said to be basic.

$$pH_{(baking\ soda\ solution)} \approx -\log\left[\frac{1}{300{,}000{,}000}\right] \approx 8.5 \qquad \text{(Eq. 6)}$$

H^+ ions are highly reactive and aggressively bind to other molecules, making high $[H^+]$ environments highly corrosive. As H^+ ions bind to or disassociate from other molecules, they change the structure of those molecules; the abundance or scarcity of H^+ ions therefore conditions which molecular forms predominate, the many effects of which include making some nutrients more/less biologically available and altering the efficiency or function of proteins by stressing or relaxing molecular bonds and changing the distribution of electrons across molecular orbitals. In short, $[H^+]$ is tremendously important for the chemistry of life.

Daily and seasonal fluctuations in pH in large limnetic systems like Lake St. Clair are governed in part by fluctuations in water temperature, though several countervailing responses to fluctuations in water temperature compete for influence.

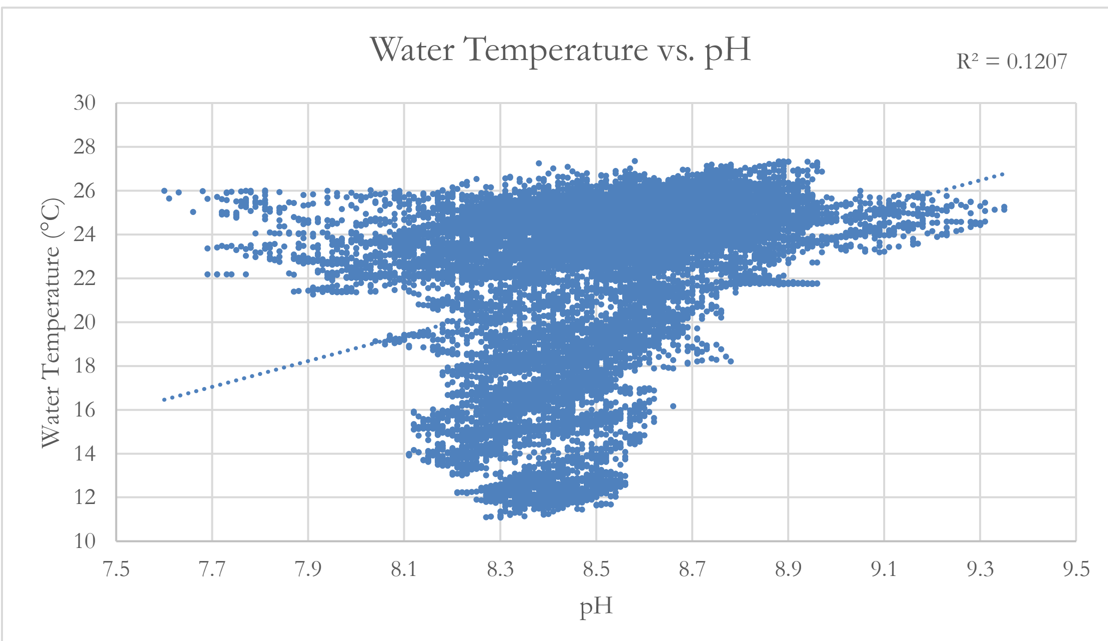


Figure 20. Observed relationship between water temperature and pH.

An increase in water temperature is synonymous with an increase in average molecular kinetic energy; as water molecules vibrate and collide with greater force, they are more likely to ionize (disassociate into H^+ and OH^- ions) which leads to an increase in $[H^+]$—synonymous with a decrease in pH and an increase in acidity.

However, an increase in water temperature also lowers the saturation point of carbon dioxide (CO_2) in water, which tends to drive carbon dioxide out of solution. Higher water temperatures also encourage higher rates of photosynthesis, which consumes dissolved carbon dioxide.

Carbon dioxide reacts with water to form carbonic acid (H_2CO_3), an H^+ donor. As with concentrations of water and hydroxide and hydronium ions, concentrations of dissolved carbon dioxide, carbonic acid, and bicarbonate (HCO^-_3) and carbonate (CO^{2-}_3) ions exist in a state of dynamic equilibrium.

$$H_2O + CO_2 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons 2H^+ + CO_3^{2-} \qquad \text{(Eq. 7)}$$

As higher water temperatures and higher rates of photosynthesis lower CO_2 concentrations, the equilibrium between HCO_3^-, HCO_3^{2-} and H^+ ions is renegotiated; H^+ ions preferentially recombine with HCO_3^- and HCO_3^{2-} to bring the system back into equilibrium, leading to a decrease in $[H^+]$—synonymous with an increase in pH and a decrease in acidity.

In practice, the effects of CO_2 drawdown tend to overwhelm the countervailing influence of increased rates of ionization, and higher water temperatures are typically associated with elevated pH and lower acidity. However, the OHM team observed only a very weak correlation between water temperature and pH as average water temperatures climbed from late spring into late summer (Figure 20).

The increase in water temperature between May and August had a much greater effect on the amplitude of daily cycling than on average pH. As water temperatures increased and days grew longer, photosynthetic activity increased, leading to greater daytime drawdowns of dissolved CO_2 and commensurate increases in pH. In both late spring and late summer, daily peaks in pH occurred between 5:00 PM and 7:00 PM. At night, the aerobic respiration of aquatic life released dissolved CO_2 back into the water, leading to an increase in CO_2 concentrations and a commensurate decrease in pH. As expected, pH tended to reach daily lows in the early morning, after a full night of CO_2-producing aerobic respiration (Figure 21, Figure 22, Figure 23).

Typical pH values for a large lacustrine system range between 6.5 and 8.5. Higher values are often observed when large amounts of algae or submerged vegetation are photosynthesizing, consistent with observed pH values above 9.0 in midsummer (Table 14).

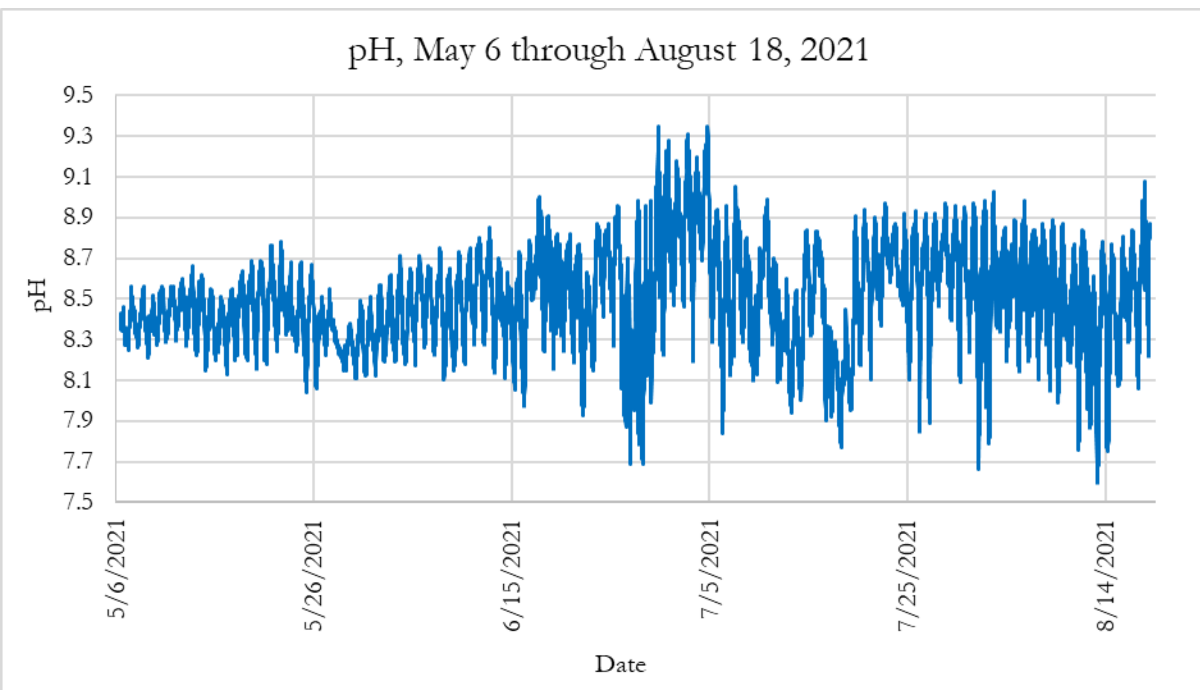


Figure 21. pH between May 6 and August 18, 2021.

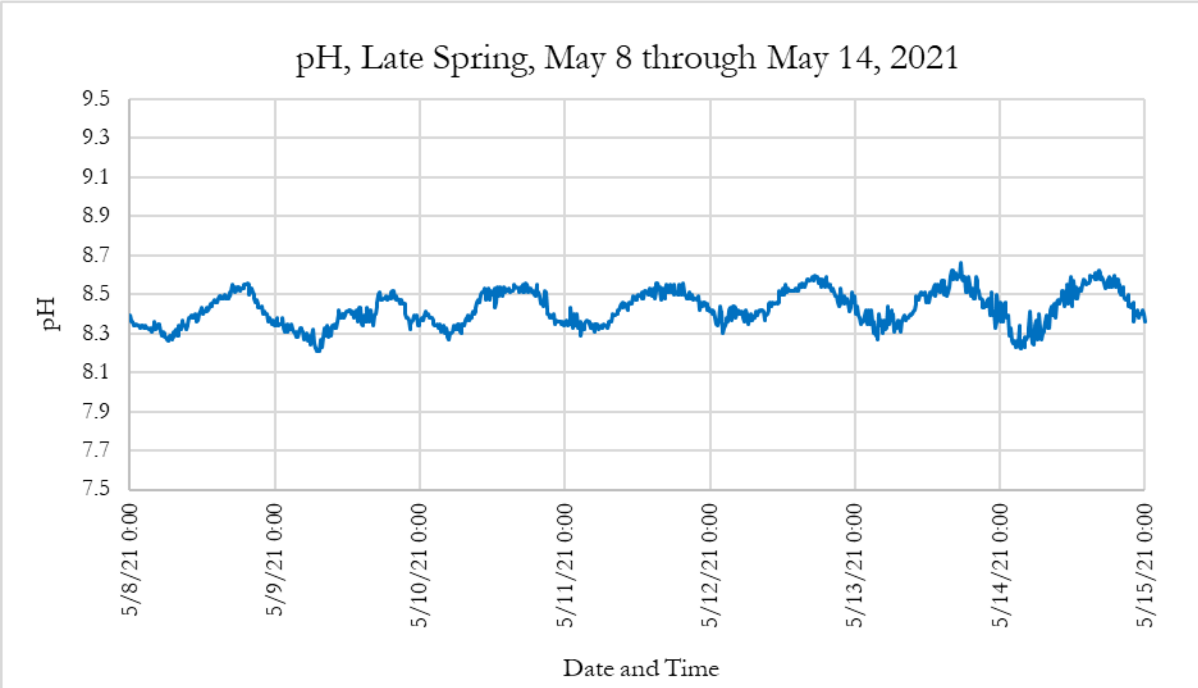


Figure 22. pH between May 8 and May 14, 2021, representative of late spring.

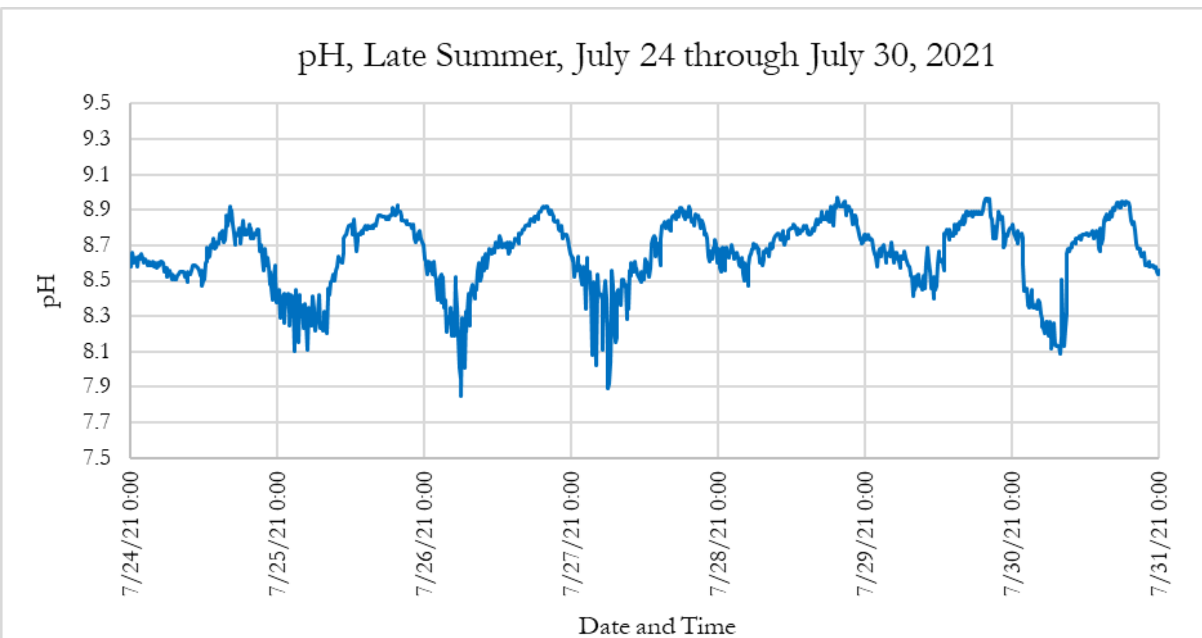


Figure 23. pH between July 24 and July 30, 2021, representative of late summer.

Dissolved Oxygen

Because gaseous oxygen (O_2) dissolves readily in both air and water, the concentration of oxygen in the atmosphere and in surface waters tends, all else being equal, toward dynamic equilibrium. The capacity of water to dissolve oxygen, the "saturation point" or "saturation threshold" of oxygen in water, is governed by many factors, notably temperature and pressure; lower temperatures and higher pressures raise the saturation point (allow water to hold more dissolved oxygen), higher temperatures and lower pressures lower the saturation point (allow water to hold less dissolved oxygen). Where the concentration of dissolved oxygen exceeds the saturation point, dissolved oxygen will diffuse from the water out into the atmosphere. Where the concentration of dissolved oxygen falls below the saturation point, oxygen will diffuse from the atmosphere into the water.

However, the rate of chemical or biological production or consumption of dissolved oxygen in surface waters commonly exceeds the rate of diffusion between surface waters and the atmosphere, which can result in persistent disequilibrium between atmospheric and aqueous oxygen concentrations or in large fluctuations in dissolved oxygen concentrations, despite the relative constancy of water temperature, pressure, availability of atmospheric oxygen, and other factors that govern the dissolution of oxygen in surface waters.

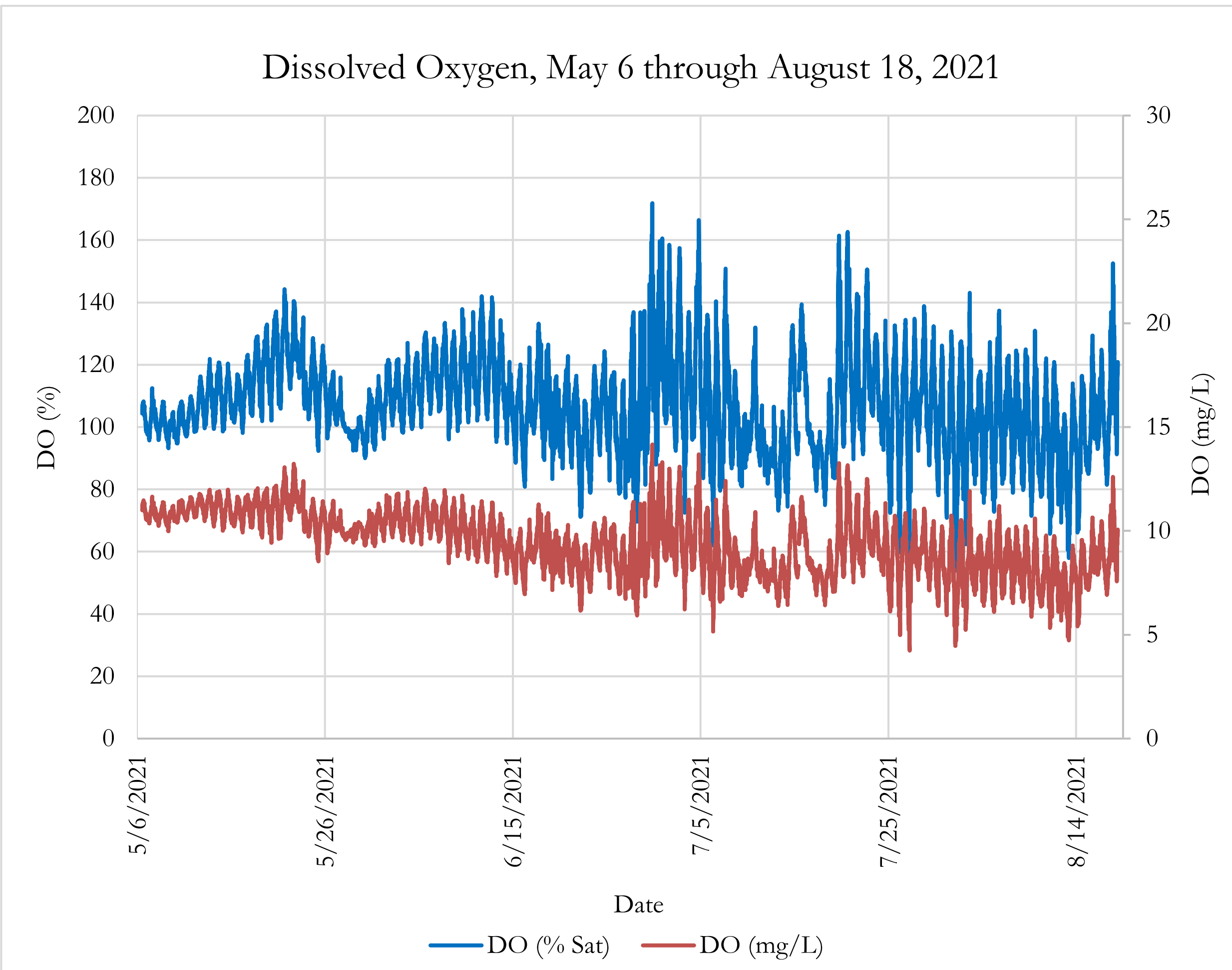


Figure 24. Dissolved oxygen content between May 6 and August 18, 2021.

The dissolved oxygen content ("DO") of a given volume of water can be expressed either in absolute terms (e.g., mg O_2/L) or as a percentage of the oxygen content at saturation (e.g., water with a dissolved oxygen concentration double the content at saturation is said to have a DO of 200%), which is a function of both absolute oxygen content and water temperature, pressure, etc.

As Ford House waters warmed from late spring to late summer, the saturation threshold for dissolved oxygen dropped. Within this seasonal trend smaller changes in water temperature due to daily cycling or weather events also drove fluctuations in oxygen saturation threshold. In a state of perfect equilibrium with the atmosphere, we would expect this decline in saturation threshold to have driven a commensurate decline in absolute dissolved oxygen content. However, warmer water temperatures also corresponded with longer, sunnier days and a pronounced uptick in photosynthesis and aerobic respiration, processes which generate or consume dissolved oxygen at rates that tend to swamp the effects of atmospheric diffusion in large limnetic systems over the short term.

The observed net effect of warmer waters, lower saturation thresholds, and increases in photosynthesis and aerobic respiration was a slight seasonal decline in the absolute concentration of dissolved oxygen from late spring to late summer, and little change in average DO as a percentage of the concentration at saturation (Figure 24). As with pH, the increase in photosynthesis and aerobic respiration between late spring and late summer drove an increase in the amplitude of daily cycles in absolute and relative DO as photosynthesis drives up DO during the day and aerobic respiration continues to consume DO throughout the night (Figure 25, Figure 26).

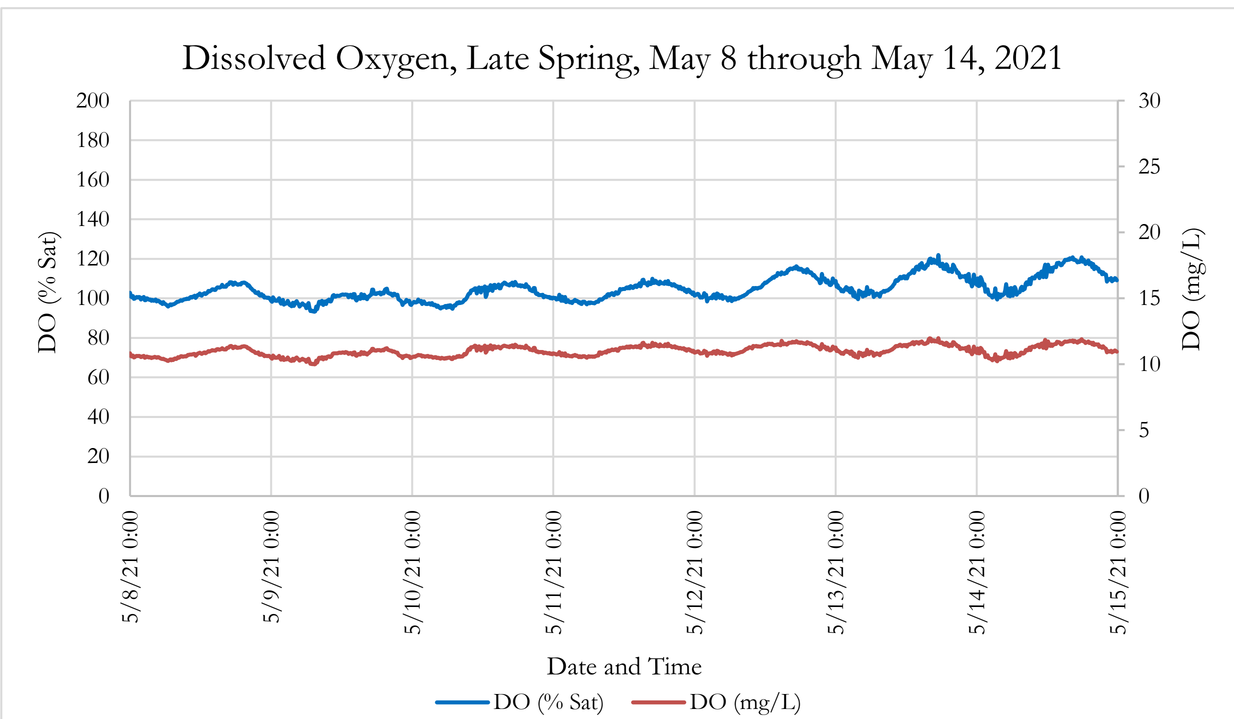


Figure 25. Dissolved oxygen content between May 8 and May 14, 2021, representative of late spring.

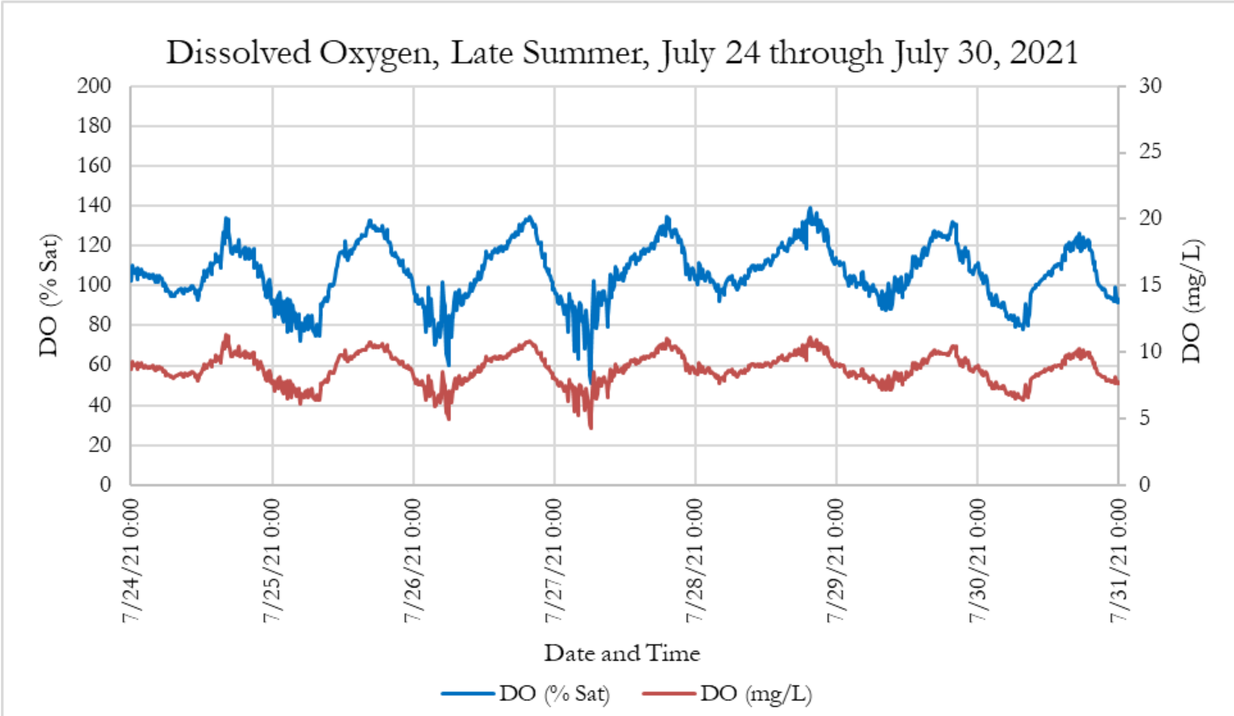


Figure 26. Dissolved oxygen content between July 24 and July 30, 2021, representative of late summer.

Separate investigations of fish, mussel and macroinvertebrate communities across the Ford House waters revealed that macrophytic aquatic vegetation is relatively sparse, especially along the lakeward shore of Bird Island. Therefore, algae likely account for much of the photosynthetic activity suggested by dissolved oxygen supersaturation and daily cycling. Algal and submerged vegetative photosynthesis are most efficient between 20°C and 30°C, consistent with the range of water temperatures within which the OHM team observed the largest amplitude in daily cycling.

Generally, warm water lake fish require a DO of 4-5 mg/L or greater, while benthic organisms can subsist on far less and cold water stream fish require more. The dissolved oxygen content observed from late spring to late summer is sufficient to support robust communities of warm water lake fish, mussels, and macroinvertebrates.

Turbidity

Turbidity is a measure of clarity or cloudiness. It is an expression of the degree to which light is scattered as it travels through a liquid, reported (within the scope of this investigation) in Nephelometric Turbidity Units (NTU). Larger values of NTU denote a greater degree of scattering—a greater degree of cloudiness or turbidity. Common sources of turbidity include suspended sediment, algae, and solutions of water soluble compounds.

Turbidity measurements at Bird Island Bridge did not reveal clear seasonal trends or daily cycling, but did reveal episodic surges of turbidity, likely related to storm events that stir up fine lakebed sediments and spur erosion along the lakefront (Figure 27, Figure 28, Figure 29). Periods of low turbidity are the norm, suggesting that in the absence of storm events or similar disturbances, the Ford House shoreline experiences little erosion, consistent with the extensive riprap armor along the shore (Table 14).

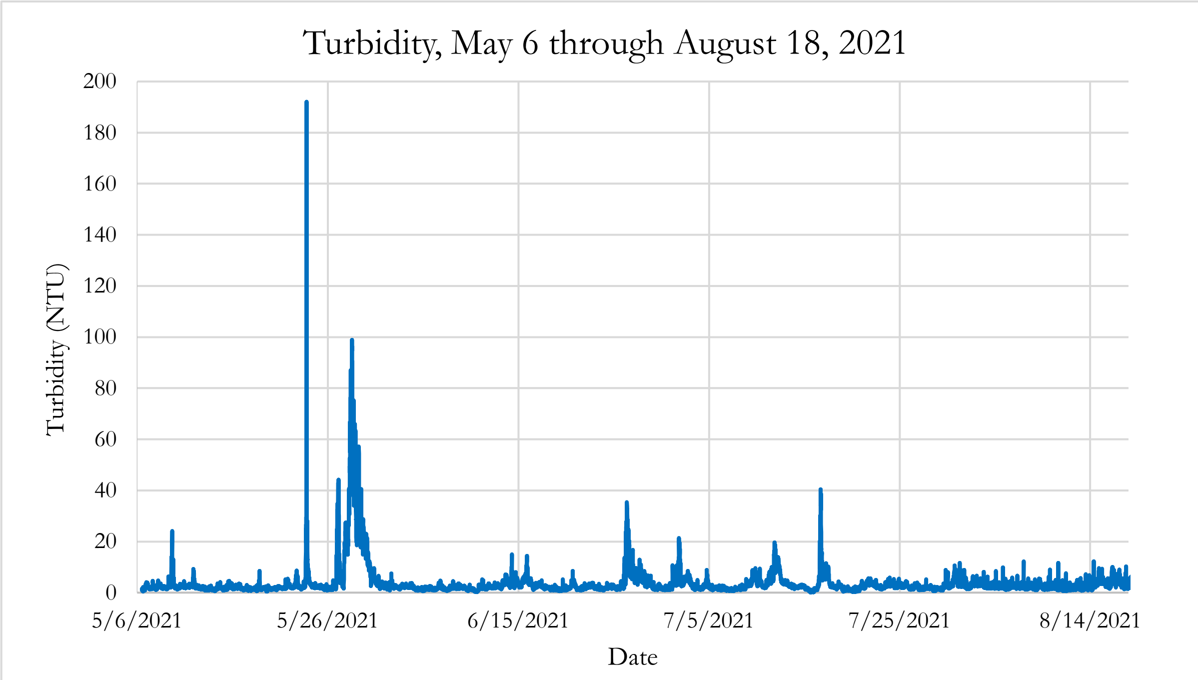


Figure 27. Turbidity between May 6 and August 18, 2021.

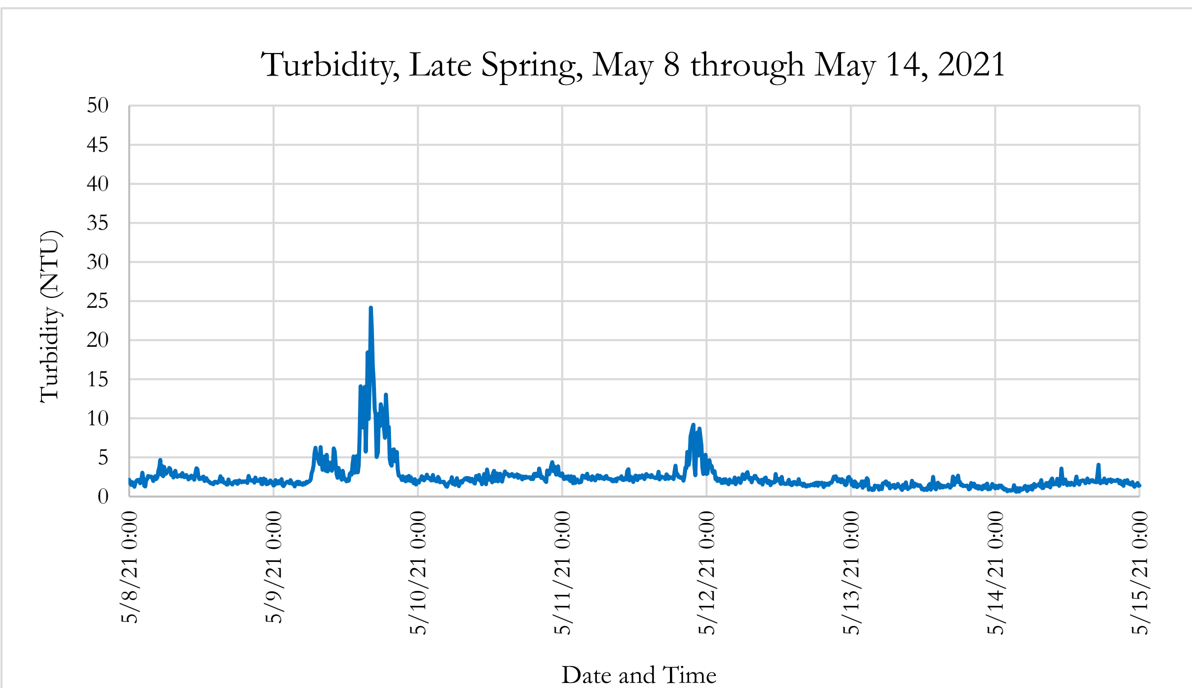


Figure 28. Turbidity between May 8 and May 14, 2021, representative of late spring.

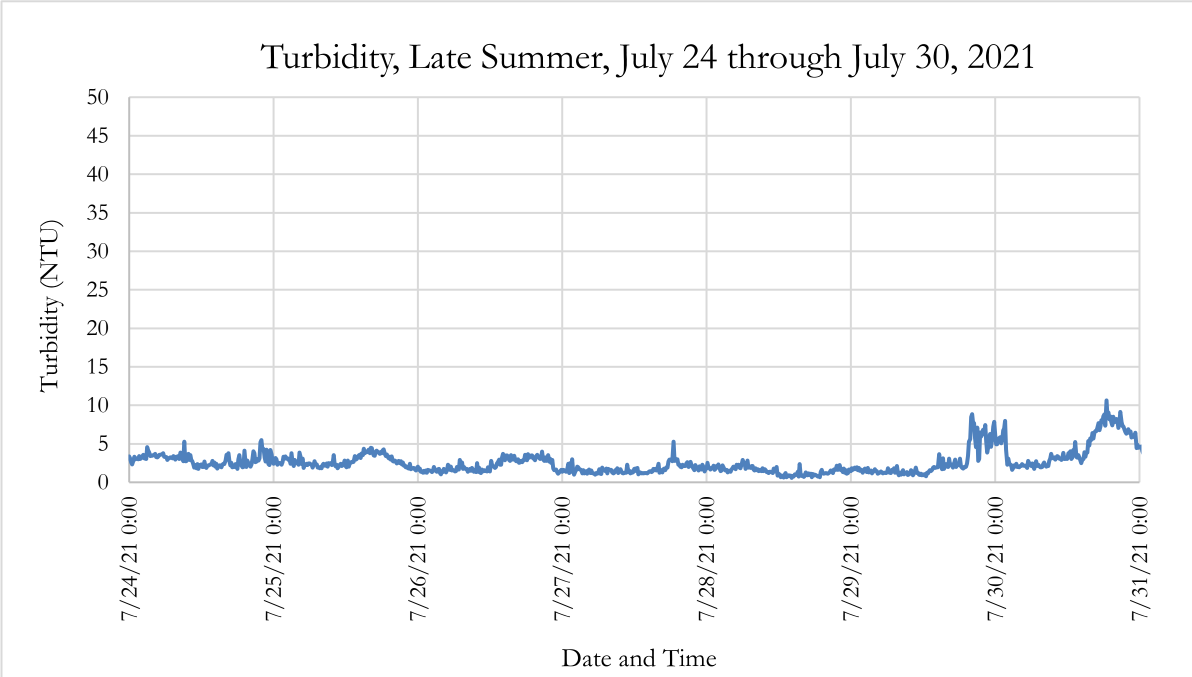


Figure 29. Turbidity between July 24 and July 30, 2021, representative of late summer.

Spot Sonde and Grab Sample Analysis

The low levels of ammonia, nitrite, and total phosphorus detected in the grab samples are consistent with high DO environment, as conversion of ammonia to nitrate, conversion of nitrite to nitrate, and oxidation of phosphorus (and subsequent sequestration in lakebed sediments) are all aerobic processes (Table 15).

Low ammonia, nitrites and nitrates, and high DO are indicators of suitable fish habitat. Removing the riprap and encouraging the accretion of coastal wetlands will encourage an increase in macrophytic vegetation in the littoral zone, which would maintain high DO concentrations while improving the habitat value of the waters surrounding the Ford House.

Differences in nitrate, phosphorus, color, pH, and chlorophyll values between May and September samples taken from sheltered sites are much more pronounced than differences between May and September samples from lakeward sites, suggesting that Ford Cove is somewhat hydraulically distinct from adjoining Lake St. Clair. The waters of Ford Cove are influenced by the connection to Lake St. Clair, but their character is predominantly determined by Ford Cove's small size, shallow bathymetry, and insulation from waves and currents. Flows through the inlet beneath Bird Island bridge and the exchange of waters at the mouth of the Ford Cove are, at present, insufficient to reduce the local character of the waters within Ford Cove.

For the following supporting documents, see Appendix H:

- Attachment #1: Paragon Laboratories Water Quality Analysis Results
- Attachment #2: Full In-situ YSI EXO Data Set
- Attachment #3: Full Teledyne ISCO Flowlink Data Set

Geotechnical and Soil/Sediment Chemistry Investigation

Intent

The intent of this investigation was to assess the chemical and geotechnical characteristics of nearshore and onshore sediments within the potential project area to inform the restoration design (particularly the design of offshore erosion control structures), anticipate measures for the containment, mitigation, or disposal of contaminated sediments, if any, and establish a basis for future monitoring.

Methodology

On May 24, 2021, Somat Engineering performed a soil exploration consisting of two hand auger probes and seven subaqueous soil probes across the potential project area (Figure 30). Work was performed under a Joint Permit from the Michigan Department of Environment, Great Lakes, and Energy.

Figure 30. Sediment probe and hand auger soil boring locations. Image prepared by Somat Engineering.

Subaqueous probes were performed from a small floating pontoon using a conventional 2-inch OD piston sampler which was manually driven using a slide hammer. On-shore sampling was performed using an all-terrain-capable, track-mounted, direct-push (Geoprobe™) soil probing rig. Sample intervals for subaqueous and hand auger samples at depths ranged between 1.0 and 5.5 feet below existing grades.

All geotechnical soil samples were transported to Somat Engineering's laboratory for further analysis. The size distribution of soil/sediment particles within subaqueous and hand auger samples was evaluated with sieve and hydrometer analyses. Particle size distribution and soil texture have implications for compressive strength, settlement potential, and susceptibility to wave erosion of onshore and nearshore sediments, as well as for habitat suitability for aquatic or benthic species.

Environmental soil sampling was performed in conjunction with the geotechnical investigation. Each retrieved soil sample was examined for evidence of discoloration, unusual odors, or non-aqueous phase liquids. The environmental soil samples were taken from the interval that was determined to be most representative of the materials to potentially be disturbed during the shoreline restoration project. The environmental soil samples were placed into laboratory-prepared and supplied containers. These samples were then placed on ice in a chilled cooler and maintained in that condition until delivery to the analytical laboratory. The environmental soil samples were transported under standard chain of custody procedures to Fibertec Environmental Services in Brighton, Michigan for analytical testing. Additionally, a composite sample of the seven subaqueous sediment samples was collected to test for biochemical oxygen demand (BOD) within nearshore sediments. Soil samples of the lake sediment and from the different soil strata obtained from the aqueous probes and land-side hand auger probes were sealed in glass jars in the field to protect the soil and maintain the soil's natural moisture content.

The environmental soil samples were analyzed at Fibertec Environmental Services laboratory in Brighton, Michigan for the following contaminants, via procedures prescribed the United States Environmental Protection Agency:

- Michigan 10 Metals; arsenic, barium, cadmium chromium, copper, lead, selenium, silver, and zinc by USEPA Method 6020, and mercury by USEPA Method 7471.
- Semi-Volatile Organic Compounds (SVOCs) - Polynuclear Aromatic Hydrocarbon scan (PNAs) by USEPA Method 8270.
- Polychlorinated Biphenyls (PCBs) by USEPA Method 8082.
- Biochemical Oxygen Demand (BOD) by USEPA Method SM-5210.

OHM and Somat Engineering judged these contaminants to be the most likely to be present in project area sediments given prevailing site conditions and the history of the region.

Results and Discussion

Water depth at subaqueous probe sampling locations ranged from 2.0 to 5.5 feet at the time of sampling, while the water level in Lake St. Clair at the time of the topographic survey (June 1 and June 2, 2021) was 576.05 feet per NAVD88 datum. The total exploration depth of the subaqueous probes (depth relative to the surface of the lake) ranged from 6.0 to 10.5 feet, with sediment thicknesses of 1 to 4 feet. The two land-side hand auger probes had exploration depths of 5.5 to 8.5 feet.

The sediment samples recovered by the seven subaqueous probes consisted generally of a mixture of sand, silt, gravel, wood pieces, and shells. All subaqueous probes terminated in native lean clay. The two onshore hand auger probes suggested a generalized onshore soil profile of 18 inches of sandy topsoil over native stiff silty clay and lean clay which extended to the explored depths of the hand auger probes.

Analysis of the subaqueous and hand auger samples revealed notably elevated levels of benzo(a)pyrene at one nearshore sampling location and notably levels of arsenic at one onshore sampling location (Table 16). Given that the contaminated sediments have been saturated/inundated for decades, Somat Engineering judged the applicable exposure standards for hazardous contaminants to be those concerned with particle inhalation or dermal or oral contact (EGLE Residential and Nonresidential Exceedance Criteria and Screening Levels) as may be experienced by workers during construction, rather than those intended to protect groundwater from toxic leachates or those concerned with the volatilization of toxins into the air. The detected concentrations of benzo(a)pyrene and arsenic exceed those allowable in residential applications, but do not necessitate that the contaminated sediments be remediated or removed from the project area. Excavated material can be used for upland fill within the project area or sent offsite for use in non-residential applications.

Table 16. Results of soil sample laboratory analysis for hazardous contaminants. Due to their proximity, samples from P-04 and P-05 and from P-06 and P-07 were analyzed as composite samples.

Boring ID	Water Depth (feet)	Sample Interval (below ground surface/top of sediment) (feet)	Contaminants exceeding EGLE Residential Criteria, detected concentration	Contaminant, EGLE Residential Criteria Exceedance threshold
P-01	2.0	0-2.0	None	N/A
P-02	2.5	2.0-4.0	None	N/A
P-03	4.5	0-1.0	Benzo(a)pyrene, 2100 ug/kg	Benzo(a)pyrene, 2000 ug/kg
P-04/P-05	3.5-5	0-2.0	None	N/A
P-06/P-07	3.5-5	0-2.0	None	N/A
HA-08	N/A	1.5-3.5	None	N/A
HA-09	N/A	1.5-3.5	Arsenic, 12000 ug/kg	Arsenic, 7600 ug/kg

The establishment and longevity of coastal wetlands or other soft-shoreline features along lakeward sections of the shoreline will likely depend upon the construction of breakwaters or similar structures around part or all of the project area to prevent excessive wave and wake erosion. The design of these erosion protection features depends in part on geotechnical properties of lakebed sediments such as load bearing capacity, settlement potential, and susceptibility to erosive scour.

Somat Engineering suggests that either loose stone revetment or marine mattress revetment be used for the creation of breakwaters in the nearshore environment along the northern shore of the potential project area. These breakwater designs are cost effective and represent acceptable compromises between wave energy attenuation and sediment accretion, habitat value for aquatic flora and fauna, risk of settlement into the lakebed, longevity, and maintenance burden. Of these two designs, it is the opinion of the OHM team that loose stone revetment should be used to construct the breakwaters along the shore of Lake St. Clair.

For the following supporting documents, see Appendix I:

- Attachment #1: Soil Probes and Hand Augers Location Diagrams
- Attachment #2: Logs of Test Borings and General Notes
- Attachment #3: Grain Size Analysis Test Results
- Attachment #4: Summary of Soil Sample Analysis
- Attachment #5: Fibertec Environmental Services Laboratory Report

Topographic and Bathymetric Survey

Intent

The OHM team conducted a topographic and bathymetric survey early in the spring of 2021 to serve as a basis for future monitoring and to provide a consistent frame of reference for in the conduct of field investigations, modeling efforts and drafting of the restoration design.

Methodology

All field data collected was collected in the geodetic datum NAD83 (2011) (North American Datum of 1983, 2010.00 epoch), and projected into SPCS Michigan South (state plane coordinate system Michigan South). The vertical datum NAVD88 (GEOID18) (North American Vertical Datum of 1988) was used to translate geodetic heights to orthometric heights. Intervisible project control points (either an 18" rebar set in soft ground surfaces, or magnetic survey nails set in hard surfaces) were set and observed using GNSS (Global Navigation Satellite Systems) receivers in conjunction with the MSRN (Michigan Spatial Reference Network) to obtain RTK (real-time kinematic) solutions to improve accuracy. These control points remain stable for a period of 24 months.

Field efforts for primary data collection consisted of a water bathymetry survey in the area of interest, and a more conventional, on shore topographic mapping. To create a full 3D representation of the existing terrain, aerial lidar data from the State of Michigan was supplemented for the upland conditions away from the cove.

The GNSS units have default settings to not allow data to be collected if the following requirements are not met:

- A minimum of 5 satellites shared with the MSRN
- A Position Dilution of Precision (PDOP) value of 6 or less
- Positional precisions of 0.07' horizontally and 0.10' vertically

The bathymetry survey utilized a portable catamaran with an onboard GNSS receiver paired with an echosounder. In the office, a boundary was established for the extents of the area of interest (AOI). Using this boundary as a guide, a path was created to maximize data collection within the AOI. The data was evaluated after every few passes to ensure adequate coverage of the lake bottom was collected. This data was then analyzed to identify potential anomalies and vegetation influence. A full terrain was then created of the lake bottom to near shoreline.

Shoreline to top of bank topography was conducted using traditional survey methods. These methods included total stations and GNSS receivers. Data acquired overlapped with the bathymetry survey at least 25'. This overlap was used as a QA/QC for the combined field data. Traditional topography collection also extended at least 25' upland from the top of bank. Integration of available lidar data into the project terrain allowed for the extension of contours past the project AOI. This step was done to assist in giving context to the public during engagement.

Results and Discussion

Surveys spanned multiple days due to weather and lake conditions. Lakebed observations were taken at a closer interval than originally planned to accommodate the increased wave action during the survey. Nearshore and onshore actions went as planned. The full terrain of the lakebed, shoreline, top of bank, and upland areas reflects the AOI very well. A final QA/QC was conducted in field with the digital terrain model. As expected, the lakebed was relatively uniform in elevation. No large drop-offs or mounds were observed. Ford Cove did show a significant depth change at the western end, likely due to the constriction beneath Bird Island bridge that leads to an increase in water velocity through the inlet and the scour of nearby sediments.

For the following supporting documents, see Appendix J:

- Attachment #1: Ford Cove Topographic and Bathymetric Survey Map

Hydrodynamic Modeling

Intent

The intent of this investigation was to develop an understanding of how water moves around and interacts with the existing morphology and bathymetric features within the potential project area, evaluate the impact of proposed restoration measures on flows within the potential project area, identify areas of potential erosion/scour and deposition based on the modelled shear stresses and sediment characteristics, and simulate wave energy potential across the potential project area in order to inform the restoration design.

Methodology

For analyses of the potential project area, LimnoTech developed a fine-scale hydrodynamic model within a FVCOM framework as well as a SWAN model of wind-driven waves.

The Finite Volume Community Ocean Model (FVCOM) is a three-dimensional fully coupled ice-ocean-wave-sediment-ecosystem model that operates on an unstructured grid. The model was originally developed and is widely used to simulate hydrodynamics in coastal ocean regions; however, it has recently gained popularity for use in large lakes. Because the model was developed for coastal ocean regions where tidal fluctuations are significant, FVCOM can simulate wetting and drying of areas that are not continuously under water, an important feature for this project. The source code was developed by researchers at the University of Massachusetts-Dartmouth and the Woods Hole Oceanographic Institute.

The Simulating WAves Nearshore (SWAN) model is a third-generation wind wave model, developed at Delft University of Technology, which computes random, short-crested wind-generated waves in coastal regions and inland water. SWAN accounts for wave propagation in time and space, shoaling, refraction, frequency shifting, three- and four-wave interactions, whitecapping, bottom friction and depth-induced breaking, and dissipation. The main inputs required to run SWAN are bathymetry and wind conditions.

The availability of accurate, fine-scale bathymetry near and within the potential project area was critical to this investigation. Existing NOAA bathymetry data were available for the Lake St. Clair, although the resolution was relatively coarse near the potential project area and nonexistent within Ford Cove itself. These limited data were augmented with bathymetric survey data collected by the OHM team in the spring of 2021 (see Topographic and Bathymetric Survey, above). The OHM team also provided potential restoration design configurations with proposed crest elevations for breakwaters and other structures.

NOAA's Great Lakes Environmental Research Laboratory (NOAA-GLERL) maintains an operational FVCOM model for the Huron-Erie Connecting Waterways (Huron Erie Connecting Waterways Forecasting System, HECWFS), which simulates the hydrodynamic transport from the headwaters of the St. Clair River to the confluence of the Detroit River and Lake Erie (Figure 31).

HECWFS uses an unstructured grid, otherwise known as a flexible mesh, consisting of triangular cells and nodes corresponding to the vertices of each cell. This framework allows the grid to be highly variable in spatial resolution with very small cells in focus areas and larger cells in open water regions. HECWFS was developed for regional operational forecasting and the spatial resolution within the potential project area was inadequate for this analysis. LimnoTech developed a nested, higher resolution sub-model of the potential project area using an SMS software package from Aquaveo (Figure 32).

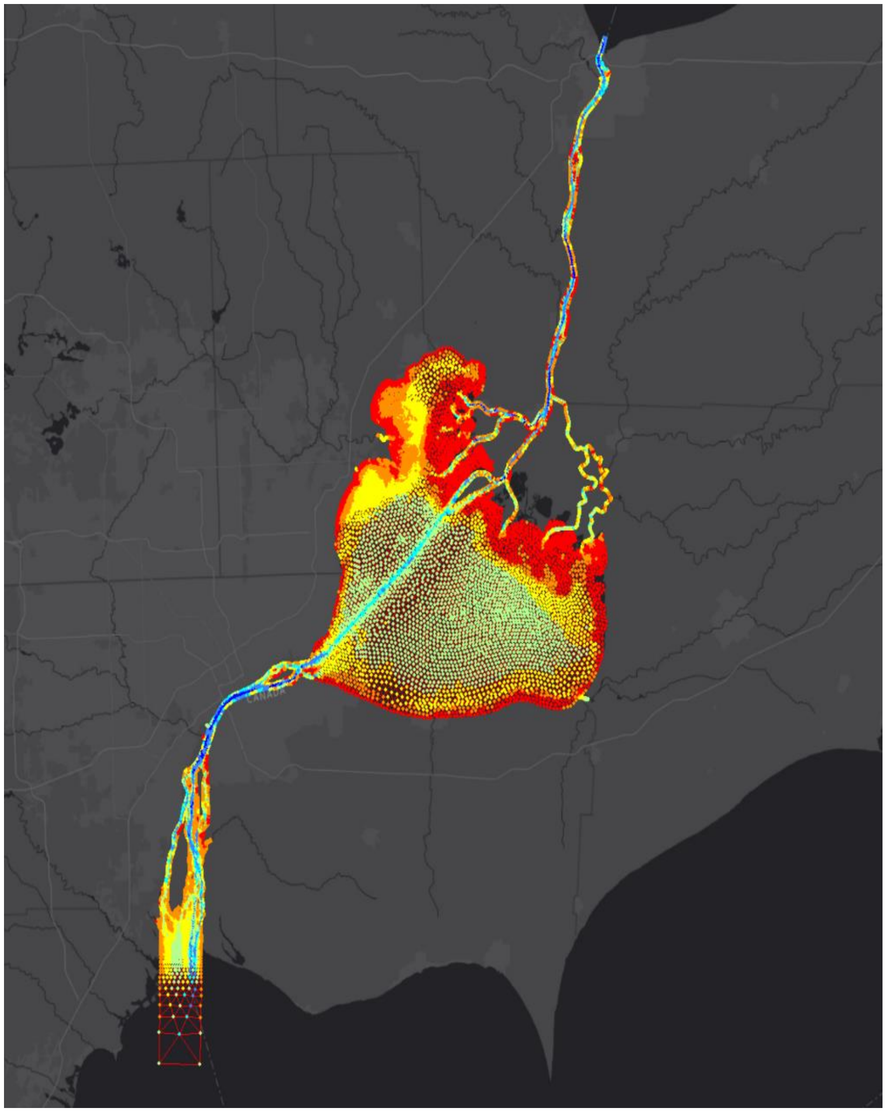


Figure 31. NOAA-GLERL Huron Erie Connecting Waterways Forecasting System (HECWFS) model domain. Image prepared by LimnoTech.

LimnoTech obtained the HECWFS model run files from NOAA-GLERL for May through October, 2021, and simulated the full extent of the HECWFS domain for this period. This full domain model run allowed LimnoTech to use the output from HECWFS as boundary conditions for the nested potential project area domain in simulations of hydrodynamics within the potential project area for this same period.

FVCOM requires several inputs and forcings to represent the physical environment that is being modelled. HECWFS, as developed by NOAA-GLERL requires upstream and downstream water surface elevations, tributary flow rates and temperature, mesh geometry, bathymetry, initial hydrodynamic conditions, and atmospheric conditions. All required inputs for running the HECWFS full domain model were provided by NOAA-GLERL and consistent with their operational forecasts for the simulated period. Modifications to mesh geometry and bathymetry inputs for the sub-domain model are described below.

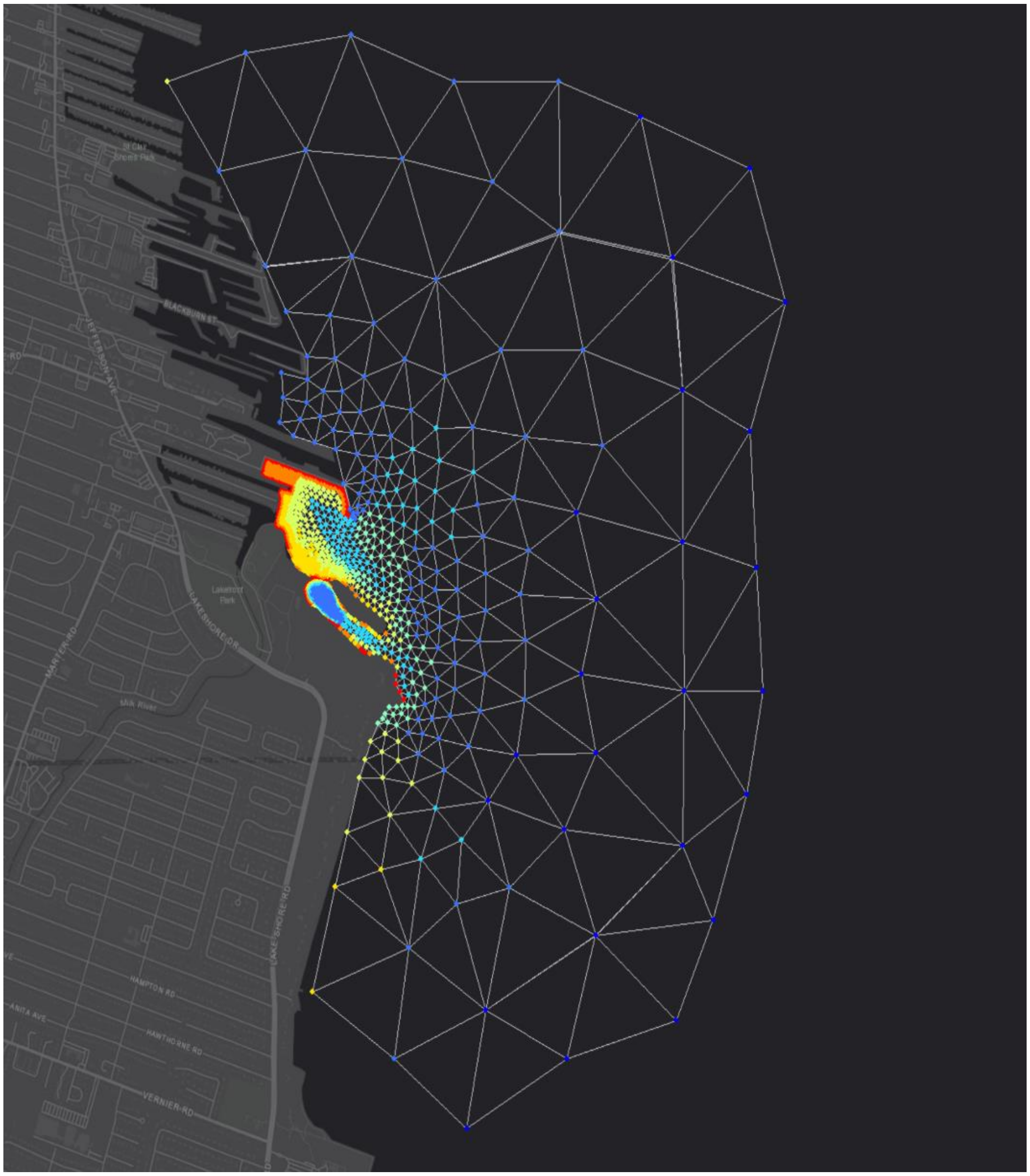


Figure 32. Nested sub-domain model of potential project area. Image prepared by LimnoTech.

FVCOM computes velocities and water surface elevations on an unstructured, user-defined mesh. The mesh defines how each triangular element is constructed by specifying the three constituent vertices, or nodes. The horizontal and vertical location of each node is defined in the FVCOM mesh input files, and the model computes the area and orientation of the elements. For this application, the horizontal and vertical locations were defined using longitudinal and latitudinal values, rather than using a geographic projection. The vertical resolution was defined using six layers of uniform thickness to maintain consistency with HECWFS.

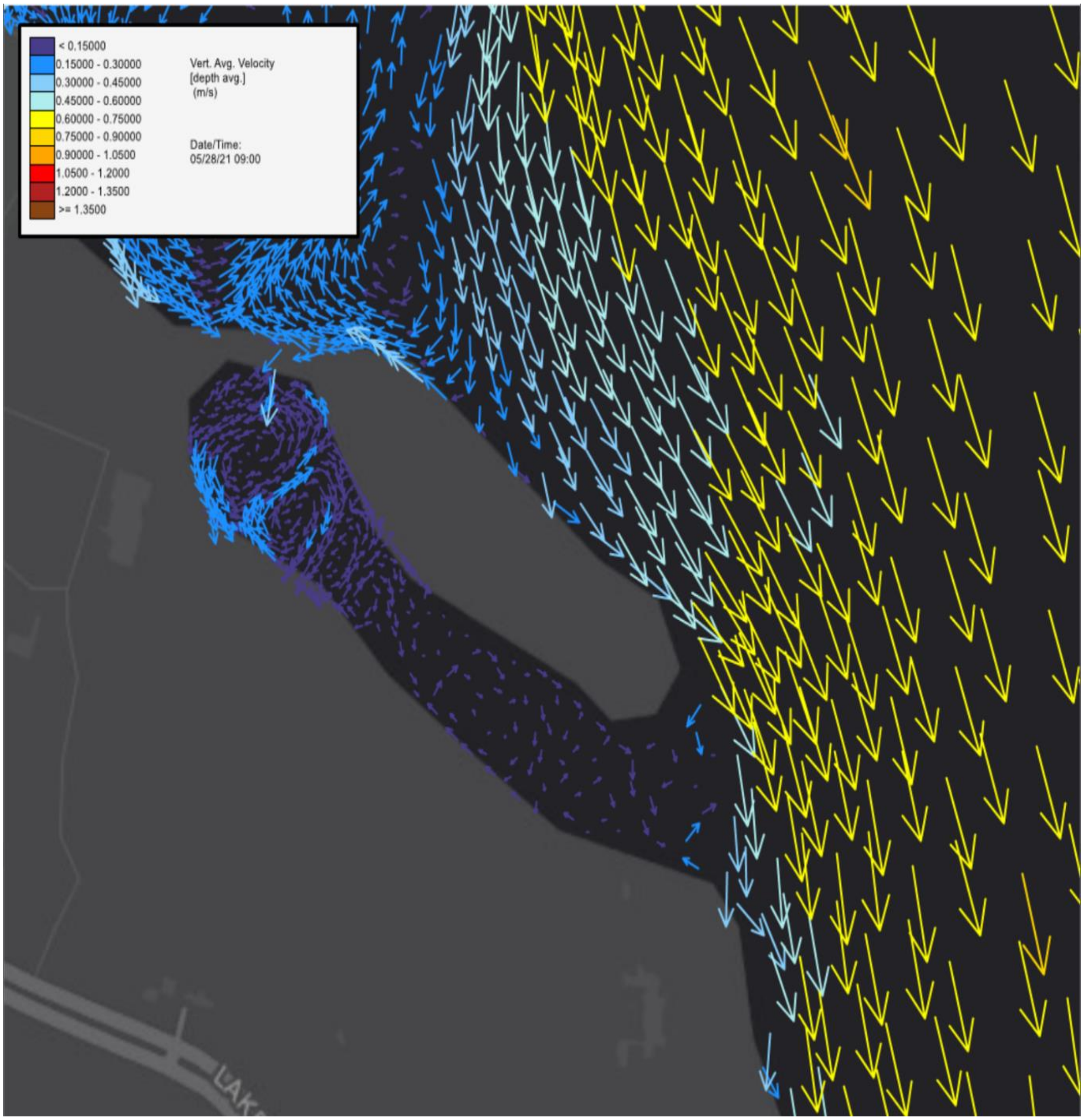


Figure 33. Modelled flow velocities and directions for a high-velocity flow scenario under existing bathymetric conditions. Image prepared by LimnoTech.

Both HECWFS full domain and nested sub-domain models of baseline (existing) conditions used bathymetric data from NOAA and from recent bathymetric surveys of the potential project area. For analyses of restoration design alternatives, bathymetry data were modified to reflect proposed conditions. Grid nodes that fell within proposed breakwater structures were assigned an elevation of 577 feet ASL, representing obstructions to flow that extended above the observed water surface. Grid nodes that fell within proposed wetland or submerged vegetation or soil lift areas were assigned an elevation of 572 feet ASL, representing obstructions to flow that did not permanently extend above the observed water surface.

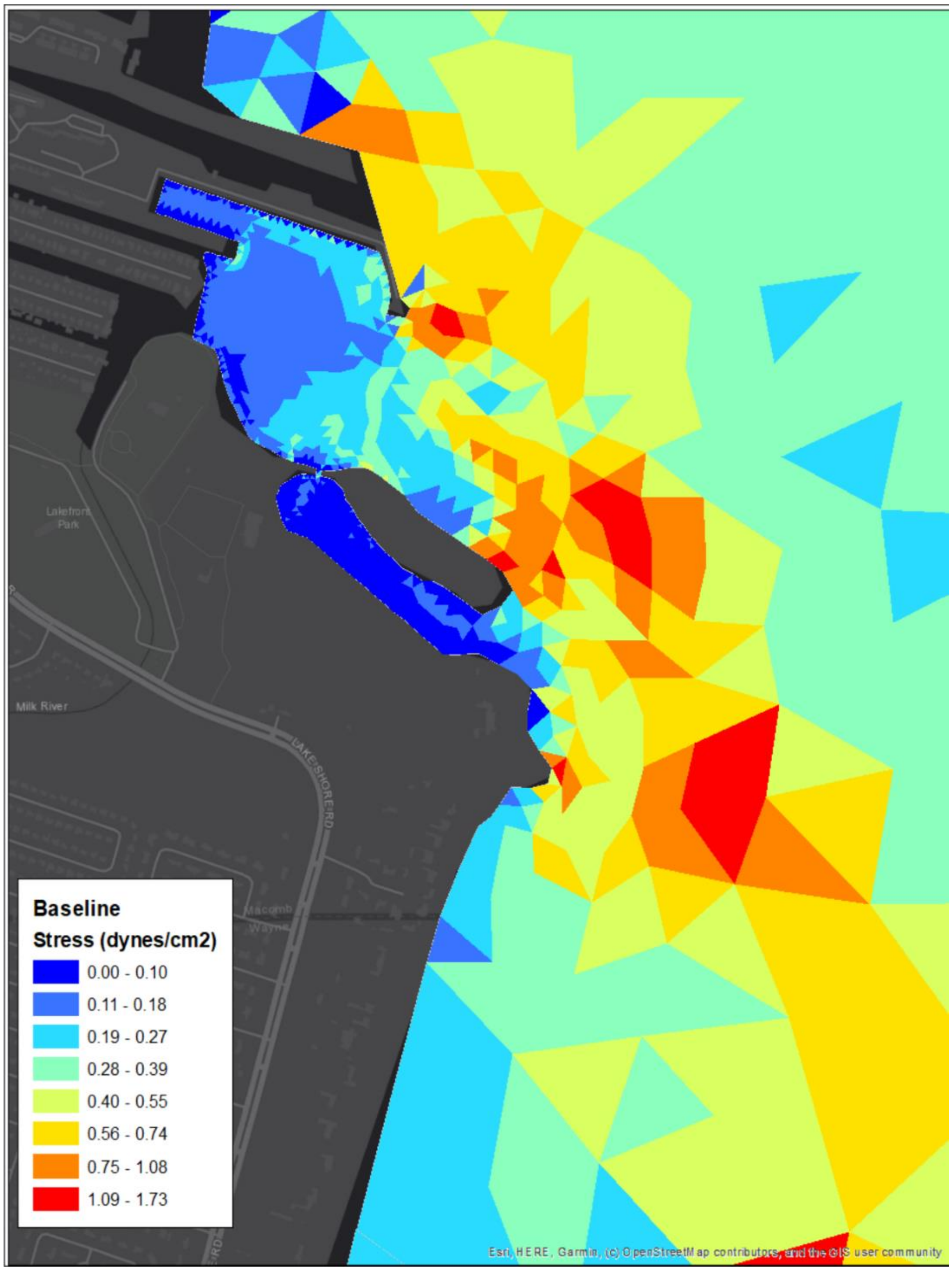


Figure 34. Modelled current-induced bed stress for a high-velocity flow scenario under existing bathymetric conditions. Image prepared by LimnoTech.

The FVCOM model was used to simulate current velocity and current-induced bed stress under existing and proposed bathymetric conditions. Figure 33 through Figure 36 depict simulations of a high-velocity current scenario, thought to be typified by conditions on May 28, 2021.

Figure 33 depicts modelled flow velocities and directions under existing bathymetric conditions. Modelled current velocities within Ford Cove are low, with flows near Bird Island bridge dominated by eddies. Modelled current velocities along the lakeward shore of Bird Island are higher, with currents flowing largely parallel to the shore.

Current-induced bed stress is expressed in dynes/cm². Generally, a stress magnitude of 2 dynes/cm² is sufficient to produce scour and erosion in sandy substrate. Figure 34 depicts modelled current-induced bed stress under existing bathymetric conditions. Current-induced bed stress is low within Ford Cove and along most of the northern shore of the potential project area, with a notable increase near the eastern end of Bird Island.

Proposed breakwaters along the northern shore of Bird Island reduced modelled flow velocities along the northern shore of Bird Island relative to modelled flows under existing bathymetric conditions. Breakwaters directly north of Bird Island bridge shunt currents northward, creating a local increase in modelled current velocity (Figure 35).

Proposed breakwaters along the northern shore of Bird Island reduced modelled current-induced bed stress along the northern shore of Bird Island (Figure 36).

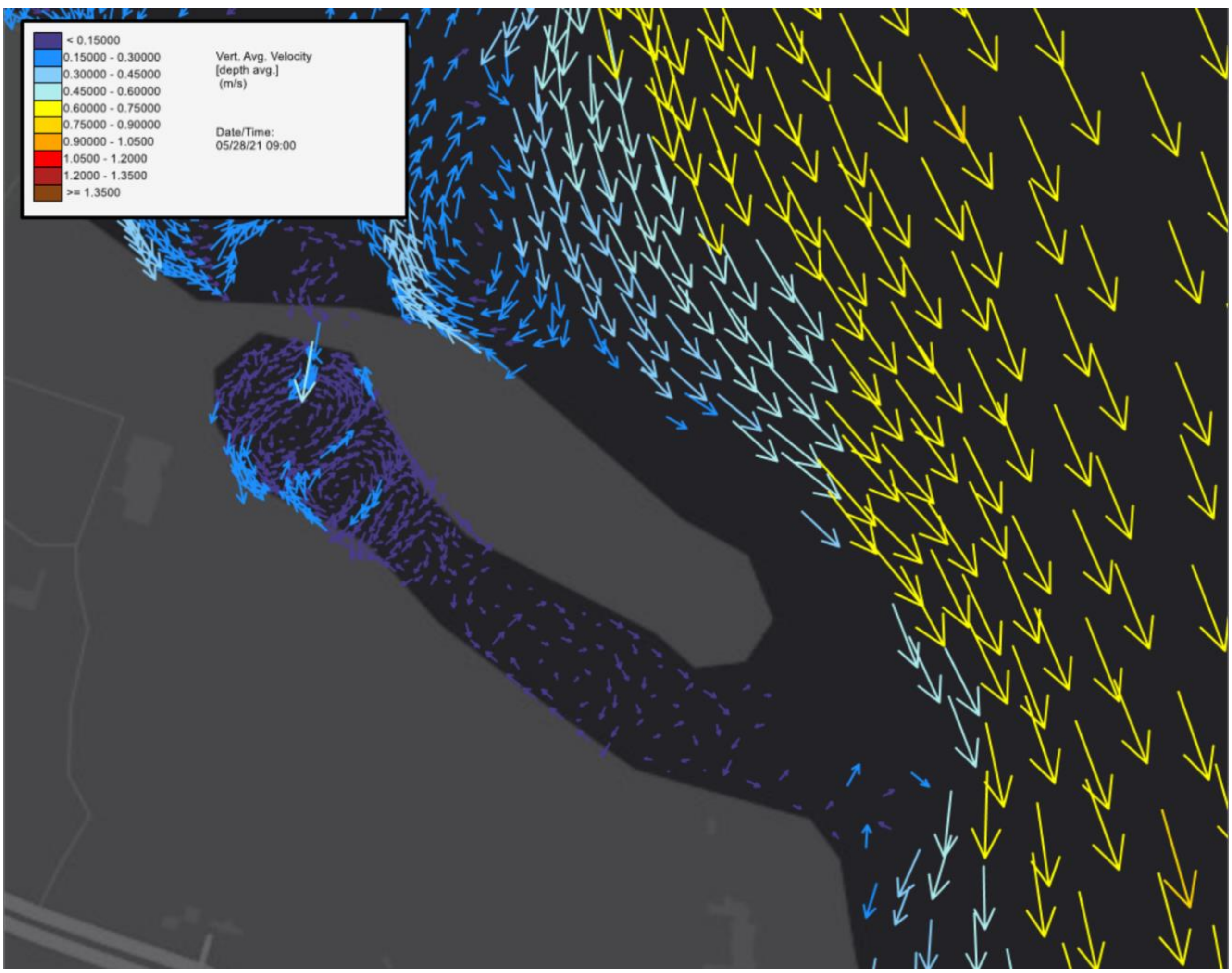


Figure 35. Modelled flow velocities and directions for a high-velocity flow scenario under proposed bathymetric conditions. Image prepared by LimnoTech.

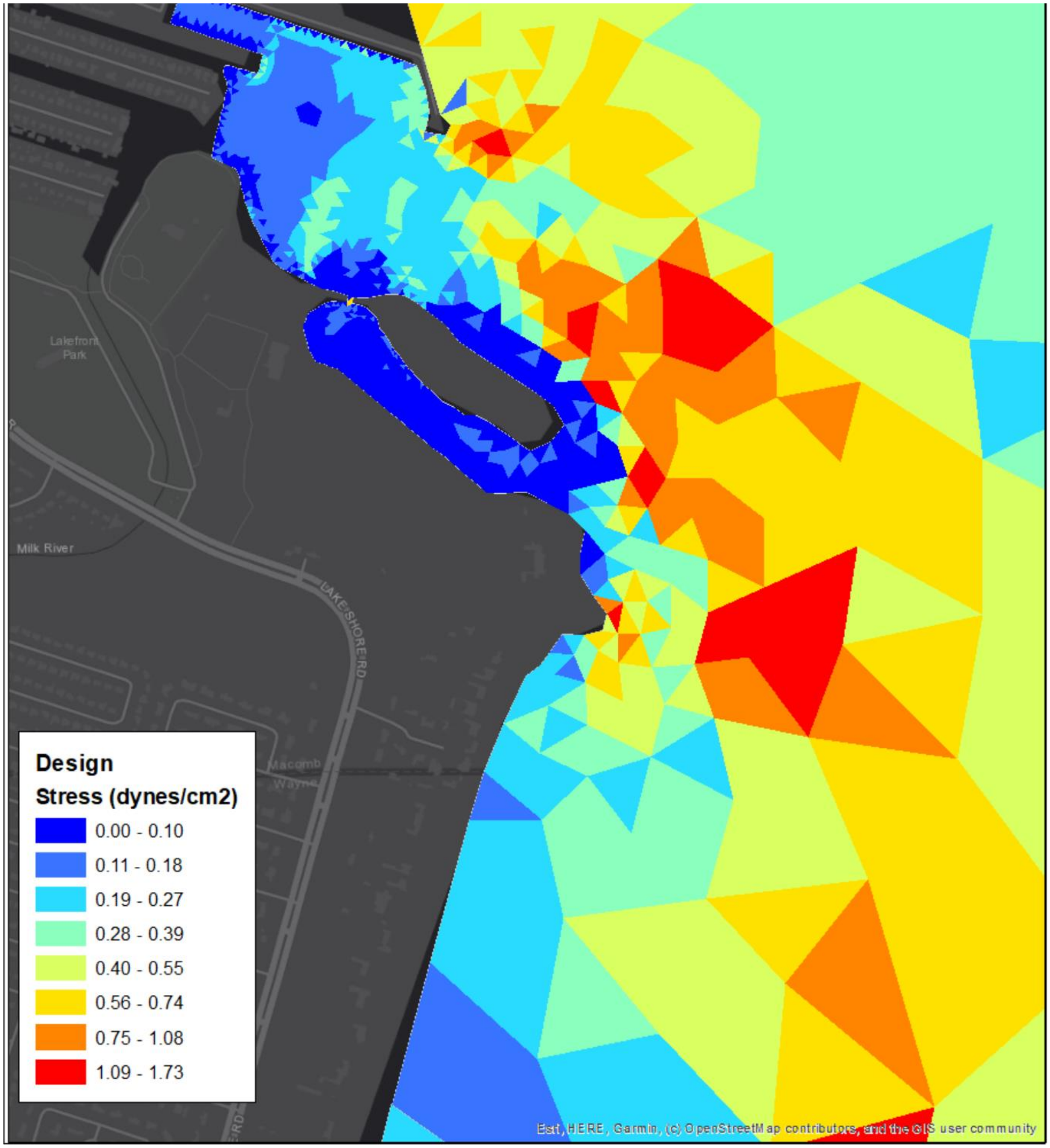


Figure 36. Current-induced bed stress under proposed bathymetric conditions. Image prepared by LimnoTech.

The SWAN model simulated steady-state scenarios of high winds (20 m/s) from the eight ordinal directions to assess the impact of wave energy across the potential project area.

As the model domain captures the entirety of Lake St. Clair, no external boundary conditions were required for these simulations, as the domain is effectively surrounded with land boundaries. The only required model inputs other than wind speed and direction are mesh geometric configurations and bathymetric data. The SWAN model used the same baseline and proposed bathymetric values as were used for the FVCOM hydrodynamic model.

Modelled maximum wave heights under existing bathymetric conditions were low within Ford Cove but higher along the northern shore of Bird Island (Figure 37). Modelled maximum wave-induced bed stress under existing bathymetric conditions was very low within Ford Cove but higher along the northern shore of Bird Island (Figure 38).

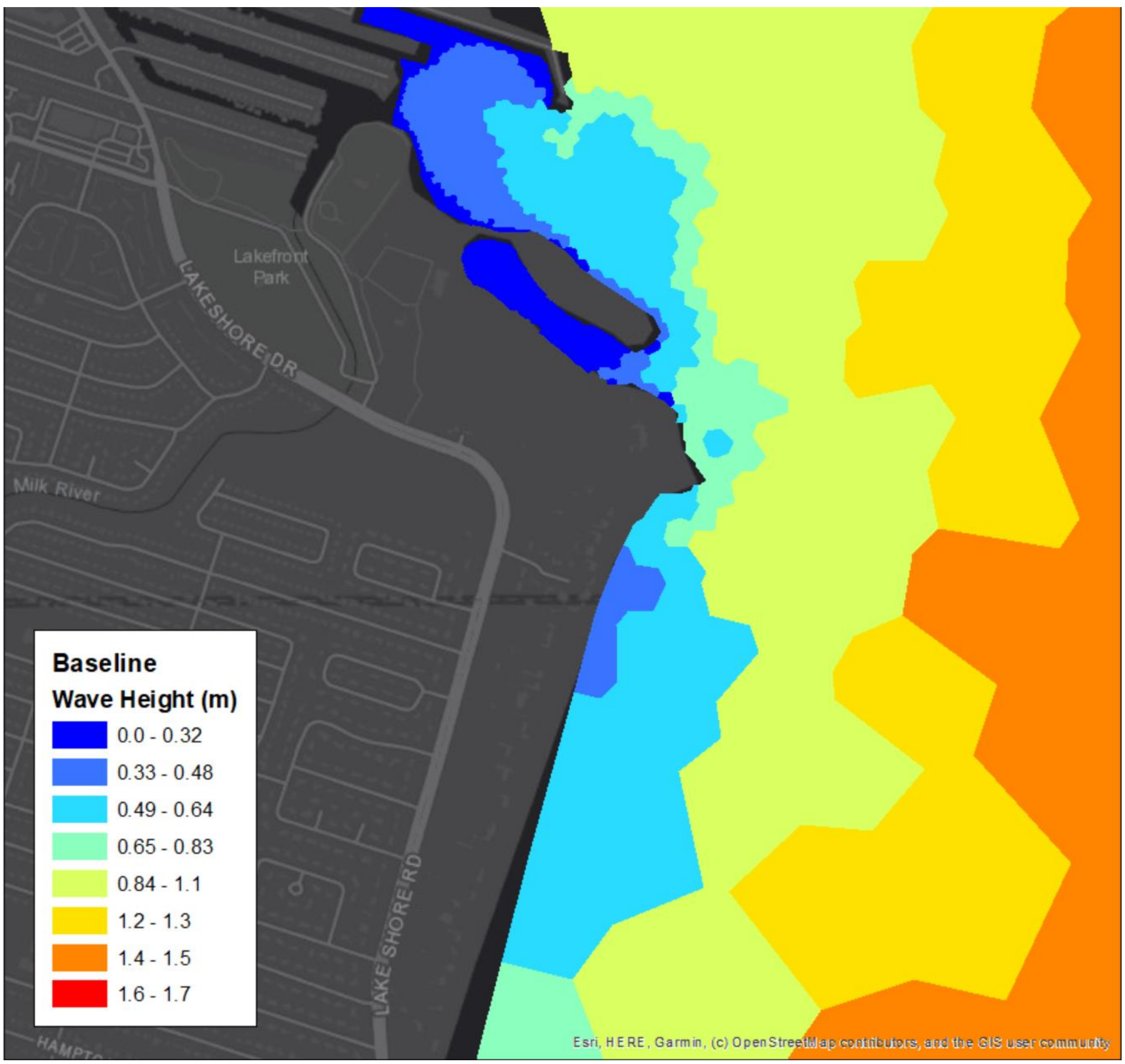


Figure 37. Maximum modelled wave heights for a high-wind speed scenario under existing bathymetric conditions. Image prepared by LimnoTech.

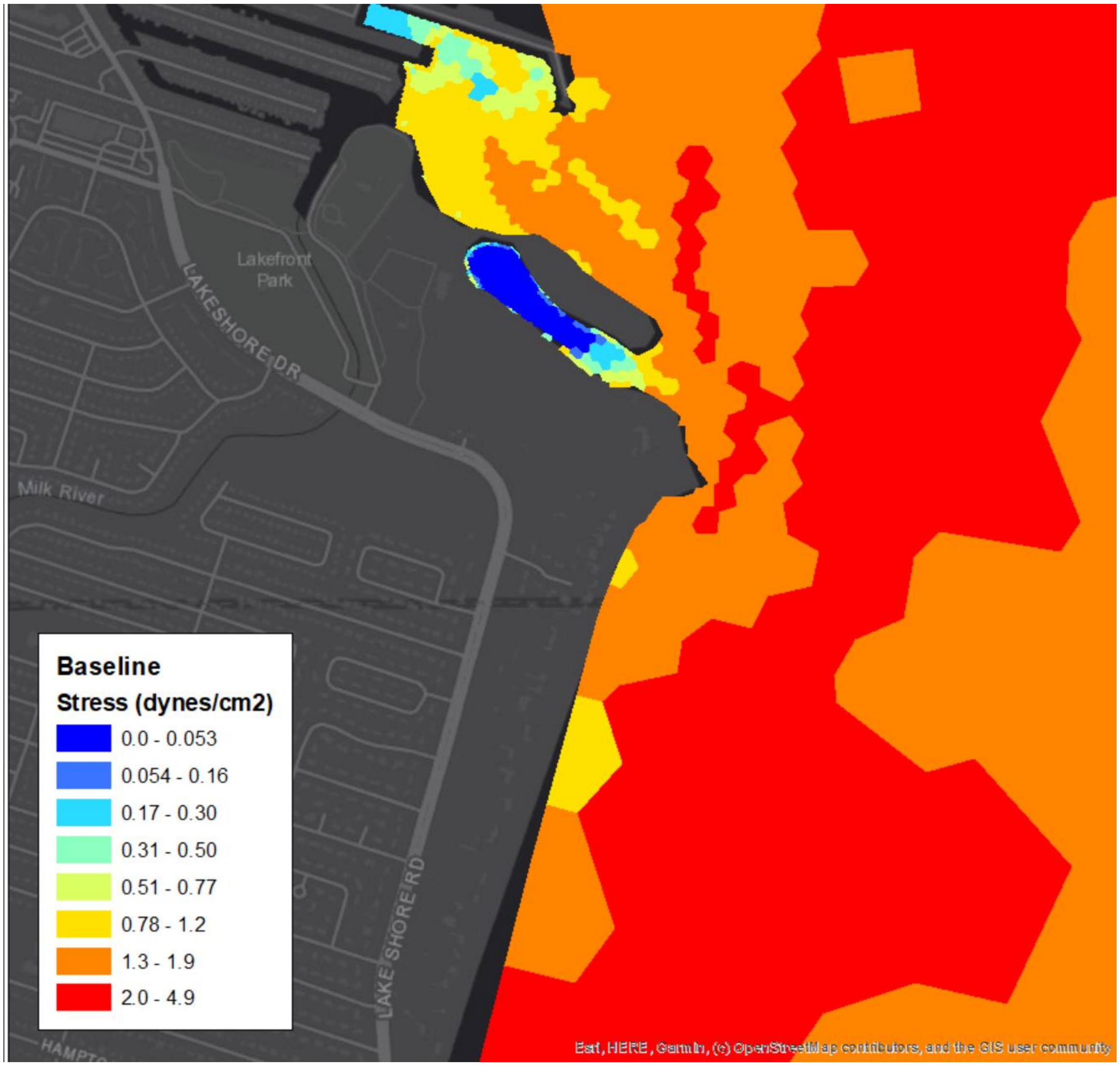


Figure 38. Maximum modelled wave-induced bed stress for a high-wind speed scenario under existing bathymetric conditions. Image prepared by LimnoTech.

Modelled maximum wave heights under proposed bathymetric conditions were low within Ford Cove and along the northern shore of Bird Island (Figure 39). Proposed breakwaters along the northern shore of Bird Island are expected to meaningfully reduce maximum wave heights along the lakeward shore and allow the accretion of wetland sediments.

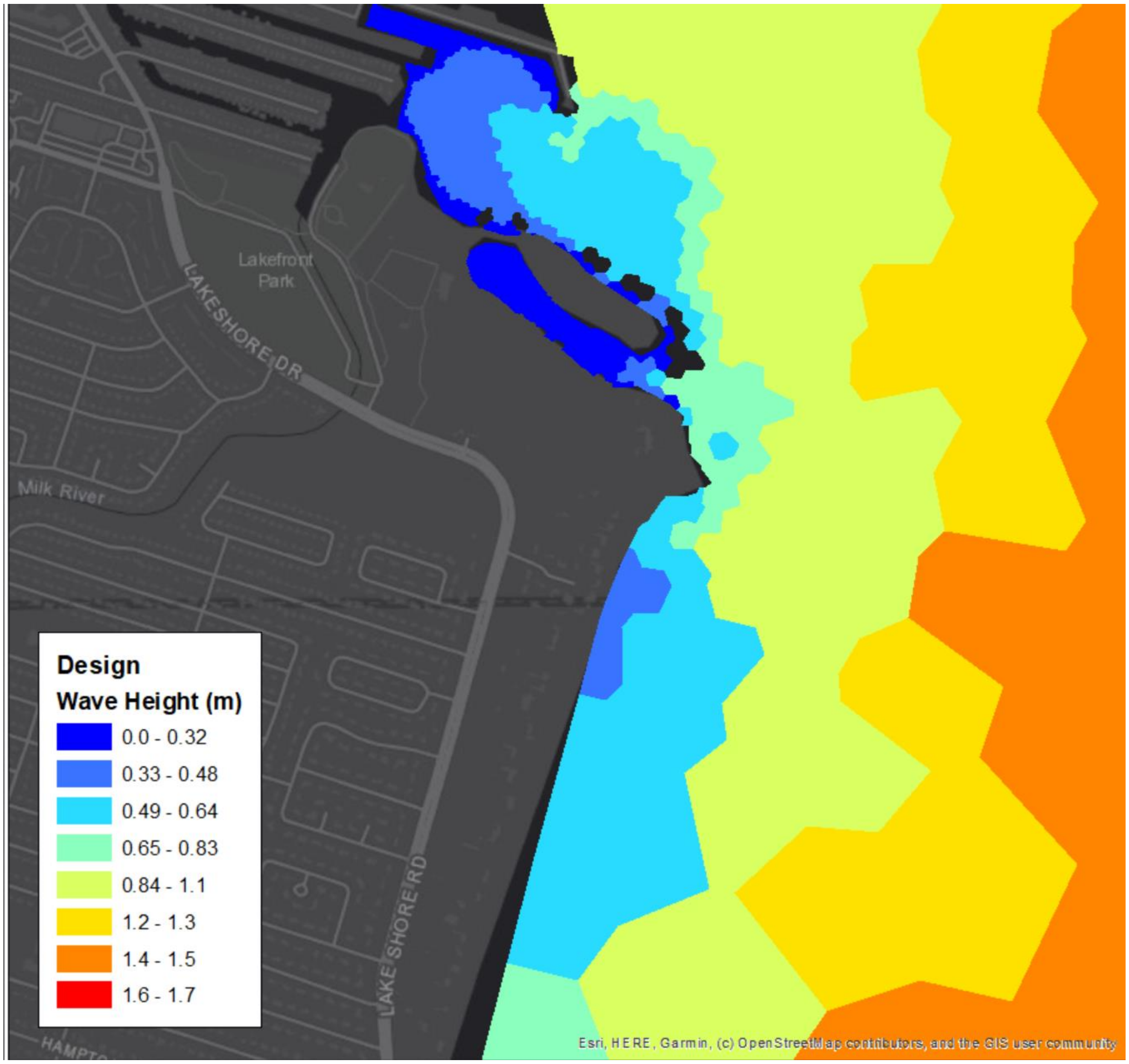


Figure 39. Maximum modelled wave heights for a high-wind speed scenario under proposed bathymetric conditions. Image prepared by LimnoTech.

Modelled maximum wave-induced bed stress under proposed bathymetric conditions was very low within Ford Cove but slightly higher along the northern shore of Bird Island and at the mouth of Ford Cove (Figure 40). Proposed breakwaters along the northern shore of Bird Island are expected to meaningfully reduce maximum wave-induced bed stress along the lakeward shore and allow for the accretion of wetland sediments.

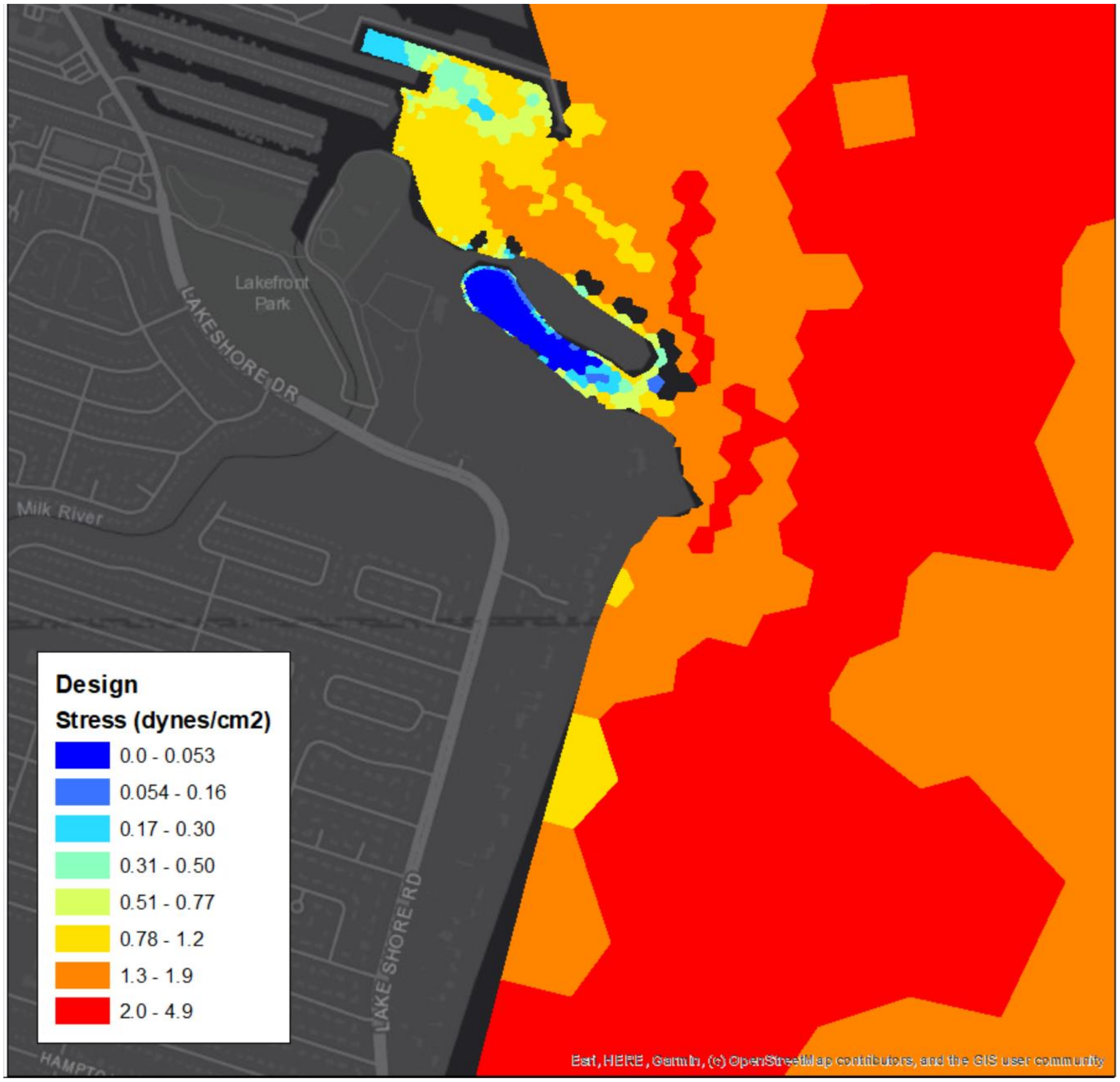


Figure 40. Maximum modelled wave induced bed stress for a high-wind speed scenario under proposed bathymetric conditions. Image prepared by LimnoTech.

Results and Discussion

This modeling effort illuminated likely hydraulic behavior across the potential project area under existing conditions and under proposed restoration conditions., allowing project stakeholders to better match existing and feasible hydraulics with appropriate restoration visions and restoration techniques.

This hydrodynamic model works to identify areas of potential erosion/scour and deposition based on the modeled shear stresses and sediment characteristics and to simulate wave energy potential across the potential project area.

Increased velocities are evident near the inlet to Ford Cove, as well as along the shore of Ford Cove near the visitor center. Especially high velocities are expected near the tip of Bird Island; the potential for erosion in this area should be carefully considered in the restoration design.

Proposed restoration design models utilized higher bathymetric elevations to simulate obstructions like breakwaters and soil lifts, resulting in "masked" or simulated dry cells for this period. Consequently, flows moved away from the existing shoreline, notably by the bridge inlet and western shore outside of the cove. Flows near the inlet beneath Bird Island Bridge increase, while circulation eddies near the bridge were little changed.

Models of the proposed restoration design predict significant changes to directional distributions near Bird Island Bridge, particularly near the break waters.

Relative to models of existing conditions, models of the proposed restoration design suggest substantial decreases in the shear stress near breakwaters and soil lifts, consistent with the restoration design goals: to mitigate shear stress and erosive flows and encourage exchange and circulation of stagnant waters within Ford Cove.

For the following supporting documents, see Appendix K:

- Attachment #1: Project Model File

Public Engagement Survey

Intent
The intent of this investigation was to engage the public in the restoration design process and to better understand the priorities and concerns of stakeholders to inform the restoration design.

Methodology
A nine-question online questionnaire composed of multiple choice and open-ended, narrative questions was made available for public comment and included the following prompts:

- How frequently do you visit Ford Cove?
- What do you like most about Ford Cove?
- How do you use the natural areas at Ford Cove?
- What nature-based activities would you like to see at Ford Cove?
- How do you hear about events taking place at Ford Cove?
- What species of fish do you most commonly catch at Ford Cove?
- What else would you like to share with us that provides valuable context for this project?
- What are improvements you feel would be valuable to enhance the natural experience at Ford Cove?
- Is there anything else you would like to tell or ask us about restoration at Ford Cove?

Results and Discussion
Responses to open-ended questions were categorized as addressing one or more themes (eg., "reduce noise pollution," "add more seating," "prioritize nature"). Survey results are summarized in Table 17.

Survey responses tended to emphasize:

- The value of Ford House as a peaceful natural area within a heavily urbanized landscape.
- Concerns about overdevelopment, overuse, or noise pollution.
- A desire for additional resources to help visitors understand the ecology of the Ford House grounds.
- The need for additional seating or improved walking paths to make the Ford House grounds more accessible for visitors with limited mobility.

Table 17. Public engagement survey results.

Question	Germane Responses	Prevailing Themes (count)	Emblematic Responses
How frequently do you visit Ford Cove?	555	A few times a year (185) A few times a month (184) Have only been once or twice (98)	
What do you like most about Ford Cove?	518	Beauty/Peace/Serenity/Relaxation (357) Birding/Nature/Wildlife (265) Buildings/Grounds/Gardens/Events (38)	"You feel like you are in a wonderful natural area, not in the middle of the metro area. It is quiet, and not built up."
How do you use the natural areas at Ford Cove?	490	Walking/Hiking/Running (304) Appreciating Nature/Birding (184) Peace/ Relaxation/Sitting (90)	"Walking the path, looking for birds, etc. Taking photos. We've picnicked on the island before. We really appreciate the nature

Question	Germane Responses	Prevailing Themes (count)	Emblematic Responses
			path because it's the only one in the area."
What nature-based activities would you like to see at Ford Cove?	379	Guided Tours/Classes/ Signage (165) Birdwatching (133) Other/General Nature Viewing (99)	"More bird watching with experts …. Bird watching evening walks …. Education Programs about the environmental and geological history of [the area] …. Walks with a gardener/botanist who can identify and talk about [the history, use, and background] of native plants …. on the island."
How do you hear about events taking place at Ford Cove?	474	Ford House Website (368) Social Media (Facebook, Twitter, Instagram, etc.) (168) Word of Mouth (127)	
What species of fish do you most commonly catch at Ford Cove?	47	Bass (non-specific) (26) Perch (14) Bluegill (5)	"We can fish there?!"
What else would you like to share with us that provides valuable context for this project?	230	Emphasize/Prioritize Nature (98) Avoid Crowds/Overuse (32) Limit Boat Access/Boat Noise (31)	"I am glad that you are removing the non-natural features and reintroducing native plants and a natural shoreline"
What are improvements you feel would be valuable to enhance the natural experience at Ford Cove?	223	Prioritize Nature, Naturalize Shoreline, etc. (102) More Seating (40) Limit Boat Access/Boat Noise (36)	"Restrict amount of boats and prohibit noisy activities (loud music, shouting, partying, motors)"
Is there anything else you would like to tell or ask us about restoration at Ford Cove?	139	Thanks, Support, Encouragement (69) Prioritize Nature, Naturalize Shoreline, etc. (38 Queries re: Restoration Plans, Fishing, Volunteering, etc. (18)	"I'm happy to hear about the restoration! If you have any volunteer days to help maintain I would be interested in attending!"

For the following supporting documents, see Appendix L:

- Attachment #1: Summaries of Survey Responses

Conclusions and Recommendations

The investigations detailed above explored the potential project area's geotechnical characteristics, pollutant burden, topography, bathymetry, hydraulic relationship to Lake St. Clair, and animal and plant communities. Though these investigations have revealed weaknesses in some aspects of the ecological function at the Ford House grounds, they have also eased concerns about what may lurk in buried sediments, confirmed the presence of several protected species and the habitat potential for many others, and illuminated a path to an ecological restoration of the grounds that honors southeastern Michigan's natural inheritance and the wishes of Ford House stakeholders and members of the local community. Ford House's status as a natural refuge within a heavily disturbed and urbanized landscape, position within prominent migratory routes, and extensive Lake St. Clair frontage presents a unique opportunity to bolster ecological health of southeastern Michigan, the Great Lakes region, and beyond.

The concrete riprap that protects Ford House's nearly one mile of Lake St. Clair shoreline from wave and wake erosion is creating a cascade of ecological problems across the potential project area. Riprap does little to dissipate wave and wake energy, but rather reflects it back out into open water. The power of these waves is more than sufficient to suspend fine sediments and prevent wetland soils from accreting in most nearshore areas, particularly along the lakeward shore of Bird Island. The abrupt, rocky, wave-beaten transition between mesic forest and open water creates a harsh barrier for species that travel between aquatic and terrestrial environments and deprives the local ecosystem of transitional habitats that support the functioning of the whole.

Natural coastlines in low-wave-energy environments (like the sheltered waters of Ford Cove) are typically characterized by a gentle gradation from unsaturated soils to saturated soils, to inundated soils, and finally to open water, and by intergrading plant communities distinguished by growth habit and preferred degree of soil saturation/ inundation. Belts of vegetation sap the energy of waves and currents as they approach the shore and still the waters beneath the surface, protecting fine sediments from erosion and encouraging the deposition of suspended solids which creates a rich matrix of organic matter, knit by plant roots and senescent fibers, that supports a host of macroinvertebrates, which in turn support other animal communities that feed, shelter, and reproduce amid the welter of plant life and detritus. This highly productive, organic wetland matrix is the basis of many shoreline and lacustrine food webs and the nursery of many species that are more colloquially associated with riverine, open water, or terrestrial habitats.

Submerged aquatic vegetation (SAV), the vegetative community that emerges under continuous inundation, is the first line of defense against shoreline erosion, dissipating wave energy in advance of the shoreline and allowing emergent plant communities to establish. SAV also serves as a nursery for juvenile fish and macroinvertebrates, creating the base of the food chain for larger fish species within the ecosystem, and plays a critical role in overall ecosystem health as plants produce oxygen and stabilize the lake bottom, lowering turbidity levels.

The plant community historically found along much of the Lake St. Clair shoreline was emergent marshland. These shallow water wetlands intergrade with the SAV community and are composed of herbaceous species including water plantains (*Alisma spp*.), sedges (*Carex spp*.), spike-rushes (*Eleocharis spp*.), pond-lilies (*Nuphar spp*.), pickerel weed (*Pontedaria cordata*) and bulrushes (*Schoenoplectus spp*. and *Scirpus spp*.). Like the SAV community, the emergent marsh community provides shelter for aquatic fauna as well as foraging ground for avian and terrestrial species that feed on the plants and animals that occur within this habitat. Emergent marshes help to maintain water quality by slowing water moving through the system, allowing sediment and other pollutants to fall out of the water column and settle on the bottom where the plants and microorganism use the nutrients for growth, fixing them in their own tissues or sequestering them in the lakebed sediments.

As the water grows shallower the emergent marsh community gives way to the wet meadow, or sedge meadow. This herbaceous plant community is typically composed of sedges (*Carex spp*.), grasses like brome (*Bromus ciliates*) and fowl manna grass (*Glyceria striata*), and a variety of forbs including swamp milkweed (*Asclepias incarnata*), marsh bellflower

(*Campanula aparinoides*), common boneset (*Eupatorium perfoliatum*), joe-pye-weed (*Eutrochium maculatum*), northern bugle weed (*Lycopus uniflorus*), tufted loosestrife (*Lysimachia thyrsiflora*), Virginia mountain mint (*Pycnanthemum virginianum*), common arrowhead (*Sagittaria latifolia*), and common skullcap (*Scutellaria galericulata*). This plant community provides food and shelter for a variety of native pollinators as well as aesthetic beauty for visitors, with its shifting mosaic of colorful flowers throughout the growing season.

Farther inland the sedge meadow community gives way to the scrub/shrub community. Shrub/scrub is dominated by diminutive woody species like dogwood *(Cornus spp.*), alder (*Alnus spp.*) and willow (*Salix spp.*) that thrive in the abundant sunlight and saturated soils. The scrub/shrub community offers forage and shelter for pollinators and nesting birds and protects soils and delicate herbaceous plant species from waves and high winds during extreme weather events. As these woody plants senesce and decay, they create ecological niches for fungi and other decomposers, and create habitat structure and complexity for the animals that spend their lives amid the sweltering undergrowth.

As the soils grow firm enough to support the weight of trees, scrub/shrub succeeds to southern hardwood swamp and wet-mesic forest. Canopy trees like silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*) and American beech (*Fagus grandifolia*) preside over an understory of flowering forbs and vernal pools. Birds nest and feed among the trees, amphibians lay their eggs in the relative safety of the vernal pools, spring ephemerals flash into life before the flush of the canopy leaves, and armies of macroinvertebrate pollinators, grazers and detritovores convert the abundant plant matter into important links in the food chain.

The transition from submerged aquatic vegetation to emergent marsh, sedge meadow, scrub/shrub and finally wet and mesic hardwood forest will create ecological opportunities for many bird, mammal, herptile, macroinvertebrate, and plant species now likely absent from the site.

In contrast to these intergrading wetland communities, the existing riprap is habitable only to the hardiest and most tenacious pioneer species. The wave action prevents the accretion of organic matter, and macroinvertebrates are comparatively few. Fish fry, juvenile amphibians and shorebirds find little to sustain them.

Natural coastlines in moderate-wave-energy environments, like that along the lakeward shore of Bird Island, are generally characterized by the absence of fine sediments – which in moderate wave energy environments, vegetation alone is inadequate to protect – and by the extensive sorting and transport of sediments which produces sand beaches, sand/gravel bars, and other features commonly associated with Great Lakes shorelines. As waves and currents run through the shallow water they accelerate and accept sediment from the lakebed before spending their energy against the shore and depositing their suspended sediments once again. The largest sediments – cobbles and gravels – are typically left behind or deposited first, below the waterline, while the fine gravels and sands are carried onto the beach before then, too, dropping out of suspension. In this way, waves and currents naturally sorts the nearshore sediments by particle size, creating distinct bands and regions of relatively uniformly-graded aggregates.

These regions of sorted aggregates, continuously swept free of smaller sediments, are ecologically important. They are often rich in filter-feeding bivalves, which risk being smothered by fine sediment or starved of oxygen in stagnant waters and so prefer to anchor to well-oxygenated beds of sand, gravel or cobble and feed on passing suspended organic matter. Many fish species also prefer to deposit their eggs in beds of sorted gravels and cobbles, where wave action and strong currents ensure a steady supply of well-oxygenated water for their developing young, discourage macro-invertebrate predators, and sweep away fine sediments that may otherwise smother the eggs before they hatch.

Coastal wetlands can also exist in moderate-wave energy environments at the mouths of river systems, where the rapid deposition of river-borne sediments matches the high rate of wind and wave erosion at the margin of the wetland. However, the Ford House grounds are not situated at the mouth of a river, so in the absence of a hard shoreline, the ecosystem and topography along moderate-wave energy sections of the shoreline is likely to evolve towards that of the sandbar upon which Bird Island was constructed unless steps are taken to reduce the energy of waves and currents lashing the shore.

The wave energy within Ford Cove is governed by complex interactions between the bathymetry of the cove and the gross deflection of waves and currents around Bird Island but will generally be low enough to allow for the gradual accumulation and sustainment of coastal wetlands through the accretive process described above, given that the concrete riprap is removed, and the grade of the existing bank reduced. In some areas, living shoreline bio-engineering structures like soil lifts and wood toe will be necessary to support the long term stability of the shore while still encouraging the establishment of native hydrophilic vegetation and creating habitat for macroinvertebrates and juvenile fish and herpetofauna species. Emergent wetlands with significant western and southern exposure (like along the western shore of Bird Island) will provide turtles and other herpetofauna with gently graded, sun-drenched beaches they're known to prefer for nesting. Plantings of emergent vegetation like bulrushes will create habitat diversity, harbor communities of macroinvertebrates, fish and herptiles and encourage the dispersal of native plants now likely absent from the potential project area. The inlet beneath Bird Island bridge will be widened considerably to improve water exchange between Lake St. Clair and Ford Cove and encourage the sorting and transport of sediments along the bottom of Ford Cove which will increase habitat diversity and improve habitat for native fish and mussels.

The lakeward shore of the potential project area is not sheltered by Bird Island and is therefore exposed to more powerful waves and currents coming off Lake St. Clair. Informed by the results of geotechnical investigations and hydrodynamic modeling, loose stone breakwaters should be installed at strategic locations to protect the shore from erosion after the removal of the concrete riprap and facilitate the accretion and persistence of a wetland ecosystem along the northern shore of the potential project area and at the mouth of Ford Cove. Gravel and cobble beds should be created at appropriate points along the lakeward shore to provide habitat for native mussels and fish.

Lakebed mudpuppy structures, salamander nesting boxes, turtle nesting boxes, habitat logs and woody debris should be placed throughout the potential project area to encourage year-round occupation and successful reproduction.

Upland areas will benefit from the ecological invigoration of the wetland community but will also be a target of restoration efforts. During the wetland assessment and the floristic quality assessment the OHM team identified many communities of invasive, overcrowded, or stunted plants. Where appropriate this vegetation will be thinned and or supplemented with native plantings. As in the wetland community, upland ecological diversity will beget diversity as pollinators exploit new niches, wetland and shoreline animals that feed in the shallows court and shelter among the trees, and invasive species are held at bay by robust assemblages of native plants.

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